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Human Factors and Ergonomics Society
Policy Statement on Energy and Environment

HFES Policy Statement: Energy and the Environment

The Human Factors and Ergonomics Society recognizes the scientific consensus on the effects of green-house gases and carbon emissions on climate change, and its negative outcomes for human well-being and the natural environment. [1; 2] In order to address climate change, we support policies that will reduce climate-disrupting emissions and minimize the rise in global temperatures. These policies will most likely include increasing the use of renewable energy sources and ensuring the safety of nuclear power generation as well as the safety of any continuing carbon-based energy operations in the foreseeable future. In order to meet human needs for energy production, transmission and distribution, as well as protection of the natural environment, it is critical that both existing and newly developed energy systems be developed to allow for successful human performance in the control of these operations as a critical component of system safety.

Recommendation: To ensure a safe, effective energy infrastructure for the 21st Century, the U.S. Department of Energy should establish and fund Centers of Excellence for Human Factors & Safety in Energy Systems (HFASES) to conduct needed research and support the application of human factors science to the energy field.

Such centers should engage existing U.S. Department of Energy national lab capabilities in human factors in addition to providing new collaborations with university and industry research partners. These centers should inform other areas of the national government such as regulators and safety boards that are involved in the energy sector.

Renewable Energy & the Power Grid

Power outages and blackouts lead to $44 billion annually in costs and damages in the United States as well as deaths.[3] The root cause of many major power outages has been linked to inadequate situation awareness—the inability of grid operators, reliability coordinators and others to visualize events across the entire system and comprehend current and anticipated future impacts. [4; 5] Common problems include poor real-time information, an excess of alarms, inadequate sharing of information across distributed control rooms, training deficiencies, ineffective communications, and inadequate reliability tools and backup capabilities. [6]

Solar, wind and other forms of renewable energy are a small but increasing source of energy in the U.S. The successful path for growing renewable energy to a major energy source will require the application of human factors research and design principles to the design of visualization systems and decision support tools. Major barriers to large-scale adoption are transmission constraints, the need to align the grid to match the site of energy production with the locations of usage, and the need for grid operators to adopt methods for managing the fluctuation of power levels which are an inherent property of solar and wind sources. A higher penetration of wind and solar energy will introduce increased variability and uncertainty in power system operations and control, and create significant challenges in grid operators' ability to accurately forecast energy supplies that will be available to meet projected demands.[7] To prevent blackouts and brownouts, grid operators must adopt policies that increase investment in energy storage systems and match the growth of renewable sources to end-user energy use patterns. Grid operators also have to plan the transition to renewable energy by balancing against non-renewable sources.

Further, risk management for offshore wind energy is currently expected to be guided almost exclusively by guidelines associated with offshore oil and gas operations (Bureau of Safe Environmental Enforcement-BSEE). This is despite the dearth of research on the short- and long-term personal, environmental, or financial risks associated with its use. On and offshore wind energy managers must have effective risk profiles that take into account the human operators in order to develop effective safety management systems, however given how new these systems are, these risk profiles currently do not exist.

(1) Research is needed on effective visualization and decision support tools for the integration and balancing of mixed energy generation sources in power grid operations and the adoption of effective tools by power grid operators, coordinators, and regulators.

(2) Research is needed on effective tools for grid operators to use in the day-to-day management of fluctuating power levels from renewable energy sources that incorporates prediction based on weather, planned maintenance, and other relevant factors.

(3) Research is needed to develop long-term planning tools for managing the transition to renewable energy (planning grid, storage, backup, incentives, etc.).

(4) Research is needed on the effective methods for human-system integration for on- and off-shore wind energy operations to mitigate risks of personal, environmental, and financial incidents.

Electric Vehicle Infrastructure

Transportation is a major source of green-house gas production in the US and one method of addressing it is through the rapid adoption of zero emission cars and trucks, bicycle usage, and public transportation. Public concerns about electric vehicle range limitations (e.g., range anxiety) are a barrier to adoption and can be addressed with a well-designed national distribution of vehicle charge stations that are easy for drivers to use and will rapidly charge cars and trucks. Although public charge stations are increasing in number, they may not be placed to optimally match vehicle flow patterns for long-distance travel. In addition, there is little uniformity in charge station design, function, vehicle match, and energy availability leading to confusion and reduced confidence the system.

(5) Research is needed on improving the usability of high throughput charge stations in order to increase the uniformity of charge station designs and decrease end user confusion.

(6) Research is needed on the placement, integration, and size of public and private charge stations in order to optimize on end user needs.

Nuclear Power Generation

Given that America would like to reduce its reliance on fossil fuel powered energy generation, nuclear power is one potential candidate for supplying the base power needs of the country as part of a future energy system. Nuclear power provides the advantage of producing a large and consistent zero emission energy supply over time that is not subject to the fluctuations of wind and solar power. Any continued or increased use of nuclear power, however, is dependent on the presence of highly reliable, safe systems that must pay significant attention to the performance of human operators and maintainers.

Emergent nuclear technologies like fission batteries and micro and small modular reactors may lead to increased presence of nuclear energy sources in remote areas and at military installations where maintaining the supply chain for fossil fuels proves prohibitive. Mobile microreactors may also be quickly and temporarily deployed to areas where traditional power distribution is disrupted such as

following natural disasters. These smaller scale reactors are being designed with high levels of automation that facilitate reduced staffing compared with the existing fleet of commercial reactors. New reactor types using more accident tolerant fuel and passive cooling systems promise to potentially increase plant safety while minimizing the requirement for large operational staff.

