# Revision 1

## Light Water Reactor Sustainability Program

## Factors Affecting Hiring and Retaining the Nuclear Workforce

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**2 August 2023**

**Prepared for the Idaho National Laboratory**

**Light Water Reactor Sustainability Program**

# EXECUTIVE SUMMARY

As identified by the Nuclear Energy Institute (NEI), the United States (U.S.). nuclear energy industry faces significant challenges in attracting and retaining the required levels of qualified workers to meet the current as well as future needs of the industry. This is in part due to on-going retirements, worker retention issues, changing workforce demographics, and other factors. Moreover, existing forecasts[16, 35] indicate that U.S. labor market conditions will worsen over the next decade and continue into the 2060s.

The extended operation of the current U.S. nuclear plant fleet and the proposed construction and operation of advanced nuclear plants and other clean energy generating facilities will require educating, training, and hiring a significant number of workers from a limited and in some cases decreasing perspective worker pool. Several studies have been completed that project the potential jobs associated with the expansion of the energy production sector as follows:

- Approximately 4,000 workers per year for a total of 108,000 workers by 2050 need to be hired and trained to sustain the current U.S. nuclear plant operating fleet workforce.
- Vibrant Clean Energy projects 27,000 to 177,000 average annual fulltime equivalent jobs by 2050 depending on the scenario.
- The Department of Energy (DOE) Commercial Liftoff report projects 375,000 jobs to manufacture, construct, and operate 200GW of new nuclear generation by 2050.
- The DOE Office of Environmental Management projects 65,800 total workers are needed at U.S. cleanup sites over the next five years.
- The Blue Green Alliance projects 1.55 million wind and solar jobs by 2035.
- The Nuclear Energy Agency (NEA) and International Atomic Energy Agency (IAEA) project 1,800 jobs for each single unit 1000-MW advanced light water reactor.

In addition to the projected jobs associated with the expansion of the energy production sector the employee turnover, new hire, and new employee turnover rates for currently operating nuclear power plants have steadily increased in the past three years resulting in a need for more replacement workers to sustain the fleet.

**Total Employee Turnover, New Hire, and New Employee Turnover Rate by Fleet and Non-Fleet**

Historical employee turnover rate for nuclear plant companies from 2010 to 2022 averaged 7.3 percent, which is six times lower than the average employee turnover rate for other U.S. industries. However, nuclear plant company employee turnover rates in 2022 increased to about 9 percent. See Figure 1

| Total Percent of Employee Turnover by Company Type | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 5.7% | 7.5% | 8.9% |
| NON-FLEET | 6.9% | 10.6% | 11.2% |
| **Total Turnover for all Company Types** | **5.9%** | **7.9%** | **9.2%** |

Figure 1: Total Percent of Employee Turnover by Company Type

The increase in employee turnover rates correlates with the increase in new hires for the same period. See Figure 2.

| Total Percent of New Hires by Company Type | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 4.6% | 4.7% | 10.2% |
| NON-FLEET | 5.3% | 6.2% | 9.3% |
| **Total Hires for all Company Types** | **4.7%** | **4.9%** | **10.0%** |

Figure 2: Total Percent of New Hires by Company Type

New employee turnover, defined as an employee that leaves the company within three years (0 to 3 years of service) of their hire date, also increased since 2020. See Figure XX.

| Total Percent of New Employee Turnover | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 1.6% | 2.1% | 3.2% |
| NON-FLEET | 1.1% | 1.7% | 1.7% |
| **Total New Employee Turnover for all Sites** | **1.5%** | **2.0%** | **3.0%** |

Figure 3: Total Percent of New Employee Turnover

**Employee Turnover, New Hire, and New Employee Turnover Rates by Job Group**

While turnover rates for plant security workers have been traditional higher than other job groups in the nuclear fleet, there has been an on-going increase in turnover rates for power plant engineers (includes probabilistic risk assessment, fuels, systems, and design engineers). Traditionally the engineering turnover rate average is the same rate as the balance-of-plant worker: however, the recent trend has increased 200 percent from 2020 to 2022. This group now experiences the second highest turnover rate behind plant security workers. See Figure 4 below.

| Turnover Rate by Job-Group (ALL SITES) | 2020 | 2021 | 2022 |
|---|---|---|---|
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 5.1% | 6.1% | 6.1% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.1% | 5.2% | 7.0% |
| Planners – Schedulers – Work Week Managers – all types | 5.1% | 8.1% | 5.3% |
| Plant Security Workers – all types | 8.0% | 11.7% | 15.6% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 6.9% | 9.0% | 12.8% |
| Radiation Protection and Chemistry Workers – all types | 7.1% | 9.7% | 8.9% |
| Training Instructors & Curriculum Developer – all types | 5.8% | 8.8% | 8.7% |
| **Turnover Rate by Job-Group (FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 4.9% | 5.3% | 5.7% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.0% | 5.0% | 6.4% |
| Planners – Schedulers – Work Week Managers – all types | 4.2% | 7.3% | 4.9% |
| Plant Security Workers – all types | 8.3% | 12.1% | 16.7% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 6.5% | 8.3% | 12.1% |
| Radiation Protection and Chemistry Workers – all types | 6.7% | 9.0% | 7.9% |
| Training Instructors & Curriculum Developer – all types | 5.4% | 7.6% | 7.4% |
| **Turnover Rate by Job-Group (NON-FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 6.0% | 10.6% | 8.4% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.3% | 6.5% | 10.4% |
| Planners – Schedulers – Work Week Managers – all types | 12.4% | 14.5% | 8.1% |
| Plant Security Workers – all types | 5.5% | 9.2% | 8.8% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 9.2% | 13.1% | 16.8% |
| Radiation Protection and Chemistry Workers – all types | 9.8% | 13.4% | 14.5% |
| Training Instructors & Curriculum Developer – all types | 8.9% | 16.4% | 17.3% |

Figure 4: Turnover Rate by Job Group (All Sites, Fleet, Non-Fleet)

**New Employee Turnover Rate**

Plant security workers had the highest new employee turnover rate in 2022 of 8 percent which is about double the rate for other job groups. The next highest group is power plant engineers at the rate of 4.1 percent. This is indicative of the demand for engineers in general industry and indicates a need to develop retention strategies for that job-group. See Figure 5.

| New Employee Turnover Rate by Job-Group (ALL SITES) | 2020 | 2021 | 2022 |
|---|---|---|---|
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 0.8% | 1.1% | 1.3% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.0% | 1.2% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.9% | 0.7% | 1.1% |
| Plant Security Workers – all types | 3.1% | 5.0% | 8.0% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 2.3% | 2.7% | 4.1% |
| Radiation Protection and Chemistry Workers – all types | 1.1% | 2.0% | 2.8% |
| Training Instructors & Curriculum Developer – all types | 1.5% | 1.7% | 1.8% |
| **New Employee Turnover Rate by Job-Group (FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 0.9% | 1.1% | 1.3% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.0% | 1.1% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.9% | 0.6% | 1.1% |
| Plant Security Workers – all types | 3.2% | 5.5% | 8.9% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 2.5% | 2.7% | 4.4% |
| Radiation Protection and Chemistry Workers – all types | 1.1% | 2.0% | 2.9% |
| Training Instructors & Curriculum Developer – all types | 1.4% | 1.7% | 1.9% |
| **New Employee Turnover Rate by Job-Group (NON-FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) all types | 0.5% | 1.1% | 1.0% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.1% | 1.8% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.5% | 1.1% | 1.1% |
| Plant Security Workers – all types | 2.1% | 1.7% | 2.1% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) all types | 1.1% | 2.6% | 2.8% |
| Radiation Protection and Chemistry Workers – all types | 0.9% | 2.1% | 2.1% |
| Training Instructors & Curriculum Developer – all types | 1.9% | 1.4% | 1.4% |

Figure 5: New Employee Turnover by Job Group (All Sites, Fleet, Non-Fleet)

**Market Factor Impact**

Overall, the following market factors are impacting or could impact the future of commercial nuclear power plant's ability to attract and retain a workforce:

- **New Nuclear Power Plant Resurgence** - In advanced reactors alone, the DOE projects 236,000 workers will be needed to manufacture, construct, and operate advanced reactors through 2035, with that number increasing to approximately 376,000 workers by 2050.

- **Competition from Domestic Nuclear Projects** - The DOE Office of Environmental Management has projected it will need 11,000 operators, 8,700 radiological technicians, 6,500 electricians, 5,500 project controls analysts, 3,500 project managers, 3,500 mechanics and 2,300 work planners at its U.S. cleanup sites over the next five years.

- **Competition from Domestic Clean Energy Projects** - According to an analysis performed for the BlueGreen Alliance, the clean energy tax credits and the 45X manufacturing tax credit will induce demand for 1.6 million additional solar and wind jobs.

- **Competition from International Nuclear Power Plant Construction and Operation** - Most projected nuclear plant startups by country will occur outside the U.S., creating opportunities for U.S. workers. In one example, EDF Energy hired about 100 experienced U.S. and Canadian welders, pipefitters, and boilermakers to fix its ageing nuclear reactors and build more of them.

- **Competition from Non-Nuclear Industries** - Other domestic industries such as aviation, batteries, and computer chips need workers with the same skills, knowledge, and experience as the nuclear workforce. For example, Intel broke ground on two massive computer chip factories in Ohio that aim to employ 3,000 people. Hefty new government subsidies aimed at reshoring manufacturing are sparking a construction boom of new chip factories, but a dire shortage of engineers threatens the ambitious project.

**Retention Strategies**

Human Resources managers or directors from 66 percent of all operating reactors (92) identified the following as the most often used retention strategies:

- Pay for Licensees or Skill Competencies
- Relocation Benefits - New Hire ONLY
- Employee Development Program – Career Services
- Employee Technical Training Programs
- Mentorship Programs
- Hiring Bonuses – New Hire ONLY
- Flexible Work Environment (Remote Work – Hours)
- Technology Program – Reimbursement of Cell Phone – Home Internet
- Educational Reimbursement

**Exit Survey Findings Summary from Selected Organizations**

Human Resources managers or directors from 66 percent of all operating reactors (92) identified the following top three reasons for voluntary employee turnover in their organization:

- Leadership – Organization Management
- Career Opportunity – Job Change
- Work-life Balance, Work Schedule Changes

**Identified Barriers to Hiring and Retention**

- Labor-force Participation Decline - For December 2022, the Labor Department reported that the labor-force participation rate – the share of the noninstitutionalized population aged 16 and up that is either working or looking for work – was a seasonally adjusted 62.3 percent. That compared with 63.3 percent in February 2020. There are many open jobs, but not

enough workers to fill them. If every unemployed person in the country found a job, the U.S. would still have more than 4 million open jobs.

- Great Resignation - The Great Resignation, first gained momentum in the U.S. in 2021, when roughly 47.4 million people quit their jobs. For comparison, 42.1 million people quit in 2019, which was also considered a tight labor market.

- Aging Demographics - The number of U.S. people 65 years or older continues to increase and is projected to represent about 22 percent of the U.S population by the year 2050.

- Diversity, Equity, and Inclusion (DE&I) - According to the NEI Strategic Workforce Plan, across the energy sector, approximately 22 percent of the current workforce is female, while minority populations comprise 24 percent of the energy workforce. North American Young Generation in Nuclear (NAYGN) noted discrepancies in pay by gender and by ethnicity. The first comprehensive survey of gender balance in Organization for Economic Co-Operation and Development (OECD) Nuclear Energy Agency (NEA) countries substantiates women's underrepresentation in the sector, especially in STEM and leadership roles.

- Work – Life Balance – Employees and prospective employees identified nuclear plant location (typically away from urban areas), Emergency Response Organization (ERO) participation, flexible work schedules, remote work opportunities, and increased workloads as adversely impacting work-life balance.

- Insufficient Construction and Supplemental Workforce - There is already a shortfall in mechanical and electrical engineering talent as well as skilled craftsman in the critical trades (welding, machining, electronics, electrical, etc.) needed to support existing labor force demand. Growth in nuclear development will only exacerbate that shortfall.

- Insufficient NRC Staffing - Construction and operation of new nuclear power plants will first require NRC license approvals. A lengthy approval process, with a history of delays, will stall the need for hiring workers causing those workers to seek careers in other industries. The DOE Liftoff Report says the NRC would need to scale its license-application capacity from approximately 0.5 GW per year to 13-GW-per-year to meet projected demand. This would likely require significant additional resources for the NRC.

- Late Student Engagement - Engagement and outreach to students is not occurring in a timely manner nor is it broad and comprehensive enough to be fully effective. None of the students interviewed at the 2023 ANS Annual Student Conference mentioned being contacted by or seeing a presentation from a nuclear company regarding career opportunities. Miss America 2023, a University of Wisconsin nuclear engineering student, said she was not offered a tour of a commercial nuclear power plant until her junior year of study.

- Uncertainty to Build and Operate New Plants - Uncertainty regarding if new nuclear power plants will be built might cause perspective workers to seek employment in other industries. Finance, policy, and environmental factors favor the development of several new nuclear generation units over the next decade in the U.S. but challenges persist. An offer of as much as $300 billion in nuclear financing remains untouched. The industry is stuck in a stalemate, where utilities are waiting announcements from reactor developers on design readiness and pricing, reactor developers are looking to suppliers to complete designs, and no real capital decisions are being made about building new nuclear plants.[18]

**Going Forward Strategy and Recommendations**

U.S. commercial nuclear power plant companies, government organizations, and academic institutions are preparing for the expected increased need for workers and, in some cases, are implementing programs to address this need. To accelerate these efforts the following actions are recommended for consideration by DOE/INL:

- Assist the commercial nuclear power plant industry with obtaining federal and state appropriations and support related to workforce issues (e.g. NRC, DOE (NEUP), internships, apprenticeships, scholarships, grants, awards, etc.) and ensure the industry is aware of opportunities.

- Assist the commercial nuclear power plant industry with increasing the focus on energy and energy careers in the K-12 educational system by working with the U.S. Department of Education to add "Energy" as a 17th Career Cluster; to date, neither the federal government nor a majority of states have taken the same action. A career cluster is a grouping of similar jobs with career pathways. Adding Energy as the 17th Career Cluster would help to drive

increased focus and visibility regarding energy and energy careers through the K-12 educational system.

- Implement the National Academies - Laying the Foundation for New and Advanced Nuclear Reactors in the United States (2023) report Recommendation 6-1: In anticipation of the necessary expansion in workforce to support more widespread deployment of nuclear technologies, the Department of Energy should form a cross-department (whole of government) partnership to address workforce needs (spanning the workforce from technician through PhD) that is comparable to initiatives like the multi-agency National Network for Manufacturing Innovation. The program would include the Departments of Labor, Education, Commerce, and State, and would team with labor organizations, industry, regulatory agencies, and other support organizations to identify gaps in critical skills and then fund training and development solutions that will close these gaps in time to support more rapid deployment. In carrying out these efforts, it will be important to take full advantage of existing efforts at commercial nuclear facilities and national laboratories that already have well-established training and workforce development infrastructure in place.

- To improve oversight and effectiveness of more than 300 recommendations related to attracting and retaining a nuclear workforce identified in the reports, studies, and news articles analyzed for this report DOE should collect nuclear workforce-related reports/studies, analyze the report recommendations, sort the recommendations into similar categories and priorities, and add this information to the factors affecting operating nuclear power plant workforce hiring and retention report. The recommendations should be grouped into the following categories:

    - Career Awareness
    - Pipelines
    - Training and Qualifications
    - DE&I (cross-cuts many areas)
    - Policy & Federal/State Legislation
    - Employee Engagement & Retention

**Industry Readiness to Implement Change:**

While many nuclear plant companies continue to work on process improvement and technology changes, only a few have taken on the challenge of making the necessary changes to ensure nuclear industry sustainability. Five of nine companies surveyed indicated they are highly ready to implement technology changes affecting operating nuclear power plant workforce hiring and retention.

