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Protecting People and the Environment

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Supplement 37

Generic Environmental Impact Statement for License Renewal of Nuclear Plants

Supplement 37

Regarding Three Mile Island Nuclear Station, Unit 1

Final Report

Office of Nuclear Reactor Regulation

8.0 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

The National Environmental Policy Act (NEPA) mandates that each environmental impact statement (EIS) consider alternatives to any proposed major Federal action. NRC regulations implementing NEPA for license renewal require that a supplemental EIS "consider and weigh the environmental effects of the proposed action [license renewal]; the environmental impacts of alternatives to the proposed action; and alternatives available for reducing or avoiding adverse environmental impacts," (10 CFR 51.71[d]). In this case, the proposed Federal action is issuing a renewed license for Three Mile Island Nuclear Station, Unit 1 (TMI-1), which will allow the plant to operate for 20 years beyond its current license expiration date. In this chapter, we examine the potential environmental impacts of alternatives to issuing a renewed operating license for TMI-1.

While NUREG-1437 "Generic Environmental Impact Statement for License Renewal of Nuclear Plants", (GEIS; NRC 1996, 1999), reached generic conclusions regarding many environmental issues associated with license renewal, it did not determine which alternatives are reasonable or reach conclusions about site-specific environmental impact levels. As such, NRC staff must evaluate environmental impacts of alternatives on a site-specific basis.

Alternatives to the proposed action of issuing a renewed TMI-1 operating license must meet the purpose and need for issuing a renewed license; they must

> "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."

The NRC staff ultimately makes no decision as to which alternative (or the proposed action) to implement, since that decision falls to utility, State, or other Federal officials to decide. Comparing the environmental effects of these alternatives will assist the NRC in deciding whether the environmental impacts of license renewal are so great that preserving the option of license renewal for energy-planning decisionmakers would be unreasonable (10 CFR 51.95[c][4]). If the NRC acts to issue a renewed license, all of the alternatives, including the proposed action, will be available to energy-planning decisionmakers. If the NRC decides not to renew the license (or takes no action at all), then energy-planning decisionmakers may no longer elect to continue operating TMI-1 and will have to resort to another alternative—which may or may not be one of the alternatives the NRC considers in this section—to meet their energy needs.

In evaluating alternatives to license renewal, we first select energy technologies or options currently in commercial operation, as well as some technologies not currently in commercial operation but likely to be commercially available by the time the current TMI-1 operating license expires.

Second, we screen the alternatives to remove those that cannot meet future system needs. Then, we screen the remaining options to remove those whose costs or benefits don't justify inclusion in the range of reasonable alternatives. Any alternatives remaining constitute alternatives to the proposed action that the NRC evaluates in-depth throughout this section. At the end of the section, we will briefly address each alternative that we removed during screening.

The NRC staff initially considered 17 discrete potential alternatives to the proposed action, and narrowed the list to the four discrete alternatives and one combination alternative, which are considered in Sections 8.1 through 8.5.

In-Depth Alternatives

- **Coal-fired Supercritical**
- **Natural-gas-fired Combined-cycle**
- **Conservation / Energy Efficiency**
- **Combination Alternative**
- **Purchased Power**

Other Alternatives Considered

- **Coal-fired IGCC**
- **Wind Power**
- **Solar Power (photovoltaic and concentrating)**
- **Wood Waste**
- **Conventional Hydroelectric Power**
- **Wave and Ocean Energy**
- **Geothermal Power**
- **Municipal Solid Waste**
- **Biofuels**
- **Oil-fired Power**
- **Fuel Cells**
- **Delayed Retirement**

Once we identify the in-depth alternatives, the staff refer to generic environmental impact evaluations in the GEIS. The GEIS provides overviews of some energy technologies available at the time of its publishing in 1996, though it does not reach any conclusions regarding which alternatives are most appropriate, nor does it precisely categorize impacts for each site. Since 1996, many energy technologies have evolved significantly in capability and cost, while regulatory structures have changed to either promote or impede development of particular alternatives.

Where applicable, our analyses draw on the GEIS and include updated information from sources like the Energy Information Administration (EIA), other organizations within the Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), industry sources and publications, and information submitted by the applicant (Exelon Generation Company, LLC [Exelon Generation]) in the Environmental Report (ER).

For each in-depth analysis, we analyze environmental impacts across seven impact categories: (1) air quality, (2) ground water use and quality, (3) surface water use and quality, (4) ecology, (5) human health, (6) socioeconomics, and (7) waste management. As in earlier chapters of this supplemental EIS, we use the NRC's three-level standard of significance—SMALL, MODERATE, or LARGE—to indicate the intensity of environmental effects for each alternative that we evaluate in-depth. By placing the detailed alternative analyses in this order, the NRC staff do not mean to imply which alternative would have the least impact, or which alternative an energy-planning decisionmaker would be most likely to implement.

Sections 8.1–8.5 contain our analyses of environmental impacts of alternatives to license renewal. Alternatives include a supercritical coal-fired plant (Section 8.1), a combined-cycle natural gas-fired power plant (Section 8.2), a conservation alternative (Section 8.3), and a combination of alternatives (Section 8.4), which includes some natural gas-fired capacity, uprates at hydropower dams in Pennsylvania, and about one-half of the conservation capacity utilized in Section 8.3. The NRC also considers a purchased-power alternative in Section 8.5. A

Energy Outlook: Each year the Energy Information Administration (EIA), part of the U.S. Department of Energy (DOE), issues its updated *Annual Energy Outlook (AEO)*. *AEO 2008* indicates that coal and natural gas are likely to fuel most new electrical capacity through 2030, with significant contributions from new renewable sources, and some growth in nuclear capacity (EIA 2008a), though all projections are subject to future developments in fuel price or electricity demand:

"Natural-gas-fired plants generally have lower capacity costs but higher fuel costs than coal-fired plants. As a result, coal-fired plants . . . account for 40 percent of total capacity additions from 2006 to 2030, compared with a 36-percent share for natural gas. Renewable and nuclear plants tend to have high investment costs and relatively low operating costs. EPACT2005 and State RPS programs are expected to stimulate generation from renewable and nuclear plants, which represent 18 percent and 6 percent of total additions, respectively. . . The quantity and mix of capacity additions can also be affected by different fuel price paths or growth rates for electricity demand."

discussion of alternatives considered but dismissed is included in Section 8.6. Finally, in Section 8.7, the NRC considers the environmental effects that could occur if NRC takes no action and does not issue a renewed license for TMI-1.

8.1 Supercritical Coal-Fired Generation

In this section, we evaluate the environmental impacts of supercritical coal-fired generation at an offsite location. Given that the available space at the TMI-1 site is smaller than the amount of space we predict a new coal-fired alternative would require, we will not consider a coal-fired alternative at the TMI-1 site. A summary of the environmental impacts from the coal-fired alternative compared to continued operation of TMI-1 is contained in Table 8-1 on page 8-5.

Coal-fired generation accounts for a greater share of U.S. electrical power generation than any other fuel (EIA 2007). Furthermore, the EIA projects that coal-fired power plants will account for the greatest share of capacity additions through 2030—more than natural gas, nuclear, or renewable generation options. While coal-fired power plants are widely used and likely to remain widely used, we acknowledge that future coal capacity additions may be affected by perceived or actual efforts to limit greenhouse gas emissions. For now, we consider a coal-fired alternative to be a feasible, commercially-available option for providing electrical generating capacity beyond TMI-1's current license expiration.

Supercritical technologies are increasingly common in new coal-fired plants. Supercritical plants operate at higher temperatures and pressures than most existing coal-fired plants (beyond water's "critical point," where boiling no longer occurs and no clear phase change occurs between steam and liquid water). Operating at higher temperatures and pressures allows this coal-fired alternative to operate at a higher thermal efficiency than many existing coal-fired power plants. While supercritical facilities are more expensive to construct, they consume less fuel for a given output, reducing environmental impacts. Based on technology forecasts from EIA, we expect that a new, supercritical coal-fired plant beginning operation in 2014 would operate at a heat rate of 9,069 British thermal units per kilowatt-hour (Btu/kWh), or approximately 38 percent thermal efficiency (EIA 2008b).

In a supercritical coal-fired power plant, burning coal heats pressurized water. As the supercritical steam/water mixture moves through plant pipes to a turbine generator, the pressure drops and the mixture flashes to steam. The heated steam expands across the turbine stages, which then spin and turn the generator to produce electricity. After passing through the turbine, any remaining steam is condensed back to water in the plant's condenser.

In most modern U.S. facilities, condenser cooling water circulates through cooling towers or a cooling pond system (either of which are closed-cycle cooling systems). Older plants often withdraw cooling water directly from existing rivers or lakes and discharge heated water directly to the same body of water (called open-cycle cooling). For this analysis, the NRC assumed that a new supercritical coal-fired power plant would rely on closed-cycle cooling with cooling towers.

The plant likely would withdraw makeup water from nearby surface water sources and discharge blowdown (water containing concentrated dissolved solids and biocides) back to that same surface water. Cooling towers could be either natural draft (similar to the existing towers at TMI-1: tall towers powered only by the difference in density between heated, humid air, and surrounding cooler and usually drier air) or mechanical draft (shorter towers powered by mechanical fans).

In order to replace the 802 megawatt-electric (MWe) that TMI-1 currently supplies, the coal-fired alternative would need to produce roughly 850 megawatts (MW), using about 6 percent of power output for onsite power usage (AmerGen 2008). Onsite electricity usage powers scrubbers, cooling towers, coal-handling equipment, and other onsite electrical needs. A supercritical coal-fired power plant equivalent in capacity to TMI-1 would require slightly less cooling water than TMI-1 because the plant operates at a higher thermal efficiency.

