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Life Cycle Assessment & Public Policy: Supporting Precautionary Principle Decision-Making

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LIFE CYCLE ASSESSMENT (LCA) & PUBLIC POLICY

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SUPPORTING PRECAUTIONARY PRINCIPLE DECISION-MAKING

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SOS 598: Life Cycle Assessment for Civil Systems

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TABLE OF CONTENTS

Life Cycle Assessment (LCA) & Public Policy

SUPPORTING PRECAUTIONARY PRINCIPLE DECISION-MAKING

EXECUTIVE SUMMARY

This paper's intent is to explore the environmental gap analysis tool, Life Cycle Assessment (LCA), as it pertains to the decision-making process.

Life Cycle Assessment and Precautionary Principle

As LCA is more frequently utilized as a measurement of environmental impact, it is prudent to understand the historical and potential impact that LCA has had or can have on its inclusion in public policy domain - specifically as it intersects the anticipatory governance framework and the supporting decision-making precautionary principle framework. For that purpose, LCA will be examined in partnership with the Precautionary Principle in order to establish practical application.

LCA and Precautionary Principle have been used together in multiple functions. In two case studies, the California Green Chemistry Initiative and in Nanotechnology uncertainty, there is a notion that these practices can create value for one another when addressing complex issues.

Challenges of Life Cycle Assessment within Decision-making

Although life cycle thinking is being espoused in many forums to help solve diverse and temporal issues, there are mixed feelings towards LCA and its legitimacy. LCA is leveraged for many reasons, such as product improvement, though many times the information it offers is manipulated for suggestive reasoning. Increased utility has benefited LCA in the implementation of standards for its use. Even so, those standards have different methods for accomplishing

compliance. Additionally, large amounts of resources must be invested if data is readily unavailable or is unattainable due to proprietary seclusion.

Recommendations and Roadmap

The recommendations presented in this paper are ones that recognize the current dynamics of the LCA field along with the different sectors of decision makers. For effective catalytic initiatives, adoptions of these recommendations are best initially leveraged by government entities to lead by example. The proposed recommendations are summarized into the following categories and explored in further detail later in the paper:

- Improvement in data sharing capabilities for LCA purposes
- Common consensus on standards and technical aspects of LCA structure
- Increased investment of resource allocation for LCA use and development

INTRODUCTION

"The precautionary principle is an approach to decision-making aimed at reducing potential harm by triggering a process to consider a wide range of alternatives to harmful action. The precautionary principle provides for anticipatory action to be taken when threats of irreversible harm to people or nature exist, to prevent damages to human and environmental health, with the intent of safeguarding the quality of life for current and future generations" (Takeuchi, 2005). The precautionary principle framework diverges from historical risk assessment, in that precautionary principle seeks the minimal amount (or elimination) of risk whereas risk assessment typically seeks to identify acceptable risk levels.

In 2003, the City of San Francisco adopted an ordinance implementing precautionary principle into the decision matrix of applicable city purchases, business practices, and services. The city however, stopped short of implementing precautionary principle into private practice – due to extensive pushback from industry and trade groups. Preferred lists of vendors was created, though little enforcement capacity or capability existed, other than the ability to publicly shame city departments into compliance.

This paper will review the supporting role that Life Cycle Assessment (LCA) can play in the decision-making process, and review the linkage between precautionary principle and LCA to determine whether there is sufficient integrity and support for LCA to be implemented into governance structure and policy. "Scientific defensibility" (ICSS symposium, 2012) will be the litmus test that measures the linkage, and thus supports LCA inclusion into the decision-making process. Scientific defensibility will be key support, allowing governmental activism in other place-based locations.

LCA AND PUBLIC POLICY

Increasing complexity in social-ecological systems has left a void in standard analytical approaches for measuring the dynamic inputs and outputs of a system. Standard approaches to analyzing environmental impacts of competing consumer products and processes do exist, and seemingly are growing in demand. LCA in particular, is increasingly utilized in areas of consequential decision-making, such as in purchasing. LCA is comprised of four components – 1) goal and scope definition, 2) inventory analysis, 3) impact assessment, and 4) interpretation (Baumann & Tillman, 2004).

