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P.O. Box 71
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69FR 71437
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Chief
Rule Review and Directives Branch
U.S. Nuclear Regulatory Commission
Mailstop T-6D59
Washington, DC 20555-0001

Re: **Draft Report For Comment on Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Regarding Millstone Power Station, Units 2 and 3, NUREG-1437, Volumes 1 and 2, Supplement 22**

Dear Chief Rule Review and Directives Branch:

"[t]he problem at hand, which is that centrally generated electricity is a vulnerable genie. In order to be used it must travel on an ugly, complex and inefficient labyrinth of wires and substations Even from a security view (national or otherwise) such a fragile system is suicide." Gordes, Hartford Courant, Letter to the Editor, February 1978.

Dominion has not provided a comparative analysis and assessment of life cycle energy consumption to determine that re-licensing of Millstone is the preferred option. Nor, has Dominion considered cumulative alternatives (i.e., energy sources) to meet the current and future energy demands.

A. INTRODUCTION

"The United States Nuclear Regulatory Commission ("NRC") considered the environmental impacts of renewing nuclear power plant operating licenses ("Ols") for a 20-year period in its *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2, and codified the results in 10 Code of Federal Regulations (CFR) Part 51. In the GEIS (and its Addendum 1), the staff identifies 92 environmental issues and reaches generic conclusions related to environmental impacts for 69 of these issues that apply to all plants or to plants with specific design or site characteristics. Additional plant-specific review is required for the remaining 23 issues. These plant-specific reviews are to be included in a supplement to the GEIS." [GEIS, p. iii.]

"This draft supplemental environmental impact statement ("SEIS") has been prepared in response to an application submitted to the NRC by the Dominion Nuclear Connecticut (Dominion) to renew the OLs for Millstone Power Station, Units 2 and 3 (Millstone) for an additional 20 years under 10 CFR Part 54. This draft SEIS includes the NRC staff's analysis that considers and weighs the environmental impacts of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the staff's preliminary recommendation regarding the proposed action." Id.

B. BACKGROUND

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Add = R.L. Emch (RLE)

"By letter dated January 20, 2004, the Dominion Nuclear Connecticut, Inc. (Dominion) submitted an application to the U.S. Nuclear Regulatory Commission (NRC) to renew the operating licenses (OLs) for Millstone Power Station, Units 2 and 3 for an additional 20-year period. If the OLs are renewed, State regulatory agencies and Dominion will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. If the OLs are not renewed, then the plants must be shut down at or before the expiration dates of the current OLs, which are July 10 2015 for Unit 2 and November 2025 for Unit 3. **The NRC has implemented Section 102 of the National Environmental Policy Act (NEPA) (42 United States Code [USC] 4321) in 10 CFR Part 51.** In 10 CFR 51.20(b)(2), the Commission requires preparation of an environmental impact statement (EIS) or a supplement to an EIS for renewal of a reactor OL. In addition, 10 CFR 51.95(c) states that the EIS prepared at the OL renewal stage will be a supplement to the *Generic Environmental Impact Statement for License Renewal of Nuclear Plants* (GEIS), NUREG-1437, Volumes 1 and 2." (Emphasis added.) [Executive Summary, p. xv.]

"Upon acceptance of the Dominion application, the NRC began the environmental review process described in 10 CFR Part 51 by publishing a notice of intent to prepare an EIS and conduct scoping. The NRC staff visited the Millstone site in May 2004 and held public scoping meetings on May 18, 2004, in Waterford, Connecticut. In the preparation of this draft supplemental environmental impact statement (SEIS) for Millstone, the staff reviewed the Dominion Environmental Report (ER) and compared it to the GEIS, consulted with other agencies, conducted an independent review of the issues following the guidance set forth in NUREG-1555, Supplement 1, the *Standard Review Plans for Environmental Reviews for Nuclear Power Plants, Supplement 1: Operating License Renewal,* and considered the public comments received during the scoping process. ..." Id.

"This draft SEIS includes the NRC staff's preliminary analysis, which considers and weighs the environmental effects of the proposed action, the environmental impacts of alternatives to the proposed action, and mitigation measures for reducing or avoiding adverse effects. It also includes the staff's preliminary recommendation regarding the proposed action." Id, xv-xvi.

