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# Worker Safety in Offshore Wind as a Door for Sociotechnical Engineering Education

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**ABSTRACT.** While touched on in ABET's student outcome, worker safety is difficult to conceptualize for many engineering students and likely engineering professionals. For many safety professionals, only until the hazards of an industry are identified can safety protocols be developed. However, in a new industry, such as offshore wind in the United States, these hazards have yet to be identified. Broadly speaking, occupational safety and health in the US have a history of regulation starting in the industrial revolution, with a big push following the Triangle Shirt waist fire of 1911. The Occupational Safety and Health Act is perhaps the most known safety regulator in the public's eye. OSHA was signed in 1971 by President Nixon, following a series of workplace catastrophes. Yet these regulations and standards are difficult to adapt to different industries, especially in new industries where contexts and hazards differ.

This paper is inspired by conversations between worker safety and safety regulators in the growing US offshore wind industry. One of the main safety initiatives outlined by researchers (Rosenberg, 2021) has been to design out hazards by bringing workers into the design discussions. Instead, engineers in offshore wind emphasize the need to automate more high-risk work. These different framings around worker safety in engineering have inspired us to examine how worker safety is discussed in engineering.

In this paper, we will first detail a brief history of worker safety standards and engineering accreditation criteria related to safety. Next, we will review engineering education and STS literature for discussions of worker safety related to engineering education and engineering studies. Lastly, we will focus on the case of the growing offshore wind industry in the US to highlight different actors' responses to safety compliance through an analysis of public webinars and documentation provided by the Bureau of Safety and Environmental Enforcement (US) and the Health and Safety Executive (UK) relating to offshore wind.

Through this work, we seek to synthesize safety insights in an industry that is new in the US with scholarship around safety in engineering as a sociotechnical endeavor. By connecting notions of sociotechnical engineering to a case in worker safety in offshore wind, we seek to provide insights into engineering education that paints worker safety as a door to understanding the social, political, and economic contexts of engineering work.

# Worker Safety in Offshore Wind as a Door for Sociotechnical Engineering Education

## Introduction

Occupational health and safety is a field that brings engineering, politics, economics, public health and history together. In engineering education, safety is more generally meant to refer to *public* safety rather than worker safety and health. In this paper, we work to center a conversation around occupational health and safety, and the role of workers as they relate to different facets of safety: culture, regulation, and design. Like many other aspects of the industrial era, changes to occupational health and safety are not isolated from market forces, in which many safety initiatives have shifted the responsibility of occupational health and safety onto workers rather than the industries that create the hazardous environments of production.

We begin with a historical discussion of occupational health and safety, and end by connecting this history to the currently burgeoning offshore wind industry in the US. Historical context about regulation and industrial growth is especially important because, while offshore wind offers promise for large-scale harm reduction to the general environmental, it is not without many potential harms to local environments and the health of workers (Fried, Ozkan, Halldén, et al., 2022).

In this interrogation, we draw from Bell, Daggett and Labuski, who posit that there is a need to "name the injustices inherent in the life cycles of all types of energy production – not just fossil fuels" (2020, p. 7). They note that, while solar adoption is critical for the transition away from fossil fuels, it has its own set of issues around the hazardous materials used in the manufacture of solar cells (Bell, Daggett, and Labuski, 2020). While the authors acknowledge the wariness of efforts to challenge any aspect of the long-awaited energy transition, particularly "given the high stakes of the climate crisis" (ibid, 4) they maintain that integrating thinking and action around systemic change alongside the energy transition is necessary to meet the high stakes of such conversations. Bell and colleagues outline three assumptions embedded in the calls of urgency that can push justice discussions to the wayside.

1. "that authoritarian-, imperial-, and/or capital-led forces exist with sufficient motivation to lead a global decarbonization;
2. that such pathways would in fact be easier and faster than more democratic and inclusive ones;
3. [...] that a decarbonization effort brought about via hegemonic political styles could ever be truly sustainable from an ecological and social perspective." (Bell et al., 2020, p. 4).

