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Ecological Footprint Analysis of the Nuclear Power Industry

Shafi Andseta, Ph.D., P.Geo., QP
XCG Consultants Ltd.
2620 Bristol Circle, Suite 300
Oakville, ON

Introduction:

Global consensus on a generic methodology to capture a full snap shot or what one may describe as a three dimensional hologram of the ecological footprint of the nuclear power industry is still an evolving process. This situation presents a paucity of data needed for a critical analysis of the impact of mankind's enabled atomic fission on our global environmental sustainability; because the nuclear power industry broadly involves use in military arsenal manufacture, scientific research and other development purposes as well as for the production of electricity. For the Canadian industry the central theme of most footprint analysis that has been undertaken so far has been as it (nuclear energy) relates to electricity production. The question often asked is; are the results from current Ecological Footprint Analysis methodologies truly representative of nuclear energy Ecological Footprint. This brief presentation will in general attempt to define the need for Ecological Footprint of this industry.

What is Ecological Footprint Analysis (EFA)?

EFA as defined by Rees and Wackernagel (1996) is simply a measurement index used to determine the effect of our utilization of the earth's resources and release of subsequent waste products on the global ecosystem. It tries to assess if we are impacting the earth disproportionately in comparison to our specific eco-niche. It defines our eco-niche as the bio-productive land area upon which we subsist as individuals, organizations, institutions, regions and nations. By defining a generic acreage for the entire global bio-productive land area, Ecological Footprint Analysis can by simple comparison determine if we are in ecological deficit or if in fact we can be attributed a reserve. Studies have shown that higher energy consumption by nations corresponds to higher footprint and that higher ecological footprint corresponds to higher human development index.

EFA can be used to monitor and eventually reduce the EF of the industry. In this way EFA appears relevant for scientific, policy and administrative decision making purposes for global energy use. Thus ecological footprint has been described as a catalyst for a sustainable future; primed to be a key global sustainability indicator for business, government, institutions, and social interactions/relationships.

Why Nuclear Energy?

The growing importance of nuclear power as a primary source of energy makes it imperative that the ecological impact of its various processes and operations be understood. Currently there are over 430 nuclear energy plants around the world and 28 plants under construction. The projection is that much more would be built in the future. Nuclear energy produces 16% of the world's electricity, while avoiding 2 Billion tonnes/year of greenhouse gas emission (Climate Change, Duffey, WNU, 2008 Summer Institute, Ottawa, ON). Energy comprises the largest sectoral footprint (55%) of the entire Canadian national footprint. Today Canada is the world's leading producer of uranium, and about 85% of the product is exported globally. The Canadian industry employs about 21,000 people with an additional 10,000 indirect employees. The major strength of uranium for environmental sustainability is that it is a carbon free resource. Carbon of course is the primary constituent of carbon dioxide a major culprit for environmental pollution from various energy producing and utilizing industries. In spite of this critical advantage, process of uranium mining and refining demands other forms of energy leading to the production and release of carbon dioxide into the environment. Notwithstanding, it is necessary to discuss effects of nuclear energy use on global environmental sustainability because given depleting fossil fuel resources and rising costs, nuclear energy appears set to play a more prominent role in the global energy future. A review of our study of carbon dioxide emission from the nuclear fuel cycle, and estimate of carbon dioxide from the CANDU fuel cycle based on actual Canadian experience with mining and refining of uranium ores and separation of heavy water was documented in CANDU Reactors and Greenhouse Gas Emission (Andseta et al., 1998) which has been highly referenced since 1998. This study showed that Canada produces about 1/3 of the world's uranium, of which 95% comes from three mines in Saskatchewan. The operations consumed 45,000 tonnes of fossil fuel, comprised of 50% propane, 47% diesel fuel and 3% gasoline. Consumption of these fuels released about 138,000 tonnes of carbon dioxide. Had all the electricity been generated using fossil fuels the additional carbon dioxide generated would have been in the order of 98,000 tonnes.

The significance of the EFA is primarily its simple ability to point a finger or track global resource utilization in almost every area of human activity. To this end, EFA has evolved into a resource utilization tool for the measurement of environmental sustainability on a generic global scale. EFA of the Canadian nuclear industry is important to understand the impact of the industry on the sustainability of the Canadian and by extension -global environment.

Recently the European Institute for Energy Research and Global Footprint Network joined hands in order to build a scientific consensus for EFA of the nuclear energy industry.

Methods used for measurement:

The goal is to determine how much global bio-productive capacity is impacted by the activities of the Nuclear Industry.