"NRC regulations [10 CFR 51.95(c)(2)] contain the following statement regarding the content of SEISs prepared at the license renewal stage:

> The supplemental environmental impact statement for license renewal is not required to include discussion of need for power or the economic costs and economic benefits of the proposed action or of alternatives to the proposed action except insofar as such benefits and costs are either essential for a determination regarding the inclusion of an alternative in the range of alternatives considered or relevant to mitigation. In addition, the supplemental environmental impact statement prepared at the license renewal stage need not discuss other issues not related to the environmental effects of the proposed action and the alternatives, or any aspect of the storage of spent fuel for the facility within the scope of the generic determination in § 51.23(a) ["Temporary storage of spent fuel after cessation of reactor operation–generic determination of no significant

environmental impact"] and in accordance with § 51.23(b)."

Id., xvi.

"If the Millstone operating licenses are not renewed and the units cease operation on or before the expiration of their current operating licenses, the adverse impacts of likely alternatives will not be smaller than those associated with continued operation of Millstone. The impacts may, in fact, be greater in some areas." (Emphasis added.) Id., xix.

"The preliminary recommendation of the NRC staff is that the Commission determine that the adverse environmental impacts of license renewal for Millstone are not so great that preserving the option of license renewal for energy planning decisionmakers would be unreasonable. This recommendation is based on (1) the analysis and findings in the GEIS; (2) the ER submitted by Dominion; (3) consultation with other Federal, State, and local agencies; (4) the staff's own independent review; and (5) the staff's consideration of public comments received during the scoping process." (Emphasis added.) Id.

"1.3 The Proposed Federal Action

The proposed Federal action is renewal of the OLs for Millstone. The Millstone site is located in Waterford, Connecticut on the coast between the Niantic and Thames Rivers, approximately64 km (40 mi) east of New Haven, 64 km (40 mi) southeast of Hartford, and 32 km (20 mi) west of Rhode Island. Unit 2 is a Combustion Engineering–designed pressurized-water reactor with a design power level of 2700 megawatts thermal (MW[t]) and a net power output of 870 megawatts electric (MW[e]). Unit 3 is a Westinghouse-designed pressurized-water reactor with a design power level of 3411 MW(t) and a net power output of 1154 MW(e). Plant cooling is provided by a once-through cooling-water system that is withdrawn from Niantic Bay and dissipates heat by discharge into Long Island Sound. Units 2 and 3 produce electricity to meet about 50 percent of the electrical use of Connecticut. The current OL for Unit 2 expires on July 31, 2015, and for Unit 3 on November 25, 2025. By letter dated January 20, 2004, Dominion submitted an application to the NRC (Dominion 2004b) to renew these OLs for an additional 20 years of operation (i.e., until July 31, 2035, for Unit 2 and November 25, 2045, for Unit 3)." [GEIS, p. 1-8.]

"1.4 The Purpose and Need for the Proposed Action

Although a licensee must have a renewed license to operate a reactor beyond the term of the existing OL, the possession of that license is just one of a number of conditions that must be met for the licensee to continue plant operation during the term of the renewed license. Once an OL is renewed, State regulatory agencies and the owners of the plant will ultimately decide whether the plant will continue to operate based on factors such as the need for power or other matters within the State's jurisdiction or the purview of the owners. Thus, for license renewal reviews, the NRC has adopted the following definition of purpose and need (GEIS Section 1.3):

> The purpose and need for the proposed action (renewal of an operating license) is to provide an option that allows for power generation capability beyond the term of a

current nuclear power plant operating license to meet future system generating needs, as such needs may be determined by State, utility, and where authorized, Federal (other than NRC) decisionmakers."

[GEIS, p. 1-8.]

"This definition of purpose and need reflects the Commission's recognition that, unless there are findings in the safety review required by the Atomic Energy Act of 1954 or **findings in the NEPA environmental analysis that would lead the NRC to reject a license renewal** application, the NRC does not have a role in the energy-planning decisions of State regulators and utility officials as to whether a particular nuclear power plant should continue to operate. From the perspective of the licensee and the State regulatory authority, the purpose of renewing an OL is to maintain the availability of the nuclear plant to meet system energy requirements beyond the current term of the plant's license. (Emphasis added.) [GEIS, pp. 1-8 to 1-9.]

"1.5 Compliance and Consultations

Dominion is required to hold certain Federal, State, and local environmental permits, as well as meet relevant Federal and State statutory requirements. In its Environmental Review, Dominion provided a list of the authorizations from Federal, State, and local authorities for current operations, as well as environmental approvals and consultations associated with Millstone license renewal. Authorizations and consultations relevant to the proposed OL renewal action are included in Appendix E." [GEIS, p. 1-9.]