Aside from cooling towers, other onsite structures would include the turbine building, boiler building, plant exhaust stack, coal pile, electrical switchyard, and a rail spur or coal dock. The GEIS (NRC 1996) estimated that a coal-fired alternative would require roughly 1.7 acres (ac) (1 hectare [ha]) per MWe capacity, or roughly 1,450 ac (587 ha). Exelon Generation indicated in their ER that the plant would require 129 ac (52 ha), a number more consistent with minimum utility needs as demonstrated by nearby power plants (including PPL Corporation's Brunner Island facility). We will adopt Exelon Generation's estimate for this analysis. Additional offsite land could be required for waste disposal, though much of the plant's ash and scrubber sludge could be reused in concrete and gypsum wallboard, respectively (ACAA 2007).

This 850 MWe power plant would consume 2.51 million tons (t) (2.28 million metric tons [MT]) of coal annually assuming an average heat content of 11,459 Btu/lb (EIA 2006). The EIA reported that most coal consumed in Pennsylvania originates in Pennsylvania. Coal would be mined either in underground mines or in surface mines, then mechanically processed and washed, before being transported—likely by rail— to the power plant site. Limestone for scrubbers would also arrive by rail. This coal-fired alternative would produce 404,000 t (366,000 MT) of ash and 263,000 t (238,000 MT) of scrubber sludge. Much of the coal ash and scrubber sludge could be reused, as noted above.

Environmental impacts from the coal-fired alternative will be greatest during construction. Site crews will clear the plant site of vegetation, prepare the site surface, and begin excavation before other crews begin actual construction on the plant and any associated infrastructure, including a rail spur to serve the plant and electricity transmission infrastructure connecting the plant to existing transmission lines. Given available space onsite, the coal-fired alternative must be located elsewhere. Impacts resulting from a coal-fired unit offsite will vary depending on the nature of the site selected (e.g., a site that has never been developed will likely experience greater impacts than a site that was previously industrial; a site near other power plants or industrial facilities will likely experience smaller impacts than a site surrounded by farmland or relatively natural surroundings).

Table 8-1. Summary of Environmental Impacts of Supercritical Coal-Fired Generation Compared to Continued Operation of TMI-1.

	Supercritical Coal-Fired Generation		Continued TMI-1 Operation
	At TMI-1 site	At alternate site	
Air Quality	N/A	MODERATE	SMALL
Ground Water	N/A	SMALL	SMALL
Surface Water	N/A	SMALL	SMALL
Aquatic and Terrestrial Resources	N/A	SMALL to LARGE	SMALL
Human Health	N/A	SMALL to MODERATE	SMALL
Socioeconomics	N/A	SMALL to LARGE	SMALL
Waste Management	N/A	SMALL to MODERATE	N/A

8.1.1 Air Quality

Air quality impacts from coal-fired generation can be substantial because emissions contain significant quantities of sulfur oxides (SOx), nitrogen oxides (NOx), particulates, carbon monoxide (CO), and hazardous air pollutants such as mercury. However, many of these pollutants can be effectively controlled by various technologies.

TMI-1 is located within the Mid-Atlantic Air Quality Control Region, as designated by the EPA. The State is divided into six air regions and Dauphin County, where TMI-1 is located, belongs to the Southcentral Air Quality Region. Dauphin County is a nonattainment area for fine particulate matter ($PM_{2.5}$) and is part of the Harrisburg-Lebanon-Carlisle $PM_{2.5}$ nonattainment area (which includes Cumberland, Dauphin and Lebanon counties). A new coal-fired generating plant developed at the TMI-1 site would need to comply with the new source performance standards for coal-fired plants set forth in 40 CFR 60 Subpart D(a), "Standards of Performance for Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978." The standards establish limits for particulate matter and opacity (40 CFR 60.42D(a)), sulfur dioxide (SO_2) (40 CFR 60.43D(a)), and NOx (40 CFR 60.44D(a)). A coal-fired power plant constructed elsewhere in Pennsylvania would also need to comply with applicable provisions of the Clean Air Act (CAA) (42 U.S.C. 7401), based on the attainment status of the selected alternate site.

Section 169A of the CAA establishes a national goal of preventing future and remedying existing impairment of visibility in mandatory Class I Federal areas when impairment results from man-made air pollution. In 1999, EPA issued a new regional haze rule (64 FR 35714). The rule specifies that for each mandatory Class I Federal area located within a state, the state must establish goals that provide for reasonable progress towards achieving natural visibility conditions. The reasonable progress goals must provide an improvement in visibility for the most-impaired days over the period of the implementation plan and ensure no degradation in visibility for the least-impaired days over the same period (40 CFR 51.308(d)(1)). If a coal-fired plant were located close to a mandatory Class I area, additional air pollution control requirements would be imposed. There are no Mandatory Class I Federal areas in Pennsylvania, the closest is Brigantine Wilderness Area in New Jersey, roughly 125 miles east-southeast of TMI-1. At an alternate site, consideration may need to be given to the installation of additional air emission control systems if that site were in proximity to any Class I areas.

Pennsylvania regulates air emissions from power plants pursuant to terms of the Pennsylvania Air Pollution Control Act (APCA) (35 P.S. §§ 4001–4015). Regulations issued by the Pennsylvania Department of Environmental Protection (PADEP) adopt the EPA's CAA rules with modifications, to limit power plant emissions of SOx, NOx, particulate matter, and hazardous air pollutants (PADEP 2008). Depending where a new coal-fired facility is located within Pennsylvania, the facility will need to comply with the applicable Federal and State air regulations.

A supercritical coal-fired alternative would produce the following quantities of air pollutants:

<u>Sulfur Oxides</u>

A coal-fired alternative at the TMI-1 site would likely use wet, limestone-based scrubbers to remove SOx. EPA indicates that this technology can remove more than 95 percent of SOx from flue gases (EPA 2002). NRC projects total SOx emissions would be 4,991 t (4,528.20MT) per year. SOx emissions from a new coal-fired power plant would be subject to the requirements in Title IV of the CAA. Title IV was enacted to reduce emissions of SO_2 and NOx, the two principal precursors of acid rain, by restricting emissions of these pollutants from power plants. Title IV caps aggregate annual power plant SO_2 emissions and imposes controls on SO_2 emissions through a system of marketable allowances. EPA issues one allowance for each ton of SO_2 that a unit is allowed to emit. New units do not receive allowances, but are required to have allowances to cover their SO_2 emissions. Owners of new units must therefore purchase allowances from owners of other power plants or reduce SO_2 emissions at other power plants they own. Allowances can be banked for use in future years. Thus, provided a new coal-fired power plant is able to purchase sufficient allowances to operate, it would not add to net regional SO_2 emissions, although it might do so locally.

<u>Nitrogen Oxides</u>

A coal-fired alternative at the TMI-1 site would most likely employ various available NOx-control technologies including low-NOx burners, over-fire air, and selective catalytic reduction. The EPA notes that when these emissions controls are used in concert, they can reduce NOx emissions by up to 95 percent (EPA 1998a). Assuming the use of such technologies, NOx emissions after scrubbing are estimated to be 628 t (570 MT) annually.

Section 407 of the CAA establishes technology-based emission limitations for NOx emissions. A new coal-fired power plant would be subject to the new source performance standards for such plants as indicated in 40 CFR 60.44a(d)(1). This regulation, issued on Sept 16, 1998 (63 FR 49442), limits gas discharges to 200 nanograms (ng) of NOx per joule (J) of gross energy output (equivalent to 1.6 lb/MWh), based on a 30-day rolling average. The NRC estimates that the total annual NOx emissions for a new coal-fired power plant with the modern emission controls identified in the previous paragraph would be approximately 12.4 percent of the new source performance standard mission rate. The EPA further controls the total amount of NOx that can be emitted on a State-level basis. Annual budget for NOx covered by allowances for 2009–2014 is 99,049 t (89,856 MT) (EPA 2005). A new coal-fired power plant would need to offset emissions through credit purchases or from a set-aside pool. It should be noted that NOx emissions would have been subject to ozone-controlling elements of the Clean Air Interstate Rule (CAIR) had CAIR not been vacated by the D.C. Circuit Court in July of 2008. On September 24, 2008, EPA filed for a rehearing of the D.C. Circuit Court decisions. Until EPA, Congress, or the courts act, future NOx regulatory approaches remain uncertain.

Particulates

A new coal-fired power plant would use fabric filters or electrostatic precipitators to remove particulates from flue gases. Exelon Generation indicates that fabric filters would remove 99.9 percent of particulate matter (AmerGen 2008). The EPA notes that filters or precipitators are each capable of removing in excess of 99 percent of particulate matter, and that SO_2 scrubbers further reduce particulate matter emissions (EPA 2002). As such, NRC staff believes Exelon Generation's removal factor is appropriate. Based on this, the new supercritical coal-fired plant would emit 161.27 t (146.3 MT) of total suspended particulates and approximately 37.09 t (33.65 MT) of PM_{10} annually. In addition, coal burning would also result in $PM_{2.5}$ emissions, and coal-handling equipment would introduce fugitive dust emissions when fuel is being transferred to on-site storage and then reclaimed from storage for use in the plant. During the construction of a coal-fired plant, on-site activities would also generate fugitive dust. Vehicles and motorized equipment would create exhaust emissions during the construction process. These impacts would be intermittent and short-lived, however, and to minimize dust generation construction crews would use applicable dust-control measures.

Carbon Monoxide

Based on EPA emission factors (EPA 1998), NRC staff estimates that the total CO emissions would be approximately 628 t (570 MT) per year.

