The Knowledge and Ignorance Dialectic in the Nuclear Debate

a report by

Gaurav Kumar *and* **Bryan W Karney**

Environmental Engineering, University of Toronto

The promise of nuclear power as an energy source relies on its potential environmental benefits, reliability, predictably and fuel availability, all attributes playing a key roll in establishing it within electrical supply mix options. Admittedly, however, the public, which directly embodies the socio-political acceptance of such undertakings, is split three ways between those who favour, those who oppose and those who are undecided about nuclear power. Certainly, too, in a democratic society, the level of acceptance of a technology can be a major determinant of its viability, and on such decisions, typically made when knowledge is still provisional, political fortunes rise or fall. Locally, Ontario is gearing up for a new provincial election, and energy issues show every sign of pushing strongly into political and public forums. But on what basis is any huge decision made, and what blend of fact, hearsay and prejudice contributes to the discussion and debate? What facts and processes are agreed on and what are disputed? And what mix of issues motivates and animates the decisions made? Such questions implicitly engage a larger and more general issue: the fascinating interplay or tension between what we know and what we do not. It is this knowledge–ignorance tension, and its significance to the nuclear debate, that motivates our reflections here.

Certainly, construction of nuclear power generation has always been a controversial and highly diversified process. Moreover, the public acceptance of nuclear power depends on the specific proponents engaging the general populace, an arena obviously dominated by politicians and law makers, not engineers or technical specialists. The debate is fought on grounds of influence and persuasion, a reality that can translate into strategic misinformation, propaganda and name-calling, rather than a calm search to establish more objective evidence. There are many factors associated with the particular level of misinformation, specifically about nuclear power among the public. But, even more basically, who are the arbitrators of what is true and known? When the issues at hand relate to assessments as complex as weapons manufacturing, covert field testing, security vulnerabilities, environmental impacts and catastrophic possibilities, who is qualified to act as judge? If even experts can have poor judgement of the probabilities of things like catastrophes and major accidents, how can the public be expected to make better choices?

Simplistic reasoning might argue that any risk is bad risk, thus preferring the 'better safe than sorry' opinion. Others may concede that nuclear power does have associated risks but that, overall, the option is well studied and engineered, and thus socially acceptable. Still others may see nuclear power as the proliferation of an unstable technology and are simply opposed to nuclear generation in principle. The bigger problem here may be intrinsic to being human: as we explore, perhaps our collective knowledge structures are not well suited to understanding highly complex and interdependent systems. Yet surely complexity alone does not alleviate us from the necessity of deciding – after all, even doing nothing is a choice with undeniable consequences and an implicit commitment to the status quo. So, can forums be created, and rules of engagement struck, that effectively balance the wide range of concerns?

Public Perception

Despite widespread opinion to the contrary, education alone cannot be the only answer to complex questions. First, from a pragmatic perspective, a sufficiently broad and deep education that goes beyond adopted opinions is very difficult to achieve.[1] Moreover, humans have a great ability to discount information perceived as biased; thus, educators might be viewed as nuclear proponents (or opponents) with ulterior motives. Indeed, acceptance of any opinion hinges at least partly on social values and a value system that, say, supports environmental preservation might be as strongly held as one favouring job security or economic health. Yet evaluating trade-offs between competing objectives is another knowledge structure that is not easily resolved by an appeal to the general populace, since opinions will inevitably differ. Furthermore, any basis for resolution must itself be rooted in values that place some concerns above others. Thus, as important as public acceptance and socio-economic factors are for nuclear energy development, inherent biases in

Gaurav Kumar is a Research Associate in the Division of Environmental Engineering at the University of Toronto. His primary research focus is on educational, engineering and investment issues in energy supply mix, energy market and storage technologies, and environmental considerations in the context of energy. He is also actively involved with studies on pumped storage and evaluations of its impacts for Ontario. In 2004, he completed the certificate programme in the University of Toronto's Centre for Technology and Social Development in Preventive Engineering.

Bryan W Karney is a Professor of Civil Engineer and Chair of the Division of Environmental Engineering at the University of Toronto, where he has worked since 1987. Dr Karney has spoken and written widely on subjects related to water resource systems, energy issues, hydrology, climate change, engineering education and ethics. He was Associate Editor for the *Journal of Hydraulic Engineering* for the ASCE from 1993 to 2005. Professor Karney was selected "Professor of the Year" in Civil Engineering in 2000 and 2003 and won the Faculty of Applied Science and Engineering Teaching Award in 2001–02. Dr Karney has published three books and over 130 papers and scientific contributions.

perspective negate purely rational decision-making. More generally, there is an intrinsic dialectical relationship between ignorance and knowledge – that is, one can only gain knowledge about a certain process or specialisation at the cost of narrowing the focus of one's attention, a process that inevitably and progressively excludes broader considerations. As Vanderburg argues so persuasively,[2] to take a picture one must position a camera, and such a choice implicitly places some objects in the foreground and others in the background. As this dialectical concept is subtle, it is worthwhile elaborating.

Suppose we ask this reasonable but difficult question: what is the break-even time for nuclear installation for the energy produced by the plant to equal the energy invested in its design, construction and operation? To answer this would require an assessment of the energy embedded in various construction materials and processes, and an assessment of the power output. But such issues themselves depend on many external factors and risks. Issues like stability of the electrical grid, the role of natural events to affect power demand and line outages and the availability of refurbishment procedures are all relevant. So, who will supply such estimates? If the 'industry' or an insider were to do so, would the public not perhaps view the results as biased? If an 'outsider', how would they obtain the necessary data? And is there still not an equal chance of 'tainting'? The complexity of the task means that years of work are required, and even when completed one must be realistic and say there would still not be the basis for a clear-cut decision. The reason is obvious. The issue of nuclear power cannot be decided without knowing the timeframes of other investments, for which all the same questions arise.