The goal and scope definition of a LCA allows the actor—persons who prepare the LCA—to establish a level of analysis that is appropriately scaled to the commissioner's objective for the LCA. A commissioner is an individual or institution that requests an actor to develop a LCA and has heavy involvement in the goal and scope definition. The commissioner is also often times the decision-maker or a persuasive party to the decision-maker within the overall process. Originally, LCA was known by various names that included: resource and environmental profile analysis (REPA), integral environmental analysis, and environmental profiles (Baumann & Tillman, 2004).

LCA's early beginnings were derived from a demand in analyzing environmental impacts between consumer products due to growing public concern of issues such as pollution and energy use. The evolutionary period from 1960s-2000s progressed LCA into the standardized approach now available. In 1969, the Midwest Research Institute (now MRI Global) was hired by the Coca-Cola Company to study and quantify the emissions and waste flows from the production of beverage containers (Guinee, Zamagni & Ekvall, 2011). The well-documented MRI REPA contained some of the foundational concepts still found in LCA today, such as the use of system boundaries within a cradle-to-grave value chain. Although it is sometimes recognized as the precursor to LCA, MRI's REPA report for Coca-Cola was just a small component of LCAs development. At the same time, pioneering research pockets across Europe were demonstrating the necessity of performing environmental gap assessments and determining the most effective tools to perform such. Accompanying this was the need for public and private decision makers to have fact-based tools in order to respond to public concerns about their companies and products.

The next phase of development for LCA came in the early 1990s amongst environmental catastrophes like Chernobyl (1986) and Exxon's oil spill (1989), after which the public demanded accountability and ways to measure environmental impact. Green parties swept into parliaments across Europe as environmental concerns took center stage. A quote from International Professional Association for Environmental Affairs (IPRE) think-tank captures perceptions about LCA at the time.

> "Life cycle analysis will emerge to be one of the most important tools for decision-making in the field of environmental management for the 1990s. However, present LCA techniques are fraught with some methodological problems and it is commonly felt that the scientific basis for assessing the environmental impact of products is still inadequate."

As consciousness surrounding how to implement LCA into policy-making increased during this period, there was simultaneous awareness that LCA standardization would escalate the tool's legitimacy as a way to address gaps in decision-making. By 1997, International Standards Organization (ISO) published the much-awaited standard LCA format (ISO 14040).

With its growing fame, an inherent amount of criticism has also accompanied LCA in its increased utilization in public and private spheres. Baumann & Tillman (2004) suggest that, "the term hired gun was used for biased studies that favored the product manufactured by those who had sponsored the LCA study. The suspicion that industry exploited the legitimacy of LCA… (by) industry putting forward similar LCA studies with divergent results" (pg. 55). This type of criticism led to a level of uncertainty for decision-makers, and thus slowed adoption and commitment to widespread utilization. Through additional standardization, improvements to data integrity and processes have been used to address uncertainty. Today, LCA techniques and processes are being researched, developed, and implemented to mitigate criticisms, though questions still remain. Regardless, the necessity of standard tools like LCA to bridge the gap and assist in understanding impact and decision-making is imperative.

ANTICIPATORY GOVERNANCE

Anticipatory governance is a framework designed to forecast scenarios pertaining to the development or use of a product in order to make optimal decisions (Ozdemir, 2009; Selin & Hudson, 2010; Wender et al., 2013). This framework is typically applied to developing technologies to anticipate impacts on social, economic, and environmental loads. Precautionary principle falls under the anticipatory thought-process umbrella given its purpose of making pre-emptive decisions on product-use, based on forecasted impacts, and often without established scientific evidence of harm.

Integrating the concept of anticipatory governance with that of LCA then produces anticipatory LCA, or a tool used to adapt the life cycle of a product based on possible and plausible future trajectories. Wender et al. (2013) has examined the use of anticipatory LCA in the development of nanotechnology to anticipate negative environmental impacts of single wall carbon nanotube anode lithium ion batteries at different stages of its life cycle. Knowing these potential social, economic, and environmental impacts allows designers and producers to create iterations of changes to avoid issues before they happen. The use of anticipatory LCA may provide useful when using precautionary principle.