**Other Nuclear Workforce Studies:**

Several studies have been completed or are in progress to identify the factors affecting attracting and retaining the nuclear workforce. Five noteworthy studies summarized and referenced in this report are as follows:

- **NEI - Industry Strategic Workforce Plan (SWP) Phase One (To Be Published August 2023)**: The Nuclear Energy Institute (NEI) created a long-term Strategic Workforce Plan (SWP) to address critical workforce issues in the industry over the next decade. Executives from organizations representing different segments of the industry partnered with industry workforce groups and allied industry organizations (INPO, ANS, EPRI, etc.) to review existing workforce data, model future data, analyze forecasts and trends, predict future workforce challenges, and develop recommendations/solutions for the identified challenges. The SWP breaks down these workforce challenges into five areas: pipelines, attracting employees into the industry, recruiting employees, retaining employees, and training/development of employees. The SWP includes recommendations for collaborative industry actions as well as individual company recommendations and is expected to be published by August 2023.
- **2022 NAYGN Career Report:** This career report discusses the results of a survey conducted by the North American Young Generation in Nuclear (NAYGN) membership to determine the state of NAYGN membership, learn what their outlook on the nuclear industry is, and determine what the membership wants from the organization to help them develop professionally. The development, implementation, and analysis of the 2022 NAYGN Career Report occurred in three phases from August 2021 to May 2022. The survey focused on several areas of interest, such as demographics, salary, career satisfaction, job importance

versus satisfaction, professional development, nuclear outlook, and NAYGN satisfaction. There were 864 respondents and all survey responses collected were anonymous. The report provides recommendations for both the NAYGN organization and, more broadly, the nuclear industry.

- **National Academies - Laying the Foundation for New and Advanced Nuclear Reactors in the United States (2023):** The National Academies of Sciences, Engineering, and Medicine appointed an ad hoc consensus committee to identify the opportunities and barriers for new nuclear technologies to contribute meaningfully to a low-carbon future. This study, funded by the Department of Energy (DOE), included an examination of the future workforce and educational needs to support the research, development, and deployment of these technologies.

- **OECD NEA - Gender Balance in the Nuclear Sector (2023):** The OECD Nuclear Energy Agency (NEA) collected data on gender balance in the nuclear sector in NEA countries to understand workforce representation, career trajectories, and challenges facing women in the sector, especially in STEM and leadership positions. In 2021, the NEA polled over 8,000 women in the nuclear workforce in 32 countries and collected human resources data from 96 nuclear organizations in 17 countries. Based on the findings, recommendations were proposed to support countries working to improve gender balance in the sector. This first comprehensive survey of gender balance in NEA countries substantiated women's underrepresentation in the sector, especially in STEM and leadership roles.

- **CEWD - Gaps in the Energy Workforce 2021 Pipeline Survey Results:** In 2021, the Center for Energy Workforce Development (CEWD) conducted the ninth Gaps in the Energy Workforce Pipeline survey. This survey has been conducted bi-annually for the past 15 years to analyze the changes occurring in the workforce within the energy sector. As in previous surveys, CEWD focused the 2021 analysis on four key job categories: Lineworkers, Technicians, Plant/Field Operators, and Engineers. In addition, following the expected growth of the renewable sector, a Renewable Technician role was added in the category of key jobs.

## DISCLAIMER

This report is not meant to be comprehensive and does not provide a complete analysis of all factors affecting hiring and retaining a nuclear workforce. Rather, it provides information that should be considered and applied, when appropriate, to improve hiring and retention.

# ACKNOWLEDGMENTS

The report authors acknowledge the following individuals and organizations for their substantial contribution of staffing data:

- Lori Brady – NEI Senior Director, Human Resources & Training and Development
- Dr. Valerie Segovia – Director, Nuclear Power Institute
- Kostas Dovas – Vice President, Training, Constellation
- Nuclear Human Resources Group (NHRG)

# Contents

# INTRODUCTION

The Light Water Reactor Sustainability (LWRS) Program is a research and development (R&D) program sponsored by the U.S. Department of Energy (DOE), performed in close collaboration and cooperation with industry. The LWRS Program provides technical foundations for the continued operation of the nation's nuclear power plants, utilizing the unique capabilities of the national laboratory system. This involves leveraging national laboratory facilities, staff, and expertise to conduct research needed to make informed decisions, demonstrate technical solutions, and provide methods needed for the long-term management and operation of nuclear power systems. The Technical Integration Office (TIO) supports the Department of Energy – Nuclear Energy (DOE-NE) LWRS Program Federal Program Manager to achieve the LWRS Program goals.

LWRS leadership commissioned Accelerant Solutions to prepare a report describing the factors affecting hiring and retaining a nuclear workforce. The report includes the following deliverables:

- An initial assessment showing the last two years of the impact of market factors, evolution of strategy, and industry events on operating nuclear power plant workforce hiring and retention.
- Explanation of the operating nuclear power plant workforce hiring and retention challenges by organizational discipline and nuclear plant company type (fleet and non-fleet).
- Explanation of the identified challenges (barriers) to operating nuclear power plant workforce hiring and retention.
- Recommendations on a going forward strategy to address challenges (barriers) to operating nuclear power plant workforce hiring and retention.
- Summary of the nuclear power industry's readiness to implement technology changes affecting operating nuclear power plant workforce hiring and retention.

To prepare this report, Accelerant Solutions developed a project charter, interviewed nuclear industry personnel, students, and education experts, collected hiring and retention data from the current operating plants, reviewed other workforce studies, analyzed the data to identify challenges, barriers, recommendations, and industry readiness to change.

## BACKGROUND

The nuclear energy sector employs a large workforce around the world, and with nuclear power projected to grow in many countries with increasing electricity demand, corresponding jobs in the nuclear power sector will also grow. Using the most available macroeconomic model to determine total employment – the "input/output" model – the Nuclear Energy Agency (NEA) and International Atomic Energy Agency (IAEA) collaborated to measure direct, indirect and induced employment from the nuclear power sector in a national economy. The results indicate that direct employment during site preparation and construction of a single unit 1,000 megawatt (1 gigawatt)-electric advanced light water reactor at any point in time for 10 years is approximately 1,200 professional and construction staff, or about 12,000 labor years. For 50 years of operation, approximately 600 administrative, operation and maintenance, and permanently contracted staff are employed annually, or about 30,000 labor years. For up to 10 years of decommissioning, about 500 people are employed annually, or around 5,000 labor years. Finally, over an approximate period of 40 years, close to 80 employees are managing nuclear waste, totaling around 3,000 labor years. This represents a total of about 50,000 direct labor-years per gigawatt of electricity produced. Direct expenditures on these employees and equipment generate approximately the same number of indirect employment, or about 50,000 labor years; and direct and indirect expenditures generate about the same number of induced employment, or 100,000 labor years. Total employment in the nuclear power sector of a given national economy is therefore roughly 200,000 labor years over the life cycle of a gigawatt of nuclear generating capacity. Therefore, the industry must strategically look ahead at the workforce needs both from the existing commercial nuclear power plant fleet but also considering the projected growth through small modular and advanced reactor builds.[8]

Currently, the US nuclear industry is undergoing a moment of unprecedented interest and growth not seen in decades. A mix of technologies and reactor types are being evaluated and

deployed such as Vogtle Units 3 and 4, and the advanced reactor demonstration projects of Kairos Power, X-energy, GEH BWRX-300, TerraPower, and NuScale to build first-of-a-kind small modular reactors. In addition, many current operating nuclear power plants have extended or plan on extending their operating licenses as follows in Figure 6:

| Initial License Renewal Status (Number of plants)[33] | | |
|---|---|---|
| **Under Review** | **Completed** | **Future Submittals** |
| 1 | 61 | 2 |
| **Subsequent License Renewal Status (Number of Plants)[34]** | | |
| **Under Review** | **Completed** | **Future Submittal** |
| 5 | 3 | 5 |

Figure 6: Currently Operating Nuclear Power Plant License Renewal Status

Note: The Nuclear Regulatory Commission (NRC) staff has defined subsequent license renewal (SLR) to be the period of extended operation from 60 years to 80 years.

However there has been a decade of decline in the industry with early plant retirements leading to consolidation and contraction that has drained expertise from the nuclear workforce. In addition, younger workers no longer saw the nuclear industry as a lifetime career. The workforce challenges faced by the nuclear industry are also being experienced by many other industries resulting in intense competition for workers.

As a result, the nuclear industry must develop and implement strategic workforce plans to hire and retain a changing and growing workforce.

In addition to this study, several other studies have been completed or are in progress to identify the factors affecting attracting and retaining the nuclear workforce. Five noteworthy studies summarized and referenced in this report are as follows:

- **NEI - Industry Strategic Workforce Plan (SWP) Phase One (To Be Published August 2023)**: The Nuclear Energy Institute (NEI) created a long-term Strategic Workforce Plan (SWP) to address critical workforce issues in the industry over the next decade. Executives from organizations representing different segments of the industry partnered with industry workforce groups and allied industry organizations (INPO, ANS, EPRI, etc.) to review existing workforce data, model future data, analyze forecasts and trends, predict future workforce challenges, and develop recommendations/solutions for the identified challenges. The SWP breaks down these workforce challenges into five areas: pipelines, attracting employees into the industry, recruiting employees, retaining employees, and training/development of employees. The SWP includes recommendations for collaborative industry actions as well as individual company recommendations and is expected to be published by August 2023.

- **2022 NAYGN Career Report:** This career report discusses the results of a survey conducted by the North American Young Generation in Nuclear (NAYGN) membership to determine the state of NAYGN membership, learn what their outlook on the nuclear industry is, and determine what the membership wants from the organization to help them develop professionally. The development, implementation, and analysis of the 2022 NAYGN Career Report occurred in three phases from August 2021 to May 2022. The survey focused on several areas of interest, such as demographics, salary, career satisfaction, job importance versus satisfaction, professional development, nuclear outlook, and NAYGN satisfaction. There were 864 respondents and all survey responses collected were anonymous. The report provides recommendations for both the NAYGN organization and, more broadly, the nuclear industry.

- **National Academies - Laying the Foundation for New and Advanced Nuclear Reactors in the United States (2023):** The National Academies of Sciences, Engineering, and Medicine appointed an ad hoc consensus committee to identify the opportunities and barriers for new nuclear technologies to contribute meaningfully to a low-carbon future. This study, funded by a generous donation to the National Academy of Engineering, and additional funding from the Department of Energy (DOE), included an examination of the future workforce and educational needs to support the research, development, and deployment of these technologies.

- **OECD NEA - Gender Balance in the Nuclear Sector (2023):** The OECD Nuclear Energy Agency (NEA) collected data on gender balance in the nuclear sector in NEA countries to understand workforce representation, career trajectories, and challenges facing women in the sector, especially in STEM and leadership positions. In 2021, the NEA polled over 8000 women in the nuclear workforce in 32 countries and collected human resources data from 96 nuclear organizations in 17 countries. Based on the findings, recommendations were proposed to support countries working to improve gender balance in the sector. This first comprehensive survey of gender balance in NEA countries substantiated women's underrepresentation in the sector, especially in STEM and leadership roles.

- **CEWD - Gaps in the Energy Workforce 2021 Pipeline Survey Results:** In 2021, the Center for Energy Workforce Development (CEWD) conducted the ninth Gaps in the Energy Workforce Pipeline survey. This survey has been conducted bi-annually for the past 15 years to analyze the changes occurring in the workforce within the energy sector. As in previous surveys, CEWD focused the 2021 analysis on four key job categories: Lineworkers, Technicians, Plant/Field Operators, and Engineers. In addition, following the expected growth of the renewable sector, a Renewable Technician role was added in the category of key jobs.

# DELIVERABLES

## Workforce Hiring, Turnover and Retention Trend Analysis

### Total Staff, Capacity Factor, and Attrition Trends

Figure 7 shows the total staff, capacity factor, and staffing factors for one- and two-unit sites and overall average, from 1997 to 2022. It is divided into four periods based on significant changes to staffing numbers and to better understand the staffing changes that occurred during specific events in time over the past twenty-five years of nuclear power operations. Figure 7 below illustrates the changes in staffing levels from 1997 to 2022, the most notable changes occurring in the last 11 years. From 2011 to 2021 average staffing levels for all sites decreased by 17.7 percent over that 11-year period. From 2021 to 2022, staffing levels increase slightly year over year, but not by a significant percentage. This could represent a reversal of the trend seen over the past 11 years. While overall staffing levels decreased over

the past 11 years, capacity factors continued to stay levelized around the 90 percent level for the fleet.

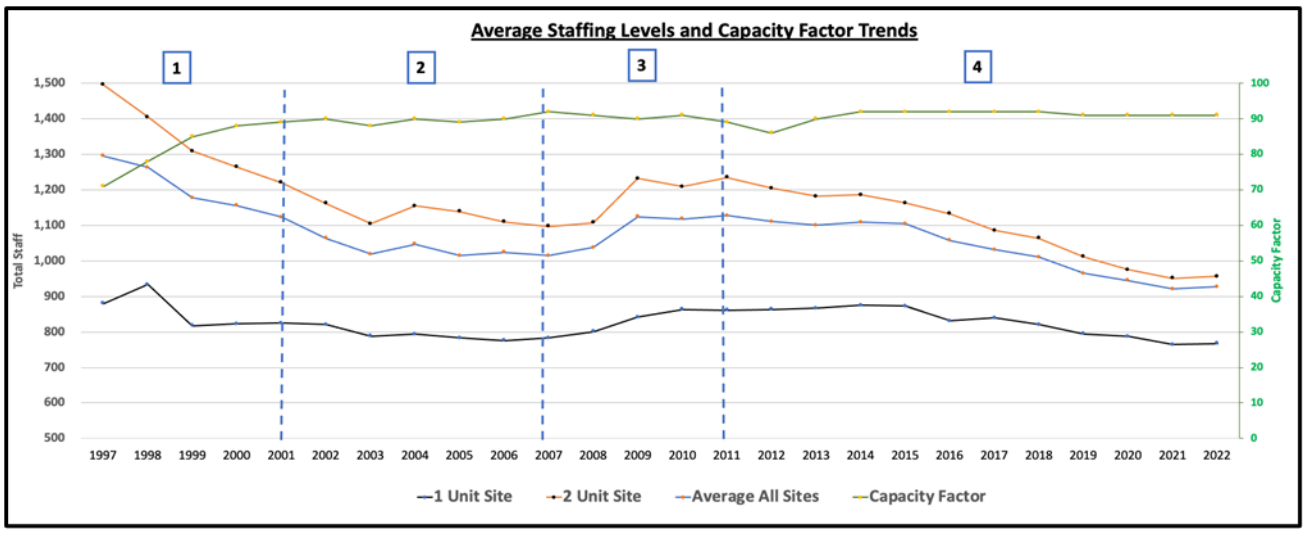



Figure 7: Average Staffing Levels and Capacity Factor Trends

The four time periods are named as follows:

- Time Period 1 – (Deregulation and Consolidation - 1997 to 2001)
- Time Period 2 – (Post 9/11 Security Event - 2001 to 2007)
- Time Period 3 – (Staffing Replacement Period – 2007 to 2011)
- Time Period 4 – (Industry Efficiency Period and Plant Closures– 2011 to 2022)

### Time Period - 1 (Deregulation and Consolidation 1995 to 2001)

1. Deregulation in the energy sector starts in parts of the U.S. electric grid system.
2. Formation of larger nuclear fleet operators (Exelon, Entergy, NextEra, Nuclear Management Company). Staffing decreases occur due to standardized operating processes and economies of scale. Currently many of these larger fleet operators have consolidated or sold off many of their assets.

3. Several nuclear operators implement process improvements resulting in decreases in staff sizes.

4. Capacity factor decreases during the special design inspection period and recover after the formation of large fleet operators and completion of inspections.

5. Many plant owners started replacing steam generators and other large components to sustain operations, resulting in additional engineering, maintenance, and support organization staff.

### Time Period - 2 (Post 9/11 National Security Event 2001 to 2007)

1. NRC issues a series of physical plant and background security orders as a result of the 9/11 National Security Event.

2. Staffing decreases slightly in industry, but security staff increases by 80 to 90 percent. Plant operators maintain total staffing constant to accommodate security staff increases. This results in less staff in areas, such as operations, work management, engineering, and training.

3. Capacity factors continue to maintain levels around 90 percent.

4. Industry starts to address aging workforce concerns. Many plants have reached 20+ years of operations and many plant owners have filed for extended plant operations. Many sites start planning for replacement of retiring staff that will occur over the next 10 years.

### Time Period - 3 (Staffing Replacement Period 2007 to 2011)

1. NRC issues Fatigue Management Regulatory Guide that requires additional staff for tracking and increases in operations, security, and support staff.

2. NRC issues Cyber Security Rule which requires additional skill and staffing to meet rule requirements. Impact in Security, Plant Computer Operations, Network Staffing, and Support Staff.

3. Nuclear Energy Institute (NEI) issues industry guidance for monitoring nuclear safety culture. Many licensees add safety culture staff, while others add work scope to existing staff members.

4. Many licensees start replacement of aging personnel, who have been with station for over thirty years. Increases in personnel staffing pipeline programs, such as operations, maintenance, and engineering occur.