"The staff has reviewed the list and consulted with the appropriate Federal, State, and local agencies to identify any compliance or permit issues or significant environmental issues of concern to the reviewing agencies. These agencies did not identify any new and significant environmental issues. The ER states that Dominion is in compliance with applicable environmental standards and requirements for Millstone. The staff has not identified any environmental issues that are both new and significant." Id.

"8.2.5 Other Alternatives

Other generation technologies considered by NRC are discussed in the following paragraphs." [GEIS, p. .]

"8.2.5.1 Wind Power

Wind power, by itself, is not suitable for large base-load electrical generation. As discussed in Section 8.3.1 of the GEIS, wind has a high degree of intermittency, and average annual capacity factors for wind plants are relatively low (less than 30 percent). Wind power, in conjunction with energy storage mechanisms, might serve as a means of providing base-load power. However, current energy storage technologies are too expensive for wind power to serve as a large base-load generator." [GEIS, p. .]

"The State of Connecticut is in a wind power Class 2 region (average wind speeds at 10-m [30-ft]) elevation of 5.6 to 6.4 m/s [18 to 21 ft/s]). On the coast, Connecticut is in a wind power Class 3 region (average wind speeds at 10-m (30-ft) elevation of 6.4 to 7.0 m/s [21 to 23 ft/s]) (DOE 2004a). In wind power Class 2 areas wind turbines are economically marginal for development, but in Class 3 areas may be suitable with future technology (DOE 2004a)." Id.

"There are active wind power facilities in the region, and others are proposed. As of January 16 2003, there were approximately 48 MW of grid-connected wind power facilities in New York State, with an additional 410 MW of additional capacity in various stages of planning (American Wind Energy Association 2003). In addition, the U.S. Army Corps of Engineers (USACE) is preparing an environmental impact statement for a proposed wind farm to generate 420 MW(e) using 170 turbines off the coast of Massachusetts (USACE 2004)." Id.

"Access to many of the best land-based wind power sites near the coast likely would require extensive road building, as well as clearing (for towers and blades) and leveling (for the tower bases and associated facilities) in steep terrain. Also, many of the best quality wind sites are on ridges and hilltops that could have greater archaeological sensitivity than surrounding areas. For these reasons, development of large-scale, land-based wind-power facilities are not only likely to be costly, but could also have MODERATE to LARGE impacts on aesthetics, archaeological resources, land use, and terrestrial ecology." Id.

"The offshore wind speeds are higher than those onshore and could thus support greater energy production than onshore facilities. Ten offshore wind power projects are currently operating in Europe, but none have been developed in the United States. The European plants together provide approximately 250 MW(e), which is significantly less than the electrical output of Millstone (British Wind Energy Association 2003). For the preceding reasons, the staff concludes that locating a wind-energy facility on or near the Millstone site, or offshore as a replacement for Millstone generating capacity, is not only likely to be costly, but could also have MODERATE to LARGE impacts on aesthetics, aquatic ecology, and shipping lanes." Id.

"8.2.5.2 **Solar Power**

Solar technologies use the sun's energy and light to provide heat and cooling, light, hot water, and electricity for homes, businesses, and industry. In the GEIS, the staff noted that by its nature, solar power is intermittent. Therefore, solar power by itself is not suitable for base-load capacity and is not a feasible alternative to license renewal of Millstone. The average capacity factor of photovoltaic cells is about 25 percent, and the capacity factor for solar thermal systems is about 25 percent to 40 percent (NRC 1996). Solar power, in conjunction with energy storage mechanisms, might serve as a means of providing base-load power. However, current energy storage technologies are too expensive to permit solar power to serve as a large base-load generator. Therefore, solar power technologies (photovoltaic and thermal) cannot currently compete with conventional fossil-fueled technologies in grid-connected applications, due to high costs per kilowatt of capacity. (NRC 1996)." [GEIS, p. .]

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"There are substantial impacts to natural resources (wildlife habitat, land-use, and aesthetic impacts) from construction of solar-generating facilities. As stated in the GEIS, land requirements are high - 14,000 ha (35,000 ac) per 1000 MW(e) for photovoltaic and approximately 5700 ha (14,000 ac) per 1000 MW(e) for solar thermal systems. Neither type of solar electric system would fit at the Millstone site, and both would have large environmental impacts at an alternate site." Id.

