Social License in the Deployment of Advanced Nuclear Technology

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Advanced reactor developers are designing many new nuclear energy products, targeting commercial demonstration before 2030. These products aim to provide different products and grid services beyond what is provided by the first generations of commercial nuclear plants, namely, gigawatt-scale electricity production. These reactors are intended for deployment in many novel scenarios, including being closer to population centers. They will be sited in governmental processes that encourage far more public participation than was possible when many of the existing plants were sited and built in the 1960s and 1970s. This means that community engagement and approval likely will be critical for project success. This article, which discusses this issue of social license, is an adaptation of "Social license in the deployment of advanced nuclear technology," published in *Energies* in 2021.[1] A more detailed discussion can be found in the original article.

By 2050, as we work toward achieving deep decarbonization, electricity demand will likely triple or quadruple due to an increased need for electrification of transportation, industry, and residential heating. Nuclear energy has the potential to play a major role in supporting this transformation. Associated

with this change is the need to build a tremendous amount of new infrastructure. Even though nuclear energy takes up far less land than other zero-carbon energy sources,[2] it still faces a significant siting challenge, especially for new products that may be located closer to population centers. Permission for the siting of infrastructure is location specific, owing to the diversity of utilities and market structures across the United States. So while there is consistently high public support for wind energy—often above 80 percent—a similarly high proportion of wind projects face local opposition when it comes to siting.[3]

Compared with their input in the 1960s and early 1970s, when many first-generation commercial nuclear power plants were built, the public now has a much larger role in siting decisions. The National Environmental Policy Act (NEPA) of 1970 requires federal agencies to perform environmental assessments for potential projects and has the ability to make the nuclear plant siting process more democratic and transparent. Unfortunately, many potential builders of infrastructure have executed NEPA with a "decide-announce-defend" model, with significant resources going to fight lawsuits brought by local groups who began using NEPA to halt projects.[4] This can place utilities at odds with the surrounding communities. With the next generation of nuclear products now being developed, the nuclear industry has an opportunity to start fresh, with more equitable processes.

How might a modern siting process be structured to be more successful and timelier? The case studies below explore both failures and successes in siting large energy infrastructure projects, and how the outcome was influenced by the process and the inclusion or exclusion of social sciences.

Yucca Mountain

The first federal legislation in the United States to address spent nuclear fuel, the Nuclear Waste Policy Act (NWPA), was passed by Congress in 1982. This law directed the federal government to take ownership of all commercial high-level nuclear waste by 1998 and began a process of evaluating sites and selecting three for further study. In 1986, the Department of Energy selected three sites for more detailed study: Yucca Mountain in Nevada; Deaf Smith County, Texas; and Hanford, in Washington state. The DOE decided that Yucca Mountain was the superior site based mainly on geology, and a 1987 amendment to the NWPA directed the DOE to focus solely on that site.

While preliminary environmental assessments for Yucca Mountain were open to public comment, there was no public engagement process. The evaluation of socioeconomic metrics was assessed by outside experts. The initial selection of potential sites and each successive narrowing down was based primarily on technical metrics.

Although the communities surrounding Yucca Mountain grew to be supportive of the project, the top-down selection process without community engagement cast a shadow over the site. Funding was ultimately cut during the Obama administration, influenced by the strong objections of then Sen. Harry Reid (D., Nev.). President Obama chartered the Blue Ribbon Commission on America's Nuclear Future to evaluate alternatives to Yucca Mountain for high-level waste. Some of the commission's recommendations included consent-based siting, an independent agency to manage nuclear waste, and interim storage, though none of these have been implemented to date.

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Opposition to wind farms

Deployment of wind turbines has also drawn opposition across North America,[5] Europe,[6,7] Australia,[8,9] and China.[10,11] Giordono et al.[3] found that 81 percent of proposed wind projects in the western United States faced opposition in some form (e.g., editorial letters, public testimony, lawsuits, petitions, and rallies). Recent studies suggest that opposition is nuanced and very dependent on location and the specific community. Communities respond to anticipated impacts, fairness of the siting process, and place attachment, reflecting deeply held values regarding the local landscape, aesthetics, and cultural traditions.

Ultimately, the fairness of the process for siting wind farms is a common cause of opposition. Bessette and Mills[12] found lower opposition in areas with more production-oriented farming and fewer natural amenities like parks. Groth and Vogt[13] took a deeper look at wind energy perceptions across four townships in a single county in Michigan and found that social factors were more important than environmental or economic factors in determining support. Mills et al.[14] surveyed residents of Michigan before and after wind farms were built in the area and found that when the planning process was perceived by residents as fair, locals also saw greater benefits from the project.