5. Capacity Factor continues around 90 percent level.

### Time Period - 4 (Industry Efficiency Period – Plant Closures (2011 to 2022)

1. The Fukushima accident occurs in 2011 and results in FLEX strategy for US nuclear industry.

2. INPO and NEI develop Efficiency Bulletins (EBs) to eliminate unnecessary work and reduce staff without impact to safety and reliability. Staffing decreases average around 10 to 15 percent depending on plant size due to NEI/INPO EB and plant process improvements.

3. Retirement replacement continues in the early part of this period. By 2020 most of the retirements have occurred. See Figure 8 below.

4. Several fleets have started closing plants due to economic and/or regulatory issues. From 2013 to 2023 there have been thirteen (13) plant closures. Two sites were scheduled to close but received federal and state incentives to continue operations. Additional plant closures are expected to occur in the future as plant operators assess economic and regulatory challenges.

3. Capacity factor continues around 90 percent level.

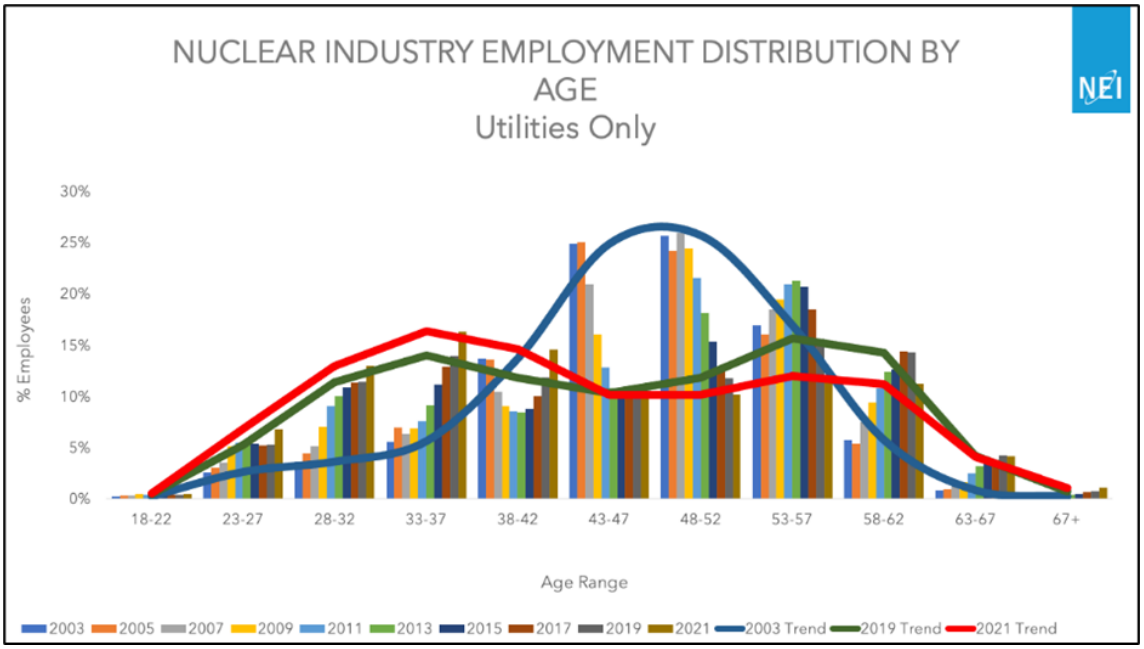



Figure 8: Nuclear Industry Employment Distribution by Age

## Nuclear Plant Turnover and Hiring Trends (2010 to 2022)

Historically, the nuclear power plant industry has experienced lower turnover rates than other industrialized sectors. Figure 9 below from the Bureau of Labor Statistics (BLS) illustrates the employee turnover rates from 2017 to 2021 by industry. These rates are significantly higher than the nuclear fleet.

**Employee Turnover Statistics by Industry[37]**

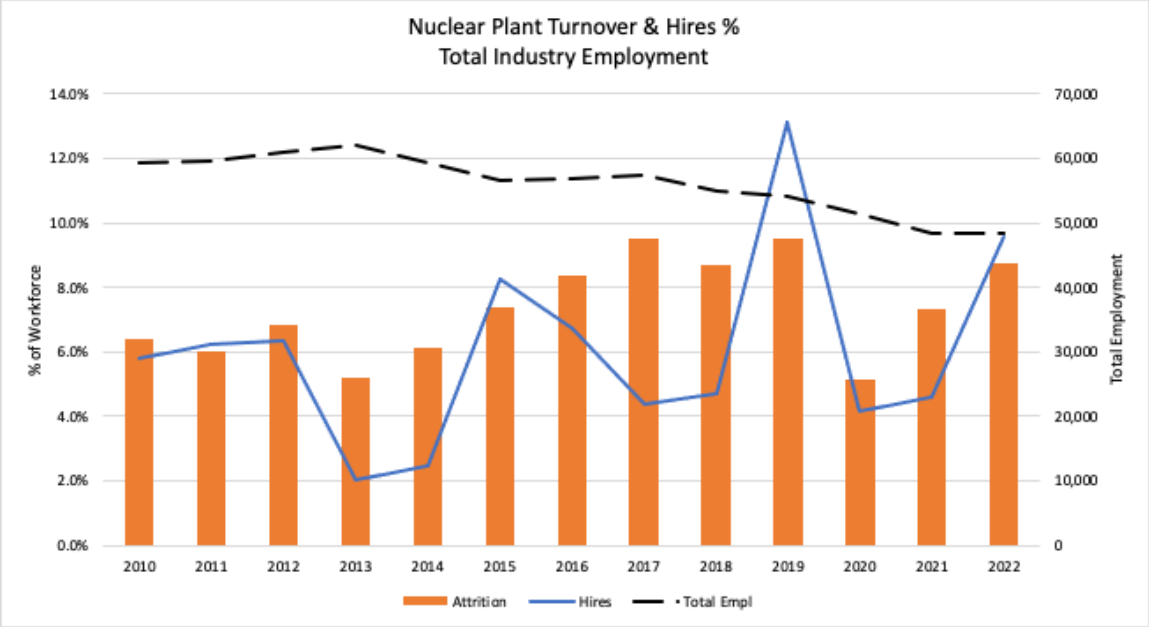
| INDUSTRY | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|
| **TOTAL** | **43%** | **44%** | **45%** | **57%** | **47%** |
| Total private | 47% | 49% | 49% | 63% | 52% |
| Mining and logging | 48% | 54% | 48% | 54% | 36% |
| Construction | 61% | 57% | 65% | 68% | 57% |
| Manufacturing | 30% | 32% | 31% | 44% | 40% |
| Durable goods | 27% | 28% | 28% | 41% | 35% |
| Nondurable goods | 36% | 38% | 36% | 48% | 47% |
| Trade, transportation, and utilities | 45% | 48% | 49% | 60% | 55% |
| Wholesale trade | 27% | 29% | 29% | 37% | 34% |
| Retail trade | 53% | 58% | 58% | 69% | 65% |
| Transportation, warehousing, and utilities | 40% | 44% | 45% | 59% | 49% |
| Information | 35% | 37% | 38% | 44% | 39% |
| Financial activities | 28% | 27% | 28% | 31% | 29% |
| Finance and insurance | 25% | 24% | 24% | 25% | 26% |
| Real estate and rental and leasing | 37% | 35% | 39% | 49% | 35% |
| Professional and business services | 63% | 63% | 63% | 69% | 64% |
| Education and health services | 32% | 34% | 33% | 44% | 37% |
| Educational services | 29% | 30% | 29% | 42% | 26% |
| Health care and social assistance | 33% | 34% | 34% | 45% | 39% |
| Leisure and hospitality | 74% | 77% | 79% | 130% | 85% |
| Arts, entertainment, and recreation | 84% | 88% | 79% | 129% | 76% |
| Accommodation and food services | 72% | 75% | 78% | 130% | 86% |
| Other services | 45% | 44% | 43% | 67% | 72% |
| Government | 18% | 18% | 18% | 24% | 18% |

Figure 9: Employee Turnover Statistics by Industry

Figure 10 below illustrates the historical employee turnover rate for nuclear plants from 2010 to 2022. The average employee turnover rate for that period had been 7.3 percent, which is 6 times lower than the average employee turnover rate for other industries in the United States. See Figure 9. From 2010 to 2014, the nuclear fleet experienced employee turnover rates of 4.5 to 6 percent. From 2015 to 2019 the nuclear fleet employee turnover rate increased up to 9.5 percent, 58 percent higher than the historical averages for the fleet. During the COVID period (2020 to 2021), the industry saw the employee turnover rates drop to 5.1 percent from the high of 9.5 percent in 2019. Since 2020, employee turnover rates have increased to about 9 percent

in 2022. While the historical employee turnover rate for the industry has been in the 4.5 to 6 percent range, there is evidence the new range may now be 8 to 10 percent. While this is a significant difference from the prior decade, it still represents employee turnover rates lower than in most other industries as illustrated in Figure 9.

Figure 10: Nuclear Plant Turnover & Hires % Total Industry Employment




In addition to increasing employee turnover rates for the nuclear fleet, the overall employment has decreased from a high of 62,000 employees to the current level of approximately 48,000 employees. This is the result of the following impacts.

- INPO and NEI developed Efficiency Bulletins (EBs) to eliminate unnecessary work and reduce staff without an impact on safety and reliability. Staffing decreases on average of 10 to 15 percent depending on plant size due to NEI/INPO EB and plant process improvements.
- Utilities have started closing sites due to economic and/or regulatory issues. From 2013 to 2023 there have been thirteen (13) plants closures.
- Impact on retiring employees and improvements on new technologies.

As stated in the prior section, from 2021 to 2022, staffing levels increased slightly year over year, but not by a significant percentage. This could represent a reversal of the trend seen over the past 11 years.

While employee turnover rates increased in the nuclear fleet, hiring also increased to keep up with needed talent and replacement of retired workers. During early 2010, staffing increased because of the need to replace workers retiring or leaving the industry. In 2013 and 2014 the industry experienced a significant decrease in staff activities (from 6 percent hiring to 2 percent). This could be attributed to the announcements of several plant closures by various utilities. That effect lasted about two years, with a significant increase in hiring up to 13 percent in 2019. This was attributed to the increase in hiring activities by staffing requirements for the Vogtle 3 & 4 project in the United States and new build international projects. When the COVID period started, staffing turnover decreased to 4 percent, which had been the industry average for the past 10 years. The 2022 hiring rate has increased back up to 10 percent to address the increasing turnover rate seen in the industry. The following section will provide further explanation of the hiring and employee turnover levels by fleet and non-fleet.

### Fleet vs. Non-Fleet Analysis for Hiring and Turnover (2020 to 2022)

In the United States commercial nuclear power plant fleet there are 11 non-fleet commercial nuclear power plants (see Figure 11) out of 54 commercial nuclear power plants sites (about 20 percent of the nuclear sites are not associated with a fleet).

| Non-Fleet Companies | Nuclear Power Plants |
|---|---|
| Ameren | Callaway |
| Energy Northwest | Columbia |
| Luminant | Comanche Peak |
| American Electric | Cook |
| NPPD | Cooper |
| PG&E | Diablo Canyon |
| DTE Energy | Fermi |
| APS | Palo Verde |
| South Texas Nuclear Operating Company | South Texas Project |
| Talen Energy | Susquehanna |
| WCNOC | Wolf Creek |

Figure 11: Commercial Nuclear Power Plant Non-Fleet Companies List

Figure 12 shows the ten fleet companies who operate the remaining 43 nuclear sites.

| Fleet Companies | Number of Nuclear Sites in Fleet |
|---|---|
| Constellation | 12 |
| Dominion | 4 |
| Duke Energy | 6 |
| Energy Harbor | 3 |
| Entergy | 4 |
| NextEra Energy | 4 |
| PSEG | 2 |
| Southern Company | 4 |
| TVA | 3 |
| Xcel | 2 |

Figure 12: Fleet Companies and Number of Nuclear Sites in Fleet

A comprehensive survey was conducted to evaluate the hiring and employee turnover data for the nuclear fleet. The survey respondents were both fleet and non-fleet companies. The survey obtained a 66 percent response rate from all operating reactors (92). This provided the researchers with a satisfactory response to conduct the following analysis on hiring, employee turnover, and retention strategies.

Fleet and non-fleet companies experienced an increase in new hires at a similar rate, which indicates the hiring requirements for fleet and non-fleet companies does not differ by type of owner. The years 2020 and 2021 were influenced by the effect of the COVID period and the increase in hiring was the result of that impact. The increase in new hires directly correlates to the increase in employee turnover rates for the same period. Both the employee turnover rate and new hires increased by double (2X) from 2020 to 2022. Figures 13 and 14 below provide detailed information on new hires by fleet type and employee turnover rates by the same grouping.

| Total Percent of New Hires by Company Type | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 4.6% | 4.7% | 10.2% |
| NON-FLEET | 5.3% | 6.2% | 9.3% |
| **Total Hires for all Company Types** | **4.7%** | **4.9%** | **10.0%** |

Figure 13: Total Percent of New Hires by Company Type

Employee turnover rates for both fleet and non-fleet operators had a similar trend. However, the non-fleet companies have been experiencing a higher rate of employee turnover than the fleet companies. Both types of companies saw an increase in the employee turnover rate. From 2020 to 2022 fleet companies have experienced a 56 percent increase, while the non-fleet companies have experienced a 62 percent increase in the employee turnover rate. The lower-than-expected employee turnover rates in the years 2020 and 2021 were influenced by the COVID pandemic. The increasing rate for both fleet and non-fleet companies should not be of significant concern, given the overall employee turnover rate prior to the COVID period was averaging 9 percent, which is the current rate for 2022. See Figure 14.

| Total Percent of Employee Turnover by Company Type | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 5.7% | 7.5% | 8.9% |
| NON-FLEET | 6.9% | 10.6% | 11.2% |
| **Total Turnover for all Company Types** | **5.9%** | **7.9%** | **9.2%** |

Figure 14: Total Percent of Employee Turnover by Company Type

New employee turnover is defined as an employee that leaves the company within three years (0 to 3 years of service) of their hire date. Fleet companies had a higher trend in new hire turnover. Their rate is approximately two times that of non-fleet companies. The reason for the lower-than-average new hire turnover rate for non-fleet companies was not determined. Feedback from respondents at some of these locations attributed their lower rate to the remote location of the nuclear plant resulting in less competition for workers from other nearby employers. From 2020 to 2022, fleet companies have seen a 2-fold increase in their new employee turnover rate, while the non-fleet companies have experienced a 54 percent increase in the new employee turnover rate. The turnover rates in the years 2020 and 2021 were influenced by the effect of the COVID period contributing to the lower-than-expected rate. The increasing rate for both fleet and non-fleet companies should not be of significant concern, given the overall turnover rate for all employees, prior to the COVID period, was averaging 9 percent, which is the rate for 2022. See Figure 15.

| Total Percent of New Employee Turnover | | | |
|---|---|---|---|
| **Company Type** | **2020** | **2021** | **2022** |
| FLEET | 1.6% | 2.1% | 3.2% |
| NON-FLEET | 1.1% | 1.7% | 1.7% |
| **Total New Employee Turnover for all Sites** | **1.5%** | **2.0%** | **3.0%** |

Figure 15: Total Percent of New Employee Turnover

Overall, the nuclear fleet experienced a remarkable decrease of hires and terminations during the COVID period (2020 through 2021). During these years, hiring and employee turnover rates decreased from the 2018 to 2019 periods. The impact of new younger generation workers,

remote work practices, changing health and safety protocols, may not be fully understood and additional fluctuations in the staffing and hiring practices could continue.

### Turnover and Hiring Analysis by Job Group (2020 to 2022)

In this analysis the following organizational disciplines and job groups were reviewed for both new hire and employee turnover rates. See Figure 16.

| Organizational Disciplines and Job Groups |
|---|
| **Maintenance Worker (Mechanical, Electrical, I&C) - all types** |
| **Nuclear Plant Operators (Non-Licensed & Licensed)** |
| **Planners – Schedulers – Work Week Managers – all types** |
| **Plant Security Workers – all types** |
| **Power Plant Engineers (PRA-Fuels-Systems-Design) - all types** |
| **Radiation Protection and Chemistry Workers – all types** |
| **Training Instructors & Curriculum Developer – all types** |

Figure 16: Organizational Disciplines and Job Groups

1. Maintenance Worker – All maintenance and planning activities associated with the operations of the plant. This includes mechanical, electrical, instrumentation and control (I&C) technicians, planners, schedulers, and fix-it-now teams. This also includes support organizations, such as welding, plumbing, and HVAC support.