Hazardous Air Pollutants

Following the D.C. Circuit Court's February 8, 2008, ruling that vacated its Clean Air Mercury Rule (CAMR), EPA is working to evaluate how it will regulate mercury emissions (EPA 2007). Before CAMR, EPA determined that coal- and oil-fired electric utility steam-generating units are significant emitters of hazardous air pollutants (HAPs) (EPA 2000a). EPA determined that coal plants emit arsenic, beryllium, cadmium, chromium, dioxins, hydrogen chloride, hydrogen fluoride, lead, manganese, and mercury (EPA 2000a). EPA concluded that mercury is the HAP of greatest concern and that (1) a link exists between coal combustion and mercury emissions, (2) electric utility steam-generating units are the largest domestic source of mercury emissions, and (3) certain segments of the U.S. population (e.g., the developing fetus and subsistence fish-eating populations) are believed to be at potential risk of adverse health effects resulting from mercury exposures caused by the consumption of contaminated fish (EPA 2000a). In light of the recent court decision, EPA will revisit mercury regulation, although it is possible that the agency will continue to regulate mercury as a HAP, thus requiring the use of best available control technology to prevent its release to the environment.

Carbon Dioxide

A coal-fired plant would also have unregulated carbon dioxide (CO_2) emissions during operations as well as during mining, processing, and transportation. Burning bituminous coal in the United States emits roughly 205.3 lb of CO_2 per million Btu (Hong and Slatick 1994). The supercritical coal-fired plant would emit approximately 5.914 million t (5.365 million MT) of CO_2 per year.

Summary of Air Quality

While the GEIS analysis mentions global warming from unregulated CO_2 emissions and acid rain from SOx and NOx emissions as potential impacts, it does not quantify emissions from coal-fired power plants. However, the GEIS analysis does imply that air impacts would be substantial (NRC 1996). The above analysis shows that emissions of air pollutants, including SOx, NOx, CO, and particulates, exceed those produced by the existing nuclear power plant, as well as those of the other alternatives considered in this section. Operational emissions of CO_2 are also much greater under the coal-fired alternative.[6] Adverse human health effects such as cancer and emphysema have also been associated with air emissions from coal combustion, and are discussed further in Section 8.1.5.

The NRC analysis for a coal-fired alternative at an alternative site indicates that impacts from the coal-fired alternative would have clearly noticeable effects, but given existing regulatory regimes, permit requirements, and emissions controls, the coal-fired alternative would not destabilize air quality. Thus, the appropriate characterization of air impacts from coal-fired generation would be MODERATE. Existing air quality at the alternate location would result in varying needs for pollution control equipment to meet applicable local requirements, or varying degrees of participation in emissions trading schemes.

8.1.2 Ground Water Use and Quality

An off-site location for a coal-fired plant was assumed because Three Mile Island is too small to accommodate the area needed for this alternative. If the alternative site is adjacent to the Susquehanna River and operates 10 percent more efficiently than the current nuclear plant, most of the approximately 13,000 gallon per minute (gpm) for maximum cooling water withdrawal would be taken from the river, with an average consumptive loss of about 16 million gallons per day (mgd). The need for ground water at the plant would be minor, with supply wells used for potable drinking water and various service water functions. No effect on ground water quality would be apparent.

Construction of a coal-fired plant at a new site could have a localized effect on ground water due to temporary dewatering and run-off control measures. Because of its temporary nature, the impact of construction would be SMALL.

6 Table S-3 in 10 CFR 51.51 indicates that electrical energy consumed during the uranium fuel cycle to supply a 1,000 MW(e) reactor is equivalent to the electricity produced by a 45 MW(e) coal-fired power plant.

8.1.3 Surface Water Use and Quality

Again, an offsite location for a coal-fired plant was assumed because Three Mile Island is too small to accommodate the area needed for this alternative. If the alternative site is adjacent to the Susquehanna River, most of the approximately 13,000 gpm needed for maximum withdrawal would be taken from the river with an average consumptive loss of about 16 mgd. This consumptive loss is less than 0.1 percent of the average annual flow of the Susquehanna River, and as such the NRC concludes the impact of surface water use at an alternative site would be SMALL. A new coal-fired plant would be required to obtain a National Pollutant Discharge and Elimination System (NPDES) permit from the PADEP for regulation of industrial waste water, storm water, and other discharges. If the plant is operated within the limits of the permit, the impact of discharges on surface water quality would be SMALL.

8.1.4 Terrestrial and Aquatic Ecology

Terrestrial Ecology

As indicated in previous sections, constructing the coal-fired alternative will require 129 ac (52 ha) of land. Coal-mining operation will also affect terrestrial ecology in offsite coal mining areas, although some of the land is likely already disturbed by mining operations. On-site and offsite land disturbances form the basis for impacts to terrestrial ecology.

Impacts to terrestrial ecology will vary based on the degree to which the proposed plant site is already disturbed. On a previous industrial site, impacts to terrestrial ecology would be minor, unless substantial transmission line right-of-ways (ROWs), railways, or roads would need to be constructed through less disturbed areas. These construction activities may have a cumulative effect of fragmenting or destroying habitats. Any on-site or offsite water disposal by landfilling will also affect terrestrial ecology at least through the time period when the disposal area is reclaimed. Some areas onsite, such as buffer areas, may remain undeveloped and could serve as habitat for terrestrial species, though site lighting, noise, and activities may degrade the value of these ecosystems. Deposition of acid rain or other emissions can also affect terrestrial ecology. Given the emission controls discussed in Section 8.1.1, air deposition impacts may be noticeable, but are not likely to be devastating. Impacts to terrestrial resources from a coal-fired alternative would be SMALL, and occur mostly during construction.

Aquatic Ecology

A new coal-burning power plant constructed at an alternate site would need a source of water for the plant's cooling system (likely closed-cycled with cooling towers) as well as a discharge point for plant cooling tower blowdown. Aquatic impacts at an alternate site depend on location and ecology of the site, and the surface water body used for intake and discharge. These impacts are likely SMALL at a previously industrial site, owing to generally closer access to pipelines and transmission lines than at undeveloped sites. Impacts could range from SMALL to LARGE at previously undisturbed sites. Decreases in withdrawal from and discharge to the Susquehanna River may partially offset some aquatic impacts at an alternate site. Impacts will depend upon location and ecology of the site, and the surface water body used for intake and discharge.

8.1.5 Human Health

Human health risks of coal-fired power plants are described in general, in the GEIS Table 8-2 and Section 8.3.9. Cancer and emphysema are identified as potential health risks to occupational workers and members of the public (NRC 1996). The human health risks of coal-fired power plants, both to occupational workers and to members of the public, are greater than those of the current TMI-1 due to exposures to chemicals such as mercury; SOx; NOx; radioactive elements such as uranium and thorium; and polycyclic aromatic hydrocarbon (PAH) compounds, including benzo(a)pyrene. However, the current Federal and State regulatory frameworks pertaining to air emission standards allow for the adequate protection of occupational workers and members of the public. Therefore, the NRC staff has adopted (where applicable) the Federal and State air quality regulatory limits as significance thresholds for determining the human health risks associated with the operation of a new coal-fired power plant.

Radiological Human Health Risks

Coal contains uranium, thorium, and other naturally occurring radioactive elements. The U.S. Geological Survey (USGS) indicates that Western and Illinois Basin coals contain uranium and thorium at roughly equal concentrations, mostly between 1 and 4 parts per million (ppm), but also indicates that some coals may contain concentrations as high as 20 ppm of both elements (USGS 1997). A typical 1,000 MWe coal-fired plant could release roughly 5.2 t (4.7 MT) of uranium and 12.8 t (11.6 MT) of thorium to the atmosphere (Gabbard 1993). The USGS and Gabbard indicate that almost all of the uranium, thorium, and most decay products remain in solid coal wastes, especially in the fine glass spheres that constitute much of coal's fly ash. Modern emission controls, such as those included for this coal-fired alternative, allow for recovery of greater than 99 percent of these solid wastes (EPA 1998), thus retaining most of coal's radioactive elements in solid form rather than releasing them to the atmosphere. Even after concentration in coal waste, the level of radioactive elements remains relatively low—typically 10 to 100 ppm—and consistent with levels found in naturally occurring granitic rocks, shale, and phosphate rocks (USGS 1997). Natural radioactive material in rocks and soil account for about 29 millirem (mrem) or 8 percent of the radiation dose a person typically receives in a year from all sources (natural and manmade). Currently, there is no scientific evidence that radiation dose exposures of 29 mrem above the natural background dose would cause adverse human health impacts. The Biological Effect of Ionizing Radiation (BEIR) committee has calculated the lifetime attributable risk (LAR) of incidence and mortality for all solid cancers and for leukemia to be four to five persons per 100,000 persons exposed to 100 milliseiverts (mSv) (10 rem), which is over 20 times that of the natural background radiation dose of 360 mrem (NAS 2005). Therefore, the radiological human health risks from a 1,000 MWe coal-fired plant to occupational workers and members of the public would be SMALL.

PAH Human Health Risks

The EPA has classified seven PAHs—benzo(a)pyrene, benz(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene—as probable human carcinogens (EPA 199a, EPA 199b, EPA 1999c). PAHs have been detected in ambient air from sources including coal tar production plants, coking plants, and coal-gasification sites. Epidemiologic studies have reported an increase in lung cancer risks in humans exposed to emission from coal tar production plants, coking plants, and coal-gasification sites. Each of these emissions mixtures contains a number of PAH compounds (ATSDR 1995, HHS 1993). The Occupational Safety and Health Administration (OSHA) has set a limit of 0.2 mg of PAHs per cubic meter (m^3) of air. Given that the plant must comply with OSHA regulatory limits, the health risks to occupational workers and members of the public from benzo[a]pyrene emission is expected be MODERATE.

