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The demographics of nuclear power: Comparing nuclear experts', scientists' and non-science professionals' views of risks, benefits and values

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ABSTRACT

Science, technology, engineering and mathematics (STEM) professionals can play an influential role in guiding other people's views of nuclear energy. There has been limited recent research to understand STEM professionals' attitudes towards nuclear and how they might vary. The present study measured these groups' attitudes towards nuclear energy as well as their perceptions regarding known determinants of attitudes – including trust in nuclear agencies, appraisals of risk and benefits of nuclear energy, and associated environmental values. Strict criteria were used to identify nuclear experts and STEM professionals. To drill deeper on the determinants of professionals' perceptions of nuclear energy, this study also investigated the determinants of attitudes towards nuclear energy, when age, gender and professional status were held constant.

The STEM professionals perceived nuclear energy to have more negative consequences than did nuclear experts, but less than non-STEM professionals. Levels of trust in the nuclear industry did not significantly differ between the STEM professional and nuclear expert groups, nor did perceived benefits or environmental impacts of nuclear energy. Gender, trust, perceived risk and benefits and environmental values contributed to acceptance of nuclear energy. The most influential of these were trust in the nuclear industry and perceived benefits of nuclear energy.

1. Introduction

Energy touches all aspects of human life. Globally, people from all walks of life are engaged in discussions around energy technologies. Opinions vary and are frequently divided over technologies and none more so than with respect to nuclear energy [1,2]. Despite the moves away from nuclear energy by some countries (e.g. Germany, Sweden), many people believe that nuclear energy will remain or increase as an essential component of the overall energy mix for some time to come [3–5] especially when considering the need for rapid decarbonisation of the world's energy supply [6] and the lack of suitable baseload alternatives. However, because of its associated perceived risks and uncertainties, gaining public support remains an important factor in any political decision about the use of nuclear energy. Many individuals feel they do not have enough knowledge to make informed decisions on nuclear as an alternative source of energy (information insufficiency) [7–9]. Often, they look to experts.

Professionals working across the science, technology, engineering and mathematics (STEM) disciplines are often called upon as the authorities on energy and nuclear energy. This can occur even if the individuals are not subject matter experts in energy technology being discussed. As a result, the arguments both for and against nuclear energy are further promulgated as they are fuelled by individuals' values and beliefs. It has been argued that if STEM professionals cannot agree on a position on nuclear energy then it is unlikely the general public and 'political decision makers' will arrive at an agreed and informed

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decision either. Given the ability of STEM professionals and experts to sway public perceptions [10], understanding this cohort's attitudes towards nuclear energy becomes an important factor in unravelling the potential future of nuclear energy as a clean source of energy to contribute to climate change mitigation. The study aimed to address the gap in the literature by documenting STEM professionals' attitudes toward nuclear energy and to gain a better understanding of what factors influence those views.

1.1. Nuclear energy today

In the 2014 Intergovernmental Panel on Climate Change (IPCC) report, nuclear energy was acknowledged as a mature low greenhouse gas (GHG) emission source of base load power [11]. However, it also documented that nuclear energy's share of global electricity generation, has been in decline since 1993 [11]. Total net installed capacity of operational nuclear energy currently sits at about 11% (391,116 MWe) of total electricity generation, which is generated from 448 commercial nuclear energy reactors that operate across 31 countries [12]. There are another 61 power reactors currently under construction [4] in growth areas: China, India and other parts of Asia, the Middle East, and Central and Eastern Europe [4]. For example, in addition to their current 37 nuclear power reactors, China has at least 20 plants under construction and many more about to start. Much of the impetus for this growth has been attributed to the growing concern around future energy needs, climate change mitigation and the increasingly intolerable air pollution from coal-fired power plants [12,13].

Those opposed to nuclear energy most often raise the following concerns: operational risks and overall health and safety risks, uranium mining risks, costs (both in building new or decommissioning old plants), regulatory risks, the opportunity for weapons proliferations, and radioactive waste management [14], as well as the firm belief that renewable energy alternatives, can ably fit the bill in a carbon constrained energy supply [15,16]. Conversely, those in favour are quick to cite the importance of nuclear energy as a low carbon dioxide (CO_2) option for climate mitigation, its ability to provide reliable base-load power, flexibility in the form of small modular nuclear reactors and new chemical processes that minimise the current life of radioactive waste. They also suggest that it is poor policy rather than fundamental technological costs that negatively influence its economics [11].