While the concept of anticipatory governance has been used in public policy, it has most recently come into use in the governance of innovation and nanotechnology. According to Guston

(2008), the National Nanotechnology Initiative (NNI) was recently funded to develop anticipatory governance strategies to aid and encourage policies relating to the development of nanotechnology. These strategies would aid in understanding the dynamics of innovation and public policy in terms of how new technologies are supported, utilized, and received by constituents. Here, in combination with potential LCA tools, anticipatory governance can contribute to developing policy in parallel with science by examining potential trajectories.

Anticipatory methods are often used in order to decrease uncertainty and facilitate intentional change (Wiek, 2012). Given this benefit, anticipatory governance has increasingly become applied in nanotechnology, medicine, and climate change research (e.g. Quay, 2010). Here, we extend the argument that the use of precautionary principle, which is generally informed by anticipatory governance, can aid policymakers and decision-makers in making informed decisions on its use, especially when incorporated with empirical LCA data.

THE PRECAUTIONARY PRINCIPLE

"When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically. In this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the Precautionary Principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action" (Wingspread Statement on the Precautionary Principle, 1998). This definition, utilized by governmental boards and agencies, environmental and social scientists, academics and practitioners, is the basis for one of the newer, albeit controversial, thought leadership principles that is increasingly governing health and environmental decision-making actions both in the United States and abroad.

The notion of taking action or inaction, in anticipation of potential side effects is founded on the premise that in the absence of facts substantiating health and environmental security and safety – caution should always rule. Precautionary principle is a paradigm shift transforming the mindset from the passive and reactive to the active and anticipatory. "Instead of asking the basic risk-assessment question – How much harm is allowable? – the precautionary approach asks, "How little harm is possible?" (Montague, 2008).

There are five key elements to precautionary principle: 1) taking anticipatory action before scientific certainty of cause and effect, 2) setting goals and backcasting to current status, 3) seeking out alternative assessments, 4) shifting of burdens of proof, and 5) developing a more democratic and participatory decision-making process (Seattle Precautionary Principle Working Group, 2004; Tickner, Raffensperger, & Myers, 1999). Several US governmental agencies notionally utilize the concept of precautionary principle. Both the Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) enforce and regulate with incomplete scientific substantiation. "The Clean Air Act, for example, requires that the administrator of the Environmental Protection Agency adopt measures to control various types of air pollution when, in the administrator's "judgment," the emission of certain pollutants "may reasonably be anticipated to endanger public health or welfare. Absolute proof or scientific certainty is not required" (Adler, 2011). The guiding precautionary principles have also been determinants in numerous regulatory and court decision outcomes.

In Canada, the Supreme Court found that regulations banning the use of pesticides in Toronto were valid, based upon the utilization of the precautionary principle, suggesting, "when an activity poses threat to human health or the environment, precautionary measures should be taken, even though the cause and effect relationship is not fully established scientifically." (Canada Ltee (Spraytech) v Hudson (Town of) [2001] 2 S.C.R. 241).

The European Union (EU) has statutorily included precautionary principle into its legal framework. Article 130R(2) of the 1992 Maastricht Treaty calls call for:

> Community policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Community. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay.

Article 130R(3) further calls for the consideration of various factors in the development of environmental policy, including "available scientific and technical data" and "the potential benefits and costs of action or lack of action" (Adler, 2011).

Therein lies both an opportunity for the incorporation of LCA, as a supporting tool for the calculation of alternative assessments and the substantiation of scientific and technical data and a criticism of the precautionary principle in general.

Among the main criticisms of precautionary principle is that it is "ill-defined, vacuous, incoherent, too weak, too strong, anti-scientific, an excuse of protectionism, and the matters should be dealt with in the courts" (Saunders, 2010). The EU has supported its decision to ban genetically modified (GM) crops and to prohibit the entry of hormone treated beef by arguing precautionary principle regulations. Critics argue, "Bans ignore the potential downside" (Goklany, 2000). In the case of GM crops, the downside is the ability of GM crops to dramatically increase food production while eliminating the need for additional acreage and increased water consumption to produce an equivalent amount of food. Likewise, the precautionary principle involvement in the ban on hormone treated beef may merely be a form of agricultural protectionism on display.