We extend Bell, Daggett, and Labuski's argument with a particular focus on elevating occupational health and safety. Active, contextually aware, and widespread conversations about worker safety are critical to bringing about an energy transition that is inclusive and democratic.

In this paper, we first detail a brief history of worker safety standards and engineering accreditation criteria related to safety. Next, we will review engineering education and STS literature for discussions of worker safety related to engineering education and engineering studies. Lastly, we will focus on the case of the growing offshore wind industry in the US to highlight different actors' responses to safety compliance through an analysis of public webinars and documentation provided by the Bureau of Safety and Environmental Enforcement (US) and the Health and Safety Executive (UK) relating to offshore wind.

## Background on U.S. Health and Safety Movements

The occupational safety and health act was passed in 1970 following decades of organizing and crises during the progressive era in the late 19th and early 20th century (Bingham, 1980). Before OSHA—worker accidents and casualties increased with high production rates. Starting in the late 19th century, each initiative toward worker safety could be traced to a crisis before. In 1907, a series of mining accidents killed over 3,000 people which spurred the Bureau of Mines, in 1910 (National Park Service, 2015). In 1913, industry leaders founded the National Safety Council, which set voluntary guidelines for safety engineering and practices. Through this initiative, industries implemented a safety curriculum for their workers and set up first aid in case of accidents.

A large component of industry-driven safety education was to put the onus of safety on the individual worker. A prominent safety film in 1911 singled out workers' carelessness as the reason for any disaster, effectively shifting the responsibility of safety from the industry to the individual (Bingham, 1980). In 1909-1910, journalist Robert Jones wrote a four-part series to contest the Pittsburg Survey, the first systematic study of injuries and fatalities in Pittsburg manufacturing industries (Slavishak, 2008). In his support of industry, Jones argued "the case for human error," he stated that "machines can be checked for safety, but the same process cannot guarantee that the men for whose protection they are designed will do their share." (Jones in Slavishak, 2008, p. 229).

The next catastrophe to push against the individualization of worker responsibility was the Triangle Shirtwaist Factory fire. In 1911, the fire killed 146 factory workers, namely women, because managers had locked the factory's exits (Bingham, 1980). When the investigation turned out that these people had been locked in by managers, the claims that individual's held sole responsibility for their safety lost some power.

In this same period, industries were creating workers' compensation programs that dropped accident and death rates but took away workers' rights to sue their employers for damages. Workers' compensation laws were pushed by employers because awards for injured workers were rising. These awards were decided by juries who were very sympathetic to workers. In 1915, the workmen's act was passed by the general assembly in Pennsylvania. The act defined injury as "violence to the physical structures of the body" and, by doing so, standardized payment to workers who had gone through industrial accidents (Slavishak, 2008, p. 246). The National Association of Manufacturers approved workers' compensation programs because "of its central concept of liability without fault" (Ibid, p. 242). The plan "acknowledged the damaged body of work but did not dwell upon it or ask it to prove itself as the result of individual or corporate culpability" (Ibid). Ultimately, through such legislature, municipalities were able to remove the injured worker's body from the publics' view in court and into standardized paperwork that set prices for level of disability (Slavishak, 2008). Juries were no longer seeing disabled workers nor deciding on their injury compensation awards.

Up until this point, acute injuries were the main concern in industrial work settings. Health implications from chronic exposures were virtually ignored. In 1910, Alice Hamilton was the first American to study the longer-term effects of lead poisoning (Bingham, 1980).

However, due to the great depression through the 1930s, employers could take advantage of desperate workers. In 1930, at Gauley Bridge, WV, 476 men died from silica exposure while diging a tunnel under disastrous and illegal working conditions– “exposure to toxic silica dust, a mineral that slices the lung like shards of glass” (Lancianese, 2019, par. 5). The National Park Services cite 764 as the death toll, in which the majority of these deaths were Black men (NPS, n.d.). Following congressional hearings and the public outcry about the working conditions at Gauley Bridge, the Walsh Healy Act was passed in 1936, which was the first federal government intervention in worker safety and health (Bingham, 1980). This act only applied to contractors working on government-funded projects, which stipulated minimum wages, overtime wages, and some health and safety requirements. Part of the act was to mandate the use of respirators, another way to shift the responsibility from the company to the workers. Today, safety regulations require industries to ensure that factory air meets an acceptable safety standard rather than relying on individual respirators.