1.2. Determinants of attitudes towards nuclear energy

Much of the research conducted on attitudes towards nuclear energy has measured the perspectives of the general public. Less attention has been given to the attitudes of STEM professionals or nuclear experts and studies that have done so are now 10–20 years old [17,18]. Since that time factors such as the growing concern regarding the effect of greenhouse gas emissions, advancement in nuclear technology and the accident at the Fukushima Daiichi Nuclear Power Plant in 2011 may have also influenced professionals' attitudes to nuclear energy.

In studies that have compared how nuclear experts and laypeople assess nuclear energy risks, it is commonly found that nuclear experts rate issues such as the disposal of radioactive waste, the misuse of radioactive materials and nuclear testing as less risky than do laypersons [19,20]. While the views of nuclear experts are known to be different from those of the general public, the views of scientists in general are not homogenous. Barke and Jenkins-Smith [21] compared the views of scientists from seven different fields of research and found that physicists perceived the least risks from all stages of the nuclear waste process, while life scientists (including biologists, biomedical researchers, and to a lesser extent those in clinical medicine) consistently perceived greatest risks, but overall, scientists were found to perceive fewer risks than did a general public group. They also found that a higher proportion of physicists than scientists from other fields strongly agreed that current technologies could sufficiently manage nuclear waste. Similarly, Sjöberg and Drottz-Sjöberg [22] found that graduate engineers not working in the field of nuclear energy perceived a proposed nuclear waste repository to have more negative risks than did a nuclear expert group. It could be concluded that those with more knowledge of nuclear energy technology hold a more positive view on its safety.

In a later study, Barke et al. [20] compared male and female life scientists' and physical scientists' perceptions of risk from nuclear energy. The life scientists' areas of expertise spanned biology, biomedical research and clinical medicine, while those of the physical scientists spanned physics, earth science, chemistry and engineering. Their results showed that male physical scientists perceived least risk followed by female physical scientists. There was no significant difference in the perceptions of female physical scientists and male life scientists, and female life scientists perceived significantly more risks than their male counterparts. Independent of gender, physical scientists perceived significantly fewer risks than life scientists. These results suggest that when level of education is controlled, both gender and field of research contribute to scientists' perceptions of risk of nuclear energy. In another study, Purvis-Roberts et al. [19] identified differences in the way that scientists, physicians and the public perceived radiation and nuclear testing risks. All participants resided near to a former nuclear test site in Kazakhstan. While the lay group was always the most risk-averse group, followed by the physicians and then the scientists, each group's attitudes differed according to context. For example, the physicians and lay group had similar risk perceptions about the health impacts of nuclear testing.

A number of explanations have been proposed to explain the differences in the way experts, STEM professionals and laypersons perceive nuclear energy risks. Earlier studies suggested it was due to experts basing their risk assessment on actual or perceived knowledge [23–25] and greater experience [26]. Another more recent view is that lay people compared to experts are likely to have different and more contextualised frameworks for determining risk and benefits of nuclear energy, including knowledge, values and relationships between power and trust [27,28]. This appears to be supported by Sjöberg's [26] finding that the correlation between knowledge and perceived risk is typically minimal in size ($\sim r = 0.2$), indicating that factors other than knowledge are driving risk perception. Other explanations include that experts self-select their career based on early interest in a particular field of research – perhaps due to family or peer influence [29]. Once established in a particular profession, they may then be socialised to adhere to certain values and risk perceptions [26]. Socialisation might therefore be another factor that explains differences between experts' and laypeople's perceptions of risks associated with nuclear power.

One confounding factor is that studies differ from one another in the criteria used to identify nuclear experts and other STEM professionals. They rely on self-reported knowledge to identify nuclear experts. In the current study, controls to overcome these issues included a test to confirm participants' factual knowledge of nuclear energy technology and criteria in relation to years of experience, as well as educational achievement.

The link between knowledge and attitudes is not resolved. More recently, Stoutenborough and Vedlitz [30] found that laypersons with higher knowledge of energy sources perceived risks in a similar way as experts. That is, they viewed risks of nuclear energy lower and coal pollutants as higher. A link between knowledge and risk perception was also reported by Sjöberg and Drottz-Sjöberg [31] who used objective tests to measure the radiation knowledge of Swedish nuclear energy plant workers in ten different jobs. The jobs varied with respect to the potential for radiation exposure and educational level. They found a negative relationship between radiation knowledge and perceived job-related radiation risks, even when controlling for the amount of time spent in the controlled area (more risk-laden).

Trust in agencies has also been shown to be an important determinant of attitude towards new technologies and energy sources