2. Nuclear Plant Operator – This includes all positions associated with the operations of a nuclear plant. These include licensed reactor operators, shift technical advisors, non-licensed operators, fire bigarades and work control operations support staff.

3. Planner - Schedulers (Work Management) – All planning and scheduling activities associated with the operations of the plant. This includes planners, schedulers, outage work week managers and associated activities.

4. Plant Security Workers - All positions associated with physical and plant security, including cyber security. This includes training for security officers and associated positions.

5. Power Plant Engineers – This includes design, systems, civils, component, equipment reliability engineering. These include all positions associated with technical engineering functions supporting the operations and configuration design control for the nuclear plant.

6. Radiation Protection and Chemistry Workers – This includes all radiation protection, radiological management, chemistry, radwaste processing functions.

7. Training – All training positions associated with National Academy for Nuclear Training (NANT) accredited training requirements for the following:

    a. Operations

    b. Maintenance

    c. Engineering

    d. Radiation Protection

    e. Chemistry

    f. Simulator Support

    g. Leadership Training for INPO/NRC requirements (e.g., Safety Culture, SOER 10-2).

As stated in the prior section, new hire rates for fleet and non-fleet had similar trends. The group for both fleet and non-fleet that had the highest new hire rate was plant security workers (all types). Traditionally, this group has a higher than industry average turnover rate, thus leading to greater than average hiring rates.

Most notability, the hire rates for plant engineering (all types) were significantly higher than the historical average for 2022 at 12 percent for both fleet and non-fleet companies. This correlates with the higher-than-average turnover rates for power plant engineers which will be explored in the next section. The significance of this points to a general industry demand for engineers. Bureau of Labor Statistics (BLS) indicates that the average growth rate, inclusive of all engineering occupations, is projected to be four percent through 2031.

The hiring rate for nuclear plant operators (non-licensed and licensed) is a notable change. From 2020 to 2022, the hiring rate has more than doubled from 2.6 percent to 8.3 percent for fleet companies. The non-fleet companies have seen an average rate of 6.5 percent to 7.3

percent. The significance of this relates to the increase in need to add additional training resources (instructors, classrooms, training materials) to account for the additional new hires. This leads to an increased number of training classes or larger class sizes and additional instructors.

Nuclear instructor hiring rate has doubled from 2020 to 2022. This accounts for the increase in turnover for this job group. This increased number of instructors is driven by the need to conduct additional training classes for new workers, such as nuclear plant operators, maintenance workers, and plant engineering. All these groups have specific training requirements as identified by the Institute of Nuclear Power Operations (INPO) and National Academy for Nuclear Training (NANT). See Figure 17 for detailed information.

| New Hire by Job-Group (ALL SITES) | 2020 | 2021 | 2022 |
|---|---|---|---|
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 4.2% | 3.1% | 7.6% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 3.4% | 3.1% | 8.0% |
| Planners – Schedulers – Work Week Managers – all types | 1.2% | 1.6% | 4.2% |
| Plant Security Workers – all types | 7.1% | 10.1% | 17.8% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 7.3% | 5.6% | 12.2% |
| Radiation Protection and Chemistry Workers – all types | 4.5% | 7.5% | 10.3% |
| Training Instructors & Curriculum Developer – all types | 3.0% | 3.4% | 7.6% |
| **New Hire by Job-Group (FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 4.3% | 3.1% | 7.6% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 2.6% | 2.6% | 8.3% |
| Planners – Schedulers – Work Week Managers – all types | 0.9% | 1.1% | 4.4% |
| Plant Security Workers – all types | 7.8% | 10.5% | 19.2% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 6.9% | 5.1% | 11.7% |
| Radiation Protection and Chemistry Workers – all types | 4.5% | 6.9% | 9.5% |
| Training Instructors & Curriculum Developer – all types | 2.8% | 3.3% | 7.3% |
| **New Hire by Job-Group (NON-FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 3.4% | 3.1% | 7.5% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 7.3% | 5.7% | 6.5% |
| Planners – Schedulers – Work Week Managers – all types | 3.2% | 5.9% | 2.7% |
| Plant Security Workers – all types | 2.9% | 8.0% | 9.2% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 9.8% | 8.5% | 15.3% |
| Radiation Protection and Chemistry Workers – all types | 4.5% | 11.0% | 14.8% |
| Training Instructors & Curriculum Developer – all types | 4.2% | 3.7% | 9.8% |

Figure 17: New Hire by Job-Group (All Sites, Fleet, Non-Fleet)

The next section will address the overall turnover rates for the same job groups and will clarify the hiring rates as noted in the above section.

While turnover rates for plant security workers have been traditional higher than other job groups in the nuclear fleet, there has been an on-going increase in turnover rates for power plant engineers (includes probabilistic risk assessment, fuels, systems, and design engineers). Traditionally the engineering turnover rate average is the same rate as the balance-of-plant worker: however, the recent trend has increased 200 percent from 2020 to 2022. This group now experiences the second highest turnover rate behind plant security workers. See Figure 18 below.

| Turnover Rate by Job-Group (ALL SITES) | 2020 | 2021 | 2022 |
|---|---|---|---|
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 5.1% | 6.1% | 6.1% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.1% | 5.2% | 7.0% |
| Planners – Schedulers – Work Week Managers – all types | 5.1% | 8.1% | 5.3% |
| Plant Security Workers – all types | 8.0% | 11.7% | 15.6% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 6.9% | 9.0% | 12.8% |
| Radiation Protection and Chemistry Workers – all types | 7.1% | 9.7% | 8.9% |
| Training Instructors & Curriculum Developer – all types | 5.8% | 8.8% | 8.7% |
| **Turnover Rate by Job-Group (FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 4.9% | 5.3% | 5.7% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.0% | 5.0% | 6.4% |
| Planners – Schedulers – Work Week Managers – all types | 4.2% | 7.3% | 4.9% |
| Plant Security Workers – all types | 8.3% | 12.1% | 16.7% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 6.5% | 8.3% | 12.1% |
| Radiation Protection and Chemistry Workers – all types | 6.7% | 9.0% | 7.9% |
| Training Instructors & Curriculum Developer – all types | 5.4% | 7.6% | 7.4% |
| **Turnover Rate by Job-Group (NON-FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 6.0% | 10.6% | 8.4% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 4.3% | 6.5% | 10.4% |
| Planners – Schedulers – Work Week Managers – all types | 12.4% | 14.5% | 8.1% |
| Plant Security Workers – all types | 5.5% | 9.2% | 8.8% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 9.2% | 13.1% | 16.8% |
| Radiation Protection and Chemistry Workers – all types | 9.8% | 13.4% | 14.5% |
| Training Instructors & Curriculum Developer – all types | 8.9% | 16.4% | 17.3% |

Figure 18: Turnover Rate by Job-Group (All Sites, Fleet, Non-Fleet)

The increase in power plant engineers turnover rate aligns with the national trend of overall engineering turnover – which is higher than historically seen in all industries. This may in part be attributed to the higher-than-average demand for engineers nationally. The U.S. Bureau of Labor Statistics (BLS) expects the engineering field to experience a 4 percent job growth increase between the years 2021 and 2031. In addition to new jobs from growth, BLS stated that opportunities arise from the need to replace workers who leave their occupations permanently. About 200,900 job openings each year, on average, are projected to come from growth and replacement needs as stated by BLS.

Another turnover rate by job-group that warrants additional discussion is the nuclear plant operators (non-licensed and licensed) staff. From 2020 to 2022, that turnover rate grew by 70 percent from 4.1 percent annually to 7.0 percent annually. The Nuclear Regulatory Commission provides guidance on minimum required licensed operator staffing in the control room for each nuclear power plant. The time to complete licensed operator training ranges from 12 months to 24 months depending on the type of license. Therefore, increases in the nuclear plant operator turnover rate has a direct effect on a plant owner's ability to maintain the minimum required staffing size for the control room. There is also a direct link to the additional cost and level of work needed to provide an adequate pipeline of talent to meet the increasing demand caused by higher turnover.

There were minimal differences in turnover by job-group for both fleet and non-fleet companies. They both experienced the same increase in turnover rate for pant security workers, power plant engineers, and nuclear plant operators. However, the turnover rate of non-fleet instructors, radiation protection, and chemistry workers is significantly higher than that of fleet nuclear plant companies. This could be due to the smaller size staff in those occupations in non-fleet companies as compared to fleet companies.

During the collection of data for this study, follow-up questions were asked about reasons for turnover. This will be explored further in the analysis.

The next section will address the new employee (defined as three years or less of service) turnover rates for the same job-groups and will clarify the hiring rates shown in Figure 21.

As with total turnover, the group that has the highest new employee turnover rate is the plant security workers with a new employee turnover rate in 2022 of 8 percent. This rate is about

double the other job groups. The next highest group is power plant engineers at the rate of 4.1 percent. This is indicative of the demand for engineers in general industry and indicates a need to develop retention strategies for that job-group.

While the new employee turnover rates range from 1.1 percent to 2.8 percent for the other job groups, this indicates that companies who operate the plants must continue to monitor and adjust retention strategies for new hires.

There is a notable difference in the non-fleet sites regarding new employee turnover for plant security workers and power plant engineers. This could be the result of small population sizes. Both groups are significantly lower than their fleet counterparts. Plant security workers experience four (4) times less turnover in non-fleet versus fleet, while power plant engineers experience two (2) times less turnover. The remaining job groups average similar new employee turnover rates. See Figure 19.

| New Employee Turnover Rate by Job-Group (ALL SITES) | 2020 | 2021 | 2022 |
|---|---|---|---|
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 0.8% | 1.1% | 1.3% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.0% | 1.2% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.9% | 0.7% | 1.1% |
| Plant Security Workers – all types | 3.1% | 5.0% | 8.0% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 2.3% | 2.7% | 4.1% |
| Radiation Protection and Chemistry Workers – all types | 1.1% | 2.0% | 2.8% |
| Training Instructors & Curriculum Developer – all types | 1.5% | 1.7% | 1.8% |
| **New Employee Turnover Rate by Job-Group (FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) - all types | 0.9% | 1.1% | 1.3% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.0% | 1.1% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.9% | 0.6% | 1.1% |
| Plant Security Workers – all types | 3.2% | 5.5% | 8.9% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 2.5% | 2.7% | 4.4% |
| Radiation Protection and Chemistry Workers – all types | 1.1% | 2.0% | 2.9% |
| Training Instructors & Curriculum Developer – all types | 1.4% | 1.7% | 1.9% |
| **New Employee Turnover Rate by Job-Group (NON-FLEET)** | **2020** | **2021** | **2022** |
| Maintenance Worker (Mechanical, Electrical, I&C) all types | 0.5% | 1.1% | 1.0% |
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1.1% | 1.8% | 1.4% |
| Planners – Schedulers – Work Week Managers – all types | 0.5% | 1.1% | 1.1% |
| Plant Security Workers – all types | 2.1% | 1.7% | 2.1% |
| Power Plant Engineers (PRA-Fuels-Systems-Design) all types | 1.1% | 2.6% | 2.8% |
| Radiation Protection and Chemistry Workers – all types | 0.9% | 2.1% | 2.1% |
| Training Instructors & Curriculum Developer – all types | 1.9% | 1.4% | 1.4% |

Figure 19: New Employee Turnover Rate by Job-Group (All Sites, Fleet, Non-Fleet)

## Level of Difficulty in Recruiting

As part of the analysis the respondents were asked to rank the level of difficulty in recruitment for the job groups stated in the section above. The responses are shown in Figure 20 below.

| Ranking Level of Difficulty to Recruit | Ranking |
|---|---|
| Nuclear Plant Operators (Non-Licensed & Licensed) | 1 |
| Power Plant Engineers (PRA-Fuels-Systems-Design) - all types | 2 |
| Radiation Protection and Chemistry Workers – all types | 3 |
| Training Instructors & Curriculum Developer – all types | 4 |
| Planners – Schedulers – Work Week Managers – all types | 5 |
| Maintenance Worker (Mech-Elect-I&C) - all types | 6 |
| Plant Security Workers – all types | 7 |

Figure 20: Ranking Level of Difficulty to Recruit

Although plant security workers have the highest turnover rates, they rank as the lowest level for recruitment difficulty. Nuclear plant operators, power plant engineers, and radiation protection and chemistry workers were ranked in the top three.

The level of difficulty can directly relate to the various competency and educational requirements for those positions. The top three groups require similar STEM (Science, Technology, Engineering, and Math) skills, and tend to have limited external talent pools to recruit from. As turnover rates rise for power plant engineers and nuclear plant operators, the sourcing pools will need to be replenished with new talent. The demand for these skills will continue to rise over time.

Traditionally, training instructors have been developed from within the organization's staff and are typically sourced from operations, maintenance, and engineering departments. Planners - Schedulers tend to be sourced from the maintenance groups. The maintenance groups are most often sourced from union and non-union apprenticeship programs.

The level of effort to recruit, train, and retain talent aligns with the priority need of talent for operating nuclear plants. Operations staff controls and manages the work at each nuclear power plant, while the power plant engineers manage equipment reliability and develop solutions to technical issues. Both groups are key contributors to safe and reliable nuclear plant operation.

Plant security workers have critical skills required by the plants operating license, but the competencies are different than those required for nuclear plant operators and power plant engineers. Some organizations have used their security department as talent pools for other roles in the organization. Since organizations recruit security staff more often, it is understandable to use the group as a feeder group to other departments – jobs in a nuclear power plant.

The next section of this report discusses recruitment strategies used by nuclear plant operating companies to attract and retain their workforce.

## Retention Strategies and Programs

Employee retention refers to an organization's ability to retain its employees over a specific period. It is a measure of how effectively an organization can keep its employees engaged, satisfied, and motivated to remain in their current roles and continue their employment with the company. Employee retention focuses on reducing turnover and retaining valuable talent within the organization.

Retention efforts involve implementing strategies and policies aimed at creating a positive work environment, providing opportunities for growth and development, offering competitive compensation and benefits, fostering strong relationships with employees, and addressing their needs and concerns.

Companies have retention strategies for employees for several reasons, and these strategies can be effective in achieving their intended goals. Reasons why companies invest in employee retention strategies and their potential effectiveness include the following:

- Talent retention: Skilled and experienced employees are valuable assets to a company. Retention strategies aim to retain top performers, high-potential employees, and those with critical knowledge and expertise.
- Cost savings: Employee turnover can be costly for companies. Recruitment expenses, onboarding and training costs, and productivity loss during the transition period all add up. Retention strategies help reduce turnover rates and mitigate these expenses.

- Productivity and performance: Retaining employees leads to better productivity and performance. Long-term employees have a deeper understanding of their roles, company processes, and relationships with colleagues and clients. This knowledge and experience can translate into higher productivity, improved customer satisfaction, and overall business success.

- Employee engagement and satisfaction: Retention strategies focus on improving employee engagement and satisfaction. Engaged employees are more committed, motivated, and aligned with the company's goals. By providing a positive work environment, opportunities for growth and development, competitive compensation and benefits, work-life balance, and recognition, companies can increase employee satisfaction and loyalty.

- Organizational culture and stability: Retaining employees contributes to a stable organizational culture. High turnover can disrupt team dynamics, hinder knowledge sharing, and lead to a sense of instability. By fostering a culture that values and supports employees, companies can promote a positive work environment and create a sense of belonging, which enhances retention.

The effectiveness of employee retention strategies depends on various factors, including the specific strategies employed, the company's culture and values, the industry, and the individual needs and motivations of employees. While no retention strategy is foolproof, effective strategies can lead to reduced turnover rates, improved employee satisfaction and engagement, increased productivity, and better overall organizational performance.

The following retention strategies were identified by the survey respondents as the most often used:

- Pay for Licensees or Skill Competencies
- Relocation Benefits - New Hire ONLY
- Employee Development Program – Career Services
- Employee Technical Training Programs
- Mentorship Programs
- Hiring Bonuses – New Hire ONLY

- Flexible Work Environment (Remote Work – Hours)
- Technology Program – Reimbursement of Cell Phone – Home Internet
- Educational Reimbursement

While the specific retention programs used by employers can vary based on industry, company size, and employee demographics, here are three commonly employed programs that have proven to be effective:

- Employee Recognition and Rewards Programs: Recognition and rewards programs aim to acknowledge and appreciate employee achievements and contributions.
- Career Development and Training Programs: Career development and training programs are designed to enhance employees' skills, knowledge, and professional growth. These programs can include mentorship initiatives, leadership development programs, skill-building workshops, cross-functional training, and educational opportunities.
- Work-Life Balance and Employee Wellness Programs: Employers recognize the importance of work-life balance and employee well-being in retention efforts. Work-life balance programs can include flexible work arrangements, telecommuting options, family-friendly policies, and generous vacation or personal time off.