In the 1930s, the National Labor Relations Act made it a legal right to unionize. At the time, labor was emerging as a powerful force to uplift health and safety issues. This coincided with World War II, which brought safety issues to the forefront and tied it to productivity (Bingham, 1980). Slogans such as “save a day to keep working, save a day to keep him flying” helped emphasize the importance of smooth and safe working conditions for productivity. Still, these were voluntary efforts and relied on the goodwill of industries (Ibid).

The 1960s were a time when three major movements came to the head–the civil rights movement, the environmental movement, and the labor movement. This era of change created a climate of reforms. The workers’ safety bill had been proposed previously but did not pass until 1968, when a mining disaster killed 78 miners in West Virginia. Following the disaster, the Federal Coal Mine Health and Safety Act passed in 1969, and in 1970, the Occupational Safety and Health Act was passed (Bingham, 1980). The 1970 act shifted the responsibility of health and safety to employers, mandating a safe and healthful workplace as a right for workers. Yet, it is one thing to pass an act and create an agency and another to implement its mission. And much of this history of workplace safety follows a dynamic that Mark Fisher posits is a function of “the idealized market”: [...] valuing of symbols of achievement over actual achievement,” where “work becomes geared towards the generation and massaging of representations rather than the official goals of the work itself” (2009, p. 42).

The environmental movement followed a similar crisis then intervention model in the 1960s and 70s culminating in the establishment of the Environmental Protection Agency (EPA) in 1970. The main overlaps between the environmental and health and safety movements were the connections between environmentalists and COSHes (Coalitions on Occupational Safety and Health. These coalitions emerged in the 1960s and 1970s and became sustainable organizations because of an OSHA funding program created by director Eula Bingham, called New Directions (Lax, 2018). COSHes were centered around the premise that:

> "employers driven by the profit motive did not have a primary interest in controlling workplace hazards; that workers through their experience and intellectual abilities had the capacity to recognize workplace hazards; and that workers themselves needed to exercise more control over the workplace if they wanted to create a healthy and safe work environment." (Lax, 2018, p. 203).

One of the main proposals that brought labor and environmental advocates together was an idea of a "Superfund" for workers who lost their jobs when plants closed for environmental reasons. The "Superfund" would fund training for workers to transition to other work. This initiative served as a point of collaboration for environmentalists and workers to reduce toxic exposures to workers and the greater public. (Lax, 2018). Another collaborative effort was the 'Campaign for a Just Transition,' where union leaders are working to transition industries away from using dangerous chemicals (Stone and Cole, 2000).

Biologist and environmentalist Joe Thornton goes so far as to say that Americans embrace a *risk paradigm* when it comes to manufacturing goods and releasing pollution into the environment. This is a paradigm in which hazards are viewed as "locally bounded, short-term, probabilistic events," and in which probabilistic risk assessment is a "primary scientific and policymaking tool" (2000, p. 318). This makes no sense to Thornton, as chemical reactions are not necessarily local, and the environment is an open system. He advocates that policymakers shift the burden of proof for unsafe pollution onto companies. This echoes the history of worker safety, in which shifting the burden of proof to employers was a decades-long process that has still not fully manifested.

Historically, solidarity across groups and collective action have been countermeasures to the neoliberal and meritocratic logics that keep people's rights individualized. However, these logics have not ceased to harm workers' health and safety. In a 2009 study of occupational safety in US nuclear facilities, Levenstein and Rosenberg point out that:

> "US policy agenda has been led by deregulation, leaving economic activity in the hands of 'the market' and voluntary compliance, with unenforced standards and guidelines for good practice" (2009, p. 284).