"The Millstone site receives approximately 3 to 3.5 kWh of solar radiation per square meter per day (Dominion 2004), compared to 6 to 8 kWh of solar radiation per square meter per day in areas of the western United States, such as California, which are most promising for solar technologies (DOE/EIA 2000). Because of the natural resource impacts (land and ecological), the area's relatively low rate of solar radiation, and high cost, solar power is not deemed a feasible base-load alternative to renewal of the Millstone OLs. Some solar power may substitute for electric power in rooftop and building applications. Implementation of nonrooftop solar generation on a scale large enough to replace Millstone would likely result in LARGE environmental impacts." Id.

"8.2.5.3 **Hydropower**

Connecticut has an estimated 43.5 MW(e) of undeveloped hydroelectric resources (Idaho National Environmental and Engineering Laboratory 1995). This amount is far less than would be needed to replace the 2024 MW(e) capacity of Millstone. In Section 8.3.4 of the GEIS, the staff points out that hydropower's percentage of U.S. generating capacity is expected to decline because hydroelectric facilities have become difficult to site as a result of public concern about flooding, destruction of natural habitat, and alteration of natural river courses." [GEIS, p. .]

"In the GEIS, the staff estimated that land requirements for hydroelectric power are approximately 4.0 × 105 ha (1.0 × 106 ac) per 1000 MW(e). Replacement of Millstone generating capacity would require flooding more than this amount of land. Due to the relatively low amount of undeveloped hydropower resource in Connecticut, and the large land-use and related environmental and ecological resource impacts associated with siting hydroelectric facilities large enough to replace Millstone, the staff concludes that, on its own, local hydropower is not a feasible alternative to Millstone OLs renewal. Siting hydroelectric facilities large enough to replace Millstone would result in LARGE environmental impacts." Id.

"8.2.5.4 **Geothermal Energy**

Geothermal energy has an average capacity factor of 90 percent and can be used for base-load power where available. However, geothermal technology is not widely used as base-load electrical generation due to the limited geographical availability of the resource and immature status of the technology (NRC 1996). As illustrated by Figure 8.4 in the GEIS, geothermal plants are most likely to be sited in the western continental United States, Alaska, and Hawaii where hydrothermal reservoirs are prevalent. There is no feasible eastern location for geothermal capacity to serve as an alternative to Millstone. The staff concludes that geothermal energy is not a feasible alternative to renewal of the Millstone OLs." [GEIS, p. .]

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"8.2.5.5 **Wood Waste**

The use of wood waste to generate electricity is largely limited to those states with significant wood resources, such as California, Maine, Georgia, Minnesota, Oregon, Washington, and Michigan. Electric power is generated in these states by the pulp, paper, and paperboard industries, which burn wood and wood waste for electrical power generation, benefitting from the use of waste materials that could otherwise represent a disposal problem." [GEIS, p. .]

"A wood-burning facility can provide base-load power and operate with an average annual capacity factor of around 70 to 80 percent and with 20 to 25 percent efficiency (NRC 1996). The fuels required are variable and site-specific. A significant barrier to the use of wood waste to generate electricity is the high delivered-fuel cost and high construction cost per MW of generating capacity. The larger wood-waste power plants are only 40 to 50 MW(e) in size. Estimates in the GEIS suggest that the overall level of construction impact per MW of installed capacity should be approximately the same as that for a coal-fired plant, although facilities using wood waste for fuel would be built at smaller scales. Like coal-fired plants, wood-waste plants require large areas for fuel storage and waste disposal and involve the same type of combustion equipment." Id.

"Due to uncertainties associated with obtaining sufficient wood and wood waste to fuel a base-load generating facility, ecological impacts of large-scale timber cutting (e.g., soil erosion and loss of wildlife habitat), and low efficiency, the staff has determined that wood waste is not a feasible alternative to renewing the Millstone OLs." Id.

"8.2.5.6 **Municipal Solid Waste**

Municipal waste combustors incinerate the waste and use the resultant heat to generate steam, hot water, or electricity. The combustion process can reduce the volume of waste by up to 90 percent and the weight of the waste by up to 75 percent (EPA 2001). Municipal waste combustors use three basic types of technologies: mass burn, modular, and refuse-derived fuel (DOE/EIA 2001). Mass burning technologies are most commonly used in the United States. This group of technologies processes raw municipal solid waste "as is," with little or no sizing, shredding, or separation before combustion." [GEIS, p. .]