Mercury Human Health Risks

As noted in Section 8.1.1, the EPA determined that coal-fired electric utility steam generating power plants were significant emitters of hazardous air pollutants and concluded that mercury is the hazardous air pollutant of greatest concern due to its persistence in the environment, potential to bioaccumulate, and toxicity to humans and the environment (65 FR 32214). Non-cancer risks of oral exposure to methyl-mercury have been observed to produce significant developmental effects in humans. Infants born to women who ingested high concentrations of methyl mercury exhibited central nervous system effects, such as mental retardation, ataxia, deafness, constriction of the visual field, blindness, and cerebral palsy. At lower methyl-mercury concentrations, developmental delays and abnormal reflexes were noted (ATSDR 1999, EPA 1997). No studies are available on the carcinogenic effects or cancer risks of methyl-mercury in humans, and only one available animal study reported renal tumors in mice; nevertheless, the EPA has classified methyl-mercury as a possible human carcinogen (EPA 1999d). The methyl-mercury dose resulting from emissions from a typical coal-fired power plant are uncertain. As noted in Section 8.1.1, EPA's CAMR regulation was vacated this year, and the near-term regulatory structure for mercury emission is uncertain. It is possible that EPA will return to regulating mercury as a HAP. The NRC staff expects that the EPA will implement new mercury regulations prior to the operational date of a coal-fired alternative. Because any new coal-fired plant will have to comply with EPA regulatory limits, the health risks to occupational workers and members of the public from mercury emissions is expected be MODERATE.

NOx and SO_2 Human Health Risks

NOx causes a wide variety of health risks and environmental impacts because of various compounds and derivatives in the family, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide. NOx reacts with ammonia, moisture, and other compounds to form nitric acid and related particles. Human health risks include impacts to the respiratory system, damage to lung tissue, and premature death. Small particles penetrate deeply into sensitive parts of the lungs, and can cause or worsen respiratory diseases such as emphysema and bronchitis, and can aggravate existing heart disease (EPA 2008a). Environmental impacts include increased acidic deposition, and contributions to acid rain.

The combustion of fossil fuels (particularly coal) accounts for 50 percent of annual global SO_2 emissions. Human health risks of SO_2 include aggravation of asthma and chronic bronchitis, emphysema, impairment of pulmonary functions, respiratory irritation, and increased mortality. Environmental concentrations of 50-100 micrograms per cubic meter ($\mu g/m^3$) affect some plants species. SO_2 also contributes to the formation of acid rain in a similar manner as NOx (EPA 2008c).

As indicated in the Air Quality section, NOx and SO_2 emissions from coal-fired power plants are subject to the requirements in Title IV of the CAA. Because CAA regulations are based on human health or environmental criteria for setting permissible levels, it sets limits both to protect public health (including the health of "sensitive" populations such as asthmatics, children and the elderly) and to protect public welfare (including protection against decreased visibility, and damage to animals, crops, vegetation, and buildings). Given that the plant must comply with CAA regulatory limits, the environmental impact and health risks to occupational workers and members of the public from NOx and SO_2 is expected be MODERATE.

Summary

Regulatory agencies, including the EPA and State agencies, set air emission standards and requirements based on human health risks. These agencies also impose site-specific emission limits as needed to protect human health. Human health risks to occupational workers and to members of the public from a coal-fired power plant are expected be SMALL to MODERATE. Trading or offset mechanisms in nonattainment areas will act to prevent further degradation.

8.1.6 Socioeconomics

Land Use

The GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a new supercritical coal-fired power plant. Land-use impacts would vary depending on where the plant would be located and whether construction would take place on undeveloped land or within a previously disturbed (brownfield) area.

Exelon Generation indicated that approximately 129 ac (52 ha) would be necessary to support a coal-fired alternative capable of replacing TMI-1. The GEIS, however, estimates a need for up to 1,700 ac (688 ha) for a 1,000-MWe generating station (NRC 1996). This amount of land use would include other plant structures and associated infrastructure. By scaling the GEIS estimate, a 853-MWe plant could require up to approximately 1,450 ac (587 ha) of land for the plant site, transmission line ROWs, and a rail spur.

Based on land use for other power plants, the NRC staff believes the Exelon Generation estimate to be reasonable, although additional land may be used for buffer around plant structures or to support transmission lines and a rail spur. Even assuming additional land use for these purposes, total land required by the coal-fired alternative is unlikely to exceed 1,450 ac (587 ha) for all uses, excluding coal mining.

Many locations suitable for siting the coal-fired alternative (especially flat terrain areas along rivers similar to power plants currently located in this part of the United States) may have been disturbed by previous development. Brownfield sites, or sites that were previously used for industrial purposes, may be the most likely location for a new supercritical coal-fired power plant. Sites along rivers generally have easier access to transportation for coal fuel and major plant components, both by barge and train. Sites that have previously been used for industrial activities may also have existing rail spurs and dock or pier infrastructure and may be closer to transmission lines.

Coal mining introduces offsite land use impacts in addition to direct land use impacts from the construction and operation of new coal-fired power plants. Land disturbance would likely occur in Pennsylvania, Ohio, or West Virginia because a significant amount of coal used in Pennsylvania power plants originates in these three States, although significant amounts of coal also come from Kentucky and western States like Wyoming (EIA 2006).[7]

According to analyses conducted for the GEIS, approximately 22,000 ac (8,903 ha) of land could be affected by coal mining and waste disposal in support of a 1,000-MWe coal plant during its operational life (NRC 1996). By scaling the GEIS estimate, an 853-MWe plant could require up to 18,800 ac (7,600 ha) of land to support a coal-fired power plant capable of replacing TMI-1; however, most of this land is located in existing coal-mining areas and has already been disturbed. The elimination of uranium fuel for TMI-1 could partially offset off site land use. In the GEIS, the NRC staff estimated that approximately 1,000 ac (405 ha) would not be needed for mining and processing uranium during the operating life of a 1,000-MWe nuclear power plant. For TMI-1, roughly 850 ac (344 ha) of uranium mining area would no longer be needed. However, an additional 159 ac (64 ha) of land would be needed for waste disposal during the 40 year plant life.[8] This is a smaller amount of land area than was estimated by Exelon Generation in the ER (AmerGen 2008), because of higher ash and gypsum recycling rates.

Land use impacts could range from MODERATE to LARGE, depending on where the power plant is located. The amount of land required under the coal-fired alternative could be reduced by constructing new transmission lines in existing ROWs.

Socioeconomics

Socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new coal-fired power could affect regional employment, income, and expenditures. Job creation is characterized by two types: (1) construction-related jobs, which are transient, short in duration, and less likely to have a long-term socioeconomic impact; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements of power plant construction and operation for the coal-fired alternative were determined in order to measure their possible effect on current socioeconomic conditions.

Exelon Generation projected a maximum construction workforce of 1,328 (AmerGen 2008). The GEIS projects a workforce of 1,200 to 2,500 for a 1,000-MWe plant (when extrapolated, a workforce of 1,000 to 2,100 for an 853-MWe plant). The NRC staff believes that the Exelon Generation estimate is reasonable and is within the range provided by the GEIS. Furthermore, the upper-end estimate of the GEIS is probably too large.

During the five-year construction period, the communities surrounding the plant site would experience increased demand for rental housing and public services, although these effects would be moderated if the construction site is located near an urban area with many skilled

7 Western coal tends to have lower sulfur and somewhat lower heating content than eastern coal. Many power stations use western, subbituminous coal to reduce sulfur oxide emissions without having to install scrubber equipment. A power plant equipped with scrubbers is more likely to use local, higher sulfur coals rather than incurring the cost of shipping low-sulfur coal from western states.

8 Only half of the land area needed for waste disposal is directly attributable to the alternative of renewing the TMI-1 operating license for 20 years.

workers. The relative economic effect of these workers on local economy and tax base would vary over time.

After construction, local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. As noted in the GEIS, the socioeconomic impacts at a rural construction site could be larger than at an urban site, because the workforce would have to move to be closer to the construction site. The impact of construction on socioeconomic conditions could range from SMALL to LARGE depending on whether the new power plant would be located at an urban or rural site. The socioeconomic impacts of power plant construction could be reduced if the power plant is located near an urban area with many skilled workers.

Exelon Generation estimated a power plant operations workforce of 92 (AmerGen 2008), while extrapolated GEIS estimates would call for up to 213 workers. The Exelon Generation estimate appears reasonable and is consistent with trends toward lowering labor costs by reducing the size of power plant operations workforces. Operations impacts will likely be SMALL to MODERATE, depending on whether the power plant is located near an urban or rural area.

Transportation

During five years of construction, up to 2,100 workers would be commuting to the construction site. This would increase the volume of traffic on roads leading to and coming from the construction site. Effects would vary depending on the number of site access roads. In addition to workers vehicles, trucks would deliver construction material and remove debris from the worksite. The number of additional vehicles on local roads could increase the overall effect. Trains or barges, or both, could be used to deliver large power plant components to the plant site.

Transportation impacts would be greatly reduced after construction of the power plant. The number of operations personnel commuting to and from the plant site would range from 92 to 213 workers. More significant, though, would be the frequent deliveries of coal and limestone to the plant site, most likely by rail, which would result in traffic delays at railroad crossings. Approximately 252 unit trains (trains with up to 100 cars carrying 100 t of coal per car for 10,000 t [9,070 MT] per train) per year would be necessary. Onsite coal storage would make it possible to receive several trains per day. Limestone would also be delivered by rail, which could cause additional traffic delays at railroad crossings (though considerably less rail traffic than that generated by coal deliveries). If coal and limestone were delivered by barge, rail transportation-related impacts to be would be reduced.

Overall, the coal-fired alternative would likely have SMALL to MODERATE transportation impacts in the vicinity of the power plant site, although the extent of impacts would depend on existing infrastructure capacity and demand, as well as whether coal and limestone would be delivered by rail or barge.

Aesthetics

Aesthetic resources are the natural and man-made features that give a particular landscape its character and aesthetic quality. The aesthetics impact analysis focuses on the degree of contrast between the power plant and the surrounding landscape and the visibility of the power plant.