With the increase of a globalized economy, the seemingly historic and unjust labor practices of the US have been exported to "other countries and the assignment of the remaining, most hazardous jobs to minority and/or immigrant workers" (Levenstein and Rosenberg, 2009, p. 284). We see similar patterns of worker marginalization in the OSW industry. However, these marginalizing dynamics are not inevitable, as engineering educators can prioritize occupational health and safety in the design of systems.

## Safety in Engineering Education

While the history of safe and healthful workplaces is largely left out of the engineering classroom, there is mention of safety in engineering accreditation and engineering licensing exams. The Accreditation Board for Engineering and Technology (ABET) has defined a student outcome around different types of safety. Through ABET, safety encompasses public safety, the safety of engineering projects, and worker safety in building and maintaining the projects (ABET, 2022). With respect to safety considerations, ABET maintains that students should have

> "an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors" (ABET, 2022-2023).

The fundamentals of engineering (FE) handbook, another document with an influence on engineering education, has a chapter dedicated to safety. Safety is defined as "the condition of protecting people from threats or failures that could harm their physical, emotional, occupational, psychological, or financial well-being. Safety is also the control of known threats to attain an acceptable level of risk." (FE Handbook, 2022, p. 13). The FE provides an overview of some Safety/Regulatory Agencies that develop codes and standards for the US.

In line with the scholars in human-machine interaction, the FE handbook defines the term 'hazard' as "the capacity to cause harm." They state that hazards are the "inherent quality of a material or a condition." The last term they define in the FE handbook is 'risk.' Risk is "the chance or probability that a person will experience harm and is not the same as a hazard. Risk always involves both probability and severity elements" (FE Handbook, 2022, p. 13). The FE handbook brings these terms together in an equation:

Risk = Hazard x Probability

Equating risk to the operationalization and measurement of safety—as the probability of hazards—affords a paradigm that engineers may find elegant and workable However, this elegance in the planning process echoes out into industry in the form of deep distrust between engineers, managers, and workers on the ground. Levenstein and Rosenberg outline a particularly stark case study in their paper "Creative Mistrust," (2012), in which workers were exposed to substances like beryllium in Cold War-era weapons manufacturing sites, in a work environment lacking transparency and freedom to report unsafe conditions.

## Safety in Engineering Practice

Scholarship on sociotechnical engineering and engineering education has several links to occupational health and safety. Starting in the field of human factors and ergonomics, scholars have linked sociotechnical ideas to their process of design. In Clegg's outline of sociotechnical principles, they state how technocentric designs seek to "remove error-prone humans from processes" rather than "viewing humans as assets who can be supported in meeting their goals" (Clegg, 2000, p. 466). Evoking sentiments from Frederick Taylor and scientific management, many efforts to improve occupational health and safety have been to remove people from processes.

In the same way scholars outline dualisms between the social and technical dimensions of engineering, there is also an artificial separation between engineering and occupational safety and health. This separation ties into classist prejudices based on who, historically, has been excluded from engineering and who, historically, has worked in the trades. The person being removed from the work process is rarely 'at the table' during the design process. From a safety perspective, the separation of these two entities was a point of justification for who was protected in mechanical accidents:

> “The mechanical engineer can guarantee that the men for whose protection they are designed will do their share." (Robert Jones, 1910 quoted in Slavishak, 2008, p. 229).

While we have come a long way, countless acts and administrations have been passed and elected, there are still artificial separations between what counts as engineering and what becomes the worker’s individual responsibility toward safety.

Aven and Ylönen describe sociotechnical perspectives on safety by emphasizing the systems view of human-machine systems. They draw from Robophl in their definition.

> “The concept of sociotechnical system was established to stress the reciprocal interrelationship between humans and machines and to foster the program of shaping both the technical and social conditions of work, in such a way that efficiency and humanity would not contradict each other.” (Robophl, 1999, p. 186).