"Growth in the municipal waste combustion industry slowed dramatically during the 1990s after rapid growth during the 1980s. The slower growth was due to three primary factors: (1) the Tax Reform Act of 1986, which made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternatives such as landfills; (2) the 1994 Supreme Court decision (*C&A Carbone, Inc. v. Town of Clarkstown*), which struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than the potentially lower-cost (lower fee) landfills; and (3) increasingly stringent environmental regulations that increased the capital cost necessary to construct and maintain municipal waste combustion facilities (DOE/EIA 2001)." Id.

"The decision to burn municipal waste to generate energy is usually driven by the need

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for an alternative to landfills rather than by energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term; however, it is unlikely that many landfills will begin converting waste to energy because of unfavorable economics, particularly with electricity prices declining in real terms. EIA projects that between 1999 and 2020, the average price of electricity in real 1999 dollars will decline by an average of 0.5 percent per year as a result of competition among electricity suppliers (DOE/EIA 2001)." Id.

"Municipal solid waste combustors generate an ash residue that is buried in landfills. The ash residue is composed of bottom ash and fly ash. Bottom ash refers to that portion of the unburned waste that falls to the bottom of the grate or furnace. Fly ash represents the small particles that rise from the furnace during the combustion process. Fly ash is generally removed from flue-gases using fabric filters and/or scrubbers (DOE/EIA 2001)." Id.

"Currently there are approximately 102 waste-to-energy plants operating in the United States. These plants generate approximately 2800 MW(e), or an average of approximately 28 MW(e) per plant (Integrated Waste Services Association 2001), much less than needed to replace the 2024 MW(e) of Millstone." Id.

"The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at wood-waste facilities. This is due to the need for specialized waste-separation and -handling equipment for municipal solid waste (NRC 1996). Furthermore, estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant should be approximately the same as that for a coal-fired plant. Additionally, waste-fired plants have the same or greater operational impacts (including impacts on the aquatic environment, air, and waste disposal). Some of these impacts would be moderate, but still larger than the environmental impacts of license renewal of Millstone. Therefore, municipal solid waste would not be a feasible alternative to renewal of the Millstone OLs, particularly at the scale required." Id.

"8.2.5.7 Other Biomass-Derived Fuels

In addition to wood and municipal solid-waste fuels, there are several other concepts for fueling electric generators, including burning crops, converting crops to a liquid fuel such as ethanol, and gasifying crops (including wood waste). In the GEIS, the staff points out that none of these technologies has progressed to the point of being competitive on a large scale or of being reliable enough to replace a base-load plant such as Millstone. For these reasons, such fuels do not offer a feasible alternative to renewal of the Millstone OLs." [GEIS, p. .]

"8.2.5.8 Fuel Cells

Fuel cells work without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air over a cathode and separating the two by an electrolyte. The only by-products are heat, water, and carbon dioxide. Hydrogen fuel can come from a variety of hydrocarbon resources by subjecting them to steam under pressure. Natural gas is typically used as the source of hydrogen." Id.

"Phosphoric acid fuel cells are generally considered first-generation technologies. These fuel cells are commercially available at a cost of approximately $4500 per kW of installed capacity (DOE 2004b). Higher-temperature, second-generation fuel cells achieve higher fuel-to-electricity and thermal efficiencies. The higher temperatures contribute to improved efficiencies and give the second-generation fuel cells the capability to generate steam for cogeneration and combined-cycle operations." Id.

"DOE has a new initiative to reduce costs to as low as $400 per kW by the end of the decade (DOE 2004b). For comparison, the installed capacity cost for a natural gas-fired, combined-cycle plant is about $456 per kW (DOE/EIA 2004a). As market acceptance and manufacturing capacity increase, natural gas-fueled fuel cell plants in the 50- to 100-MW range are projected to become available. At the present time, however, fuel cells are not economically or technologically competitive with other alternatives for base-load electricity generation. Fuel cells are, consequently, not a feasible alternative to renewal of the Millstone OLs."

C. Council on Environmental Quality Regulations, 40 Code of Federal Regulations

Sec. 1502.16. Environmental consequences.