Östhammar, Sweden
(Photo: R. Rohdin)

Nuclear waste in Sweden and Finland

Unlike the United States, Sweden and Finland have licensed repositories for spent nuclear fuel. One main difference is the process used. For example, the Swedish Nuclear Fuel and Waste Management Company (SKB) began with a technocratic process in the 1980s to find the absolute best bedrock for nuclear waste disposal. Test drilling was then initiated at ten potential sites. However, local citizen groups quickly formed in opposition, as they felt that nuclear waste was being forced on them.[15] SKB accordingly changed its strategy and in 1992 announced a new plan that focused on volunteerism, dialogue, and "just good enough" geologic conditions in a process open to all 286 Swedish municipalities. Importantly, SKB stressed that any feasibility study would not lock the community into a future repository and that the community would always have veto authority. Early analyses on two communities in northern Sweden faltered because the studies were performed by outside, technically focused organizations, and the communities felt excluded from the process. Opposition movements and referenda to reject a repository ensued, and in 1994, SKB decided to shift tactics once again and focus on volunteer communities that were already hosting nuclear facilities and include more social and nontechnical evaluations in the feasibility studies. Additionally—and importantly—communities were compensated for participation in the studies. In 2020, a license was granted in the chosen community of Östhammar.

The process in Finland, while it led to an approved repository, was quite different than that in Sweden.

Olkiluoto Nuclear Power Plant, Eurajoki, Finland
(Photo: Hannu Huovila/Wikimedia Commons)

Because the bedrock was largely consistent across the country, two communities were chosen as potential repository sites largely based on their existing nuclear power plants. These communities were given an absolute veto right on potential projects. Posiva, the private company that manages Finland's nuclear waste and is owned by the two Finnish nuclear power plant operators, put municipalities in charge of the federally required environmental impact assessment (EIA) process. In each community, groups that combined outside issue experts with local leaders who guided the process were organized. The approval process had specific stages, with many points when communities were given the opportunity to opt out. Posiva also developed a public outreach campaign and organized a series of structured seminars to address concerns, which were included in the EIA. Notably, many of the concerns were nontechnical; for example, a large concern early on was how the repository would affect the image of the community.

Both communities saw growing support for hosting the repository on the basis of perceived economic benefits and a moral obligation to host a waste repository because they had long benefited from hosting nuclear power facilities. In 2001, the Finnish parliament voted 159–3 to approve the geologic repository at Eurajoki, even garnering the support of the Green Party. The focus on developing a staged process with community veto rights was very important, as can be seen in the high community approval of the project.

Synthesis across case studies

While these case studies offer very different examples of siting energy infrastructure, important lessons can be drawn from each. Most importantly, community engagement—even direct involvement—must be built in from the beginning; it is not something to worry about after the siting decision has been made. Even when communities are engaged, however, the process can fail when project developers do not acknowledge imbalances in power or expertise. A community and its residents may not have the financial resources or technical expertise to meaningfully engage in a siting decision, and they may be distrustful of outside experts provided by project developers or government agencies. Creative funding mechanisms for communities can empower them to develop expertise and make a significant contribution to the process. Most importantly, locals who feel they had some control over the process tend to be more supportive of the outcome.

Completing large-scale energy projects can often take several years, if not decades. There is plenty of time for opposition to grow and mature in its tactics. Therefore, earning local support early in the process is key, especially when the ultimate decision on a project will be made at a higher level.

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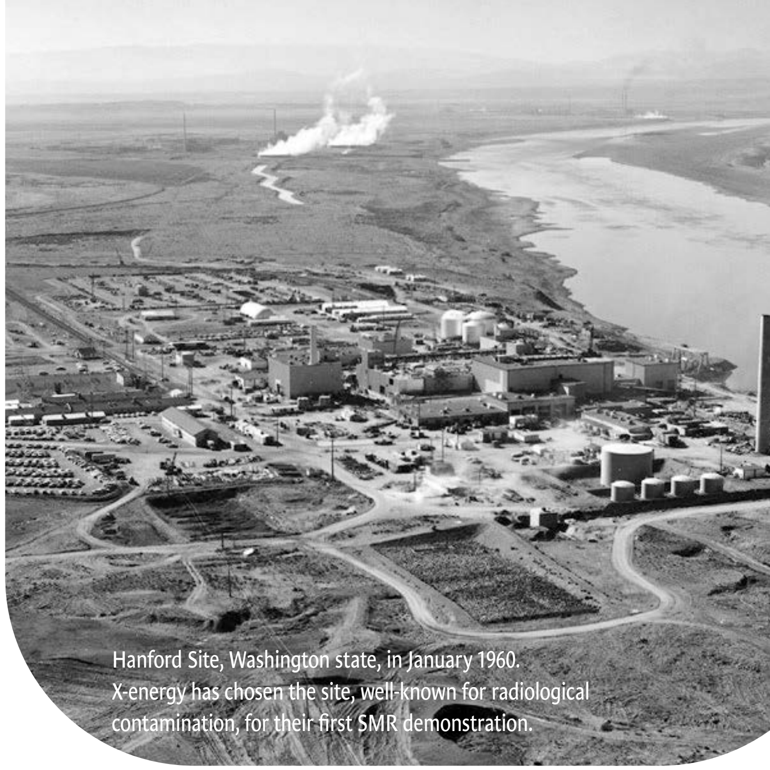
Early progress in advanced nuclear siting