Perhaps most relevant to this work, Aven and Ylönen describe “safety as an emergent phenomenon,” one that “cannot be separated from the other functions of an organization” (Aven and Ylönen, 2018, p. 14). However, the way safety has been operationalized in academia and industry is the absence of accidents (Leveson, 2016). In this definition, there is an implication that safety is inversely related to risk. Risk, however, is heavily dependent on which institutions define acceptable risk, which can neglect or overpower risk felt by the workers, especially those historically disadvantaged in society.

The academic fields of human factors engineering, and engineering psychology have expanded the relationship between engineering and safety. In one study, scholars used a framework of human-centered design to improve safety in mining equipment (Horrberry, Burgess-Limerick, Cooke, and Steiner, 2016). They discuss the issue of getting in and out of a bulldozer’s operating cabin. In their analysis, Horrberry et al., note that there are many accidents for workers because the cabins traditionally have been designed from a “technical perspective [...] with little thought to how humans interact with the equipment” (Horrberry et al., 2012, p. 29). They focus on a ‘prevention through design initiative’ in which engineers would design out hazards. The American National Standards Institute Standard z590.3, Prevention through Design, offers guidelines for addressing occupational risks in design and redesign processes (ANSI, 2022). The language for this standard is below:

> “Prevention through design addresses efforts during the design or redesign process to eliminate or reduce hazards that cause worker injuries, illnesses and fatalities.” (ANSI, 2022).

In an industry where hazards have been defined by the number of worker accidents, this process of designing out may take place, but what of one without defined hazards. Similar to critiques of the safety and risk correlation, we question the process of defining hazards:

- What is the process for finding hazards?
- Can hazards be defined without accidents?
- Can there be a *participatory* sociotechnical engineering design process that negates the need for hazard definition?

## Occupational Health and Safety in Offshore Wind

We bring this historical context on occupational health and safety into conversation with more recent conceptualizations of safety in engineering education and practice. Offshore wind is a burgeoning industry in the United States but has had high incident rates in the United Kingdom (Brennan, 2021). We seek to bring these ongoing discussions around worker safety and health in the US offshore wind industry to light as we build an engineering education curriculum for offshore wind.

To date, European countries that have employed workers in offshore wind for the past 25 years have documented higher incident rates in OSW than those in the oil and gas industry. In the early years of development, UK offshore wind safety regulations were not fully in place as a way to unfetter potential economic growth. In so doing, UK OSW reported incident rates have been four times as high as those reported in offshore oil and gas, which is one of the most dangerous industries to work in (Brennan, 2021).

In 2021, Tufts University hosted a webinar with UK trade unions involved in offshore wind to determine their main health and safety concerns. These discussions aimed to connect insights from the UK OSW industry with the growing US OSW industry. Through this webinar the trade unions listed three safety issues that they would advise the US industry to address in order to have a healthy workplace.

1. Fear of retaliation for reporting hazards
2. Workers do not have a voice in regulation.
3. Workers have no opportunity to design out hazards.

## 1. Fear of Retaliation for Reporting:

One of the biggest obstacles to creating a culture of safety on a worksite is workers' fear of retaliation for reporting hazards and incidents. How can a workplace ever be safe if workers cannot report unsafe conditions, and then work with management to ameliorate them? One of the reasons highlighted by Darren Proctor, the National Secretary of RMT Union in the UK, is that there is a misalignment of financial incentives between industries, workers, and regulators. Many of the efforts to build a safety culture are for industries to mandate safety training for workers. However, Rosenberg states that there are limits of these training programs. If workers fear retaliation, no amount of training can fix unsafe conditions over which workers have no control. "You can train people to wear seatbelts, but if the brakes in the car are not maintained, the training is for naught." There is a need to include systems level incentives and rewards for workers to report faulty brakes and other hazards, and for management to fix the hazards.

In the summer and fall of 2022, the two authors had the opportunity to visit apprenticeship training facilities of the US local trade unions–ironworkers, carpenters, and piledrivers. These union tradespeople had yet to work on offshore wind projects but were in the process of preparing their workforce with the right certifications, safety being one of them. The ironworkers and carpenters (piledrivers are included in the carpenters' union) emphasized that many of their union members were becoming certified through the Global Wind Organization (GWO) Safety Certification offered at Massachusetts Maritime Academy (Mass Maritime, n.d.).