The precautionary principle at its worst is its impediment of innovation and technological progress that could provide both relief, quality of life improvements, and even environmental stewardship by replacing existing technologies with new ones that have reduced or eliminated prior risk. "Regulatory drug approval, as conducted by the Food and Drug Administration, provides a good example of how both types of error can increase net risks to public health. The FDA must approve new drugs before they may be used or prescribed. FDA approval is fairly precautionary, as it will only approve drugs shown to be "safe and effective." This standard is designed to prevent the release of an unsafe drug. Delaying the availability of potentially lifesaving treatment, however, poses risks of its own. In the simplest terms, if a new drug or medical treatment will start saving lives once approved, then the longer it takes for the government to approve the drug, the more likely people will die awaiting treatment" (Kazman, 1990).

Despite the lack of common ground, opposing sides both argue for the requirement and implementation of supportive tools and guidelines that minimize the use subjective data interpretation and replace it with scientifically bound and standardized methodologies that measure the environmental impact of goods and services. However, in the case of the implementation of precautionary principle in San Francisco, it is suggested that due to possible manipulation, "LCA is best practiced in the context of a full range of precautionary policies such as "extended producer responsibility," whereby producers bear legal, physical, or economic responsibility for the environmental impacts of their products that cannot be eliminated by design" (San Francisco, 2003).

USING LCA TO SUPPORT THE PRECAUTIONARY PRINCIPLE

As LCA is a science-based approach to facilitate decision-making, it is thus appropriate to include LCA as one of the mechanisms to support the precautionary principle.

This paper examines two cases in which LCA and Precautionary Principle have been linked together – first, in connection with the creation of California Green Chemistry Initiative and second, in addressing Nanotechnology uncertainty.

In 2008, Governor Arnold Schwarzenegger signed Assembly Bill 1879 (AB1879) and Senate Bill 509 (SB 509), two parts of the six part California Green Chemistry Initiative (CGCI) to reduce public and environmental exposure to chemical toxins (Raphael & Geiger, 2011). The final report which was co-authored by the California Environmental Protection Agency (Cal/EPA) and the Department of Toxic Substances Control (DTSC) laid out policies that would: expand pollution prevention, develop green chemistry research, education and development, create product ingredient network, create toxics clearinghouse, evaluate chemicals and their alternatives, and move to products that are green by design (DTSC, 2008).

The initiative, while not specifically calling out precautionary principle as its premise, sought to regulate the use and development of toxins before they impacted human health and the environment. This "cradle to cradle" or "benign by design" approach specifically called out the necessity of engineering out potential risks from "chemicals, processes, and goods that have less or no adverse effects throughout their life cycle" (DTSC, 2008). Life cycle thinking was specifically called on to play a role in the analysis and assessment in a number of the policy recommendations.

In the role of preventing environmental pollution from occurring, a life cycle framework would be incorporated into evaluating the environmental footprint (e.g. energy, chemical development, end-of-life) of existing products and processes – ultimately seeking alternatives that reduced or eliminated environmental impact. In seeking safer products, a life cycle approach was to be applied in the design phase. "Identified chemicals of concern were evaluated, replaced, restricted or banned based upon life cycle approach" (DTSC, 2008). It should be noted though that the report also concluded with the consideration that since LCA can be time-intensive, that "systematic alternative analysis" should be considered along with life cycle thinking when seeking alternative solutions.

In a paper supporting the linkage between LCA and CGCI, Horvath and Chester (2011) underscore the "preeminence of the life cycle assessment framework for understanding cradle to cradle environmental impacts of products, processes, services, policies and decisions." Recommendations did include the creation of California-specific LCA data in order to facilitate assessments using existing tools such as, EIO-LCA, Gabi and SimaPro. These tools utilize entire sector data (as in the case of EIO_LCA) though the geographic disparities of the Gabi and SimaPro databases may cause results to vary. Additionally, while LCA data may exist in practice, data may not be easily accessible due to the proprietary nature of the information.

