THE USE OF NUCLEAR POWER TO ESTABLISH MICROGRIDS ON UNITED STATES MILITARY INSTALLATIONS

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ABSTRACT

From its inception up until 2006, the U.S. electric grid was considered a reliable means of power distribution. However, it was recognized by Congress that there was an innate need to upgrade the grid to allow for modern electronics demand and renewable resources with the passing of the *Energy Independence and Security Act of 2007.*[1] The largest public consumer of domestically produced electricity is the Department of Defense. With most agreeing that demand is certain to balloon with the addition of DoD sponsored artificial intelligence data centers.[2] Most military installations are connected to the grid using their regional private distribution company. However, many government and military leaders classify this as a security concern. Several reports and studies have been conducted for the use of nuclear reactors to establish military installation "microgrids." A review of these reports suggests that there is no central effort by the DoD to establish the type of reactors or a plan to develop the workforce necessary to run these facilities. Rather, each branch of the military is running an independent study that only considers the feasibility. This report advocates for a centralized Department of Defense initiative to optimize base selection for reactor power usage and training forces, with a primary focus on the Navy. District heating on many naval bases along with the Navy's long-standing tradition of naval nuclear power make it the ideal choice for establishing norms of operation and training a non-shipboard crew for manning nuclear reactors at any military installations.

1. INTRODUCTION

The United States Navy has an impeccable safety record when it comes to their nuclear program. Safety is baked into every aspect of training, planning, and execution. The father of the nuclear navy, Admiral Hymen G. Rickover designed the training program as such due to the opposition he received from Congress at the time of its inception.[3] He had to guarantee that the *USS Nautilus* would not become a floating weapon likened to that of Hiroshima or Nagasaki, which was fresh in the minds of many Americans. His program selected only the finest and most capable engineers by his definition, which he interviewed personally, often in an unorthodox manner.

To date, there have only been the loss of two nuclear submarines. Neither loss having been related to a reactor incident.[4] Many believe that this track record is in part due to the lasting mentality of Rickover within the program. One such aspect of this mind-set is the recitation of the seven watch standing principles every morning by those in training. To remind trainees that the continued success of the program lies within their hands and is directly related to their dedication to integrity. With 99 active naval reactors, the track record speaks for itself. [5] While the Army maintains a few reactors, it is obvious that the Navy holds the most experience in training a nuclear workforce and maintaining reactors.[6]

In September of 2024, the Department of Defense released a memorandum discussing the contract winners for *Project Pele* breaking ground for portable microreactor modules in Idaho.[7] *Pele* is a Joint agency project to establish operating standards for generation 3+ and generation 4 nuclear reactor types in the United States. An important detail is that the Department of Energy designates reactors with an output of 1-20 MW as a microreactor.[7] The key design detail surrounding most of the publicly available documents for the Joint project is "transportation." The compact size of a microreactor is generally around 20 TEU (twenty-foot equivalent unit), a standard unit of measurement for shipping containers and semi-trucks. This would in theory allow for portable power delivered by C-17, amphibious landing ships, or semi-trucks just about anywhere in the world. The benefit of this design to the warfighter is obvious, however, two general issues that can be identified are the lack of qualified individuals that can operate or maintain a reactor in the field and the inability for microreactors to deliver long term baseload power to military installations.[8] A report considering the operational vulnerabilities of the *Pele* was conducted by an anti-proliferation subsidiary of the University of Texas at Austin. While important, does not pertain to many Continental United States facilities.

Take for example, Naval Station Norfolk in Virginia. This installation was awarded the title of River Star Businesses Hall of Fame winner for 2020, for its achievements in environmental impact reductions. Two of the significant projects include the addition of a 10-acre solar farm providing approximately 10 MWe and the upgrade of their steam-turbine plant, which reduced their dependence on the local utility provider by nearly 10 MWe and 25 MWth respectively. A 45 MW total reduction in dependence from the local power grid is certainly noteworthy, but this number is low in comparison to the actual demand of the base. [9] Even more so when providing shore power to aircraft carriers and an assortment of smaller ships. The *Ford* class has been infamous for its incompatibility with shore power among the stateside Naval bases. Some of the problem is related to the incorrect disconnects at any given pier. However, the larger picture reveals that many bases simply cannot provide a stable power output during peak demand.[10] *Project Pele* does not and cannot seek to solve the baseload capacity of naval bases when their design at best outputs 20 MWe. Some may argue for the installation of parallel units, which may offer a solution. However, each unit is certain to require a minimum staffing which may be difficult to provide, even if many of the systems are autonomous.