It is worth noting that these specific programs are just a few examples, and effective retention programs are often comprehensive and multifaceted. Employers may combine different strategies, customize programs to meet their employees' needs, and regularly evaluate and adjust them based on feedback and data analysis. The key is to create a supportive and engaging workplace culture that addresses employees' professional development, well-being, and recognition needs.

### Exit Survey Findings – Top Reasons for Turnover

Through follow-up interviews with survey respondents were asked to provide the top three or four reasons for voluntary turnover in their organization. The responses are as follows:

- Leadership – Organization Management

- Career Opportunity – Job Change
- Work-life Balance, Work Schedule Changes

These reasons align with the top reasons for employees voluntarily leaving their jobs or employers. They are as follows:

- Better career opportunities: Employees often leave their current jobs in search of better career prospects. This could include opportunities for advancement, professional growth, or a chance to work in a different industry or with another company.
- Leadership or dissatisfaction with company culture: Lack of job satisfaction, or dissatisfaction with the company culture or leadership can drive employees to leave. Factors such as a lack of trust, poor communication, a negative or a mismatch between personal values and the organization's values can contribute to an employee's decision to move on.
- Work-life balance and stress: Achieving a healthy work-life balance is increasingly important to employees. Excessive workloads, long hours, a lack of flexibility, or high levels of stress can significantly impact an employee's well-being and personal life.

It is important to note that these reasons can vary based on individual circumstances and priorities. Employees may have unique motivations for leaving their jobs, such as relocation, family obligations, or personal circumstances. Additionally, the relative importance of these reasons can vary depending on industry, job level, and other factors specific to the individual and their work environment.

## Impact of Market Factors, Evolution of Strategy, and Industry Events

### New Nuclear Resurgence

The extended operation of the current U.S. nuclear plant fleet and the proposed construction and operation of advanced nuclear plants and other clean energy generating facilities will require educating, training, and hiring a significant number of workers from a limited and in some cases decreasing perspective worker pool. Several studies have been completed that project the potential jobs associated with the expansion of the energy production sector as follows:

- Approximately 4,000 workers per year for a total of 108,000 workers by 2050 need to be hired to sustain the current U.S. nuclear plant operating fleet workforce.
- Vibrant Clean Energy projects 27,000 to 177,00 average annual fulltime equivalent jobs by 2050 depending on the scenario.
- The DOE Commercial Liftoff report projects 375,000 jobs to manufacture, construct, and operate 200GW of new nuclear generation by 2050.
- The DOE Office of Environmental Management project 65,800 total workers are needed at U.S. cleanup sites over the next five years.
- The Blue Green Alliance projects 1.55 million wind and solar jobs by 2035.
- The NEA & IAEA project 1,800 jobs for each single unit 1000-MW advanced light water reactor.

In addition to the projected jobs associated with the expansion of the energy production sector the employee turnover, new hire, and new employee turnover rates for currently operating nuclear power plants have steadily increased in the past three years resulting in a need for more replacement workers to sustain the fleet.

See Attachment 1: Job Projections Summary, and the following information for an explanation of the above job projections.

The Nuclear Energy Institute (NEI) commissioned Vibrant Clean Energy (VCE) to study the role advanced nuclear technologies can play in providing clean dispatchable generation in an

electrified and decarbonized energy system. The two scenarios modeled in the Role of Electricity Produced by Advanced Nuclear Technologies in Decarbonizing the U.S. Energy System study[19] are as follows:

- Representative first-of-its-kind (FOAK) capital cost for advanced nuclear and no deployment constraints ("Nominal" scenario): In this scenario, the contiguous United States undergo economy-wide electrification, and the electricity sector is required to decarbonize by 95 percent by 2050. Advanced nuclear is available for the model to deploy starting 2030 with demonstration projects coming online in 2028 and 2029. A representative FOAK capital cost of $3,800/kW is assumed for the advanced nuclear technologies with a learning rate of 5 percent. **It is assumed that the supply chain along with availability of qualified workforce ramp up quickly** in response to demand along with minimal delays due to licensing from the Nuclear Regulatory Commission (NRC). It is ensured that the model is only constrained in terms of economics when deploying advanced nuclear generators. See Figure 21 for the aggregated generation for the normal scenario.

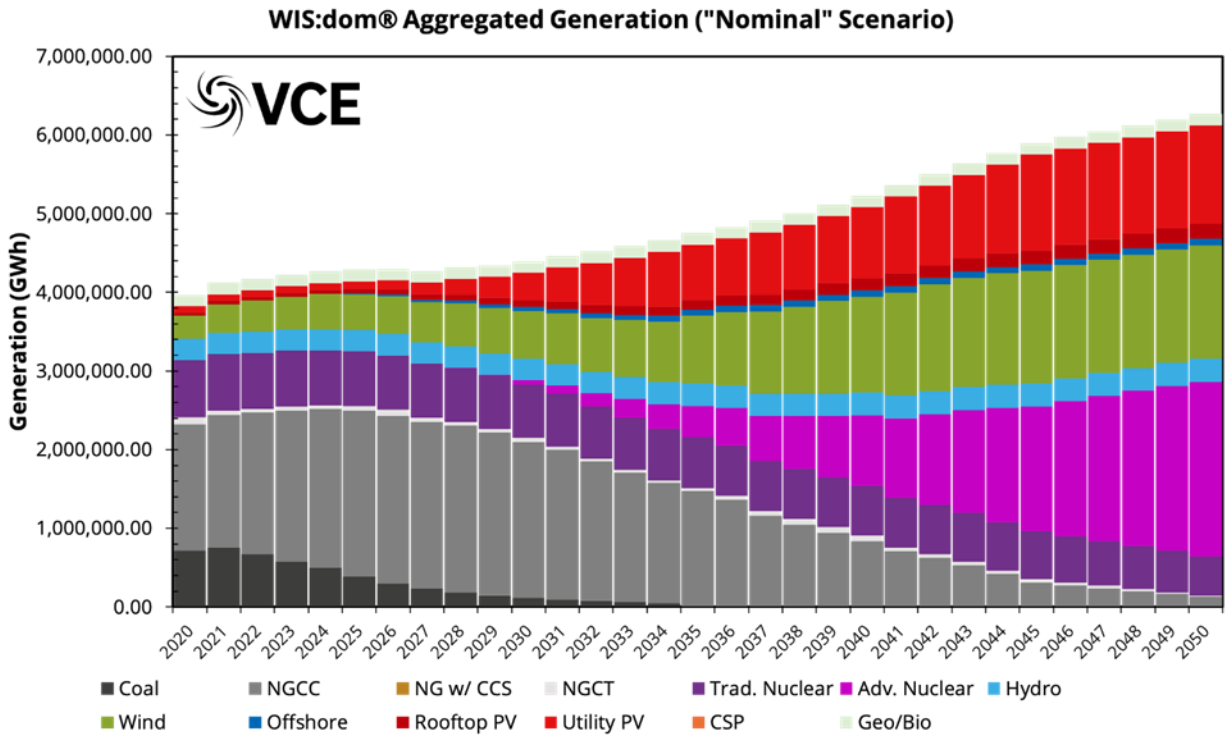



Figure 21: Aggregated Generation ("Nominal" Scenario)

- Higher FOAK capital cost for advanced nuclear with constraints in advanced nuclear deployment ("Constrained" scenario): **This scenario investigates the impact of constraints such as delays in procuring NRC licenses and permits, slower supply chain ramp up, and limited workforce availability** for advanced nuclear on the eventual generation mix installed on the grid. These constraints result in a roughly three-year lag in the response of supply to demand within the model in addition to a slower growth of the supply availability. Similar to the previous scenario, the contiguous United States undergoes economy-wide electrification, and the electricity sector is required to decarbonize by 95 percent by 2050. Advanced nuclear is available for the model to deploy starting 2030 with demonstration projects coming online in 2028 and 2029. A higher FOAK capital cost of $5,500/kW is assumed for advanced nuclear with a learning rate of 5 percent. Figure 22 for the aggregated generation for the constrained scenario.

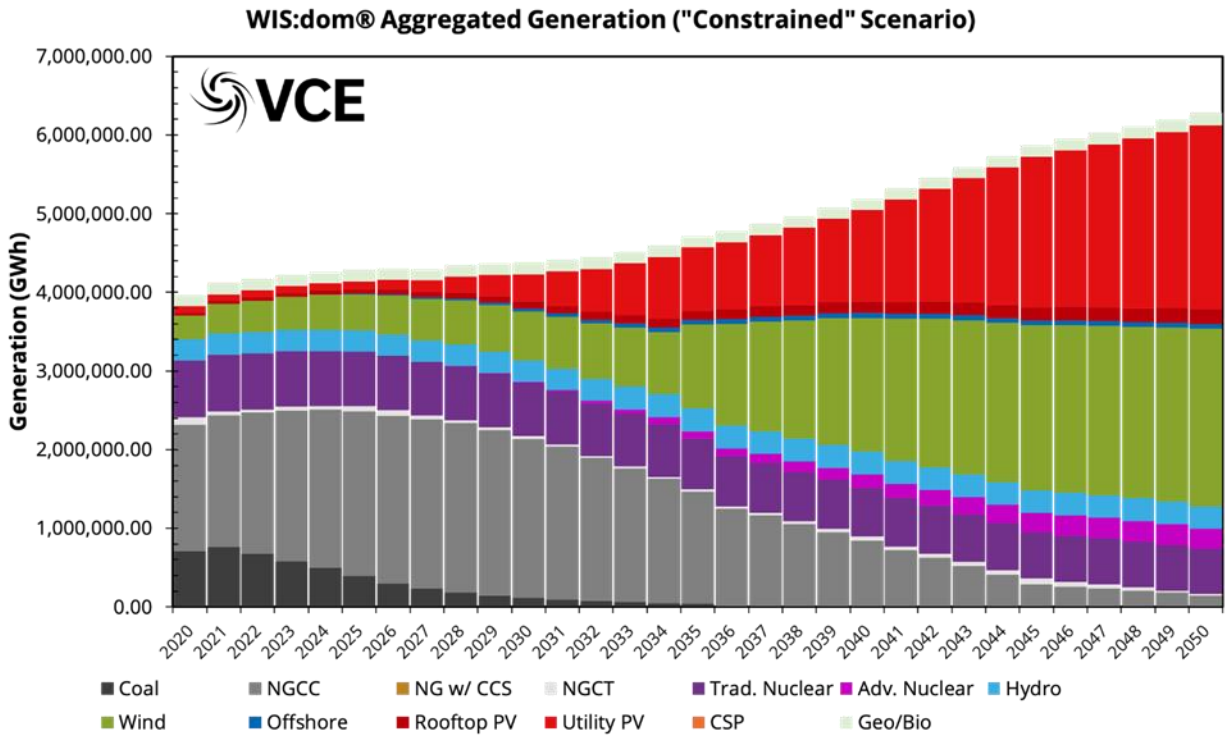



Figure 22: Aggregated Generation ("Constrained" Scenario)

Results show that in the “Nominal” scenario, the model deploys 336 GW of advanced nuclear to the grid by 2050, while in the “Constrained” scenario, the model only deploys 59.7 GW of advanced nuclear by 2050. It is found that the significantly lower deployment in the “Constrained” scenario is due to the inability of the model to deploy sufficient advanced nuclear between 2030 and 2035 where the **deployment of advanced nuclear is held back due to supply constraints, increased regulatory hurdles and unavailability of trained workforce.**

Overall, this study shows that nuclear generation can play an important role in decarbonizing the electricity sector by providing over 40 percent of total generation in 2050, requiring more than 300 GW of new nuclear.

The average annual full-time equivalent jobs created in the nuclear energy sector in the two scenarios modeled is shown in Figure 23 and explained as follows:

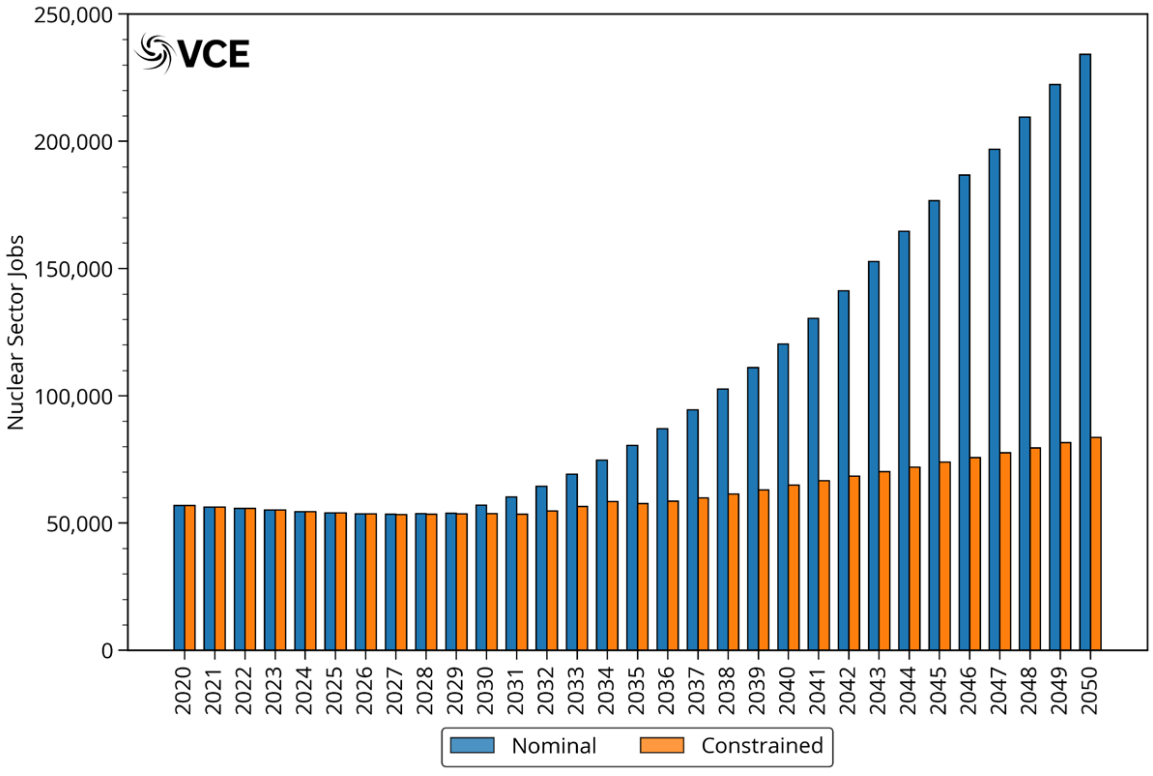



Figure 23: Average annual full-time equivalent jobs created in the nuclear energy sector for the two scenarios modeled

- In the “Nominal” scenario, nuclear energy sector jobs grow from approximately 56,000 in 2020 to 234,000 in 2050 driven by the expansion of advanced nuclear deployed to the grid and the supporting industries needed to enable that expansion. The roughly 177,000 additional jobs supported by the nuclear industry in the “Nominal” scenario is only slightly less than the 200,000 job losses that occur in the coal and gas industry due to retirement of the fossil fuel generation. Given that almost all of the advanced nuclear deployed by the model is sited at decommissioned coal and gas sites, these jobs will continue to support the communities that depended on jobs created by fossil fuel generation. Therefore, a timely deployment of advanced nuclear technologies will not only save spending in the electricity sector, but also stem the job losses occurring due to retirement of fossil fuel generation and ensuring a just transition in those communities.

- By contrast, in the “Constrained” scenario, the annual average jobs only increase to 83,000 in 2050. However, in this scenario retirement of coal and gas generation still results in about 187,000 job losses. Therefore, delays in deployment of advanced nuclear not only increases total system costs, but will cause net job losses in communities that relied on fossil fuel generators as the main source of employment.

The U.S. Department of Energy’s The Pathway to Commercial Liftoff report[20] aims to establish a common fact base and ongoing dialogue with the private sector around the path to commercial liftoff for critical clean energy technologies. Their goal is to catalyze more rapid and coordinated action across the full technology value chain. For advanced nuclear, the U.S. domestic nuclear capacity has the potential to scale from approximately 100 GW in 2023 to approximately 300 GW by 2050—driven by deployment of advanced nuclear technologies. Power system decarbonization modeling, regardless of level of renewables deployment, suggests that the U.S. will need approximately 550–770 GW of additional clean, firm capacity to reach net-zero; nuclear power is one of the few proven options that could deliver this at scale, while creating high-paying jobs with concentrated economic benefits for communities most impacted by the energy transition.