In a 2004 study commissioned by the Scientific and Technological Options Assessment (STOA), researchers looked into scientific uncertainty and the possible impact of regulating nanotechnology as governed through the lens of the Precautionary Principle of the European Union. As previously mentioned in this paper, researchers noted that critics of the Precautionary Principle argue that it is "too vague and arbitrary to form the basis for rational decision-making." (Haum, et al., 2004).

While the practice of utilizing LCA on existing processes and products is mostly well defined, supporting the use of LCA in areas of future uncertainty is a rising part of the dialogue regarding anticipatory governance and risk assessment. In an effort to address the potential for unintended consequences regarding the use of nanoscale materials, Shatkin (2008) argues that LCA, along with risk assessment, can assess potential exposure. "Even in the absence of dose-response data, researchers can characterize the relative contribution to risk at each life cycle stage…and that the logical intersection of life cycle assessment and risk analysis is at the exposure assessment phase – that is understanding where in a product life cycle there may be exposure to nanomaterial that could result in human or environmental exposure" (Shatkin, 2008).

Shatkin goes on to state that the "value of a combined approach is that broad impacts to health and environment are elucidated in a structured and consistent way that allows for the identification of the net environmental benefits as well as risks" (Shatkin, 2008).

RECOMMENDATIONS AND ROADMAP

While requiring full-scale LCA implementation within decision-making arenas is impractical, several recommendations on its use and implementation in public and private sectors can showcase its value and where it is best utilized. The numbers of anecdotal experiences that currently exist are too few, proprietary, and at times irrelevant for establishing an all-encompassing roadmap for LCA's implementation. For that reason this paper suggests a specific roadmap based on the empirical evidence presented and life-cycle field experts' opinions by examining one specific application—precautionary principle within governmental operations.

In review, fundamental challenges are evermore present in LCA's approach and use. In the earlier stages of its development, IPRE viewed LCA to have a number of flaws preventing its widespread utility. As a result, ISO standards were developed and implemented. However, there remains little consensus in private or public sectors on the use and value of LCA, which begs the question – Why, especially in the presence of standards?

Bob Boughton, an Environmental Engineer for California Environment Protection Agency (EPA), suggests reasons for LCA's underutilization. ISO standards have an innate flexibility with how a LCA can be delivered against its goal and scope because of the autonomy associated with truncation and impact methods. "You can do a completely proper and compliant LCA in many ways," suggests Boughton, when talking about maintaining a LCA against ISO standards. He goes on to suggest, "LCA never gives answers. It gives information to decision makers." The implication here being that there is an inherent environment in which LCA can be crafted in a way to achieve certain outcomes. An actor and/or commissioner have the freedom to influence decision-making by selecting and setting parameters in a way that leads to results being calculated in a particular manner. This may or may not be true for how LCA is used in a given situation, but it does leave doubt in people's mind about its legitimacy and credibility.

How then, does LCA eliminate the skepticism in a way that allows policy-making decisions for government purposes? There are plenty of possibilities – such as further investment in resources from all parties or pairing LCA with risk assessment tools and strategies, as Shatkin suggests.

There was an identifiable opportunity in the San Francisco case for the city to benchmark standards for LCAs while implementing and operating within the precautionary principle. Ultimately a lack of resources for both the city (to review submitted LCAs) and city vendors (capability to perform) was the main driver behind San Francisco's main hesitation to making LCAs a requirement. In the context of resources required to perform a LCA, Boughton suggests, "It's more about size of the company than particular industries. Medium or smaller size companies (are the ones) that have issues with implementing LCA." In order to advance LCA for decision-making, there will need to be reconciliation of investment to overcome resource requirements for improvements and accessibility, and soon.

One way to address LCA's legitimacy and credibility is to link it to another trusted analytical tool. Shatkin (2008) identifies an opportunity for life cycle thinking to mitigate uncertainty by combining forces with classical risk assessment tactics. By integrating both LCA and risk assessment, there are multiple perspectives in which to analyze situations and scenarios. This action might reduce the need for data accessibility and address the cost associated with performing an LCA.