The challenges for calculating the EF of the Nuclear Power industry includes defining methodologies to capture the footprint of all the relevant wastes emitted from the energy

production process including carbon dioxide. The long latency period that precedes nuclear waste radioactivity appears to have made it a less relevant consideration for EFA for now; a methodology that measures annual periodic snap shots. This situation appears most unlikely to escape the searchlight of current nuclear power EFA review committees established at the instance of the Global Footprint Network and other relevant Standards organizations (Global Footprint Network).

The power of EFA is simply its development of a single uniting index for measuring ecological sustainability globally. The EF unit of measurement is known as a global hectare (gha). It is calculated by dividing biologically productive land and water to global population. According to the Global Footprint Network, there were 13.3 billion hectares of biologically productive land and water on the earth in 2005. Dividing by the number of people alive in that year, 6.5 billion gives 2.1 global hectares per person. The EF works by comparing the calculated ecological footprint (using relevant ecological significant aspects converted with equally relevant factors of equivalency) with appropriated bio-productive land space capacity.

To determine whether we have a credit or are in debit of ecological capital our calculated gha EFA could be compared with in-situ land area (global, national, regional, urban, industry etc.) generated from any of the under listed methods.

- Global approach, using the average global bio-productive land per capita; where average global bio-productive land per capita X the institutions populations represents the allotted bio-productive space capacity.
- National approach, using the average national bio-productive land per capita for that country; where average bio-productive land per capita X the institutions populations represents the allotted bio-productive space capacity.
- Industry approach, using the specific allotted acreage of the nuclear industry including materials mining and processing land.

It appears without question that such open lanes of choices would present problems for standardization; as organizations may likely choose methods which benefit them by increasing the size of their eco-niche and thus reducing their EFA comparatively.

According to the National footprint Accounts 2008 edition, updated EF and Biocapcity, 2005, Canada's available biocapacity is 20 hectares (almost 10 times what is available to the rest of world's nation) per capita given our vast land mass and sea space. Canada has an Ecological Reserve of 13gha. The average Canadian has the third largest ecological footprint (7.1gha) in the world due to natural climate and levels of consumption of natural capital.

United Arab Emirate and USA have the first and second largest ecological footprint (9.5gha and 9.4gha with ecological deficit of 8.4gha and 4.4gha respectively). The ecological footprint of the world is currently 2.7gha, with 0.6gha ecological deficit.

Past studies of atomic energy ecological footprint have been accounted for in thermal units equivalent to a unit of fossil fuel energy produced. Though nuclear wastes and other production related bio-capacity compromises is said to have been accounted for in this equivalence, discussions persist concerning equating the EFA of nuclear energy with that of fossil fuels; because of the many parametric differences in processes and materials

between these two industries especially with respect to occupied eco-niche and issues of waste release and storage, many believe that a more dynamic EFA made exclusive to the nuclear energy industry may well become more beneficial in the long run.

A growing number of scientists, researchers do not think that the present EFA method for nuclear energy can be justified. In the language of the National Footprint Atlas of the Global Footprint Network (GFN), “there is no scientific basis for the parity between nuclear energy and fossil fuel EFA”.

The Past and Future:

It is clear that the footprint concept to be acceptable, differences in footprint models or how energy footprint is assessed and their results must be generic. The two main national accounting systems reported are the Footprint of Nations report and the Living Planet Reports produced by Redefining Progress (RP) and the Global Footprint Network. Therefore using a single model to compare footprint across geographic regions or over time is important.

From 1997 to 2006 the National Footprint Atlas reported nuclear land (land used for production of electricity using nuclear energy) as one of the seven categories for demand on bio-capacity. The others included, crop land, grazing land, forest, fishing ground, carbon land and built up land. Whereas previous EFA reports have estimated nuclear energy EFA as equivalent to EFA of fossil fuel energy produced, the National Footprint Atlas stopped equating nuclear energy to fossil fuel EFA from 2007. Because of these issues of evolving standards nuclear energy is no longer included in global footprint calculations of today pending work of standards committees.

To conduct a tenable EFA study for such a far reaching global industry like the Nuclear energy it is clear we have to first decide on applicable standards; and this is where some current approaches may seem a little limited.

Major changes are being effected in measurement parameters and methodologies for calculating nuclear energy EFA. According to the Footprint Network News a news letter of the Global Footprint Network changes expected include:

- Change of equivalency methods for footprint analysis
- Updating of parameters used for calculation
- Analysis of carbon emission from process and operational sources other than fossil fuel

Comparison of carbon dioxide emission from different energy sources:

EFA studies of the energy industry continue to reaffirm that nuclear energy by far portends fewer footprints than coal, oil, natural gas and hydro power. According to the following Table (2008 Duffey), the study on carbon dioxide emissions for the different energy sectors conducted in 2002 in Canada, Switzerland, International Atomic Energy Agency (IAEA) and France, nuclear power presented the lowest emissions comparatively.

