The economic, environmental and community benefits of establishing nuclear-electric generation in South Australia

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While the bulk of this submission addresses the topic of electricity generation, brief statements are included on the other three matters that are the subjects of this inquiry.

1. Exploration, Extraction and Milling

The “front end” of the nuclear fuel cycle is well established in South Australia, at least as far as mining and milling is concerned. Shipping of yellow-cake to the world market has been and is expected to continue as the principal means of realizing the value of uranium mined in South Australia. The level of these activities should be determine on the basis of the cost of producing yellow cake, including the relevant social and environmental costs that encompass the decommissioning and returning to green-field conditions of the mines and related operations, and the expected revenues from the sale of yellow cake.

2. Further Processing and Manufacture

The majority, over 90% by installed capacity, of nuclear power plants use enriched uranium fuel. The process of enrichment requires high levels of capital investment as well as the availability of low cost electricity to operate the enrichment facility. Given that there is ample supply of enriched uranium on the world market, the establishment of uranium enrichment capability in South Australia does not appear to be an economically viable proposition for the foreseeable future. Natural uranium fuel is used in some of the reactors operated in India and China, and these may provide opportunities in South Australia for the establishment of facilities for the conversion and fabrication of fuel, likely in the form of fuel pellets as distinct from complete fuel elements. Such economic decisions should be left to the private sector, likely with significant levels of foreign investment, with the government establishing and enforcing environmental and other social regulations consistent with Australian and world standards.

3. Electricity Generation

Electricity consumption is strongly influenced by the price and reliability of its supply, and is directly related to the standard of living of the users of this energy. For a heavily urbanized region such as South Australia, the supply of electricity needs to be centrally managed, and must meet the demand at all times. That demand varies with the time of the day, the day of the week, and the month of the year. However, for a given system, there is “base load” that remains relatively constant over extended periods, and variable loads that are often as much or more than the base load. It is also essential to distinguish between generation capacity (measured in megawatts – MW) and electricity generated (which at all times equals electrical energy consumed minus losses, measured in megawatt-hours – MWh).
### 3.1 Economic Impact

In a modern society, as exists in South Australia, virtually all economic activities are affected by the price of electricity. That price has increased significantly over the last several decades principally due to government policies that have subsidized such renewable generation technologies as wind and solar. As a result, economic activities that are heavy users of electricity, including manufacturing and to a lesser extent commerce, have decreased, with a corresponding loss of better paying jobs being replaced by lesser paying and often part-time jobs in the service sector. Furthermore, as tax revenues are diverted from improving the State’s infrastructure and social services to subsidizing electricity generation, the wellbeing of the citizenry has decreased. While conservation that results from less waste is laudable, reduced electricity consumption as a result of reduced economic activity and less disposable income equates to a loss in the standard of living.

### 3.2 Environmental Impact

The scope of the negative impact of the electric power system on the environment is a function of the method used to generate electricity. In South Australia the generation technologies include (and are shown in order of the percentage of the electrical energy generated by each type of energy source) the following:

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Electricity generated in 2013–14, by energy source</th>
<th>GWh</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td></td>
<td>5,546</td>
<td>45%</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td>3,796</td>
<td>31%</td>
</tr>
<tr>
<td>Coal</td>
<td></td>
<td>2,100</td>
<td>17%</td>
</tr>
<tr>
<td>Rooftop PV*</td>
<td></td>
<td>709</td>
<td>6%</td>
</tr>
<tr>
<td>Other*</td>
<td></td>
<td>64</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>12,215</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

**Table 1**  Electricity generated in South Australia by energy source in 2013-14 [1]

As evident from this table, despite the heavy subsidies received by the generators using wind and rooftop solar, over 60% of the electricity generated in the above period was from fossil fuels. Furthermore, a significant portion of the electricity imported from Victoria was generated by the burning of coal. The necessity to burn fossil fuels to generate electricity arises from the intermittent nature of wind and solar generation, while the demand for electricity exists at all times. In particular, the use of fossil fuels is essential to ensure that base load is satisfied during the night and periods of calm weather.

A key consideration in assessing the environmental impact of nuclear electric generation is to compare it with the alternatives. For such comparisons to be valid, they need to be done on a life-cycle basis that include the cradle to grave impact of all the materials and technologies that go into not only the fuel cycle that supports the generating facility, but include the construction, operation, maintenance and decommissioning of the facility itself,
as well as of the facilities that are used in each of the above activities. It has been popular to regard wind and solar as being “renewable” and “green”, while excluding nuclear from this category. However, the reality is that none of these technologies are truly renewable, since not all the materials, let alone the energy expended in the construction of these facilities, can be fully recovered and recycled. Nor are these technologies free of impact in terms of greenhouse gas emissions when considered over the life-cycle of each technology. As shown in Figure 1, while Gas has only half environmental impact of Coal and Lignite, Solar PV has about one third of the CO₂ equivalent emission due to Gas, and Wind is about double that of Nuclear, measured on a per KWh basis.

![Greenhouse Gas Emission by Electricity Production](image)

Figure 1  Greenhouse Gas Emissions by Electricity Production [2]

### 3.3 Community Impact

In a democratic society, such as the one enjoyed in South Australia, it is the perceived impact on the community that is the deciding factor in terms of the social acceptability of decisions made by the government. While the Nuclear Fuel Cycle Royal Commission is mandated to “inquire into and report upon” all the matters identified in its Terms of Reference, ultimately the recommendations will only be implemented if the government of the day believes that it has the support of the majority of the citizens in the State: a popular term to describe this reality is that the government must have the “social license” to implement such a major change of policy as would be the introduction of nuclear electric generation in South Australia. It is hoped that the report of this Royal Commission will inform the government, as well as provide a factual and unbiased assessment of the overall costs and benefits of the nuclear fuel cycle to South Australia.