The Navy is not alone in this fight against local utilities, as many would argue that most sizeable bases from all branches face a similar problem. So much in fact, that the Pentagon has published a request for information regarding the future of nuclear power for land-based operations.[11] The solution to the problem, like many others faced by the DoD of the 21st century, requires fast-tracking from the bureaucracy and a unified front among the Joint services. However, installations like Norfolk with a large electric and steam demand are positioned to benefit the most from land-based gen 3+ and gen 4 reactors. Moreover, they offer a unique opportunity to prove the ability to train members of the military for their operation, something to date that has been largely ignored.

2. INSTALLATION SELECTION

2.1 Emergency Power

A report commissioned in 2017 considered the results of isolating military installations to their microgrids. The report drew on the operational costs that were accrued at larger bases due to power outages. Some of these costs were due to emergency generators, fees paid to contractors, and lost time of research for weapons systems. While the report did discuss the high integration costs of microgrids, it concluded that the security benefit, energy efficiency, and long-term savings outweigh the current use of diesel generators scattered throughout any given installation. The report also mentioned the subjective success of the Twenty-Nine Palms and Food and Drug Administration White Oak campus microgrid projects.[12] This report does not necessarily display the urgency but highlights the desire of the DoD to explore microgrids as an option for replacing the status quo of diesel generators for backup power.

2.2 Combined Heating Plants (CHP)

Many bases make use of combined heating plants which divert a portion of the generated power for the use of steam production. In the best case, they use waste heat to produce steam, as opposed to wasting it into the environment. This steam is introduced to a distribution network as is, or used for chillers, depending on the time of year. Rather than each building maintaining its HVAC system, the central plant controls the climate. Some of these district heating systems were installed in the 1960s-1970s and have fallen into disrepair, however, many bases like Norfolk maintain the steam pipes for active use. As of 2016, the Army has reignited the interest among the DoD for combined heating plants (CHP) as their then secretary promised to add 50 MWth per year to army bases.[13] With a study as recently as 2022, considering the economic impact of one of the new Army National Guard CHP in Maine, saving the installation upwards of $60,000 annually.[14] The DoE maintains a database which lists 40 current military installations with CHP. These combined resources provide evidence that the sentiment is shifting towards more CHPs on military installations.

The advantage of an installation with existing CHP infrastructure is that the heat generation source can be replaced without the additional capital required to integrate the district heating. Of course, there is an efficiency trade-off with the use of existing steam networks. The case to be made is that new, larger capacity, land-based nuclear reactors can be placed into these existing electric and steam networks. Mentioned previously, the microreactors because of *Project Pele* may not be suitable for this application. However, there are a handful of pending or approved designs by the Nuclear Regulatory Commission that may offer the thermal and electrical output necessary to maintain base operations. For example, the NuScale small modular reactor (SMR) offers 6 – 12 pack designs of up to 250 MWth (70MWe) per unit. Like many other generation 3+ reactor designs, SMRs rely heavily on passive safety systems that make them ideal for coastal and environmentally rugged locations. The relatively small facility footprint (30 acres) for the SMRs makes it an ideal design to easily integrate onto existing CHP installations with minimal disruption to base operations.[15]

While NuScale claims that its modular devices are capable of industrial applications, this is still limited by the output design temperatures of 600 ºF. Where the type of industrial application is a function of temperature. An alternative design which may be well suited for naval applications is the high temperature gas-cooled reactors (HTGR) which offer design temperatures of 1380ºF. These reactors may be capable of steel manufacturing, hydrogen production, and petroleum cracking. Ideal for ship building and fuel production at installations like Newport News or Puget Sound. HTGR designs, while modular, are not as far in development as current water-cooled SMRs, so their integration is more speculative. However, the potential to integrate into military installation microgrids in the next 10 years exists. [12]