This section forms the scientific and analytic basis for the comparisons under Sec. 1502.14. It shall consolidate the discussions of those elements required by sections 102(2)(C)(i), (ii), (iv), and (v) of NEPA which are within the scope of the statement and as much of section 102(2)(C)(iii) as is necessary to support the comparisons. The discussion will include the environmental impacts of the alternatives including the proposed action, any adverse environmental effects which cannot be avoided should the proposal be implemented, the relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. This section should not duplicate discussions in Sec. 1502.14. It shall include discussions of:

(a) Direct effects and their significance (Sec. 1508.8).

(b) Indirect effects and their significance (Sec. 1508.8).

(c) Possible conflicts between the proposed action and the objectives of Federal, regional, State, and local (and in the case of a reservation, Indian tribe) land use plans, policies and controls for the area concerned. (See Sec. 1506.2(d).)

(d) The environmental effects of alternatives including the proposed action. The comparisons under Sec. 1502.14 will be based on this discussion.

(e) **Energy requirements and conservation potential of various alternatives and mitigation measures.** (Emphasis added.)

(f) Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures.

(g) Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures.

(h) Means to mitigate adverse environmental impacts (if not fully covered under Sec. 1502.14(f)).

Sec. 1508.8 Effects.

"Effects" include:

(a) Direct effects, which are caused by the action and occur at the same time and place.

(b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

D. COMMENTS

Dominion has not provided a comparative analysis and assessment of life cycle energy consumption to determine that re-licensing of Millstone is the preferred option. Nor, has Dominion considered cumulative alternatives (i.e., energy sources) to meet the current and future energy demands.

1. Energy Considerations

a. Embodied Energy

Most people are familiar with the concept of improving the energy efficiency of buildings by reducing the operating energy they use and increasing thermal resistance to heat loss. It's a common claim that energy-efficiency measures can reduce the operating energy of an individual building by 60% or more. Comparatively, little attention has been focused, however, on recognizing or reducing the embodied energy of structures. Embodied energy, or "embedded energy," is an assessment that includes the energy required for extracting raw materials from nature, plus the energy used in primary and secondary manufacturing or construction/demolition activities to provide a finished product or result. There is embodied energy in every processed product, from a drinking cup to a car. In embodied energy terms, buildings represent a huge, relatively long-duration energy investment. Embodied energy can be defined as the quantity of energy required by all of the activities associated with some production or construction process including the acquisition of primary material, transportation, manufacturing and handling over its useful life plus the energy for demolition, recycling and/or reuse.

Take a clay brick, for example. This includes the energy to extract the clay, transport it to the brickworks, mould the brick, fire it in the kiln, transport it to the building site and put the brick into place. It also includes all the indirect energy required, i.e. all the energy required to manufacture the equipment and materials needed to manufacture a brick, e.g. trucks, kilns, mining equipment, etc. All have a proportion of their energy invested in that brick.

Embodied energy is highly dependent on factors such as geographical location, technology employed in the manufacturing/construction process, the degree of automation, mechanization and local methods of manufacture, etc. The value is by no means absolute and is different from on location to another.

Every building is a complex combination of many processed materials, each of which contributes to the building's total embodied energy. The energy required to extract and process the raw material for an individual component, as well the energy used to transport the finished product to the job site and install it, all become part of the embodied energy cost of the completed structure. Furthermore, energy involved in maintaining an individual building component, and finally removing it and recycling or otherwise disposing of it at the end of its useful life, can all be part of the embodied energy equation for a particular building material, depending on how the embodied energy is quantified.

As the operating energy required for buildings declines, the embodied energy they represent becomes a more significant percentage of the total energy buildings use over their life. In coming years, more efforts will probably be directed toward measuring and reducing the amount of embodied energy in buildings.

Where buildings no longer serve a particular use, waste includes the material debris and the demolition energy for disposal (i.e., in-state or out-of-state).

b. Need for Energy Conservation

1. Dr. Charles Hall, a Systems Ecologist[1] has previously testified as follows:
2. 1. Each dollar of cost requires the consumption of energy for meaning to that dollar. For the nation as a whole, the cost is roughly 5,000 kilocalories (i.e., 1 kilocalorie = 1,000 calories) consumed per dollar spent, roughly half a liter of oil or its equivalent as some other fuel. Certain activities, such as construction, tend to be more