The history of nuclear energy, having first been deployed as a weapon of mass destruction, is replete with negative connotations. Accidents in the application of nuclear energy for electricity generation, such as at Three Mile Island (no casualties and no excess radiation exposure), Chernobyl (approximately 40 death directly attributed to the nuclear accident),
and at Fukushima (no deaths and no injuries due to radiation) have left many members of society with serious health and safety concerns about the use of nuclear electric power plants. While the fears created by these nuclear accidents in the minds of people are regrettable, a factual evaluation of the pros and cons for South Australia should be made relative to the alternatives available to the State’s citizens, namely:

a) the increased cost and/or reduced availability and reliability of electricity that result in the lowering of economic activity and standard of living if fossil fuels are eliminated in favour of wind and solar in the generation mix;
b) the environmental impact on climate change, and the corresponding negative views of society locally, nationally and internationally if fossil fuel use is continued;
c) the economic and environmental benefits of having nuclear generation replace fossil fuels in the supply of electricity not only to meet the demand in South Australia, but as a value-added export to Australia’s National Electricity Market (NEM).

Figure 2 shows the heavy reliance on brown coal in Victoria to meet the demand for electricity on a day in September 2014. This is a potential market for the export of nuclear-electric generation from South Australia that would be a major source of high paying jobs, as well as a large contribution to reducing greenhouse emissions from both South Australia and Victoria.

![Figure 2](image)

**Figure 2**  Sources of electricity supply in Victoria to meet the demand on the NEM [3]

4. **Management, Storage and Disposal of Waste**

The management of the bi-products of the nuclear fuel cycle, typically referred to as “waste” and considered by many as the achilles heel of the nuclear industry, is in reality a unique feature, and can be seen as a key advantage of nuclear-electric generation. In most jurisdictions all radioactive bi-products that are in excess of background radiation (and often lower than background radiation) are under strict regulatory control at every phase of the nuclear fuel cycle. This needs to be evaluated in particular with reference to the burning of fossil fuels where the key byproduct, CO\(_2\), is a well-recognized contributor to climate change, and coal in particular emits harmful particulates that shorten human life to a
significantly greater degree than the operation of nuclear plants. Furthermore, coal burning power plants emit more radioactivity than nuclear plants – such comparisons being made on a per MWe produced by the coal-fired versus nuclear fueled generating plants.

The principle advantage of nuclear fueled electricity generation arises from the very high amounts of energy per unit mass of fuel that needs to be converted to produce a unit of electric power. The radioactive nature of the nuclear by-products helps in monitoring any releases, which are under normal operating conditions in the order of 1% of regulatory limits, which in turn are established to be below background levels. The very small volumes of radioactive materials that need to be processed and stored until the levels of radiation have decreased below regulatory limits are small fractions of the volumes involved in the burning of coal, and of the by-products of fossil-fueled generation, that are simply dispersed into the atmosphere.

The safe management and storage of fuel that has been irradiated in the normal operation of a nuclear reactor has been well established and demonstrated by several thousand of reactor-years of operations. A combination of underwater storage pools and dry-storage facilities constructed and operated as an integral part of the power plant are designed to hold the radioactive fuel on the site of the power plant for up to 100 years. Longer term storage and if desired permanent disposal in deep geological repositories has been established as the preferred approach and already used in some jurisdictions. However, it has also been recognized that current nuclear reactor technology extracts less than 5% of the potential nuclear energy contained in uranium, and it is expected that by the time radioactive fuel needs to be moved from above ground dry-storage to deep geological repositories, fast reactor technology will have reached a level of economic viability wherein the reprocessing of previously used nuclear fuel will be implemented. While some long lived radioactive by-products may remain after reprocessing and subsequent passes through fast reactors, these volumes will be very small, and can be permanently stored in deep geological repositories.

Some of the bi-products of nuclear generation are radioactive isotopes that are used extensively in medical diagnosis and treatment, as well as in many agricultural and industrial applications. By all realistic measures, the benefits of using uranium for power generation and other applications far outweigh the risks associated with the radioactivity inherent to these materials, provided that the internationally established regulatory frameworks are followed by the industry, and strictly enforced by the national regulator.

Summary

The purpose of this submission is to recommend to the Nuclear Fuel Cycle Royal Commission some of the key aspects of introducing nuclear-electric generation that, in the author’s opinion, should be considered in the course of the inquiry. In particular, it is the author’s belief, that significant benefits to South Australia’s citizens would accrue in the areas of economy, environment, health and safety by replacing all coal-fired and most gas-fired generation in South Australia, and as much as practicable replacing the use of brown coal in Victoria, by the construction and operation of nuclear-electrical generating units in South Australia.
References


About the author

Dr. George Bereznai is professor and founding dean of the Faculty of Energy Systems and Nuclear Science at the University of Ontario Institute of Technology in Canada. He graduated with first class honours in electrical engineering at the University of Adelaide in 1967, received the M.Eng. and Ph.D. degrees from McMaster University, Ontario, Canada in 1969 and 1972 respectively. From 1972 to the current time he has worked in the nuclear industry and academia in Canada as well as internationally. http://nuclear.uoit.ca/people/faculty/dr-george-bereznai.php