3. WORKFORCE TRAINING

3.1 Nuclear Workforce Discrepancy

One of the persistent problems within the nuclear workforce worldwide is the disparity between qualified individuals and positions. The age distribution of workers is bimodal with peaks near retirement and entry-level ages. This is due to the large divestment in nuclear energy following Chernobyl and Fukushima.[16] The Navy has been spared due to consistent recruiting practices and large compensation for the entry-level workforce. However, the opposite problem exists in the military in that many mid-level operators are poached by industry after the initial service commitment is fulfilled. Many of these companies understand the quality of the nuclear navy workforce, but the high-quality training also comes at the cost of mental health. Where many members of the program find that submarine or carrier service is simply not for them. Many are opting to leave the community or the Navy.[17] Unfiltered accounts from the Sailors' both positive and negative can be found on social media pages like *The Reactor is Critical* on Facebook, detailing the lives of the workforce.

While there will always be members of the armed forces who face mental health concerns, in any community, the quality of life of the Navy must not be discounted. Especially during deployment. The case can be made that most of the members who start the nuclear training program, but do not see a full commitment or career in the service, are largely based following a sea tour, and not before. No publicly released data was found related to when a sailor makes the choice. Regardless of the source of a member's poor mental health, for every person that leaves the community, it is certainly a detriment to the taxpayer. Mental health must be prioritized, but certainly a compromise can be made.[18] A more comprehensive study would be in the best interest of the Navy.

However, this article is assuming that all the non-medical disqualifying losses of the nuclear Navy workforce are due to deployment conditions. If true, an alternative which would benefit the sailor, and the naval service is a shore duty at one of the prospective reactor plants for installation of microgrids. Though the working hours may remain the same, many of the stressors associated with a military deployment will not persist. The benefit to the Navy is a non-complete loss of talent from the community. In addition, to providing a third service option to navy nukes, a shore-based assignment at such a power plant may qualify as a restricted-line position, which personnel medically disqualified from other communities and ratings, or even sea-duty, may be suitable to fill.

3.2 Proposal For New Workforce Training

Though this proposal suggests that the DoD start with the Navy for the deployment of nuclear powered microgrids, there is the opportunity for Joint collaboration in the future. Where these microgrids, or even locations selected for *Project Pele* on other service installations, are still limited by workforce training. Given that there are currently no robust plans for developing a Joint force of nuclear operators, the Navy is well suited to provide this training at Naval Nuclear Power Training Command in South Carolina. Though it should be noted that the curriculum for such training would need to be slightly modified as it is currently based on pressurized water naval nuclear designs. Figure 1 provides the proposed training path for both Navy and Joint Service enlisted. Figure 2 provides the same for officers of the Navy and Joint services.

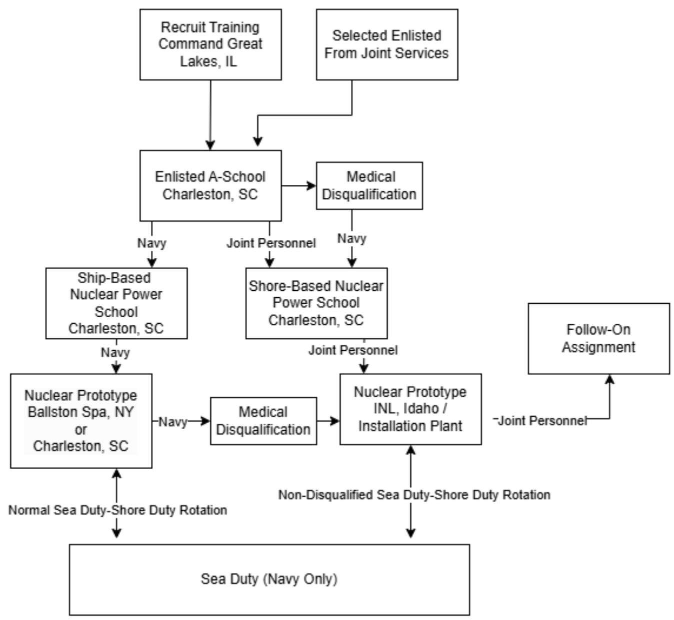

Figure 1. Timeline for enlisted nuclear training for the Navy and Joint Services.