Reduce CO_2 Intensity

Grams CO_2/kW.h

	Electric Energy Technology	Switzerland PSI GaBe 2000 www.psi.ch	Canada Andseta & Gagnon HQ, 2000	IAEA Spadero et al. 2000 www.iaea.org	France (production only) Gouvernement de France, 2000
Current 2000	Natural Gas	605		696	500
	Coal	1071	974	978	
	Solar Panels	114 - 189		97	
	Nuclear	16	3 – 15	21	0
	Oil	855	778	811	701
	Wind	36		36	
	Hydro	4	15	16 – 23	
Near Future 2020	Adv. Gas	389	511	393	333
	Adv. Coal	765		763	703
	Adv. Solar	38 - 44	13	30	
	Adv. Nuclear	6		9	
	Adv. Wind			9	0

Why Nuclear Energy Needs Footprinting?

EFA can be used to measure progress of sustainability goals and performance of the atomic energy industry and can thus lead to the development of best approaches to reduce ecological damages which can also identify areas for saving cost on projects. This is possible given that structured infrastructural development which takes into cognizance the footprint of the industry will be better primed to reduce it in order to meet sustainability targets. Having inbuilt strategies in this way will help the industry avoid the huge costs that come with remediation of damaged ecosystems. The EFA index will thus be a useful indicator for policy and administrative sensitivity to ecological responsibility and emergent issues of global resource appropriation. EFA is essential today for civic comparability of sustainability agenda's of the various eco impacting sectors of the economic mainstream.

As earlier noted for Canada, the energy footprint at 55% of the entire national EFA is without a doubt very significant. According to the Canadian Nuclear Association (CAN) Canada's Nuclear Energy 2008 report; electricity in Ontario in 2007 was derived from: Nuclear Energy – 51%, Hydro – 21%, Coal – 18%, oil & Natural Gas – 8%, and others – 2%. Nuclear power therefore is the most important energy resource for much of the Canadian economy though its footprint comparatively to other members of the energy family such as coal, oil and natural gas is small.

Proper articulation of a methodology that would align nuclear power into the current definition of ecological footprinting appears to be one of the major unresolved issues of nuclear EFA. Because ecological footprinting is somewhat limited as it does not measure full band of sustainability; it only measures bio-resource utilization and assimilation. Nuclear energy is primarily derived from uranium- a carbon free resource. One of the many open questions is the assimilation of its long latency toxic radioactive waste products in the biosphere and other layers of the earth environment; which is in itself a huge global environmental concern, but central for a consummate EFA analysis. Utilization for military weaponry also portends ecological risks in diverse time and space that does not make things easy for EFA. How does the EFA bring in such issues of risk related to nuclear into its well defined areas of concern? This is a question that awaits formal standardization for the industry.

Conclusion:

Reviewed research data on energy EFA have found nuclear energy to have lower EF compared to sources like oil, natural gas, coal and hydro power. But many of these sources may have simply calculated what may be uniquely considered nuclear power processing carbon footprint. From globally reviewed EFA sources, many significant environmental, and more precise operational and process parameters appears not have been clearly accounted for. This situation does not detract from data supporting the view that nuclear power EFA (with EFA's present conceptualization) is presently very low comparatively in the energy sector. But the question remains -how much of natures global ecological capital does the atomic energy industry impact every year with respect to its consumption of natural resources and release of wastes into the environment? EFA is clearly yet evolving its methodologies. Ecological footprinting as presently conceptualized appears to be mostly synonymous with carbon footprinting which presents obvious limitations when utilized to assess environmental impacts of non core carbon processing industries like nuclear.

In consideration of the primacy of nuclear power in the Canadian energy industry, EFA is relevant for monitoring its impact on the environment, and tracking how the populace perceives the industry's response to emergent global opinion of corporate responsibility on issues of ecological sustainability. To do this effectively a more consummate method for the measurement that takes into consideration the peculiarities of the industry is important. It is important that EFA of the industry is measured on a consistent annual routine in order to track trends/changes of its ecological impact overtime. Meanwhile, improvements in materials processing technology, waste and risk management approaches would enhance reduction on future risks associated with the industry which is a major point of contention on developing a globally acceptable EFA methodology for the industry.