Summary of Challenges and Solutions

1. *Data Integrity*

   Improve data sharing for LCA purposes, such as by requiring that peer reviewed LCAs be added to centralized databases – e.g. EIO-LCA. Invest resources at the federal level to improve and expand EIO-LCA. Address proprietary information concerns with a governance structure that prevents data from being utilized until the aggregation of data mitigates the distribution effect. Implement a review system that improves data integrity as LCAs are added into the system.

2. *Common Consensus – industry, private, public, research*

   Introduce additional standardization via ISO in areas of functional unit, product category rules, allocation scenarios, uncertainty and inventory – perhaps at an industry level – e.g. standard industrial classifications.

3. *Funding and other resource issues*

   Through grant foundations such as the National Science Foundation (NSF), source additional LCA work that can contribute both to the database funding as well as research opportunities that streamline the LCA process (without compromising integrity and increasing uncertainty). Incorporate LCA into other risk assessment tools and approaches that allow for the base LCA to exist in a framework that addresses uncertainty.

REMAINING CONSIDERATIONS

In conjunction with the recommendations made above, there are several remaining considerations to keep in mind as decision-makers, researchers, industries, and the larger public proceeds with the use and understanding of LCA in policymaking. Given the history of LCA in policy and the current obstacles it faces to optimize its potential, there are a variety of factors to consider when following the listed recommendations.

Applicability and Relevance

Perhaps the most prominent concern in the use of LCA in public policy to consider is the question of applicability and relevance. Any entity pursuing the use of LCA to support policy and decision-making needs to critically examine the data that they are 1) seeking and 2) realistically collecting. The characteristics of data sets significantly impact the applicability of the data and its capacity to be applied in comparative analyses with other similar products or generally in the greater context of the subject area. For example, consider the functional unit of an LCA. For products such as cleaning chemicals, the functional unit needs to be such that it is applicable, relevant, and comparable to those of other chemicals. Consider that different sectors among the cleaning chemicals industry should be able to directly compare their products and LCA results with one another. For example, a functional unit of ounces per bottle says nothing when different chemicals may clean better or worse than others. However, a functional unit of ounces needed per square meter of carpet to clean may provide as a better option.

Uncertainty and Tools for Anticipation

Another area of consideration when looking at incorporating LCA into public policy is future uncertainty and the use of anticipatory governance. For many, it is difficult to envision that the future of tomorrow looks any different than it does today. This can significantly impact decision in product design and use. Here, LCA can be a valuable tool in examining not only economics of a product, but also in utilizing concepts such as the precautionary principle in preparing for environmental loads that may not be evident today. This consideration will help increase the relevancy of a product or policy both today and in the future.

LCA Data and Decision-making

As mentioned in the paper above, past uses of LCA have been spotty at best, and the resulting databases are typically incomplete or unavailable. This brings the consideration that LCA databases, whether it be from private companies or public sectors, need to consider making the information available for others to use and analyze. This issue spotlights the clash between public vs. private, or in other words, competitive advantage (e.g. proprietary data) vs. the greater good for best practices. If LCA data from different sectors in the industry that are utilizing the tool are made publicly available, it would aid in ensuring the credibility of LCA data which will then also aid in more informed policy and decision-making.

CONCLUSION

Life Cycle Assessment (LCA) has full potential to inform policy and decisions. Examining its role throughout examples such as the precautionary principle, “green” chemicals, and nanotechnology have surfaced recommendations for improving its use and impact. Though the tool has historically been received with skepticism, LCA can be a valuable tool for both the private and public sector if used and interpreted correctly. Additionally, policymakers, industries, and researchers, among others, will need to consider the dynamics of the general relevance and applicability of LCA data and results when scoping and conducting studies. Frameworks for uncertainty and anticipatory governance may provide as useful conceptual aids. As this empirical tool is more frequently utilized as a measurement of environmental load, it will be crucial to utilize LCA in informing policy and decisions on complex issues.

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