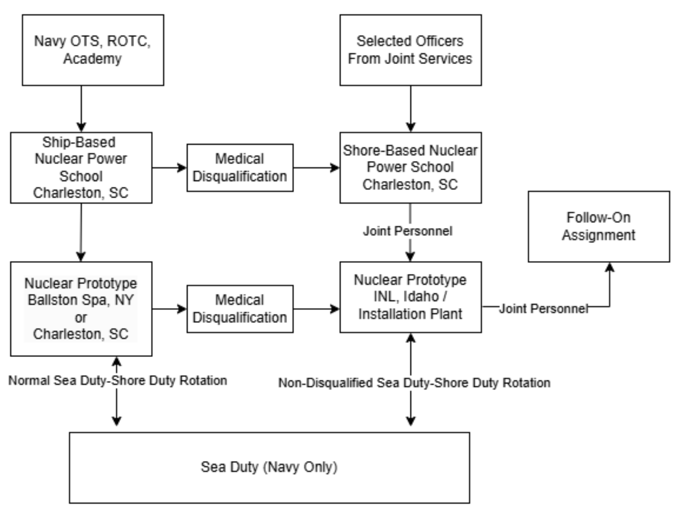

Figure 2. Timeline for officer nuclear training for the Navy and Joint Services.

4. PROBLEMS FOR INTEGRATION

4.1 Aging Infrastructure and Public Trust

While this article advocates for integration of power plants to existing infrastructure, this is often not a simple “plug-and-play” process. As discussed previously, some of these CHP facilities have been left to decay for decades. While this is not the case for all facilities, there is a social contract with military installations and their respective municipalities to ensure base operations do not harm those that live in the vicinity. The installation must ensure that the integration of these new facilities is not only to operate with high integrity, but to secure them from potential terroristic activities. The latter is easier to prove as these nuclear facilities will be on a secured base with active security forces. With one benefit being a reduction in cost to building a new nuclear power plant as the security cost is already considered from the military installation. However, like other nuclear projects, the “not in my backyard” people will fight the design process. (Although, a healthy skepticism keeps the work honest.) The problem with military installations, is that many of them exist in near proximity to municipalities. Whereas, proposed civilian plants are often in rural areas. As a result, these projects tend to receive less scrutiny. Despite the proposed use of the heat distribution plant as the tertiary loop in a nuclear cycle, these remain the systems requiring the most work to bring them up to nuclear grade construction. The age and current state of the steam distribution lines of many bases will offer a point of contention for those opposed to nuclear reactors in a vicinity close to their residence. So, should base leadership and the DoD wish to convince their base neighbors to get on board with the project, they need to develop positive public relations describing the isolation of the reactor from the steam plant.

4.2 Passing Cost to Rate Payers or Tax Payers

No discussion of nuclear would be complete, without cost. Of course, these projects are considered significantly costly compared to their coal, natural gas, or renewable counterpart. This is the problem with the SMR deployment by corporations. While there exists an economy at scale, no one wants to be the first. As this is considered incredibly risky to shareholder values. [19] The advantage of the DoD being the first purchaser of these reactor types, allows for a distribution of the cost to the tax payers, as opposed to the rate payers in local municipality. Some argue that this is less fiscally responsible, and is counter to the democratic process, as it is much easier for people to vote for a local corporate entity as opposed to a federal entity. However, to provide a relevant counter to this point is that local providers may now charge rate payers less as there would be a reduced demand on base load, if the military installation is no longer dependent upon the same grid. Of course, there is reason to believe that the utility may charge more to compensate for the loss of their largest customer. Though it is believed this is less likely in the long term to prevent competition from coming in replacing the current provider.

4.3 Quality of American Workforce

What many believe to be the elephant in the room is recruiting in general. Despite the proposed medical disqualification pipeline in the above section, there are simply not enough qualified U.S. citizens to join the military in the first place. The DoD at large has difficulty to find recruits physically qualified, but the pool of applicant qualified for nuclear training and physically qualified is smaller. Yet, another challenge is the security clearance that will certainly be required to learn and operate these facilities. One of the issues at current for federal jobs in general is the ability for most Americans to pass a background check and drug screening. [20] This has continued to be a problem as many states pass recreational cannabis use, yet it remains a federal crime. A similar problem among the American workforce is the longstanding "brain drain". [21] A problem where highly technical expertise leaves an area for better opportunities. Though the opposition may show that there is a net gain in immigration with technical expertise to the United States, the number of individuals that can qualify for the security clearance and meet the technical qualifications is relatively small compared to the number of immigrants. While there are calls to relax the clearance requirements for western countries that align with the United States Politically and Asian countries like Japan and Korea, this is a political battle which may play out in the future. However, even if it passes will not immediately provide relief to the United States nuclear workforce.