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1. [1] Dr. Hall received his Doctorate of Philosophy at the University of North Carolina at Chapel Hill in the field of energy and natural resource relationships to economics, which is his primary scholarly and intellectual academic focus, studied under Dr. H.T. Odum, who is the most noted scholar in the field. Dr. Hall has published more than 160 papers and five books on energy, natural resources and its relationship to economics in prestigious journals. Dr. Hall is a full professor at the State University of New York College of Environmental Science and Forestry and has been a professor previously at the University of Montana (2 years), Cornell University (13 years) and Research Associate at the Ecosystems Center Woods Hole and Brookhaven National Laboratories.

energy intensive per unit dollar spent. Very careful assessments of these energy costs were made in the 1970s and are still useful when corrected for inflation. Spending large amounts of money requires spending large quantities of energy for that money to have meaning;

3.

2. An important consideration in our society is the energy expenditures of various social alternatives.... Energy consumption is the direct cause effectuating pollution, impairment or destruction of the air, water or other natural resources;

3. Any time energy is used there are environmental impacts and consequences ranging from impacts at extraction sites (e.g. oil facilities in Southern Louisiana, Alaska and Venezuela and coal mines in Wyoming or Pennsylvania), processing, fabrication and transportation and at sites of consumption (i.e. where cement or steel or bulldozers are made and also on site). These impacts include e.g. terrain disruption, sulfur dioxide emissions and so forth;

4. These impacts include essentially irrevocable changes to the atmosphere with possible severe climatic impacts. There is roughly one kilogram of carbon dioxide released per dollar of economic activity in the U.S. Thus each unit of economic activity generates very long term disruption to our atmosphere;

4.

5. The principal source of our energy use is fossil fuel, by definition non-renewable. Our domestic petroleum and gas supplies are quite finite. For example, U.S. production of oil peaked in 1970 (as predicted by Hubbert in 1955). It has been declining steadily since then despite huge drilling investments, so that we now produce roughly half of what we did in the 70's. We make up the difference from imported oil, which now represents approximately 60 percent of our supply. It is not clear when the total world oil production will peak, but it might be as soon as about this year (predicted by Hubbert in 1968) or 2007 (predicted by Campbell in 1998). It is hard to find a prediction made by any competent researcher that pushes the peak beyond about 2030 assuming continued economic growth, and most suggest sooner. Natural gas supplies are harder to predict but might not be too different form oil. Amongst the world authorities on these estimates are my former students Cutler Cleveland and Robert Kaufmann, Director and Associate Professor of the Boston University Center for Energy and the Environment."

6. It is important to understand that there are many scientific, environmental, economic and political reasons for minimizing energy usage and waste, over foreseeable time.

7 Historical resource planning has primarily concerned corrective considerations and

8. Comparative energy assessments for the expected life of alternatives (a/k/a life-cycle energy assessment) provide the best scientific basis for selecting the preferred option to demolition for conservation of energy and natural resources.

5. c. Life Cycle Energy Analysis and Assessments.

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This tool provides accurate energy analysis of projects (e.g., residential/commercial/industrial facilities) resulting in detailed reports designed to reduce energy consumption, greenhouse gas emissions and meet statutory energy requirements by comparative assessments of alternatives directed towards selection of the preferred option.

6.

(1) Assessment of the phases of a product's lifecycle

Every product, service or facility has impacts on the environment. Those impacts don't just effect operations but also all activities from "cradle to grave":

Raw materials: The materials that are used to manufacture the product are either extracted from the Earth by mining, drilling and similar processes, or they are recycled from previous products.

Manufacturing/Fabrication/Assembly: In order to fabricate the product, a factory consumes energy and materials. Some of the materials, especially process chemicals, do not end up in the product, but rather are discarded and therefore have environmental impacts that are not easily known by the consumer.

Packaging, storage and transportation: The packaging used to transport and sell the product consumes energy and materials in its manufacture. Transportation of the product from the factory to store shelves, and then to the purchaser's home, also costs energy. Even storage of the product in a warehouse has impacts associated with construction and use of the warehouse.

Use: Some products have large environmental impacts while they are under use by the consumer. For instance, automobiles output large quantities of air pollutants and greenhouse gases as they are used, and homes consume large quantities of energy when they are heated and cooled.

Disposal: Most discarded products become "municipal solid waste," meaning they are either buried in a landfill or incinerated. Some products are partially or fully recycled, a process that itself requires certain amounts of heat, transportation and chemicals.