The coal-fired alternative's power plant could be up to 200 ft (61 m) tall and may be visible off site in daylight hours. The exhaust stack could be up to 600 ft (183 m) high (at least 500 ft [152 m] for good engineering practice). Additional visual impacts would occur if a natural-draft cooling tower is constructed. Similar to the cooling towers at TMI-1, the natural-draft cooling tower may be several hundred feet high and sometimes topped with condensate plumes. Mechanical draft towers would also generate condensate plumes but will be lower than the plumes from the natural-draft tower. Other buildings onsite may also affect aesthetics, as could construction of new transmission lines. Noise and light from plant operations, as well as lighting on plant structures, may be detectable off site.

If the coal-fired alternative is located along a river valley terrain, impacts may be moderated by higher elevation ridges along the valley rim, which could make it difficult to see and hear the plant outside of the river valley. Aesthetic impacts could be further mitigated if the plant were located in an industrial area adjacent to other industrial facilities and power plants. Overall, the aesthetic impacts associated with the coal-fired alternative would likely be SMALL to MODERATE, depending on the location of the site, topography, and proximity to other industrial facilities, as opposed to areas where visual resources are particularly valued.

Historic and Archaeological Resources

It is difficult to determine the effects on historic and archaeological resources when a specific location has not been selected. The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas will need to be surveyed to identify and record historic and archeological resources, identify cultural resources, and develop possible mitigation measures to address any adverse effects from ground-disturbing activities. Studies will be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction will occur (e.g., roads, transmission corridors, rail lines, or other ROWs). In most cases, project proponents should avoid areas with the greatest sensitivity. Depending on the resource richness of the site ultimately chosen for the coal-fired alternative, impacts will range from SMALL to MODERATE.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new supercritical coal-fired power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. The minority and low-income populations are subsets of the general public residing around the site, and all are exposed to the same hazards generated from various operations at the site.

Minority and low-income populations could be affected by the construction and operation of a new supercritical coal-fired power plant. Some of these effects have been identified in resource areas discussed in this section. The extent of environmental justice effects is difficult to determine since it would depend in part on the location of the coal-fired power plant and whether a plant in a given location would contribute to impacts that are both adverse and disproportionate for minority or low-income populations. For example, increased demand for rental housing during construction could disproportionately affect low-income populations. However, demand for rental housing could be mitigated if the alternate plant site is constructed near a metropolitan area. Also, increased coal consumption may affect employment opportunities and environmental conditions in low-income regions in Pennsylvania, Ohio, or West Virginia.

Environmental justice impacts on minority and low-income populations from the construction and operation of a coal-fired alternative could range from SMALL to MODERATE and would depend on whether effects from the plant on minority and low-income populations are adverse and disproportionate.

8.1.7 Waste Management

Coal combustion generates several waste streams including ash (a dry solid) and sludge (a semi-solid by-product of emission control system operation). The NRC staff estimates that an 850-MWe power plant would generate 222,000 t (201,000 MT) of ash and approximately 55,200 t (50,000 MT) of scrubber waste per year, which would need to be disposed of onsite or in an offsite landfill (ACAA 2007). Based on industry-wide average recycling rates, of this waste, 182,000 t (165,000 MT) of the ash and 208,000 t (188,000 MT) of scrubber sludge could be recycled (ACAA 2007).

On-site disposal is likely to encompass approximately 159 ac (64 ha) over 40 years of operation. In addition to coal combustion wastes, a supercritical coal-fired alternative would also produce small amounts of domestic and hazardous wastes.

Waste impacts to ground water and surface water would extend beyond the operating life of the plant if leaching and runoff from the waste storage area makes its way into ground water or surface water. Disposal of the waste would noticeably affect land use and ground water quality if not properly managed, but with appropriate management and monitoring, impacts to ground water resources would be prevented. After closure of the landfill and revegetation, the disposal area would be available for other uses. Impacts of the waste generated by a coal-fired alternative are considered by the NRC to be SMALL to MODERATE.

8.2 Natural Gas Combined-Cycle Generation

In this section, we evaluate the environmental impacts of natural gas-fired combined-cycle generation at the TMI-1 site and at an alternate site. On page 8-18, Table 8-2 contains a summary of environmental impacts of natural gas combined-cycle generation in comparison to continued operation of TMI-1.

Natural gas fueled 20 percent of electric generation in the United States in 2006 (the most recent year for which data are available), accounting for the second greatest share of electrical power after coal (EIA 2007). Like coal-fired power plants, natural-gas-fired plants may be affected by perceived or actual action to limit greenhouse gas emissions, though they produce markedly fewer greenhouse gases per unit of electrical output than coal-fired plants. Natural gas-fired power plants are feasible, commercially available options for providing electrical generating capacity beyond TMI-1's current license expiration.

Combined-cycle power plants differ significantly from coal-fired and existing nuclear power plants. They derive the majority of their electrical output from a gas-turbine cycle, and then generate additional power—without burning any additional fuel—through a second, steam-turbine cycle. The first, gas turbine stage (similar to a large jet engine) burns natural gas which turns a driveshaft that powers an electric generator. The exhaust gas from the gas turbine is still hot enough, however, to boil water to steam. Ducts carry the hot exhaust to a heat recovery steam generator, which produces steam to drive a steam turbine and produce additional electrical power. The combined-cycle approach is significantly more efficient than any one cycle on its own; efficiencies can exceed 60 percent. Since the natural-gas-fired alternative derives much of its power from a gas turbine cycle, and because it wastes less heat than either the coal-fired alternative or the existing TMI-1, it requires significantly less cooling water and smaller cooling towers.

In order to replace the 802 MWe that TMI-1 currently supplies, the NRC selected a gas-fired alternative that uses two General Electric S107H combined-cycle generating units. While any number of commercially-available combined-cycle units could be installed in a variety of combinations to replace the power currently produced by TMI-1, the S107H is a highly-efficient model that will help to minimize environmental impacts. Other manufacturers, like Siemens, offer similar high efficiency models. This gas-fired alternative produces a net 400 MWe per unit. Two units produce a total of 800 MWe, or nearly the same output as TMI-1.

The combined-cycle alternative operates at a heat rate of 5,690 Btu/kWh, or nearly 60 percent thermal efficiency (GE 2007). Allowing for onsite power usage, including cooling towers and site lighting, the gross output of these units would be roughly 830 MWe. As noted above, this gas-fired alternative would require much less cooling water than TMI-1, because it operates at a higher thermal efficiency and requires much less water for steam cycle condenser cooling. Cooling towers for this alternative would likely be mechanical draft-type towers approximately 65 ft (20 m) in height.

In addition to cooling towers, other visible structures onsite include the turbines and heat recovery steam generators (which may be enclosed in a single building), two exhaust stacks, an electrical switchyard, and, possibly, equipment associated with a natural gas pipeline, like a compressor station. The GEIS (NRC 1996) estimated that a 1,000 MWe gas-fired alternative would require 110 ac (40 ha), meaning this 830-MWe plant would require 92 ac (37 ha). Exelon Generation indicated that the plant would require 32 ac (13 ha), a number more consistent with minimum utility needs as demonstrated by nearby power plants (including Dominion Resources' Fairless Energy Works). We will adopt Exelon Generation's estimate for the purposes of the following analysis.

This 830 MWe power plant would consume 34.2 billion cubic feet (ft^3) (970 million m^3) of natural gas annually assuming an average heat content of 1,033 Btu/ft^3 (EIA 2006). Natural gas would be extracted from the ground through wells, then treated to remove impurities (like hydrogen sulfide), and blended to meet pipeline gas standards, before being piped through the interstate pipeline system to the power plant site. This gas-fired alternative would produce relatively little waste, primarily in the form of spent catalysts used for emissions controls.

Environmental impacts from the gas-fired alternative will be greatest during construction. Site crews will clear vegetation from the site, prepare the site surface, and begin excavation before other crews begin actual construction on the plant and any associated infrastructure, including a pipeline spur to serve the plant and electricity transmission infrastructure connecting the plant to existing transmission lines.

Constructing the gas-fired alternative on Exelon Generation property located immediately south of remaining TMI Unit 2 plant structures would allow the gas-fired alternative to make use of TMI-1's existing transmission system, as well as take advantage of an already cleared and graded section of Three Mile Island. During the environmental site audit, TMI-1 staff indicated that some of this land is occasionally used for parking during outages and could be used during TMI-1 and TMI Unit 2 decommissioning. Additional offsite land, land farther south on Three Mile Island, or remaining land around the new gas-fired plant may be available for occasional use to offset this land requirement.

A gas-fired unit constructed offsite may cause additional construction-related impacts depending on the nature of the site selected (e.g., a site that has never been developed will likely experience greater impacts than a site that was previously industrial; a site near other power plants or industrial facilities will likely experience smaller impacts than a site surrounded by farmland or relatively natural surroundings).

Table 8-2. Summary of Environmental Impacts of Natural Gas Combined-Cycle Generation Compared to Continued Operation of TMI-1.

	Natural Gas Combined-Cycle		**Continued TMI-1 Operation**
	At TMI-1 site	**At alternate site**	
Air Quality	MODERATE	MODERATE	SMALL
Ground Water	SMALL	SMALL	SMALL
Surface Water	SMALL	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL TO LARGE	SMALL
Human Health	SMALL	SMALL	SMALL
Socioeconomics	SMALL TO MODERATE	SMALL TO MODERATE	SMALL
Waste Management	SMALL	SMALL	N/A

8.2.1 Air Quality

Dauphin County does not meet the National Ambient Air Quality Standards established by EPA under the CAA and is a nonattainment area for $PM_{2.5}$. A new gas-fired generating plant developed at the TMI-1 site would need to comply with the new source performance standards set forth in 40 CFR 60 Subpart D(a). The standards establish limits for particulate matter and opacity (40 CFR 60.42(a)), SO_2 (40 CFR 60.43(a)), and NOx (40 CFR 60.44(a)).