4.4 Supply Chain and Construction Logistics

Another critical challenge facing the integration of nuclear-powered microgrids is the current state of the supply chain for reactor-grade materials and components. Due to decades of underinvestment in domestic nuclear manufacturing, many essential components, such as reactor pressure vessels, steam generators, and specialized control systems, are either backlogged or sourced from international vendors, some of whom are based in geopolitically unstable regions. For military applications, reliance on foreign suppliers poses a strategic vulnerability. Therefore, the DoD must consider investing in or incentivizing a domestic supply chain tailored to SMRs. This would not only ensure the timely deployment of reactors but also create a pipeline of jobs that support the manufacturing base—a win for both national security and economic development. However, such an initiative will require interagency cooperation and a long-term commitment to build up this infrastructure from what is currently a fragile starting point.

4.5 Regulatory Bottlenecks

Beyond physical integration and infrastructure, regulatory hurdles may present a significant roadblock to the timely implementation of nuclear microgrids. The Nuclear Regulatory Commission (NRC), while an essential guardian of safety, has a lengthy and rigorous permitting process that is often ill-suited for the urgent needs of military installations. Although there are pilot programs aimed at streamlining approval for advanced reactor designs, they are not yet widespread or optimized for DoD applications. One proposed solution is the creation of a dedicated DoD-NRC liaison office that facilitates expedited licensing pathways for reactors intended solely for secured federal facilities. Such a model could mirror existing frameworks used for defense aerospace projects, which balance speed and oversight. By adopting a dual-track approval process for commercial versus defense reactors, the DoD may avoid years-long permitting delays that undermine readiness and innovation.

4.6 Long-Term Operational Sustainability

Sustainability of these nuclear microgrids must be considered beyond the initial installation phase. Long-term operation of nuclear facilities requires a comprehensive plan for maintenance, fuel supply, waste handling, and eventual decommissioning. Currently, the United States lacks a permanent solution for spent nuclear fuel, and military installations adopting reactor technology will need a clear agreement on fuel lifecycle management. Options such as centralized interim storage or advanced reprocessing may be explored in collaboration with the Department of Energy. Additionally, to ensure the longevity of the workforce and infrastructure investment, a robust system for monitoring reactor performance, safety, and cybersecurity must be implemented. Incorporating digital twin technologies and AI-driven diagnostics may offer predictive maintenance capabilities that reduce operational downtime and prevent failures. The long-term vision must be one where nuclear microgrids not only meet mission requirements but evolve with them over time.

5. CONCLUSION

The dependence of DoD installations on their local utility providers for power production creates a strategic vulnerability. Though there exists an opportunity for advisories to exploit, regular and increasing disruptions to the grid due to aging infrastructure have raised significant concerns for increasing demand and current installation operations. While several efforts have been made by all services to explore alternative means of on-installation power production, the most complete and cohesive attempt is *Project Pele* with production of microreactors. While microreactors offer a unique opportunity for remote operations, their output does not meet the demand required by many military bases. Additionally, the project does not outline a significant effort for developing a workforce, which is a problem throughout the nuclear industry. Subsequently, it is proposed that larger capacity small-modular reactors are considered to establish microgrids on military installations. Combined heating plants that currently exist on many bases offer a unique opportunity to integrate SMRs for both electrical and steam demand, while maximizing efficiency and economic return. Furthermore, the Navy has a long-standing record for training military nuclear workers. With a minor alteration to the training pipeline, there exists the prospect of training a Joint force which is capable of operating nuclear reactors for any military installation, removing the current dependence on aging generators and civilian providers.

[1] *Energy Independence and Security Act of 2007*. 2007.

[2] Joe Biden, *Executive Order on Advancing United States Leadership in Artificial Intelligence Infrastructure*. 2025.

[3] J. W. Crawford and S. L. Krahn, “The Naval Nuclear Propulsion Program: A Brief Case Study in Institutional Constancy,” *Public Administration Review*, vol. 58, no. 2, p. 159, Mar. 1998, doi: 10.2307/976363.