The Global Wind Organization is a non-profit that was created by wind turbine manufacturers and operators (GWO, 2018). This safety curriculum has been created by manufacturing companies rather than regulators such as OSHA or BSEE. The GWO curriculum equips workers with “an awareness of the hazards encountered when working within the wind industry and how to control and mitigate these hazards.” The courses through GWO consist of first aid training, fire awareness training, working at heights, manual handling, and for the offshore environment, a sea survival module. It should be noted that this training has a cost, which the unions have covered for their members to gain entry into the US offshore wind workforce.

While the carpenters, piledrivers, and ironworkers we visited and spoke with had yet to start work on offshore wind projects, they expressed great pride in creating and maintaining a safety culture. On the walls of the facilities, we saw posters that took pride in a safe worksite. Union members discussed their experiences of peaceful protests on unsafe worksites. One ironworker described how he and the other largest workers would simply stand on the materials to halt the work. Carpenters and ironworkers alike described the role of the safety stewards, who were on each site and were charged with keeping an eye on safety issues. However, these site tours were at the training facilities of these unions and thus only provided a public-facing perspective on safety. While these insights were helpful, we cannot discount the broader contexts that disincentivize and counter efforts to maintain a safe workplace. Because these workers are paid hourly, reporting hazards or an injury can pause or take them off of the work site. In a study on union carpenter apprentices, researchers documented the experiences around safety culture by reporting injuries and hazards. In a survey of roughly 1,020 carpenter apprentices in three union training programs, researchers highlighted the multiple disincentives for reporting safety issues (Lipscomb, Nolan, Patterson, Sticca, and Myers, 2013). On the topic of metrics, one respondent noted,

> “I worked for a company that had to maintain a zero-accident policy to be able to keep their contract with a major company. I got the impression, which was strongly implied, if I got hurt, I was no longer employed.” (Lipscomb et al, 2013, p. 395)

The lead author of this study, Hester Lipscomb, a researcher at Duke University Medical Center, noted that underreporting is a huge issue (Lipscomb et al., 2013). There are many competing factors for workers to report injuries, rather, she suggests, that the safety incentive programs should focus on hazard identification instead. While identification is one key need, the second is that management needs incentives to fix the hazards that workers identify.

## 2. Regulation needs to have worker voice

The Global Offshore Wind Health and Safety Organization (G+) is made up of the world’s most prominent offshore wind developers who “have come together to form a group that places health and safety at the forefront of all offshore wind activity and development. (Energy Institute, 2019, p.7). In 2015, G+ (G9 at the time) was invited as a key industry player to the UK HSW (Health and Safe Workplace) workshop. The workshop acknowledged the leadership role for G+ on health and safety performance in the offshore wind industry.

In 2012, the Crown Estate developed workshops under the theme of ‘Safe by Design.’ In 2014, G+ took over these workshops as it was becoming recognized as an authority in offshore wind. In 2019, the G+ partnered with the Energy Institute (EI) to develop a set of 'Safe by Design' workshop materials that outlined good practices to improve health and safety in offshore wind workplaces. These workshop materials were developed through the analysis of incident data provided by G+ member companies, which do not include workers (Energy Institute, 2019). The G+ has seven of their 'Safe by Design' workshop materials publicly available.

In the United States, regulators for offshore wind are distributed with sometimes overlapping priorities. The Occupational Safety and Health Administration is the existing regulator on health and safety but has not necessarily adapted its work to the construction of offshore wind projects. The Bureau of Ocean Energy Management (BOEM) works on the permitting of ocean parcels for offshore wind projects. BOEM's focus is on the environmental effects of offshore wind development. The Bureau of Safety and Environmental Enforcement (BSEE) is the main regulator of the OSW industry. They maintain that projects meet environmental and safety regulations through on-site inspections. The founding of BSEE was due to the rise of the offshore oil and gas industry. The majority of their standards are geared towards the offshore oil and gas industry with newer standards being developed for OSW.