(2) Environmental (Energy) Impacts

Traditionally, environmental impacts of a given activity or project are catalogued across a spectrum of environmental realms, for instance, air quality, water quality and land use. However, of far greater significance are the environmental impacts of each phase of a project's lifecycle by measuring the total energy consumed during that phase.

By adding together the energy consumed in each project's phase, one can calculate an energy content for the product: the total amount of energy consumed during the project's entire lifetime. The projected energy consumed then becomes the "analytical embodied energy" of the project, and is a rough but effective measure of that project's total environmental impact.

7. Example of Life Cycle Analysis

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The automobile instrument panel (IP) is a complex component that is fabricated of numerous parts and must fulfill a variety of requirements. As the engineering manager for one of the major automotive companies, your responsibility is to design and manufacture instrument panels for one of your company's most popular vehicles. For the current version of this vehicle, the structural parts of the IP are built primarily of steel. However, for the 1999 model, you and your staff are evaluating a design that is lighter and replaced much of the steel with magnesium.

Issue

Thus far, the new design appears to meet all of your company's safety, aesthetic, cost and other criteria. However, a recent technical report indicated that the material production energy of magnesium is much greater than that of any other materials used in current IP's. Since one of your company's objectives is to lower the life cycle energy of the instrument panel, you must now assess if the new design will achieve this objective. Does the new design lower the life cycle energy of the instrument panel? Please show your calculations and state assumptions.

Data

Material Production Data

Material	Material Production Energy (MJ/kg)	Current Design (kg)	New Design (kg)
Steel	40	10	4
Magnesium	285	0	3
Polyurethane Foam	72	3	3
PVC	65	2	2
Other Plastic	93	10	8
TOTAL		25	20

Manufacturing Phase Data

- Approximately 500 MJ/IP are required to produce either the current or new design.

Use Phase Data

- Average car last 180,000 km.
- For this model of car, 1.0 MJ of energy are consumed to move one kg of weight for a distance of 1,000 km, i.e. the efficiency factor is 1.0 MJ/(kg*1000 km).

End of Life Phase Data

- For either design, a total of 10 MJ/IP are consumed during the shredding and other end of life processes.

Key Assumption:

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The mass of each material in the product is equal to the mass of each material required for manufacturing. This assumes no scrap is generated.

Life Cycle Analysis

Material production:

$E_{material} = E_{steel} + E_{magnesium} + E_{polyurethane} + E_{PVC} + E_{other}$

$E_{current}$ = 10 kg * 40 MJ/kg + 0 kg * 285 MJ/kg + 3 kg * 72 MJ/kg + 2 kg * 65 MJ/kg + 10 kg * 93 MJ/kg
= 400 MJ + 0 MJ + 216 MJ + 130 MJ + 930 MJ

$E_{current}$ = 1676 MJ

E_{new} = 4 kg * 40 MJ/kg + 3 kg * 285 MJ/kg + 3 kg * 72 MJ/kg + 2 kg * 65 MJ/kg + 8 kg * 93 MJ/kg
= 160 MJ + 855 MJ + 216 MJ + 130 MJ + 744 MJ

E_{new} = 2105 MJ

Manufacturing Phase Data

E_{mfg} = 500 MJ for both the current and new designs

Use Phase Data

E_{use} = 1.0 MJ/(kg * 1000 km) * 180,000 km * W_{IP}

$E_{current}$ = 1.0 MJ/(kg * 1000 km) * 180,000 km * 25 kg
= 4500 MJ

E_{new} = 1.0 MJ/(kg * 1000 km) * 180,000 km * 20 kg
= 3600 MJ

End of Life Phase Data

E_{eol} = 10 MJ for both the current and new designs

Total Life Cycle Energy

$E_{total} = E_{material} + E_{mfg} + E_{use} + E_{eol}$

$E_{current}$ = 1676 MJ + 500 MJ + 4500 MJ + 10 MJ
= 6686 MJ

E_{new} = 2105 MJ + 500 MJ + 3600 MJ + 10 MJ
= 6210 MJ

Therefore, we can see that the new design does lower the life cycle energy of the instrument panel.

8.

9. E. CONCLUSIONS

10.

Dominion has not provided a comparative analysis and assessment of life cycle energy consumption to determine that re-licensing of Millstone is the preferred option. Nor, has Dominion considered cumulative alternatives (i.e., energy sources) to meet the current and future energy demands.

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Cordially,

Robert Fromer

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