[4] The National Interest, “How the Tragic Sinking of Two Nuclear Submarines Transformed the U.S. Navy.” [Online]. Available: https://nationalinterest.org/blog/buzz/how-tragic-sinking-two-nuclear-submarines-transformed-us-navy-169720

[5] World Nuclear News, “Nuclear-Powered Ships.” [Online]. Available: https://world-nuclear.org/information-library/non-power-nuclear-applications/transport/nuclear-powered-ships#:~:text=Other%20sources%20quote%20108%20reactors,to%202021%2C%20with%20526%20reactors.

[6] Eielson Air Force Base Public Affairs, "Micro-Reactor Pilot Program." [Online]. Available: https://www.eielson.af.mil/microreactor/
[7] W. Jeff, "Project Pele Overview Mobile Nuclear Power For Future DoD Needs," Office of the Secretary of Defense - Stragic Capabilities Office, May 2022. [Online]. Available: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.nrc.gov/docs/ML2212/ML22126A059.pdf
[8] A. Horwood, J. Vitali, A. Thueme, R. Ibanez, and T. Knight, "DOD's Need for a Transportable Energy Solution: The Promise of Nuclear Power," *Defense Logistics Agency*, Jul. 2024, [Online]. Available: https://www.dla.mil/About-DLA/News/News-Article-View/Article/3842532/dods-need-for-a-transportable-energy-solution-the-promise-of-nuclear-power/
[9] "Naval Station Norfolk: A Super-Star amongst the Constellation of River Stars," Jan. 2020, [Online]. Available: https://www.nepa.navy.mil/About-NEPA-Website/Media-Resources/News/NewsArticleView/Article/2129444/naval-station-norfolk-a-super-star-amongst-the-constellation-of-river-stars/
[10] "Shore Power Technology Assessment at U.S. Ports," Enviornmental Protection Agency, EPA-420-R-17-004, Mar. 2017.
[11] "U.S. Navy soliciting ideas for nuclear energy," NuclearNewswire. [Online]. Available: https://www.ans.org/news/article-6466/us-navy-soliciting-ideas-for-nuclear-energy/
[12] J. Marqusee, D. Olis, X. Li, and T. Oddleifson, "Long-Duration Energy Storage: Resiliency for Military Installations," National Renewable Energy Laboratory, NREL/TP-5C00-87646, Oct. 2023.
[13] Office of the Deputy Assistant Secretary (Energy and Sustainability), "Army commits to dramatic increase in combined heat and power energy production." [Online]. Available: https://www.army.mil/article/178316/army_commits_to_dramatic_increase_in_combined_heat_and_power_energy_production
[14] Energy For Everyone Propane, "How the Army National Guard saves $60,000 annually with CHP." [Online]. Available: https://propane.com/2022/02/09/how-the-army-national-guard-saves-60000-annually-with-chp-bwp/
[15] NuScale, "The NuScale Advantage." [Online]. Available: https://www.nuscalepower.com/products/nuscale-power-module
[16] L. W. Townsend, L. Brady, J. Lindegard, H. L. Hall, E. McAndrew-Benavides, and J. W. Poston, "Nuclear engineering workforce in the United States," *J Applied Clin Med Phys*, vol. 23, no. S1, p. e13808, Dec. 2022, doi: 10.1002/acm2.13808.
[17] Anjali Nair, "Nuclear-trained sailors, considered the Navy's 'best and brightest,' face mental health challenges," *NBC News*, Feb. 11, 2023.
[18] Hope Hodge Seck, "These Navy jobs have the highest turnover," *NavyTimes*, Jan. 16, 2024.
[19] B. Mignacca and G. Locatelli, "Economics and finance of Small Modular Reactors: A systematic review and research agenda," *Renewable and Sustainable Energy Reviews*, vol. 118, p. 109519, Feb. 2020, doi: 10.1016/j.rser.2019.109519.
[20] CNN, "As more Americans fail drug tests, employers turn to refugees," Mar. 29, 2017. [Online]. Available: As more Americans fail drug tests, employers turn to refugees
[21] M. Prato, "The Global Race for Talent: Brain Drain, Knowledge Transfer, and Growth," *The Quarterly Journal of Economics*, vol. 140, no. 1, pp. 165–238, Jan. 2025, doi: 10.1093/qje/qjae040.