## 3. Designing Out Hazards with Worker Voice:

The third point brought up by the safety experts is that there is a lack of worker voice in the design of systems needed to design out hazards. The G+ organization has offered a series of workshops titled, Safe by Design, to focus on various aspects of offshore wind. These topics range from 'Blades' to 'Marine transfer and access' to 'Hydraulic Torquing and Tensioning Systems' (Gplus, 2019). The workshop materials are publicly available and detail the methods and activities in each workshop. Particular to the issue of worker voice, these 'Safe by Design' workshops do not include trade unions or workers on the projects discussed in the workshops. The participants are "composed of stakeholders across the industry" which range from a financial service company (Macquarie) to energy developers from across the Globe (EDF Renewables, Equinor, Orsted, to list a few). In these workshops, the participants work to identify hazards through "brainstorming techniques," analyze the most significant hazards, and devise solutions for them. In efforts for G+ to continue offering these workshops, they state they are "keen to hear from companies with innovative designs that have the potential to improve facets of health and safety in the offshore wind industry" (Gplus, 2022). The emphasis is on companies to innovate rather than to bring in workers who experience first-hand the issues and hazards to help design them away rather than be designed out of the system.

We have seen these patterns historically, with industries trying to address safety issues by creating councils and consortiums. Additionally, by designing out workers to reduce the number of incidents. As Reporter Robert Jones wrote in defense of industry safety processes in 1910, "machines could be checked for safety" unlike people (Jones in Slavishak, 2008, p. 229). This is in line with recent engineering practice that works to design away the "error-prone human" rather than the hazard (Clegg, 2000).

In any industry, Darren Procter, the National Secretary of RMT Union in the UK, states that "you've got to have safety at every part of the supply chain." A prioritization of safety at each step helps to form a question of safety for whom? Improving safety is heavily related to the power relations of engineers, workers, and the public in which safety becomes an issue for those with the least ability to make change.

This issue is especially prominent for workers whose collective power is diminished during times of economic upheaval. This was prevalent during the Great Depression, in which workers' desperation for work gave industries the power to disregard safety issues. As it was prominent in the recent 2008 economic crisis, in which "rewards to corporate management and owners reaped from increased income inequality, combined with soaring unemployment rates, have tamped down establishment concerns for stability (Levenstein and Rosenberg, 2009, p. 284). Even in alleged 'good economic times,' "industry hides behind many veils, among them the export of manufacturing and its attendant hazards to other countries and the assignment of the remaining, most hazardous jobs to minority and/or immigrant workers. (Levenstein and Rosenberg, 2009, p. 284).

Instead of working to exclude and silence workers or export practices to international workplaces, what if instead engineers humanized the worker and included them through the design process? With the emphasis on organized labor and union work, offshore wind has potential to design away hazards by listening and empowering people working at every stage of the supply chain.

## Conclusion and Implications

In the world of engineering and industry, as in law, a fair amount of weight is placed on precedent. Perhaps with the best of intentions, policymakers and engineers want to replicate what has been done before, so as to avoid unintended disasters and disruptive consequences. However, the history of worker safety and environmental safety in the U.S. make something quite clear: there is no excellent precedent for what ought to be done to protect workers, and to give organized labor a stronger voice when it comes to burgeoning fields like OSW. Engineers can work with organized labor to develop new precedents that are attuned to the histories of labor, to environmental justice, and to justice for workers and for communities who need safe, equitable work.

In this study, we ask what are the doors in the engineering curriculum and engineering practice that allow engineering to be reframed as sociotechnical? We focus on occupational safety and health in the offshore wind industry to show an opportunity to connect organized labor through the construction trades to offshore wind engineers to safety regulatory bodies. Seemingly, these participatory and design practices would require engineering to be understood as sociotechnical. Current logics in safety are incremental and operationalized around measuring risk and identifying hazards, but what if the emphasis on occupational health and safety became doors to a different logic of engineering. In the context of worker safety, engineering practice and education could benefit from participatory design methods and an interdisciplinary ideology that values worker knowledge.

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