A gas-fired power plant constructed elsewhere in Pennsylvania would need to comply with applicable provisions of the CAA, based on the attainment status of the selected alternate site. If a natural gas-fired plant were located close to a mandatory Class I area, additional air pollution control requirements could be imposed. Pennsylvania does not have any designated Class I wilderness areas, the closest being Brigantine, New Jersey. For an alternate site, consideration may need to be given to installation of additional air emission control systems if the plant could potentially affect visibility in any of the Class I areas.

Pennsylvania regulates air emissions from power plants pursuant to terms of the APCA, as discussed in Section 8.1.1. Regulations enforced by the PADEP adopt the EPA's CAA rules, with modifications, to limit power plant emissions of SOx, NOx, particulate matter, and hazardous air pollutants, among other matters (PADEP 2008). Depending where a new gas-fired facility is located within the State, that facility will need to comply with the applicable Federal and State air regulations.

NOx is typically the pollutant of greatest concern for natural-gas-fired power plants. This gas-fired alternative relies on dry, low-NOx burners, as well as selective catalytic reduction (SCR) to reduce NOx emissions.

Pennsylvania and most other eastern states had been subject to requirements of 40 CFR 51.121(e), "Findings and requirements for submission of State implementation plan revisions relating to emissions of oxides of nitrogen," and the total amount of NOx emissions allowed for the Pennsylvania State implementation plan was 257,928 t (233,988 MT) for the 2007 ozone season, and would have been subject to ozone-controlling elements of the Clean Air Interstate Rule (CAIR) had CAIR not been vacated by the D.C. Circuit Court in July of 2008. On September 24, 2008, EPA filed for a rehearing of the D.C. Circuit Court decisions. Until EPA, Congress, or the courts act, future NOx regulatory approaches remain uncertain.

The NRC staff projects the following emissions for a gas-fired alternative based on data published by the EIA, on EPA emissions factors, and on performance characteristics for this alternative and its emissions controls:

- Sulfur dioxide – 60 tons per year (t/yr)
- Nitrogen oxides – 192 t/yr
- Carbon monoxide- 40 t/yr
- PM_{10} – 33.5 t/yr

A natural gas-fired plant would also have unregulated CO_2 emissions and, in the case of this alternative to TMI-1, would emit approximately 1.99 million tons of CO_2 per year.

In December 2000, the EPA issued regulatory findings on emissions of hazardous air pollutants from electric utility steam-generating units (65 FR 32214). Natural gas-fired power plants were found by the EPA to emit arsenic, formaldehyde, and nickel. Unlike coal- and oil-fired plants, the EPA did not determine that emissions of hazardous air pollutants from natural gas-fired power plants should be regulated under Section 112 of the CAA.

Construction activities would also result in some air effects, including those from temporary fugitive dust, though construction crews would employ dust-control practices to limit this impact. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process, though these emissions are likely to be intermittent in nature and will occur over a limited period of time. As such, construction stage impacts would be SMALL.

The overall air-quality impacts of a new natural gas-fired combined cycle plant sited at TMI-1 or at an alternate site would be MODERATE.

8.2.2 Ground Water Use and Quality

The use of ground water for a natural gas combined cycle plant would likely be limited to supply wells for drinking water and possibly filtered service water for system cleaning purposes. The impact of ground water use would be SMALL. No effects on ground water quality would be apparent except during the construction phase when possible dewatering and run-off controls are used.

8.2.3 Surface Water Use and Quality

Consumptive use of surface water from the Susquehanna River, or from another body of water at an alternate site, would be much less for a gas-fired plant than the 18 mgd currently used on average by TMI-1. In addition, the discharge of waste water using this technology would be minimal. Impact on surface water resources at both the TMI-1 site and an alternate site would be SMALL.

8.2.4 Terrestrial and Aquatic Ecology

Terrestrial Ecology

As indicated in previous sections, constructing the natural gas alternative will require 32 ac (13 ha) of land. These land disturbances form the basis for impacts to terrestrial ecology. (Gas extraction and collection will also affect terrestrial ecology in offsite gas fields, although, as noted in Section 8.2.6, much of this land is likely already disturbed by gas extraction, and the incremental effects of this alternative on gas field terrestrial ecology are difficult to gauge.)

Impacts to terrestrial ecology will be minor because the selected site has been previously disturbed and is located on the southern end of the island. There is potential for disturbance of some areas with trees or manmade wetlands, and possible habitat fragmentation would occur. Construction of transmission line ROWs, a lengthy pipeline, or additional roads on undisturbed or less-disturbed areas could adversely impact terrestrial ecology by fragmenting or destroying habitats. However, a pipelined fuel source and a small workforce would help to minimize the need for additional transportation infrastructure.

In addition, construction onsite may eliminate onsite habitats and alter the site for a long period of time. Some areas onsite, such as any buffer areas, may remain undeveloped and could still harbor habitat for terrestrial species, though site lighting, noise, and activities may degrade the value of any remaining ecosystems. Deposition of air pollutants from this alternative may affect terrestrial ecology, but it is unlikely to be noticeable. Impacts to terrestrial resources from a natural gas combined-cycle alternative at both the TMI-1 site and an alternate site would like be SMALL.

Aquatic Ecology

Aquatic ecology actually benefits from the onsite, gas-fired alternative, as the combined-cycle plant rejects significantly less heat to the environment than the existing TMI-1, thus requiring less water. A gas-fired alternative would require less than half as much water as the existing plant due to its much higher thermal efficiency. As the onsite gas-fired alternative would continue to use the existing cooling system, impacts to aquatic ecology would also be minimal. Aquatic impacts at an alternate site depend on location and ecology of the site, and the surface water body used for intake and discharge. These impacts are likely smaller at urban or previously industrial sites, owing to generally closer access to pipelines and transmission lines than at undeveloped sites. Overall, the ecological impacts are considered SMALL at the TMI-1 site and could range from SMALL to LARGE at a different location, depending on the sensitivity of local aquatic communities.

8.2.5 Human Health

Like the coal-fired alternative discussed above, a gas-fired plant would emit criteria air pollutants, but generally in smaller quantities (except NOx, which requires additional controls to reduce emissions). Human health risks of a gas-fired alternative are generally low, although in Table 8-2 of the GEIS (NRC 1996), the NRC staff identified cancer and emphysema as potential health risks from a gas-fired alternative. However, the current Federal and State regulatory frameworks, pertaining to air emission standards, allow for the adequate protection of occupational workers and members of the public. Therefore, the NRC staff has adopted (where applicable) the Federal and State air quality regulatory limits as significant thresholds for determining the human health risks associated with the operation of a new gas-fired power plant.

NOx emissions contribute to ozone formation, which in turn contribute to human health risks. Emission controls on this gas-fired alternative maintain NOx emissions well below air quality standards established for the purposes of protecting human health, and emissions trading or offset requirements mean that overall NOx in the region would not increase. Health risks to workers may also result from handling spent catalysts that may contain heavy metals. Overall, human health risks to occupational workers and to members of the public from gas-fired power plant emissions sited at TMI-1 or at an alternate site would be similar to the risks described for coal-fired alternative and therefore, would likely be SMALL.

8.2.6 Socioeconomics

Land Use

A discussed in Section 8.1, the GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a natural gas-fired combined-cycle generation power plant at the TMI-1 site and at an alternate site. Land-use impacts would vary depending on where the plant would be located and whether construction would take place on undeveloped land or within a previously disturbed (brownfield) area.

Exelon Generation indicated that approximately 32 ac (13 ha) would be necessary to support a natural gas-fired alternative capable of replacing TMI-1. The GEIS, however, estimates 110 ac (45 ha) for a 1000-MWe generating station (NRC 1996). This amount of land use would include other plant structures and associated infrastructure. By scaling the GEIS estimate, an 853-MWe plant could require up to 92 ac (37 ha) of land. This amount of land will encompass the plant site at both TMI-1 and an alternate site, and transmission line ROWs at an alternate site. The NRC staff believes that the Exelon Generation estimate is reasonable. However, if additional land would be necessary for a buffer around plant structures or to support transmission lines at an alternate site and gas pipelines at both TMI-1 and at an alternate site, the NRC staff believes the GEIS estimate for land use provides a more useful approximation. Nevertheless, land use impacts from construction would be SMALL, and could be further reduced if the power plant is collocated with another generating station or on a previously industrial site like TMI-1. Impacts could be further mitigated at an alternate site by constructing new transmission lines in existing ROWs.

In addition to onsite land requirements, land will be required off site for natural gas wells and collection stations. The GEIS estimates that 3,600 ac (1,457 ha) would be required for wells, collection stations, and pipelines to bring the gas to a 1,000-MWe generating facility. If this land requirement were scaled directly with generating capacity, an alternative to TMI-1 could require up to 3,000 ac (1,200 ha) (though actual requirements will vary significantly). Most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas that could be used by the new power plant may come from outside of the United States and would be delivered as liquefied gas. Effects from gas extraction are generally smaller than those for coal mining, as most land around a gas extraction site remains undisturbed, except for roads and collection pipe network. Site reclamation after natural gas extraction would be less involved than land previously used for coal mining.

The elimination of uranium fuel for TMI-1 could partially offset off site land requirements. In the GEIS, the NRC staff estimated that approximately 1,000 ac (405 ha) would not be needed for mining and processing uranium during the operating life of a 1,000-MWe nuclear power plant. For TMI-1, roughly 850 ac (344 ha) of uranium mining area would no longer be needed. Overall land use impacts from a gas-fired power plant would be SMALL to MODERATE, depending on local land use and the availability of land near the proposed site.

Socioeconomics

As discussed in Section 8.1, socioeconomic impacts are defined as changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new natural gas-fired power could affect regional employment, income, and expenditures. Job creation is characterized by two types: (1) construction-related jobs, which are transient, short in duration, and less likely to have long-term socioeconomic impacts; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements of power plant construction and operations for the gas-fired alternative were determined in order to measure their possible effect on current socioeconomic conditions.