To achieve full scale industrialization of advanced nuclear power through 2050 the U.S. would need approximately 375,000 additional workers with technical and non-technical skillsets to construct and operate 200 GW of advanced nuclear.

### Competition from Domestic Nuclear Projects

Competition for workers from other domestic nuclear projects impacts the pool of available workers. For example, the U.S. DOE Office of Environmental Management has projected it will need 11,000 operators, 8,700 radiological technicians, 6,500 electricians, 5,500 project controls analysts, 3,500 project managers, 3,500 mechanics and 2,300 work planners at its U.S. cleanup sites over the next five years. The office said it will use the analysis, which has been developed in conjunction with the Energy Facility Contractors Group, to help shape potential new workforce development efforts and refine existing programs.[32]

### Competition from Domestic Clean Energy Industries

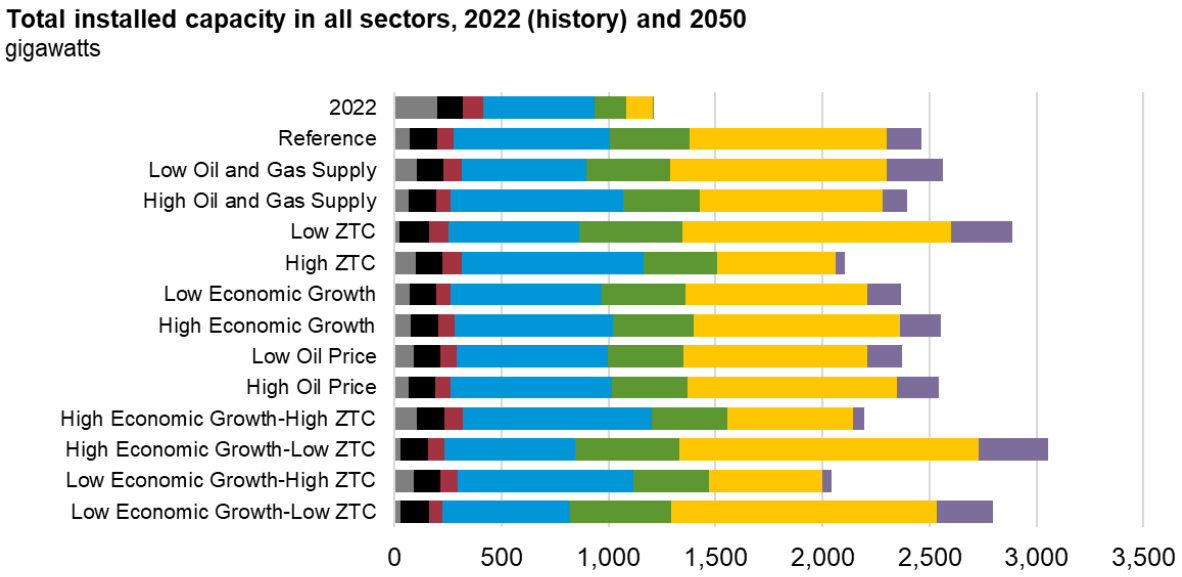
The clean electricity production and investment tax credits (PTC and ITC) expanded and extended by the Inflation Reduction Act (IRA) substantially reduce the levelized cost of utility-scale solar and wind projects deployed in the United States (U.S.), making renewable energy projects economically viable across much wider extents of the country. Employers in clean energy fields are especially optimistic now, as jobs in their sectors are poised to surge under the Inflation Reduction Act. According to an analysis performed for the BlueGreen Alliance, the clean energy tax credits and the 45X manufacturing tax credit will induce demand for 1.6 million additional solar and wind jobs. These two provisions alone in the Inflation Reduction Act are projected to induce demand for about 1.3 million additional jobs related to utility-scale solar PV and about 0.25 million additional wind related jobs in 2035, compared to projected employment levels if the Inflation Reduction Act had not passed.[21]

The U.S. Energy and Employment Report (USEER) 2022 analysis shows that energy jobs have rebounded, after sharply declining in 2020 due the COVID-19 pandemic and subsequent economic fallout.[5] In 2021, energy jobs grew 4 percent from 2020, outpacing overall U.S. employment, which climbed 2.8 percent in the same period. The energy sector added more than 300,000 jobs, increasing the total number of energy jobs from 7.5 million in 2020 to more than 7.8 million in 2021. At the end of 2021, over 3.3 million people worked in wind, solar, efficiency and other clean energy fields. About 40 percent of all energy jobs in the U.S. last year were aligned with the goal of bringing greenhouse gas emissions down to net zero, according to

the USEER 2022. The Electric Power Generation sector employed 857,579 people in 2021, an increase of 24,006 jobs (+2.9 percent). Employment changes by generation type are as follows:

- Solar +17,212 jobs (+5.4%)
- Wind +3,347 jobs (+2.9%)
- Hydropower +1,383 jobs (+2.2%)
- Combined Heat and Power +996 jobs (+3.5%)
- Bioenergy +349 jobs (+2.9%)
- Geothermal +220 jobs (+2.8%)
- Coal -572 jobs (-0.8%)
- Nuclear -2,440 jobs (-4.2%)

The U.S. Energy Information Administration (eia) Annual Energy Outlook (AEO2023) report predicts renewable generating capacity will grow in all regions of the United States in all AEO2023 cases, supported by growth in installed battery capacity.[12] AEO2023 sees stable growth in U.S. electric power demand through 2050 in all cases considered because of increasing electrification and ongoing economic growth. The combination of declining capital costs and government subsidies, including Inflation Reduction Act (IRA) initiatives, drive rising renewable technologies for electricity generation, such as solar and wind. Once built and when the resource is available, wind and solar are the least cost resources to operate to meet electricity demand because they have zero fuel costs. Over time, the combined investment and operating cost advantage increases the share of zero-carbon electricity generation. As a result, in AEO2023, renewable generating capacity will grow in all regions of the United States in all cases. The total installed generating capacity more than doubles across most scenarios from 2022 (baseline reference) to 2050. See Figure 24.




**Coal, Other, Nuclear, Oil and Natural Gas, Wind, Solar, Stand Alone Storage**

Note: ZTC=Zero-Carbon Technology Cost; other=geothermal, biomass, municipal waste, fuel cells, hydroelectric, pumped hydro storage

Figure 24: Total Installed Capacity in all sectors, 2022 (history) and 2050

Electric utilities reported the following regarding hiring nuclear electric power generation workers:

- Very difficult = 24%
- Somewhat difficult = 58%
- Not difficult = 19%

The most common reasons for hiring difficulties were as follows:

- Competition/small applicant pool 47 percent
- Lack of experience, training, or technical skills 36 percent
- Insufficient non-technical skills (work ethic, dependability, critical thinking) 22 percent

### Competition from International Nuclear Power Plant Construction and Operation

Experienced U.S. nuclear power plant workers could be recruited by international projects to build and operate new nuclear power plants. The International Energy Agency (IEA) projects a sustained ramp-up for renewables and nuclear power—if markets rebalance. "Recent events, market conditions and policies are shifting views on natural gas and limiting its role, while underlining the potential for nuclear power to cut emissions and strengthen electricity security," the IEA noted. However, "the continued role of nuclear power in the electricity sector relies on decisions to extend the lifetime of existing reactors and the success of programs to build new ones," it said.[8]

According to the World Nuclear Association, as of May 2023 about 100 power reactors with a total gross capacity of about 100,000 MWe are on order or planned, and over 300 more are proposed. Many countries with existing nuclear power programs either have plans to, or are building, new power reactors. In addition, about 30 countries are considering, planning or starting nuclear power programs.[31]

In one example, EDF hired about 100 experienced U.S. and Canadian welders, pipefitters, and boiler makers to fix its ageing nuclear reactors and build more of them[22].

### Competition from Non-Nuclear Industries

Other domestic industries need workers with the same skills, knowledge, and experience as the nuclear workforce. Examples of the demand and challenges for these workers experienced by other domestic industries include the following:

- Aviation - Boeing Company said it plans to hire 10,000 employees in 2023, about half the number it hired in 2022. Boeing accelerated hiring in 2022 to deal with a surge in retirements that led to 8,000 staff departing the company. The planned hires in 2023 will be focused on its engineering and manufacturing operations.[10]
- Computer Chips - Tech leaders traveled to a small-town campus on the Wabash River to fix one of the biggest problems that they — and the U.S. economy — face: a desperate shortage of engineers. Intel broke ground on two massive chip factories in Ohio that aim to

employ 3,000 people. Hefty new government subsidies aimed at reshoring manufacturing are sparking a construction boom of new chip factories, but a dire shortage of engineers threatens the ambitious project. By some estimates, the United States needs at least 50,000 new semiconductor engineers over the next five years to staff all of the new factories and research labs that companies have said they plan to build with subsidies from the Chips and Science Act, a number far exceeding current graduation rates nationwide, according to Purdue. Additionally, legions of engineers in other specialties will be needed to deliver on other White House priorities, including the retooling of auto manufacturing for electric vehicles and the production of technology aimed at reducing U.S. dependence on fossil fuels. The Chips Act includes $200 million for worker training. Intel and the National Science Foundation also recently announced an effort, as have a number of universities and industry associations to work together to develop the training programs—from GEDs to PhDs—that will benefit workers and strengthen our global competitiveness. At the same time, the rise of social media and other software-focused companies has shifted more students to those sectors, where starting salaries were often higher than in the chip business, engineers say. The university also invited semiconductor experts to join an advisory board to make recommendations on curriculum and training, which is what brought the chip executives to campus. When Purdue held an evening session last month about semiconductor careers and its new chip courses, more than 600 students filled the lecture hall and spilled into an overflow crowd watching outside on their phones.[23.]

- Battery Factories - The Inflation Reduction Act encourages new dedicated capacity for energy storage. The law includes manufacturing tax credits for battery modules, cells, and materials; a new stand-alone storage tax incentive for project owners; and bonus incentives for using certain levels of domestic content. Such plans could drive a tenfold jump in U.S. lithium-ion cell manufacturing capacity between 2021 and 2025, to 382 GWh, according to a forecast from S&P Global Commodity Insights. Project owners anticipate materials challenges, labor challenges, and know-how challenge[25]. The Department of Energy's (DOE) Vehicle Technologies Office highlights 13 new projects at various stages that are expected to be completed by the end of 2025. Total manufacturing output will be more than 300 GWh per year by 2025[26]. One example of the challenge and solutions experienced by a battery factory is as follows:

    - Panasonic said it has faced an industry-wide shortage of battery engineers after a construction boom in lithium-ion battery mega-factories to address the shift towards

electric vehicles. The company hired chemical engineers from the non-battery sectors and trained them in working with lithium-ion batteries. Now it employs 3,000 people, as well as about 200 technical assistants from Japan.[24]

## Identified Barriers

Significant barriers to hiring and retaining a nuclear workforce identified during this analysis include the following:

### Civilian Labor Force Participation Decline

The U.S. Chamber of Commerce hears every day from its member companies—of every size and industry, across nearly every state—that they are facing unprecedented challenges trying to find enough workers to fill open jobs. Currently, the latest data shows that there are 9.9 million job openings in the U.S., but only 5.8 million unemployed workers. There are many open jobs, but not enough workers to fill them. If every unemployed person in the country found a job, the U.S. would still have more than 4 million open jobs[27].

At the end of November 2022, the U.S. Labor Department recorded a seasonally adjusted 10.5 million job openings, or 1.7 unfilled jobs for each person counted as unemployed. The highest rate recorded before the pandemic was 1.2. For December 2022, the Labor Department reported that the labor-force participation rate – the share of the noninstitutionalized population aged 16 and up that is either working or looking for work – was a seasonally adjusted 62.3 percent. That compared with 63.3 percent in February 2020. If the participation rate was back at the pre-pandemic level, with the unemployment rate remaining at December's 3.5 percent, there would be over 2.5 million additional people counted as unemployed.[6] See Figure 25.

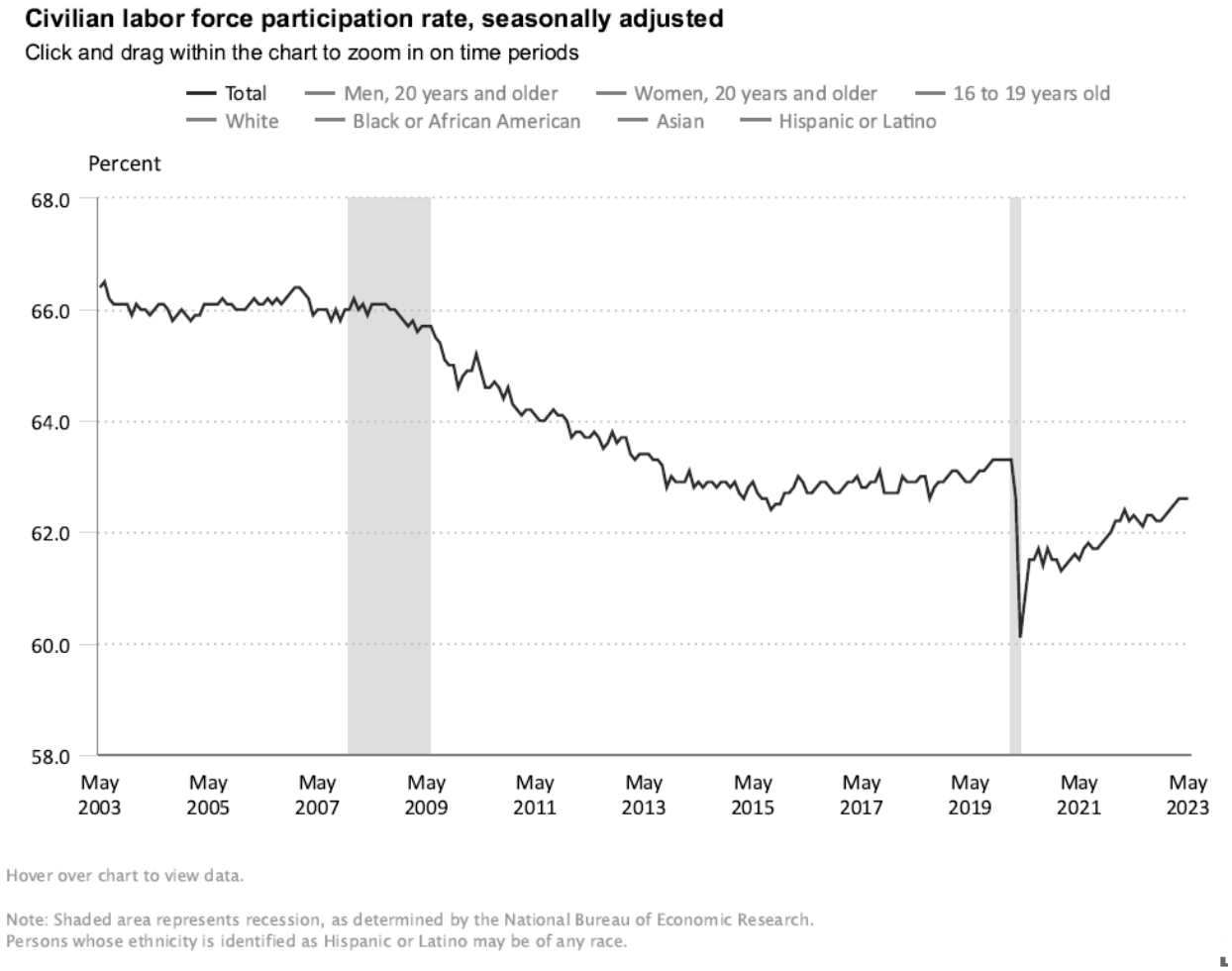



Figure 25: Civilian Labor Force Participation Rate, Seasonally Adjusted

According to the Bureau for Labor Statistics, STEM jobs will grow by eight percent between now and 2029. For engineering occupations specifically, employment is projected to grow approximately three percent in the next 10 years — adding over 74,800 new jobs by 2029.[6]

## Great Resignation

The nationwide labor shortage has been a hot topic in every industry over the last two years with the "Great Resignation" and a major shift in how nearly every industry conducts business.

According to an article from Indeed.com[14], the Great Resignation, also known as the Great Realization, the Big Quit, and the Great Reshuffle, first gained momentum in the U.S. in 2021,

when roughly 47.4 million people quit their jobs. For comparison, 42.1 million people quit in 2019, which was also considered a tight labor market. The new trend of "quiet quitting" has also meant that even if employees are not outright quitting as part of the Great Resignation, at least half are disengaging from their jobs and doing only the minimum required. Tips for retaining employees mentioned in the article include the following:

- Rethink educational and industry experience requirements – is a college degree necessary for the job?
- Offer greater flexibility and/or remote work options.
- Assess wage competitiveness.
- Prioritize happiness and well-being.
- Support employee's reproductive rights.