While no commercial advanced reactor projects have been constructed yet in the United States, there are two recent examples of new ways of siting and developing projects that are worth learning from as well.



Hanford Site, Washington state, in January 1960. X-energy has chosen the site, well-known for radiological contamination, for their first SMR demonstration.

The NuScale story

The Utah Associated Municipal Power Systems (UAMPS) is a state-authorized nonprofit that provides electricity, power, transmission, and other energy-related services across Utah, Idaho, Nevada, New Mexico, Wyoming, and California. It is a unique business model wherein its 47 municipal members opt in or out of different projects to meet their various energy needs.[16] According to their website, "UAMPS provides comprehensive energy services to its members, including planning, financing, developing, acquiring, constructing, operating, and maintaining varied projects and transmission for the benefit of members." Historically, projects include hydroelectric, coal, natural gas, wind, waste heat to power, and all aspects of the regional transmission system.

In 2015, UAMPS partnered with SMR company NuScale to launch the Carbon Free Power Project (CFPP)—the first nuclear project for UAMPS and potentially the first commercial SMR to be built in the nation. Because UAMPS member concerns carry significant weight and project risks are shared across many stakeholders, UAMPS is a candidate well suited for early adoption of SMR technology. Another favorable aspect of the project is the proximity to Idaho National Laboratory, which sits right in the center of the region UAMPS serves and offers many decades of experience with nuclear energy technologies. As another layer of risk reduction for the project, a site at INL was chosen to host the NuScale SMR as a part of a public-private partnership model between the DOE and UAMPS. This arrangement has given the project access to serious technical and financial muscle, including unique research capabilities, knowledgeable staff, and, importantly, several rounds of federal funding to keep the project steady. On the UAMPS side, they were able to secure significant commitments from members to uphold their end of the arrangement and move the project forward. Members have built-in off ramps, so if the project planning or costs change, they can back out without penalty. This is where the UAMPS business model holds key insights to what community-based nuclear could look like going forward.

For existing nuclear energy technologies, specifically light water reactors over 1,000 MW, only the largest, most regulated utilities could finance and manage such a project. For small co-ops and municipalities, the scale of large LWR technology has proved unattainable in recent decades. Advanced reactors and SMRs may prove to be a catalyst for opening up new customer bases, like UAMPS, especially as the pressures of climate change start to influence federal, state, and local energy policies and decarbonization goals. With new business models that resemble those of renewables and other smaller-scale projects, advanced nuclear technologies could be a good fit for community ownership, public power authorities, municipal governments, universities, hospitals, military bases, and more. UAMPS serves as an important harbinger of a changing customer base and way of doing business.

The ARDP

In the fall of 2020, the DOE awarded two advanced reactor companies, TerraPower and X-energy, $80 million each through the Advanced Reactor Demonstration Program (ARDP) to build a commercial reactor demonstration that will begin operations by 2027.[17] In a promising first move, TerraPower announced that their demonstration would be built in Wyoming, where they initially considered four potential host communities. While Wyoming does not currently operate any commercial nuclear power plants, they have a long history in uranium mining, favorable politics toward

TerraPower chose a site near a coal plant that is scheduled for retirement in the community of Kemmerer, Wyo., to build an SMR. (Photo: Decumanus/Wikimedia commons)

nuclear, and several retiring coal power plants that need to be replaced.

In 2020, Wyoming passed a bill to authorize permits for SMRs under 300 MW and is planning to expand the bill to allow larger advanced reactors.[18] The TerraPower project appears to have strong support from state government, including the governor, as well as the local uranium mining industry. The state legislature has passed several pieces of legislation to codify regulatory consideration, including licensing authority, waste storage, siting and jobs impact reporting, and even tax exemption if the project uses domestic uranium.[19] These pieces of legislation are positive signs that the state government is supportive and also feels a sense of authority and control over the process. The reporting requirements in particular are a good requirement to help the potential host community decide if the project has enough benefits for them to move forward. In the fall of 2021, after extensive community engagement, TerraPower announced that they had chosen to site their project in the community of Kemmerer near a coal plant scheduled for retirement in 2025.[20]