The socioeconomic impacts from constructing and operating a gas-fired plant would have little noticeable effect. Compared to the coal-fired alternative, the small size of the construction and operations workforce would have little or no socioeconomic impact.

Exelon Generation indicated that a 483-member workforce would be required to construct the gas-fired alternative (AmerGen 2008). After construction, local communities may be temporarily affected by the loss of construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. The impact of construction on socioeconomic conditions could range from SMALL to MODERATE depending on whether or not the new power plant would be located at TMI-1 or an alternate site. The socioeconomic impacts of power plant construction could be reduced if the power plant is located near an urban area with a large pool of skilled workers.

Following construction, a gas-fired alternative could provide up to 27 jobs, based on Exelon Generation estimates, or up to 125 jobs based on an extrapolated estimate fro the GEIS. Depending on location, the small number of workers would not have a noticeable effect on socioeconomic conditions in the region. Therefore, socioeconomic impacts associated with operation of a gas-fired power plant would be SMALL.

Transportation

Transportation impacts associated with construction and operation of a two unit power plant under the gas-fired alternative would consist of commuting workers and truck deliveries of construction materials to the TMI-1 worksite. Transportation effects would vary depending on the characteristics of site access roads. In addition to commuting workers, trucks would deliver construction materials to the worksite. These vehicles would increase the overall number of vehicles on local roads. Pipeline construction and modification to existing natural gas pipeline systems may also have a short-term impact.

Conversely, transportation impacts would almost disappear during plant operations. The estimated number of operating personnel would be approximately 27 workers, although the GEIS indicates that as many as 125 operations workers could be required. Since fuel is transported by pipeline, most transportation infrastructure will experience little increased use from plant operations.

Since fuel would be transported by pipeline, the transportation infrastructure would experience little to no increased use from plant operations. Overall, the gas-fired alternative would have a SMALL impact on transportation conditions in the region around TMI-1. Transportation impacts may vary at an alternate site and would depend on roadway capacity and average daily volume.

Aesthetics

As discussed in Section 8.1, aesthetic resources are the natural and man-made features that give a particular landscape its character and aesthetic quality. The aesthetics impact analysis focuses on the degree of contrast between the power plant and the surrounding landscape and the visibility of the power plant.

The two gas-fired units could be approximately 100 ft (30 meters [m]) tall, with two exhaust stacks at least 175 ft (53 m) tall or taller depending on the topography at an alternate site. Some structures may require aircraft warning lights. If the plant is located near the existing TMI-1, impacts may be moderated as higher elevations and vegetation along the river valley could make it difficult to see or hear the plant outside of the river valley. Power plant infrastructure would generally be smaller and less noticeable than TMI-1 containment and cooling tower. The mechanical draft cooling towers would be markedly shorter than the natural-draft towers located at TMI-1, but they would also generate condensate plumes and operational noise. Noise during power plant operations would be limited to industrial processes and communications.

In addition to seeing new power plant structures, the alternate plant site may require the construction of transmission lines and natural gas pipelines. The transmission lines would have a lasting visual effect on the landscape.

Noise from plant operations would be primarily limited to industrial processes and communications. Unlike the coal-fired alternative, pipelines would deliver natural gas fuel, thus eliminating the noises from fuel and waste handling and associated transportation equipment. Noise from the pipelines could be audible off site near compressors.

In general, aesthetic changes would be limited to the immediate vicinity of TMI-1 or an alternate site. Impacts would likely to be SMALL to MODERATE, depending on the amount of new transmission line required.

Historic and Archaeological Resources

The potential for historic and archaeological resources can vary greatly depending on the location of the proposed site. To consider a project's effects on historic and archaeological resources, any proposed areas will need to be surveyed to identify and record historic and archeological resources, identify cultural resources, and develop possible mitigation measures to address any adverse effects from ground disturbing activities. Studies will be needed for all areas of potential disturbance at the proposed plant site and along associated corridors where new construction will occur (e.g., roads, transmission corridors, rail lines, or other ROWs). In most cases, project proponents should avoid areas with the greatest sensitivity.

Depending on the resource richness of the site ultimately chosen for the gas-fired alternative, impacts will range from SMALL to MODERATE.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a new natural gas-fired combined-cycle generation power plant. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. The minority and low-income populations are subsets of the general public residing around the site, and all are exposed to the same hazards generated from various power plant operations.

Minority and low-income populations could be disproportionately affected by the construction and operation of a new natural gas-fired power plant. Some of these effects have been identified in resource areas discussed in this section. For example, increased demand for rental housing during construction could disproportionately affect low-income populations. However, demand for rental housing could be mitigated if the alternate plant site is constructed near a metropolitan area. Environmental justice impacts from the construction and operation of a gas-fired alternative could range from SMALL to MODERATE and would depend on whether effects from the plant on minority and low-income populations are adverse and disproportionate.

8.2.7 Waste Management

Minor quantities of waste are generated during burning of natural gas compared to other alternatives, however use of SCR to control NOx will generate spent SCR catalysts and small amounts of solid waste products.

It is concluded in the GEIS by the NRC staff that gas-fired technology waste generation would be minimal (NRC 1996) and the waste impacts would be SMALL for a natural gas-fired combined-cycle plant sited at TMI-1 or at alternate site.

8.3 Energy Conservation/Energy Efficiency

In this section, the NRC staff evaluates the environmental impacts of a demand-side energy conservation or energy efficiency alternative. On the following page Table 8-3 summarizes the environmental impacts of energy conservation and energy efficiency compared to continued operation of TMI-1.

Though often used interchangeably, energy conservation and energy efficiency are different concepts. Energy efficiency typically means deriving a similar level of services by using less energy, while energy conservation simply indicates a reduction in energy consumption. Both fall into a larger category known as demand-side management (DSM). DSM measures—unlike the energy supply alternatives discussed in previous sections—address energy end uses. DSM can include measures that shift energy consumption to different times of day to reduce peak loads, measures that interrupt certain large customers during periods of high demand or measures that interrupt certain appliances during high demand periods, and measures like replacing older, less efficient appliances, lighting, or control systems. DSM also includes measures that utilities use to boost sales, such as encouraging customers to switch from gas to electricity for water heating.

Unlike other alternatives to license renewal, the GEIS notes that conservation is not a discrete power generating source; it represents an option that states and utilities may use to reduce their need for power generation capability (NRC 1996). In addition, conservation represents a possible option in case of the no-action alternative. The GEIS "assumes that conservation technologies produce enough energy savings to permit the closing of a nuclear plant."

Prior to the implementation of Pennsylvania's Alternative Energy Portfolio Standard (AEPS), several Pennsylvania foundations sponsored a study by engineering firm Black and Veatch to document the potential effects renewable energy, conservation/efficiency, and unconventional power sources like waste coal (Pletka 2004). The study distinguished between energy efficiency and conservation, and defined conservation as demand-side measures, and efficiency as supply-side measure like repowering or other power plant, transmission, or distribution improvements. Because Black and Veatch's defined energy efficiency as only supply-side options, and because Black and Veatch defined conservation as including all demand-side measures to reduce electricity consumption, we will only use Black and Veatch's conservation estimates in the following section. Black and Veatch's analysis indicated 18,206 gigawatt-hours (GWh) of conservation could be achieved within 10-15 years of the study's 2004 publication date (Pletka 2004), or roughly three times the amount of electricity produced by TMI-1 in a given year. The total magnitude of these savings could be as large as 6872 MW, or more than eight times TMI-1's power output. Overall, Black and Veatch indicated that Pennsylvania had "good" conservation resources.

Since the study, PJM[9] has instituted new measures to capture energy efficiency potential, and energy efficiency measures which now count for inclusion in the AEPS. The NRC had difficulty determining how much of the potential identified in the 2004 report remains available in Pennsylvania, though it appears unlikely that all or even most of this potential would already have been exploited. Beyond near-term potential, Black and Veatch's analysis identified an additional 70,000 GWh or 28,824 MW of conservation potential, some of which may be available at higher costs or on longer time horizons. Also, because TMI-1 sells power into the PJM interconnection, conservation in other nearby states may also help to offset power produced by TMI-1, even though sufficient capacity appears to exist in Pennsylvania alone. Therefore, the NRC staff chose to evaluate conservation as an alternative to license renewal.

A conservation alternative will produce different impacts than the other alternatives addressed. Unlike the discrete generation options, there is no major construction and few ongoing operational impacts. The most significant effects occur during installation or implementation or conservation measures, when old appliances may be disposed of, buildings may be retrofitted, or control devices may be installed. In some cases, increases in efficiency may come from better management of existing control systems. Many of these items may be recycled, though volumes of landfilled trash may still increase.

The GEIS generally indicates that impacts from a conservation alternative are small and that some postulated effects (like increases in mercury, polychlorinated biphenyls (PCBs), or chlorofluorocarbon (CFC) releases as fluorescent bulbs, old transformers or old refrigerators are replaced) may prove not to be significant as effective disposal methods can prevent health effects, and as more environmentally-benign alternatives have emerged (NRC 1996).

Table 8-3. Summary of Environmental Impacts of Energy Conservation/Energy Efficiency Compared to Continued Operation of TMI-1.

	Energy Conservation/Energy Efficiency	Continued TMI-1 Operation
Air Quality	SMALL	SMALL
Ground Water	SMALL	SMALL
Surface Water	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL
Human Health	SMALL	SMALL
Socioeconomics	SMALL	SMALL
Waste Management	SMALL	N/A

[9] PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia, including Pennsylvania.

8.3.1 Air Quality

Implementation of the energy conservation alternative reduces direct fuel use and reduces environmental emissions resulting from plant fuel cycles, workers' commuting, and plant operation and maintenance. Improvements in efficiency may also reduce consumption of fuels used for space or water heating at the same time they reduce electrical consumption.