The NEI Strategic Workforce Plan states "Like the full US economy, the nuclear energy industry has been experiencing increased voluntary attrition, particularly among those who have less than ten years of service - suggesting higher turnover among younger workers. While it is undetermined whether voluntary attrition will persist at these rates, with the competition for workers growing, it can be assumed that voluntary attrition will persist at a high level, even if not at the historic rates recently seen[16].

### Aging Workforce Demographics

The number of U.S. people 65 years or older continues to increase and is projected to represent about 22 percent of the U.S population by the year 2050. See Figure 26. During Lori Brady's Conference on Nuclear Training and Education (CONTE) 2025 conference presentation[1] she described the following key demographic turning points:

- Two major turning points projected for the early to mid 2030s:
    - Older adults will outnumber children for the first time in American history

- Immigration is projected to overtake natural increase (excess of births over deaths)

- Two additional important current trends:
  - U.S. Population Growth Rate decline
  - Labor Force Participation Rates continue to trend down historically

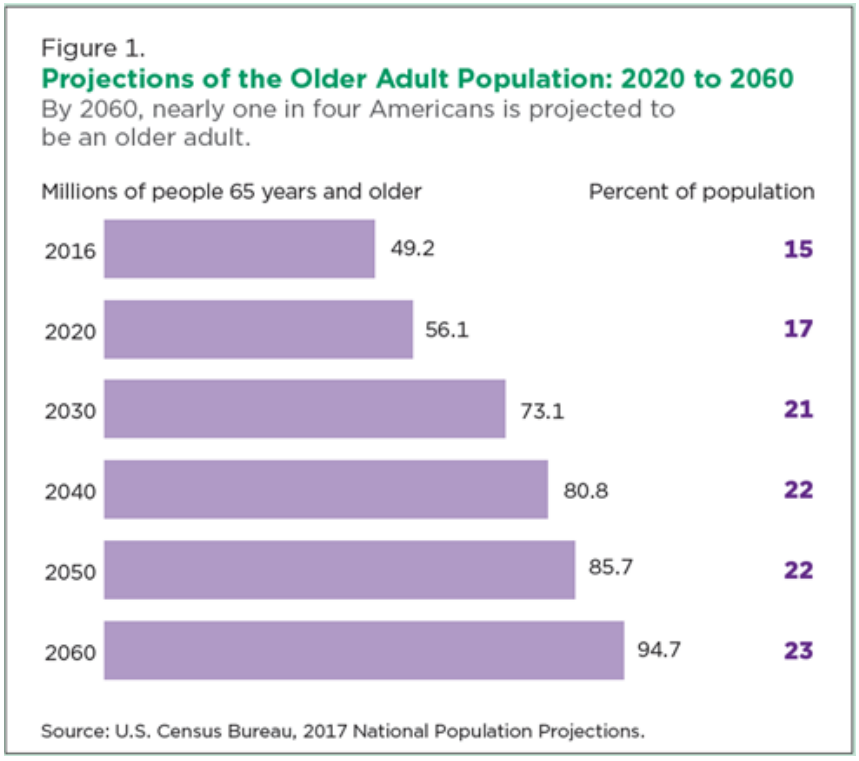



Figure 26: Projections of the Older Adult Population: 2020 to 2060

## Diversity, Equity, and Inclusion (DE&I)

According to the NEI Strategic Workforce Plan[16], across the energy sector, approximately 22 percent of the current workforce is female, while minority populations comprise 24 percent of the energy workforce. Given these statistics, the Nuclear Energy Institute joined together with representatives from various energy companies, as well as nine other energy organizations (many of which are trade associations representing a large number of individual energy

companies) to collaborate and co-author a DE&I Roadmap for Change, which was created to elevate DE&I efforts across the entire energy sector. (Full Document is in the NEI Strategic Workforce Plan -- Appendix A).

The development of the 2022 NAYGN Career Report[13] occurred in three phases from August 2021 to May 2022. The survey focused on several areas of interest, such as demographics, salary, career satisfaction, job importance vs. satisfaction, professional development, nuclear outlook, and NAYGN satisfaction. In most cases, the percentages identified in the report are based upon a total of 864 survey respondents. The percentage of female NAYGN members increased from 35 percent (2020 Career Report) to 40 percent. Compared to the United States Energy and Employment Report (USEER) 2021, NAYGN is outpacing female membership in the Nuclear Electric Power Generation industry where females represent 34 percent of the industry. The NAYGN report noted that males consistently make more than females at every level of experience. The gap is most apparent early in career (0-4 years of experience) and late in career (>14 years of experience). This early career gap is attributed to the fact that males had a higher average starting salary than females in 12 of the past 16 years (in only 4 years was the average starting salary higher for females). The NAYGN membership data also uncovered a pay gap based on ethnicity. Caucasian/White NAYGN members are paid more than their minority peers at every experience level. The gap is most apparent after 14 years of experience in the nuclear industry which indicates this is not the same type of issue as the gender pay gap (where starting salary discrepancies were identified as a major cause). Additional compensation and demographic data can be found in the 2022 NAYGN Career Report.

The first comprehensive survey of gender balance in OECD Nuclear Energy Agency (NEA) countries (Note: the U.S. is a member but no U.S. organization provided data) substantiates women's underrepresentation in the nuclear sector, especially in STEM and leadership roles.[11] OECD NEA collected data on gender balance in the nuclear sector in NEA countries to understand workforce representation, career trajectories, and challenges facing women in the sector, especially in STEM and leadership positions. In 2021, the NEA polled over 8,000 women in the nuclear workforce in 32 countries (approximately 500 women in the U.S responded to the survey) and collected total workforce data from 96 nuclear organizations in the following 17 countries (No U.S. organization provided data). See Figure 27.

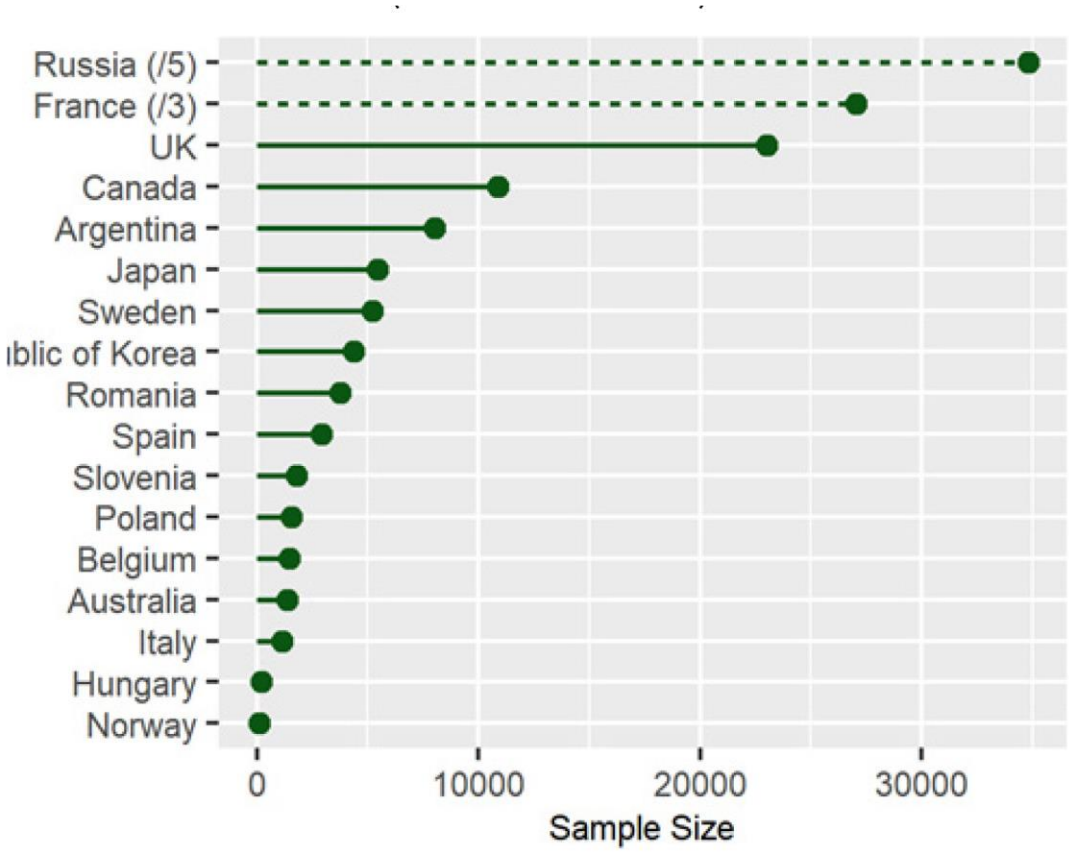



Figure 27: Total Workforce by Country (women and men)

The data detailed in the report from NEA members other than the U.S. show that women are underrepresented in the nuclear sector, especially in STEM and leadership roles as follows:

- Women comprise 24.9 percent of the nuclear workforce, based on data from 17 countries, and constitute only 20.6 percent of the STEM workforce and 18.3 percent of senior leadership roles.

Furthermore, current recruitment, attrition and promotion rates are insufficient to significantly improve gender balance in the sector. See Figure 28.

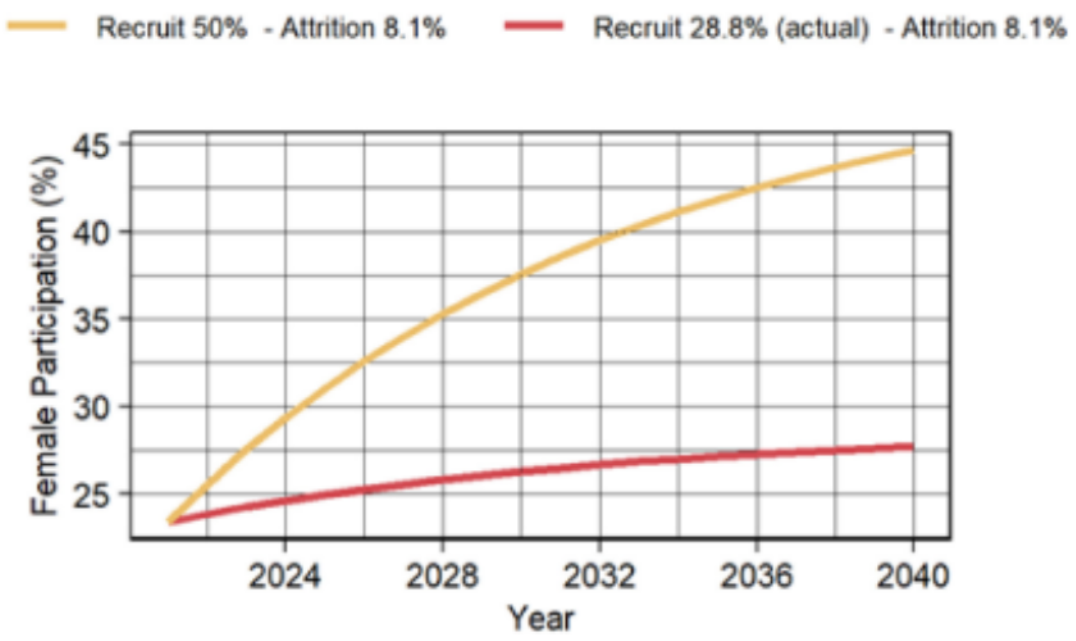



Figure 28: Simple Projection of Gender Balance with Current and Balanced Recruitment

Women face barriers to career progression and are not effectively supported by their workplaces to fully realize their potential. Accordingly, direct, practical, and substantive actions are recommended to increase the proportion of women in the sector, support their career development, and enhance their contributions. The report's guidance is organized as a framework consisting of the following three pillars:

- **ATTRACT** women into the nuclear sector;
- **RETAIN** and support women in the workforce (including addressing impacts related to the conduct of familial responsibilities); and
- **ADVANCE** and develop women as leaders and enhance their contributions.

The goal of these pillars is to provide an overarching, strategic framework through which governmental institutions and other nuclear sector actors can develop context-specific policies and programs. Each pillar contains targeted recommendations developed from the data findings to address the needs and challenges of women in the sector. The recommendations are organized under each of the three pillars and include provisions for data collection and accountability.

Based on the findings in OECD NEA report, recommendations were proposed to improve gender balance in the sector. Key findings categorized by pillar discussed in the OECD NEA report include the following:

**Challenges to attracting women:** Recruitment into the nuclear sector is not gender balanced, although women in the sector would recommend nuclear careers to other women.

- Women are 28.8 percent of new hires in the nuclear sector but are better represented in non-STEM hires (40.7 percent female) than in STEM hires (24.6 percent female). The percentage of new female hires marks the upper limit of women's future workforce representation. Because STEM roles in the nuclear sector are those that most typically lead to senior management, the low percentage of STEM hires does not point to substantial future change.

- The majority of women surveyed would encourage other women to pursue a career in the sector. However, there is significant ambivalence and regional variation.

- Women rank improving the visibility of women in the sector, including in STEM and leadership roles, as an effective solution for enhancing the attractiveness of the sector for women.

- Increasing career flexibility and developing comprehensive solutions to balance professional and family responsibilities poll strongly as ways to increase the sector's gender balance.

**Challenges to women's retention:** Retention and attrition trends are insufficient for improving the gender balance in senior leadership roles. Pregnancy and family responsibilities are rated by women as major career impediments. Women experience hostile work environments in the nuclear sector, especially in STEM roles.

- Attrition in the nuclear workforce (women and men) is 8.1 percent, of which women constitute 23.9 percent. This is lower than the workforce percentage of female new hires (28.8 percent) and women in the nuclear workforce overall (24.9 percent). However, the highest attrition is among women in non-managerial and lower management positions. This signals leakage from the leadership pipeline and will result in a smaller pool of women eligible for senior roles.

- Women surveyed overwhelmingly state that pregnancy, family responsibilities, and/or accommodating a spouse's career have negative impacts on their careers.

- Women experience hostility in the nuclear workplace, including sexual harassment. Accounts are higher for women in STEM roles, women with lower educational attainment and women who are members of minority groups.

- Approximately two-thirds of the women surveyed believe that gender stereotyping, micro-aggressions, unconscious bias and/or male-dominated work cultures negatively impact women's careers in the nuclear sector.

- Over half of the women surveyed indicate that their workplace culture is inclusive, but there is significant regional variation.

- Women report a lack of management commitment to improving gender balance in the workplace and insufficient institutional support. Women ages 25-44 poll more negatively, and there are regional variations. Employees in regulatory organizations poll more positively.

- Women highly rank improving workplace inclusivity through better training on countering stereotyping and unconscious bias, developing collaborative leadership models and monitoring workplace culture.

- Women highly rank comprehensive solutions to balance family life (including increased workplace flexibility and access to childcare), increased visibility of women, mentoring and cultural change as needed to improve gender balance in the nuclear sector.

**Challenges to women's advancement:** Women are, on average, paid less than men in the nuclear sector. The female promotion rate is insufficient for significantly improving the gender balance in STEM roles. Women regard opportunities for career advancement as unequal.

- Women in the nuclear sector tend to be paid less than men, based on limited datasets and supported by qualitative survey results. Salary disparities between men and women are lowest in European countries.

- Women are awarded 27.1 percent of promotions in the nuclear sector, which is higher than the proportion of women in the nuclear workforce (24.9 percent). Women in positions requiring university degrees and in management roles are being promoted above their

proportional workforce representation in these categories. However, female promotion rates for non-STEM roles significantly exceed those for STEM roles, exacerbating trends that concentrate women in non-STEM areas.

- Women surveyed state that they want to progress in their career. However, women do not regard opportunities in the nuclear workplace as equal, and believe that there are tacit or explicit institutional barriers to their retention and advancement. Stereotypes or unconscious bias about leadership characteristics; real or perceived incompatibilities between family and career responsibilities; and workplace cultures unsupportive of women's professional development rate as major hurdles.

- Women constitute 26 percent of participants in career development programs. This exceeds their proportional representation in the nuclear workforce (24.9 percent). However, the qualitative survey of women's experiences indicates that men are perceived to be selected for career-enhancing projects, development opportunities and training at greater rates than women. In addition, women surveyed indicate that programs to support their professional development, especially at the management level, are not available or not effective.

