# Fuel Choice, Nuclear Energy, Climate and Carbon

**A. Shpyth**[1]
[1] EcoMetrix Incorporated, Saskatoon, Saskatchewan, Canada
(ashpyth@ecometrix.ca)

## Abstract

Strategic environmental assessments for future fuel choices in electricity generation, particularly ones that consider the use of life cycle assessment information, would be useful for decision-makers wrestling climate change issues. But more importantly from an impact assessment perspective, provide for a comparative assertion for public disclosure on the environmental impacts of fuel choice. This would provide the public and government decision makers with a more complete view of the role nuclear energy may be able to play in mitigating the climate and carbon impacts of increased electricity production, and place issues of accidents and radioactivity in a more understandable context.

## 1. Introduction

According to the International Association for Impact Assessment (IAIA), a good-quality Strategic Environmental Assessment (SEA) process informs planners, decision makers and affected public on the sustainability of strategic decisions, facilitates the search for the best alternative and ensures a democratic decision making process. This, in turn, enhances the credibility of decisions and leads to more cost- and time-effective EA at the project level [1].

There are important differences between SEA and environmental impact assessment (EIA): SEA addresses policies, plans and programs while EIA is project specific. SEA focuses on decision-making processes rather than the final assessment report of these processes. The scope of SEA is wider and more sustainability-oriented; therefore its time scale tends to be longer. SEA requires mostly qualitative information and only necessary quantitative data, while EIA is generally based on the latter. Unlike EIA, SEA is regarded as a process rather than a single activity or output (e.g. a report) [2]. SEA came about not only in response to EIA insufficiencies, but to support the development of policy and planning practices with a stronger environmental component, and fulfill a fundamental role in promoting sustainable principles and practices and the consideration of cumulative effects.

Given its greater potential to inform sustainability-led decisions, this paper argues that SEA is better suited to consider the complexities and challenges that accompany nuclear energy related projects than EIA. Nuclear energy is one of only two primary energy sources found to be favourable across the dimensions of energy accessibility, availability and acceptability by the World Energy Council (the other being hydro) [4]. With regards to climate and carbon (i.e. the climate problem), the IEA's 2011 World Energy Outlook calculates less nuclear power would boost demand for fossil fuels. This would be put additional upward pressure on energy prices, raise additional concerns about energy security and make it harder and more expensive to combat climate change (some $1.5 trillion). The consequences would be particularly severe for countries with limited indigenous energy resources which have been planning to rely relatively heavily on nuclear power, and make it considerably more challenging for emerging economies to satisfy their rapidly growing demand for electricity [5].

Fuel choice matters to the climate problem. Life cycle assessment of the various options for electricity generation can provide sufficient, reliable and usable information for development planning and decision making. In addition to greenhouse gases (GHG), qualitative information exists with regards to a variety of valued environmental, social and economic components, including: stratospheric ozone depletion, acidification, eutrophication, photochemical smog and other air pollutants, terrestrial toxicity, aquatic toxicity, human health impacts, water use, land use, biodiversity, raw materials/resource depletion and energy payback. SEA provides for the incorporation of such information better than project-focussed EIA as it concentrates on key issues of sustainable development.

## 2. Integrating LCA into SEA

Many different forms of SEA have developed over the past three decades (e.g. World Bank – regional and sectoral EAs; UNDP – environmental overview; Canada - policy environmental assessment; USA – programmatic environmental impact assessment), for a variety of different purposes (policy assessment, regional and spatial planning, sector planning, regional). When energy has been subjected to a SEA, it has been largely covered either as a sectoral policy or plan (e.g. SEA of the 2nd Dutch National Structural Scheme Electricity Supply; Strategic/Sectoral, Social and Environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region – the World Bank/CIDA). Over the same time period, a range of life cycle assessments of energy options and impacts have been completed (e.g. Hydro Quebec – Greenhouse Gas Emissions from Power Generation Options; European Union – ExternE-Pol; IAEA – Guide to life-cycle greenhouse gas emissions from electric supply technologies). This experience provides us with the opportunity on a going forward basis to integrate the two approaches.

A life cycle assessment (LCA) is the assessment of the environmental impact of a given product (electricity) throughout its lifespan.[1] The goal of LCA is to compare the environmental performance of

[1] The lifespan of a product is referred to as its life cycle, and includes raw material production, manufacture, distribution, use and disposal (including all intervening transportation steps). ISO 14040 and related publications provide guidance for conducting LCAs.

products to choose the least burdensome. Given the significance of the predicted environmental impact of climate change, life cycle information pertaining to carbon and climate in fuel choice for electricity generation is of immense value to decision makers.

Life cycle assessment (LCA) can be integrated in many SEA forms as a source of information with regards to:

- Baseline studies ("points of reference" for valued ecosystem components);
- Formulating options (comparative risk assessments);
- Impact analysis (environmental indicators and criteria); and
- Documentation for decision-making (cross-impact matrices).

The purpose of integrating LCA into SEA would be to assist with the comparison and assessment of alternatives, and the identification of strategic options. As such, it is likely best applied at the policy/strategy stage, through a sectoral SEA or policy appraisal, particularly when coupled with explicit reference to sustainability objectives, principles or targets.