Thus, clearly, the quest for a perfect solution is first of all impractical. Knowledge of any process comes at the cost of ignorance of its connections and it is precisely these connections that determine a project's ultimate value. Any isolated solution would only function well in an idealised environment, otherwise the robustness of the system is bound to be lost. Thus the only real solution to this impasse is to include as much variety and diversity of expertise during the planning process, so to improve the adaptability of the proposed system. It must be a community decision that balances the losses and gains of information more comprehensibly. Planners, engineers, stakeholders and economists collectively possess tools to affect this situation so that it would be beneficial to all, at least if a proper forum can be created for discussion, debate and decision. Energy mix debates may become quite heated in the coming decades. Increases in demand, fewer resources, renewable intermittencies, transmission constraints, system securities and socio-economic constraints all create an intense and brittle decision-making environment, with little tolerance to error but with high environmental, economic and human vulnerabilities.

Analogous to the public discourse whose limitations stem from their inability to evaluate trade-offs effectively, the nuclear industry implicitly engages the dialectic between knowledge and ignorance. Design engineers can construct efficient and reliable units but are ignorant of the system requirements. The trade-off between understanding how the system operates and optimising the design of a nuclear station could lead to a bifurcation between network stability and constituent requirements. Planners are well aware of system requirements but have less expertise with generation-specific design criteria and constraints. Introduce economic and political factors and who is in a position to make the best decisions? Furthermore, real and perceived biases may again influence decisions. System-wide considerations and performance metrics are an initial step towards reconciling the domains of knowledge and ignorance. An holistic evaluation is almost always more complex than an individual component analysis but yields much better synthesis between those components and minimises the associated externalities.

In the related case of wind power, engineers need to consider the connections and power quality of the technology with the network, but what investment in wind energy would be most beneficial to the system? Wind proponents might state that, as long as the potential exists, the externalities do not outweigh the benefits of clean power, yet it is obvious that an independent – both economic and socio-political – entity is required to assure that this is indeed the case – with a more formal evaluation approach and then comparing them with other alternatives. Similar externalities apply to the nuclear industry. Nuclear designers know that a heavy reliance on nuclear energy leaves the system vulnerable since the intrinsic nature of the units requires time for starting or changing power output. Although solutions are indeed available, the point is that they often lie outside the direct domain of a particular power technology. Decision-making must emphasise the inclusions of such externalities into a designer's scheme.

A typical example comes from North America where, in August of 2003 a massive system-wide blackout occurred. Though power production in the US had some storage capacity, nuclear stations took about two days to return to full service. Ontario, however, essentially a system without storage, heavy reliance on nuclear energy (~ 40%) and relatively minimal spinning reserve, took more than eight days to return to full service.[3] The power stations were operating within normal parameters but the system was not able to adapt quickly. The ignorance of these externalities cost the province billions of dollars but no one can be held singly liable. If the system requirements were accounted during the design of the individual components it may have led to greater system efficiency and fewer externalities, not to mention a system that could adapt better to changing circumstances – this was not the first time a blackout had propagated in this fashion. Thus again an independent entity comprising a diversified portfolio of experts whose collective blind spots would be exposed might have prevented the catastrophe with a much better, adaptive and robust system. Ontario is preparing to spend some C$46 billion towards the development of the energy sector and correspondingly scale up the nuclear slice of the pie as the ratio currently stands.[4]

Sustainability and the Future

Other system considerations include viable energy storage, transmission constraints and safe fail design criteria. Some of these externalities associated with the system are being reinserted back into its context with the concept of sustainability. Sustainability in this context is defined as a process that does not inherently shift externalities, delay its consequences to a later time, decrease the planet's natural capacity for replenishment and induce stresses towards its own continuation. For the nuclear framework, the principle of sustainability is not, in fact, satisfied. This is primarily due to the requirement for extensive hazardous waste isolation that stresses future endeavours to monitor the process. If sustainability were incorporated into the design process, it would force engineers to process the waste or find other uses that could exploit it as an advantage towards nuclear power. Yet can design experts also claim the foresight to envision such a development? The externality here has been at least partly ignored due to economic constraints. By emphasising the long-term performance and embedded energy, incorporating the ignored adaptive system requirements during design and accounting for externalities more so than other power production industries, the gap between knowledge and ignorance can practically be bridged. In particular there is an on-going need for several assessments:

a) integration of system planning and supply mix incorporating generation issues;
b) minimising environmental and socio-economic externalities with power production to develop a set of comprehensive and balanced system metrics;
c) continuous evaluation of the sensitivity of generation variables and transmission as the system evolves at the component level; and
d) continuous valuation of other energy alternatives for a more robust and responsive system overall.

In every complex technological system it is clear that competing technologies will be presented with a bias and both governments and individuals need to make critical choices under less than ideal conditions. No standard or informed judge or jury exists to decide what is best, nor how these decisions ought to be handled. No one can claim to be experts at all the available technologies or specify the right mix. The act of becoming an expert in any field intrinsically promotes ignorance in context and other fields.

This dialectic of knowledge and ignorance is a fundamental characteristic of learning and understanding. In order to engage the decisions made and the consequences, and to gain an implicit understanding of our choices, it is essential to understand the limitations and the context in which such knowledge applies. This recognition should lead to a degree of humility, since all single perspectives are necessarily limited, and a high evaluation of community, since collective decisions can better balance losses and gains inherited from finite perspectives. Overall, this approach shifts attention to the overall system and its interconnections, while not forgetting the contribution of components. It also highlights a commitment to a deeper environmental and production ecology. A value-rich, multi-dimensional outlook could greatly improve the integration of nuclear energy and promote a healthier, more informed and responsive environment for its future. ■

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