- Women identified the lack of female role models, mentors, and leaders, as well as sociocultural perceptions that nuclear careers are masculine, as barriers specific to the nuclear sector that need to be changed in order to improve gender balance.

### Work-Life Balance

Work-life balance for the nuclear workforce is influenced by the following factors:

- Nuclear Plant Location (typically away from urban areas) - Nuclear plants are not located near urban centers, so the industry loses potential employees seeking more life-style variety available in larger cities.

- Emergency Response Organization (ERO) Requirements – Participation in the ERO, an expectation for nearly all nuclear power plant workers, requires workers to be on-call for response to the nuclear plant in the event of an incident. Workers are required to be "fit-for-duty" which means they cannot consume alcohol during their on-call period, typically

one week every three to five weeks. They also must be able to arrive at the nuclear plant within one hour of a notification to respond, which limits the location/distance where they can reside.

In addition to nuclear plant location and ERO requirements, NAYGN identified a gap between individual contributors and company leadership: work schedules and working remotely.[13] Those in higher levels of leadership (executives and managers/directors) prefer a traditional 5-day workweek much more than first-line supervisors and individual contributors who prefer alternate work schedules. Supervisors, management, and executives are more likely to prefer in-office work arrangements. In contrast, individual contributors are much more likely to prefer work formats that include work-from-home at least half the time. Generally, 85 percent of NAYGN members prefer at least some time working from home and younger NAYGN members were more likely to prefer remote work options. These disconnects are industrywide and need to be explored in more depth to buoy vertical organizational alignment. Fixing these disconnects will positively impact recruitment and retention of talent within the nuclear industry.

The two biggest threats to both NAYGN and the nuclear industry unveiled via their analysis were (1) low morale and (2) retention issues due to increasing workloads. The greatest disconnect between important job attributes and satisfactory job attributes was employee morale with less than 40 percent satisfaction but 80 percent importance. Low employee morale results in low participation in NAYGN and less productive employees for companies. In addition, note that while satisfaction with compensation was high, overall job satisfaction has decreased. Seventy-two percent of NAYGN members are satisfied or very satisfied with their jobs. This is a decrease from the 2020 Career Report, in which 86 percent of NAYGN members reported satisfaction with their jobs. Approximately half (49 percent) of NAYGN members surveyed are job hunting with nearly 12 percent of them identifying pursuit of higher compensation/better benefits as the reason. While 28 percent of NAYGN members are passively looking for a new job, 21 percent are actively looking for a job, whereas the 2020 Career Report showed only 12 percent of NAYGN members actively looking for a new job. Only 32 percent of NAYGN job seekers are restricting their job search to the nuclear industry. 27 percent of job seeking NAYGN members are looking to get out of the nuclear industry altogether. The top reason for why an NAYGN member would leave the nuclear industry is a lack of work/life balance. This report shows 31 percent (4 percent more than in 2020) of NAYGN members work 45 hours or more per week.

Other observations include (1) the importance of SMR technology and (2) climate change as a motivating force behind what is keeping half of NAYGN members in the industry. Note that utility professionals are less motivated by climate change compared to professionals at other types of companies. Lastly, NAYGN members at government organizations or research laboratories had a less positive outlook on the future of the nuclear industry.

Although NAYGN 2022 survey respondents expressed high satisfaction with their compensation that sentiment might be changing as the job market becomes more competitive. Today's younger generation workforce more readily discusses and compares their salary to the salary of their peers. Students interviewed at the ANS 2023 Annual Student Conference commented on the noncompetitive salary they are being offered by nuclear power plant companies as compared to other industries. One female student said she was offered a lower salary than the salary offered to a male friend with the same education and experience for the same job position.

### Insufficient Design, Construction, Operating, and Supplemental Workforce

The workforce development challenge will certainly manifest itself in the U.S. if nuclear is chosen as a technology to meet our low-carbon needs. There is already a shortfall in mechanical and electrical engineering talent as well as skilled craftsman in the critical trades (welding, machining, electronics, electrical, etc.) needed to support existing labor force demand. Growth in nuclear development will only exacerbate that shortfall. Importantly, the growth in this workforce is also likely to have a diluting effect on supervisory experience at any individual facility.

The NEI Strategic Workforce Plan states that in advanced reactors alone, the Department of Energy projects 236,000 workers will be needed to manufacture, construct, and operate advanced reactors through 2035, with that number increasing to approximately 376,000 workers by 2050.[16]

The preliminary results for CEWD 2021 Survey Contractors report[15] identifies the following regarding the contractor workforce:

- Workforce for contractors is extremely young.

- Minorities represent 29 percent of this total population.
- In line with the young population, there is a high turnover rate, with 94.7 percent of the population leaving within the first 5 years.
- There is a low retirement risk considering the age composition of the workforce.
- Contractor workforce composition is 6.8 percent women with 0.35 percent within key jobs, the highest percentage being from safety/quality compliance.
- Contractor workforce composition is 29 percent minorities with 23.4 percent within the key jobs, with the highest percentage being from lineworker technicians.

### Insufficient NRC Staffing

Construction and operation of new nuclear power plants will first require NRC license approvals. A lengthy approval process, with a history of delays, will stall the need for hiring workers causing those workers to seek careers in other industries. Subsequent License Renewal (SLR) for a majority of the current operating fleet will require increased NRC staffing. Advanced reactor designs require an initial NRC review and then subsequent reviews for each new licensee applicant requiring more NRC staff.

The DOE Pathways to Commercial Liftoff: Advanced Nuclear[20] report says the NRC would need to scale its license-application capacity from approximately 0.5 GW per year to 13-GW-per-year to meet projected demand. This would likely require significant additional resources for the NRC. The licensing process could be streamlined through deliberate actions from both the NRC and the industry.

### Late Student Engagement

Engagement and outreach to students is not occurring in a timely manner nor is it broad and comprehensive enough to be fully effective. About 60 students attending the 2023 ANS Annual Student Conference were asked how or why they became interested in a nuclear career. None of the students mentioned being contacted by or seeing a presentation from a nuclear company regarding career opportunities. Miss America 2023, a University of Wisconsin nuclear

engineering student, said she was not offered a tour of a commercial nuclear power plant until her junior year of study.

Currently, there exists several major pipelines of labor into the nuclear energy industry:

- Universities
- Community Colleges
- Vocational/Trade Schools
- Apprenticeships such as the Nuclear Mechanic Apprenticeship Program (NMAP)
- Military

For many of these pipelines to be successful, there needs to be a focus on energy and energy careers in the K-12 educational system. While several states have added "Energy" as a 17th Career Cluster; to date, neither the federal government nor a majority of states have taken the same action. Adding Energy as the 17th Career Cluster would help to drive increased focus and visibility regarding energy and energy careers through the K-12 educational system.[16]

### Uncertainty New Build will Occur

Uncertainty regarding if new nuclear power plants will be built might cause perspective workers to seek employment in other industries. One commercial nuclear power plant training manager said he was hesitant to offer perspective employees "a long career runway" due to uncertainty surrounding continued plant operation and new build projects.

Finance, policy, and environmental factors favor the development of several new nuclear generation units over the next decade in the U.S. but challenges persist, experts said June 11 during a panel discussion at the Edison Electric Institute's 2023 conference in Austin, Texas. An offer of as much as $300 billion in nuclear financing remains untouched, said panelist Julie Kozeracki, U.S. Department of Energy senior advisor for loan programs. "The industry is stuck in a stalemate, where utilities are staring at reactor developers, reactor developers are staring at the suppliers, and no one is really ready to move or make real capital decisions about building new nuclear," Kozeracki said. "There are two big things that we have to get right in order to

break through that, and one of those is establishing the mandate for clean firm power, and the fact is that we just don't have many good options for it."[18]

As stated in the NEI Strategic Workforce Plan, prior to the Inflation Reduction Act, there was some uncertainty about the sustainability of the currently operating full fleet due to economic challenges and conditions, as demonstrated by early plant closures. Moreover, there were highly publicized policy conversations about the economic viability of certain nuclear plants. This likely led to perceptions of industry instability by prospective workers, particularly in certain areas where these issues were more public. Moreover, the overall visibility of nuclear energy has decreased over the years while other industries have increased their visibility—e.g. technology, health care, etc. In fact, the energy industry, overall, is not perceived as one of the top ten industries in which employees currently want to work in the U.S.[16]

## Going Forward Strategy Recommendations

U.S. commercial nuclear power plant companies, government organizations, and academic institutions are preparing for the expected increased need for workers and, in some cases, are implementing programs to address this need. To accelerate these efforts the following actions are recommended for DOE/INL:

- Assist the commercial nuclear power plant industry with obtaining federal and state appropriations and support related to workforce issues (e.g. NRC, DOE (NEUP), internships, apprenticeships, scholarships, grants, awards, etc.) and ensure the industry is aware of opportunities.

- Assist the commercial nuclear power plant industry with increasing the focus on energy and energy careers in the K-12 educational system by working with the U.S. Department of Education to add "Energy" as a 17$^{th}$ Career Cluster; to date, neither the federal government nor a majority of states have taken the same action. A career cluster is a grouping of similar jobs with career pathways. Adding Energy as the 17$^{th}$ Career Cluster would help to drive increased focus and visibility regarding energy and energy careers through the K-12 educational system.

- Implement the National Academies - Laying the Foundation for New and Advanced Nuclear Reactors in the United States (2023) report Recommendation 6-1: In anticipation of the

necessary expansion in workforce to support more widespread deployment of nuclear technologies, the Department of Energy should form a cross-department (whole of government) partnership to address workforce needs (spanning the workforce from technician through PhD) that is comparable to initiatives like the multi-agency National Network for Manufacturing Innovation. The program would include the Departments of Labor, Education, Commerce, and State, and would team with labor organizations, industry, regulatory agencies, and other support organizations to identify gaps in critical skills and then fund training and development solutions that will close these gaps in time to support more rapid deployment. In carrying out these efforts, it will be important to take full advantage of existing efforts at commercial nuclear facilities and national laboratories that already have well-established training and workforce development infrastructure in place.[35]

- To improve oversight and effectiveness of more than 300 recommendations related to attracting and retaining a nuclear workforce identified in the reports, studies, and news articles analyzed for this report DOE should collect nuclear workforce-related reports/studies, analyze the report recommendations, sort the recommendations into similar categories and priorities, and add this information to the factors affecting operating nuclear power plant workforce hiring and retention report. The recommendations should be grouped into the following categories:
    - Career Awareness
    - Pipelines
    - Training and Qualifications
    - DE&I (cross-cuts many areas)
    - Policy & Federal/State Legislation
    - Employee Engagement & Retention

## Nuclear Power Industry Readiness to Implement Changes

While many nuclear plant companies continue to work on process improvement and technology changes, only a few have taken on the challenge of making the necessary changes to ensure nuclear industry sustainability.

Survey respondents indicated their organization's readiness to implement technology changes affecting operating nuclear power plant workforce hiring and retention as shown in Figure 29.

| Summary Readiness of Change | Results |
|---|---|
| **Not Ready for Change** | 2 |
| **Somewhat Ready for Change** | 2 |
| **Highly Ready for Change** | 5 |

Figure 29: Readiness to Implement Technology Changes

Readiness for change in the nuclear industry among employees refers to their willingness and ability to adapt to and embrace changes within the industry, whether they are technological advancements, regulatory updates, organizational transformations, or shifts in industry practices. It reflects the employees' attitudes, beliefs, and behaviors when faced with change initiatives.

In the context of the nuclear industry, readiness for change can be influenced by various factors, including:

- Awareness and Understanding: Employees' level of awareness and understanding of the need for change, its objectives, and the potential impact it may have on their roles, responsibilities, and the overall industry.
- Knowledge and Skills: Employees' possession of the necessary knowledge and skills to adapt to the change. Providing training, upskilling, and reskilling opportunities to equip employees with the required competencies can enhance their readiness and confidence in navigating the changing landscape of the nuclear industry.

- Organizational Support: The extent to which employees perceive that their organization supports and facilitates the change process. This includes providing resources, tools, and support systems to help employees cope with the change, addressing their concerns, and involving them in decision-making processes when appropriate.

- Trust and Leadership: Employees' trust in the leadership and management of the organization. Trust in leadership is crucial for fostering a sense of security and confidence in the change process.

- Organizational Culture: The prevailing organizational culture and its alignment with change. A culture that values innovation, continuous learning, and adaptability promotes employees' readiness for change.

- Employee Engagement: The level of employee engagement and involvement in the change process. Engaging employees by seeking their input, involving them in decision-making, and empowering them to contribute to the change efforts fosters a sense of ownership and increases their readiness to embrace and drive change.

- Personal Resilience: The individual employees' personal resilience and their ability to cope with change and uncertainty. Resilient employees are more likely to adapt quickly and positively to changes in the nuclear industry.

It is important for nuclear companies to assess and understand their employees' readiness for change to effectively plan and implement change initiatives. This can be achieved through surveys, focus groups, interviews, and ongoing communication and feedback channels that allow employees to express their concerns, provide suggestions, and share their experiences during the change process.

## INTERVIEWEE LIST

The following individuals were interviewed in support of this study:

- John Austin, General Manager Nuclear & Technical Training, Xcel Energy
- Aaron Bergeron, Corporate General Manager Training & Performance Improvement, TVA
- Jeff Bourgeois, Training Manager, Waterford 3 SES, Entergy
- Lori Brady, Senior Director, Human Resources & Training and Development, NEI
- Kimberly Cook-Nelson, Executive Vice President & Chief Nuclear Officer, Entergy
- Kostas Dovas, Vice President of Training, Constellation Generation
- David DuBey, Vice President, HR Business Partners, Nuclear Entergy
- Calen Fitzsimmons, E-Learning Training Designer, EPRI
- James Hettel, Director, Strategic Business Services, Arizona Public Service
- Dr. Kathryn Huff, Assistant Secretary Office of Nuclear Energy, US Department of Energy
- Steven Mirsky, Senior Technical Advisor, Research Collaborations, NuScale Power
- Steven Nevelos, Senior Director – Nuclear Training, PSEG Nuclear
- Dr. Valerie G. Segovia, Director, Nuclear Power Institute, Zachry Engineering Education Complex (ZACH), Texas A&M University
- Grace Stanke, Miss America 2023
- Public Education Institutions and Military Academy Undergraduate and Graduate engineering students attending the 2023 ANS Annual Student Conference
- Perspective employers participating in the 2023 ANS Annual Student Conference Job Fair such as U.S.NRC, DOE, Duke Energy, Southern Nuclear, Dominion Energy, Constellation, Kairos Power, BWXT, Studsvik, IB3 Global Solutions, Naval Nuclear Laboratory, and DOE NUEP.

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# FIGURES

21. Aggregated Generation (“Nominal” Scenario)
22. Aggregated Generation (“Constrained” Scenario)
23. Average annual full-time equivalent jobs created in the nuclear energy sector for the two scenarios modeled
24. Total Installed Capacity in all sectors, 2022 (history) and 2050
25. Civilian Labor Force Participation Rate, Seasonally Adjusted
26. Projections of the Older Adult Population: 2020 to 2060
27. Total Workforce by Country (women and men)
28. Simple Projection of Gender Balance with Current and Balanced Recruitment
29. Readiness to Implement Technology Changes

# ATTACHMENT

- Attachment 1:  Job Projections Summary

Attachment 1: Job Projections Summary

| Job Projections Summary | | | | | | |
|---|---|---|---|---|---|---|
| **Vibrant Clean Energy by 2050[1]** | | **DOE Commercial Liftoff by 2050[4]** | **DOE Office of Environmental Management by 2028[5]** | **Blue Green Alliance by 2035[6]** | **NEA & IAEA[7]** | **Currently Operating Nuclear Fleet by 2050[8]** |
| 177,000[2] | 27,000[3] | 375,000 | 65,800 | 1.55M | 1,800 | 108,000 |

1. Average annual fulltime equivalent jobs
2. Nominal scenario
3. Constrained scenario
4. Manufacture, construct and operate advanced nuclear of 200GW
5. Total workers needed at U.S. cleanup sites over the next five years in the following job categories:
    a. Operators: 37,500
    b. Radiological Techs: 11,000
    c. Electricians: 6,500
    d. Project Controls: 5,500
    e. Project Managers: 3,500
    f. Work Planners: 2,300
6. Wind and solar jobs
7. Nuclear Energy Agency (NEA) and International Atomic Energy Agency (IAEA) direct employment during site preparation, construction, and operation for single unit 1000-megawatt advanced light water reactor in the following job categories
    a. Professional & Construction: 1,200
    b. Administrative, operation, & maintenance: 600
8. Assumes hiring 4000 workers per year until the year 2050.