## 3. LCA and Fuel Choice

At the highest levels, core sustainability indicators (i.e. objectives, principles or targets) cover economic, social and economic considerations. For SEA, such topics may cover biodiversity (e.g. conserve biodiversity at the ecosystem level), flora and fauna (e.g. conserve native habitats); population and human health (e.g. protect human health); water (e.g. limit water pollution); soil (e.g. safeguard soil quality); and air (e.g. limit air pollution) [6]. As noted above, LCAs of electricity generation options can bring a wide range of information of relevance to a SEA. For the purposes of this paper LCA information for nuclear energy and its "carbon footprint," compared to other electricity generation options is presented in Table 1.

The LCAs for electricity generation indicate that life cycle emissions of GHG from nuclear are significantly lower than with fossil fuels by several orders of magnitude and, in general, in the same range as renewable energy sources such as hydro and wind. Replacing fossil fuel electricity with low carbon sources of electricity, including nuclear, has significant potential for abating GHG emissions in the electricity generating sector. In fact, the IPCC's Fourth Assessment Report shows that nuclear power has the largest mitigation potential at the lowest average cost in the energy supply sector.

Table 1 – Life-cycle assessment of GHG emissions and nuclear energy
(all values $gCO_2eq/kWh$)*

| ***Study Cited*** | ***Best/Min*** | ***Typical/Mean/ Reported*** | ***High/Max*** | ***Nuclear's Rank*** |
|---|---|---|---|---|
| Gagnon (Canada) | 6 | 16 | | 2nd lowest source after hydro run-of-river (4) |
| Weisser (Austria) | 2.8 | 10 | 24 | 2nd lowest source after hydro (8) |
| Yamada (Japan) | 9 | 29 | 44 | 3rd lowest source after hydro (11) and geothermal (15) |
| CERI (Canada) | | 1.8 | | No ranking (coal and natural gas comparison) |
| Vattenfall (Sweden) | | 2.6 | | Lowest of their sources |
| Meier (USA) | | 17 | | 3rd lowest source after wind (14) and geothermal (15) |
| EurElectric (EU) | 1 | 16 | 220 | 4th lowest source after hydro (4), wind (12) and ocean energy (8) |
| WEC | 3 | | 40 | No ranking (ranges provided) |
| IEA | 2 | | 59 | 2nd lowest source to hydro (1-48) |
| Voss (Germany) | | 20 | | Lowest source |
| Lenzen (Australia) | 10<br>10 | 60 (LWRs)<br>65 (HWRs) | 130<br>120 | 3rd lowest source after hydro (15) and wind (21) |
| Beerten (Belgium) | 8 | 58 | 110 | No ranking |

*Some values above converted from kt eq $CO_2$/TWh and t $CO_2$/GWh

LCAs for electricity generation also indicate that on most criteria considered, nuclear energy has among the lowest adverse impacts. Several studies which use the results of LCA have shown nuclear to have among the lowest (and at times the lowest) external costs of the primary energy sources. Voss (2009) reports nuclear energy's external costs as comparable to wind and small hydro (< 0.5 euro cents/kWh), and its total costs to be the lowest (around 5 euro cents/kWh) [8]. Similarly, the NEEDS study (2009), has nuclear as being comparable to wind (offshore) with regards to quantifiable external costs, and the lowest with regards to social costs. Both these studies echo the findings in the Final Technical Report of the ExternE project (2005).

## 4. LSA and Accidents at Nuclear Plants

A 2005 update to the methodology of the ExternE/Externalities of Energy project addressed the issue of major accidents in the energy sector. It found the lowest expected fatality rates for western hydropower and nuclear power plants, resulting in low associated external costs for these sources. However, it also found the maximum credible consequences are very large and somewhat dryly noted "the corresponding risk valuation is subject to stakeholder value judgments" [10]. The Fukushima accident confirms this finding and the one that followed – that the damages caused by severe accidents in the energy sector are substantial but quite small compared to those caused by natural disasters. Nonetheless, they can have a significant impact on the publics' risk perception of, and political support for, the nuclear option.

## 5. Conclusions

It has been said that SEA deals with paths and not places, with concepts and not particular activities in terms of its geographic or technical specification and design. It is understood that SEA must address the strategic component of any decision instrument in a way that is practical and responsive to integrated approaches towards sustainability goals [3]. If our strategic imperative is to deal with the problem that is climate and carbon – among the largest and most pressing of our sustainability goals, we must consider fuel choice in any and all decision instruments when choosing how we will generate electricity.

Incorporating LCA information into SEA can help it achieve its two main aims [6]:

- promote environmentally and socially sustainable development by considering and identifying best practicable environmental options based on their life cycle impacts;
- strengthen and streamline project EIA by providing environmental "clearance" of policy and planning issues that are addressed either ineffectively or not at all by EIA (such as justification and major alternatives).

Incorporating LCA information in SEAs of electricity generation would provide a comparative assertion of the impacts of the nuclear fuel choice on climate and carbon, and help us deal with the climate problem. From a GHG emission perspective nuclear power plants are very attractive since they have a huge GHG life-cycle reduction potential when displacing fossil fuel fired power plants, while providing energy services similar to most fossil fuel based energy technologies [11]. Table 1 shows that on average nuclear power plants have among the lowest life-cycle GHG emissions of all assessed technologies. When the climate change benefits of nuclear energy are explained, public support for nuclear energy increases significantly [12].

## 6. Recommendations

The nuclear industry would benefit from a more detailed and complete information base for life cycle assessment of it as a primary energy option, and should invest in an industry-wide data collection effort to this end.

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