The importance of designing nuclear power plant control rooms that are consistent with the needs and capabilities of human operators was demonstrated by the Three-mile Island Nuclear accident. Inadequate training and attention to the design of the human computer interface were a direct cause of the failure of operators to detect and understand the loss-of-coolant in the system.[8] Other major disasters, such as Chernobyl and Fukishima, similarly were at least partially due to an insufficient attention to human factors and safety culture in these organizations.[9; 10] While significant improvements in the design of nuclear power plants were initiated over the past 30 years, a continued emphasis on human factors in the design and operation of nuclear plants is critical for ensuring that they provide a safe, reliable source of energy, both for the existing fleet and for proposed new reactors. In particular, advances in the use of automation create new challenges for effective human performance, and the need for increased attention to strengthening safety culture has been highlighted by the U.S. Nuclear Regulatory Commission.[11]

(7) Research is needed to establish effective human-interface solutions for advanced nuclear power plant control rooms that should account for the roles of personnel and automation.

(8) With emerging reactor technologies, research is needed to establish new training, tools to support the management of both normal and emergency operations, alarm management, and human-automation teaming.

(9) Research is needed to enhance current risk analysis tools to better account for new digital and automation interactions and provide real-time risk monitoring capabilities.

(10) Human factors tools, methods, and processes must be developed to support the design, testing and validation of operator interfaces with fully and partially automated systems.

(11) Training programs for improving the safety culture of nuclear power organizations should be developed, validated and delivered as a part of an ongoing focus on safety.

Fossil Fuel Industries—Oil, Gas and Petrochemical Operations

While the US may wish to reduce its dependence on the drilling and use of fossil fuels, it is anticipated that these operations will continue at some level into the foreseeable future, both to supply legacy transportation and power systems, as well as for the production of plastics, chemicals, and other materials. It is critical, however, that oil and gas drilling, transportation and refining operations be conducted in a way that maintains their safety, both for workers and for the environment.

The blowout of the Deepwater Horizon Macondo Well in 2005 was the largest oil spill in US history, resulting directly in 11 deaths and over $65 billion in clean-up costs, as well as significant environmental and economic impact to the gulf region. In the same year, the explosion at BP's Texas City Refinery killed 15 people and injured 180 others.[12] Further, ongoing incidents at petrochemical facilities have resulted in remarkable health and environmental damage. According to the Chemical Safety Board, since January of 2020, there have been 8 fires or releases at petrochemical facilities, with three of these incidents resulting in fatalities and all of them resulting in detrimental environmental impacts. [13]

Similar issues occur in natural gas transmission and distribution. For example, the high-profile San Bruno gas explosion in 2010 ravaged a residential neighborhood outside San Francisco, destroying 38 homes and taking eight lives. The cause of the gas pipeline explosion was linked to aging infrastructure and decision making from incomplete information on the condition of underground gas pipes and suitable pressure loads. The response to the explosion was significantly hampered by a recent

consolidation and upgrade of the operations center, resulting in poor situation awareness by the human controllers, including inability to respond to the resulting alarm avalanche as large sections of downstream pipeline depressurized.[14]

Since 2005, there have been many investigations to determine the root causes of these types of enormous personal, environmental, and economic disasters. These investigations revealed that applying the science and practice of Human Factors and Ergonomics could have mitigated or prevented both these event and other potential incidents in this domain.[15-18] Human Factors and Ergonomics science can and should be applied to create safer offshore and onshore energy, gas transmission and transmission, and petrochemical operations.[19; 20] Significant gaps in the research base, as well as the incorporation of Human Factors science in both land and off-shore fossil fuel based systems should be addressed. [21] In addition, investigations of Deepwater Horizon and other accidents have pointed to the significant need for improved Safety Culture programs in the industry, and the Bureau of Safety and Environmental Enforcement (BSEE) has issued a policy statement promoting safety culture.[19; 22; 23]

(12) Efforts are needed to develop detailed human factors and ergonomics standards for the oil and gas and petrochemical industries, and to support the adoption of human-system integration approaches as part of the design and operation of drilling and refining systems.

(13) Research is needed to create effective human-machine interfaces for drilling and operation systems that support the situation awareness and decision-making needs of operators, particularly when operating in conjunction with automated systems.

(14) Research is needed regarding the relationship between organizational factors, risk perception, and performance & safety, with the goal of improving regulatory oversight for the accurate perception of and response to risk in operational settings.

(15) Experimental and/or longitudinal studies need to be conducted to determine causes of and effective mitigations for stressors (sleep issues, cognitive and physical fatigue, irregular work schedules, job stress, perceived personal risk, environmental conditions) in onshore and offshore operations and petrochemical industries.

(16) Research is needed to identify factors leading to loss of situation awareness in oil and gas and petrochemical operations, and methods for improving situation awareness during normal and abnormal conditions.

(17) Research is needed to identify effective alarm presentation methodologies, that support the rapid understanding, diagnoses, and management of multiple alarms, including the effects of alarm reliability.

(18) Training programs for improving the safety culture of oil, gas and petrochemical operations should be developed, validated and delivered as a part of an ongoing focus on safety.

About the Human Factors and Ergonomics Society (HFES)

With over 4,600 members, HFES is the world's largest nonprofit association for human factors and ergonomics professionals. HFES members include psychologists, engineers and other professionals who have a common interest in working to develop safe, effective, and practical human use of technology, particularly in challenging settings.

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