X-energy has chosen an area in Richland, Wash., near the Hanford Site, a site well-known for radiological contamination from the nuclear weapons complex, for their first reactor demonstration. While it may have made a certain amount of sense to site a new reactor at a location very familiar with nuclear activities (the 1.2-GW Columbia Generating Station is also nearby), it comes with unique challenges, including much stronger preexisting antinuclear public sentiment, with opposition from environmental groups.[21] Washington state is also much less supportive of nuclear than Wyoming is and has abundant carbon-free, cheap electricity from hydroelectric resources. These conditions may prove challenging when X-energy tries to garner community and state support, both of which will be critical for its success.

Conclusion and policy recommendations

The case studies above illustrate that community participation in energy siting decisions correlates with deployment of energy projects. Given that developers of advanced nuclear concepts envision many different sizes and types of nuclear energy systems, with many novel deployment scenarios, the industry needs to develop best practices for community engagement to optimize the chance of success. What might the elements of a consent-based program include? Engineering communities often use standards, operational guidelines, and regulatory guidelines to ensure consistency and best practices in the construction and operation of complex engineering systems. These standards require answers to certain questions:

- What are the credible damage mechanisms for each plant application?
- What types of component failures affect functionality and which do not?
- What is the operating history from the current equipment installations?

Currently, there are no similar guidelines for best practices in siting and community engagement for the nuclear community, but parallel questions might be framed:

- How might a specific nuclear plant design lose community support?
- Which community responses could cause the plant to be shut down and which would not?
- What is the history of similar nuclear plants in different social contexts?

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Nuclear plant operators have strong programs in preventive and corrective maintenance to ensure that material conditions keep the plant at peak performance. A similar level of seriousness is needed to address the support for the plant from its community hosts. Vendors should start by looking for regions and communities that are likely to be supportive of nuclear and then co-develop projects that have significant benefits and minimal risks for the local community.

While a set of prescriptive guidelines likely is not useful for consent-based siting, Webler and Tuler[22] found common elements that should be delineated in the specific context of an energy system deployment:

- Consent givers must be self-directed and able to give consent that is voluntary and not coerced. "Consent-based approaches give a community authority to reject an offer outright, based on their own understandings of risk and benefits, but key to the successful remediation of competing private and public interests is a requirement that an offer is given due consideration." Consent givers must ultimately determine if the project risk is worth the benefits.
- Consent seekers "must agree to negotiating about a wider array of issues related to community well-being and not limit the negotiations to the proposed facility."
- Guidelines must be set concerning how and when consent is expressed. This will be different in each deployment scenario as local decision-making bodies, marginalized groups, and affected surrounding communities have unique cultures and histories. "For example, if the procedural rules are imposed by 'outsiders,' then local acceptance may suffer because people see the imposition as undermining local autonomy. At the same time, putting the power to define a process in the hands of local authorities can challenge the autonomy of politically marginalized groups or abutting communities."

These best practices can be incentivized in different ways, including in the structure of government R&D programs. The Good Energy Collective, a policy research organization that works to accelerate the just and equitable deployment of advanced nuclear technologies, has proposed elements that should be included in governmental programs to incentivize better consent-based approaches[23]:

- The DOE's Office of Nuclear Energy should create and fund a social science agenda with the goal of achieving more equitable adoption of advanced reactor technologies. Such a program should focus on addressing historic inequalities in nuclear technology access, expediting legacy cleanup efforts, ensuring community participation in the development of advanced nuclear projects, and fulfilling the federal government's responsibility on nuclear waste.
- Nuclear energy should be recognized as a tool of climate diplomacy, including funding for nuclear through international development and foreign aid packages. The DOE should prepare for the export of advanced reactors while recognizing the diverse energy needs of emerging economies. The DOE and State Department should work together to develop meaningful research development and demonstration partnerships with emerging nuclear countries that advance the best in technology, economics, public policy, and social science with allied countries.
- Domestically, the DOE should fund community-led climate planning and feasibility studies to enable communities to self-assess and self-determine if advanced nuclear technologies are right for them.
- For demonstration and deployment of new nuclear technologies, the DOE should adopt a sociotechnical approach that integrates consideration of technology, geography, economics, politics, social issues, and historical context. As an example of an early demonstration of the inclusion of sociotechnical considerations, the Fastest Path to Zero Initiative at the University of Michigan developed siting and decision-making tools called STAND (Siting Tool for Advanced Nuclear Development) and ANSL (Advanced Nuclear Site Locator) to help developers understand the complex intersection of social, economic, and technical issues that should be considered when researching siting for nuclear projects.[24] Work like this should continue to be encouraged.

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