As noted above, no major construction would be required and few ongoing operational impacts would be experienced during implementation of the conservation alternative. The conservation alternative would likely cause only minor and short-duration air quality impacts—use of best management practices would minimize air quality impacts during installation of new appliances or systems. Implementation of energy conservation measures would improve efficiency of boilers and heating units and would help to reduce already low air emissions.

The overall impacts on air quality of the energy conservation and/or energy efficiency alternative would be SMALL.

8.3.2 Ground Water Use and Quality

The conservation alternative would not require any groundwater. It is possible that wastes produced during installation of improved equipment could have an effect on groundwater if leachate from landfills infiltrate groundwater, but this effect is not likely to be noticeably altered by a small increase in overall waste production, if any, associated with the conservation alternative. Overall impacts to groundwater are SMALL.

8.3.3 Surface Water Use and Quality

The impacts on surface water use and quality because of energy conservation efforts would be SMALL, but positive. The consumptive use of water from the Susquehanna River would certainly decrease as would the discharge of waste water streams.

8.3.4 Terrestrial and Aquatic Ecology

<u>Terrestrial Ecology</u>

Terrestrial ecology impacts would be SMALL. No additional land disturbances on or offsite would be required.

<u>Aquatic Ecology</u>

Impacts to aquatic resources would be SMALL, but positive, as withdrawals from and discharges to the Susquehanna River would cease, since the no-power generation alternative would take the place of TMI-1. If more energy is conserved than is produced by TMI-1, then positive impacts to aquatic resources could extend beyond the Susquehanna River to other water bodies. This net conservation of energy could result in less demand for power production at other plants and could lead to lower rates of water withdrawal and discharge at these power plants. The implementation of conservation measures, such as the increased use of mercury-containing compact fluorescent light bulbs and their impact to the environment after landfill disposal, would result in SMALL impacts to the aquatic environment. While increased mercury levels in landfills could leach into adjacent waterways, State and local landfill regulations could reduce or eliminate such pollution.

8.3.5 Human Health

Energy demand reduction measures are specific procedures or technologies that are undertaken to reduce energy demands. Human health risks of the energy conservation alternative are minimal, although in Table 8-2 of the GEIS (NRC 1996) the NRC staff identified radon as the major potential health risk from the energy conservation alternative. Currently, there are no Federal or State regulatory frameworks pertaining to radon exposure standard, therefore, the NRC staff has chosen the EPA recommendation level of 4 picocuries per Liter (pCi/L) as a significant threshold for determining the human health risks associated with the energy conservation alternative.

Radon-222 is a naturally occurring radioactive noble gas that is formed from the decay of radium-226. Radiation exposure from radon-222 is indirect. Radon has a short half-life (4 days) and decays into other solid particulate radioactive nuclides that give off high energy alpha particles. These radioactive particles are inhaled and remain lodged in the lungs, causing continued exposure. People in affected localities can receive up to 10 mSv per year background radiation of radon-222. Radon-222 is thus the second leading cause of lung cancer after smoking, and accounts for 15,000 to 22,000 cancer deaths per year in the U.S. alone (Darby 1989). The general population is exposed to small amounts of polonium as a radon-daughter in indoor air; the isotopes polonium-214 and polonium-218 are thought to cause the majority of the estimated lung cancer deaths from radon (Darby 1989). A Bonneville Power Administration radon-222 exposure study found that radon-222 was a serious concern in new home construction if mitigation measures were not implemented. Cancer cases from radon-222 exposures were estimated to be 335 per 100,000 for baseline homes but as high as 767 cases per 100,000 for new homes with advanced infiltration control but no exhaust or mechanical ventilation (Pace 1991).

EPA recommends homes be fixed if the radon level is 4 pCi/L or more. Because there is no known safe level of exposure to radon, EPA also recommends that Americans consider fixing their homes for radon levels between 2 pCi/L and 4 pCi/L. The average radon concentration in the indoor air of America's homes is about 1.3 pCi/L. The average concentration of radon in outdoor air is 0.4 pCi/L, about 1/10th of EPA's 4 pCi/L action level (EPA 2008b). Given that a member of the public has taken appropriate mitigative actions—such as installing a more efficient ventilation system for radon removal, sealing cracks in basements, etc.—to achieve an indoor radon concentration below 2 pCi/L, the human health risks to members of the public from the energy conservation alternative would be within the range of the national average and would likely be SMALL.

8.3.6 Socioeconomics

Land Use

Since Exelon Generation would continue to use the existing transmission lines land use impacts of an energy efficiency alternative would be SMALL. Quickly replacing and disposing of old inefficient appliances could generate waste material and potentially increase the size of landfills. However, given the 10 to 15-year timeline for program development and implementation, the cost of replacements, and the average life of an appliance; the replacement process would probably be more gradual. Older appliances would simply be replaced by more efficient appliances as they fail (especially in the case of frequently replaced items, like lightbulbs). In addition, many items (like home appliances or industrial equipment) have substantial recycling value and would likely not be disposed of in landfills.

Socioeconomics

Socioeconomic effects of an energy efficiency program would be SMALL. As noted in the GEIS, the program would likely employ additional workers. Lower-income families could benefit from weatherization and insulation programs. This effect would be greater than the effect for the general population because low-income households experience home energy burdens more than four times larger than the average household (OMB 2007).

Transportation

Transportation impacts would be SMALL, because fewer employees would commute to TMI-1. Any transportation effects from the energy efficiency alternative would be widely distributed across the State, and would not be noticeable.

Aesthetics

Impacts from energy efficiency programs would be SMALL because TMI-1 would be decommissioned with no alternative power plant to replace it. The transmission lines would remain after plant decommissioning. Traffic to the plant would decrease, however, as would noise and emissions. Some noise impacts could occur in instances of energy efficiency upgrades to major building systems, though this impact would be intermittent and short-lived.

Historic and Archaeological Resources

Impacts from the energy conservation/energy efficiency alternative would be SMALL, since TMI-1 would be decommissioned with no alternative power plant to replace it. A separate environmental review would be conducted for decommissioning. That assessment will address the protection of historic and archaeological resources.

Environmental Justice

Weatherization programs could target low-income residents as a cost-effective energy efficiency option since low-income populations tend to spend a larger proportion of their incomes paying utility bills (according to the Office of Management and Budget, low income populations experience energy burdens more than four times as large as those of average households [OMB 2007]). Impacts to minority and low-income populations from energy efficiency programs would be SMALL, depending on program design and enrollment. The impacts from these programs may be disproportionate, but are not likely to be adverse.

8.3.7 Waste Management

The most significant effects occur during installation or implementation or conservation measures, when old appliances may be disposed of, buildings may be retrofitted, or control devices may be installed. Implementation of the recycling programs would help to decrease volumes of the generated waste, though volumes of the trash sent to the landfills may still increase.

According to the GEIS, impacts from a conservation alternative are minimal, and some postulated effects (like increases in mercury, PCBs, or CFC releases as fluorescent bulbs, old transformers or old refrigerators are replaced) may prove to be insignificant as more environmentally-benign alternatives have emerged, and if proper disposal methods are employed (NRC 1996).

Overall, the waste impacts would be SMALL for the energy conservation and/or energy efficiency alternative.

8.4 Combination Alternative

In this section, we evaluate the environmental impacts of a combination of alternatives. This combination will include a portion of the energy efficiency/conservation potential identified in Section 8.3, a portion of the combined-cycle gas-fired capacity identified in Section 8.2, and a series of uprates to existing hydroelectric dams. This alternative requires little new construction (only for the single gas-fired unit installed at the TMI-1 site and minor renovation at uprated dams). We acknowledge that we could also include some amount of wind power in this alternative as a companion to the hydropower uprates, though the NRC elected not to do so since constructing wind power facilities would likely increase the environmental impact of the combination alternative without a commensurate decrease in operating impacts from other portions of the combination alternative. Table 8-4 on the following page contains a summary of the environmental impacts of the combination alternative compared to continued operation of TMI-1.

In this alternative, slightly more than half of TMI-1's output (approximately 420 MW) would be replaced by conservation. Power uprates at existing hydroelectric dams will account for roughly 100 MWe of capacity (as identified in INEEL 1997) and 280 MWe will come from one GE S107FB combined cycle power plant. The only major construction we anticipate will happen at the current TMI-1 site where the combined-cycle gas-fired power plant would be constructed. No major construction should be necessary for the conservation portion, and relatively minor construction would occur at existing dams for purposes of power uprates.

The appearance of the single-unit gas-fired facility would be similar to that of the two-unit gas-fired alternative considered in Section 8.2, except smaller. We estimate that the single-unit gas-fired facility would require approximately 35 percent of the space necessary for the two-unit gas-fired facility considered in Section 8.2, and that all construction effects—as well as operational aesthetic, fuel-cycle, air quality, socioeconomic, land use, environmental justice, and water consumption effects—will scale accordingly.[10] Since the gas-fired portion of this alternative uses roughly a third of the available land south of TMI Unit 2 on Three Mile Island, Exelon Generation may still be able to use most of the available space for outage personnel and eventual decommissioning activities of TMI-1.

Table 8-4. Summary of Environmental Impacts of the Combination Alternative Compared to Continued Operation of TMI-1.

	Combination Alternative		Continued TMI-1 Operation
	At TMI-1 Site	At Alternate Site	
Air Quality	SMALL to MODERATE	MODERATE	SMALL
Ground Water	SMALL	SMALL	SMALL
Surface Water	SMALL	SMALL	SMALL
Aquatic and Terrestrial Resources	SMALL	SMALL	SMALL
Human Health	SMALL	SMALL	SMALL
Socioeconomics	SMALL to MODERATE	SMALL TO MODERATE	SMALL
Waste Management	SMALL	SMALL	N/A

8.4.1 Air Quality

As noted in Section 8.2.1, Dauphin County does not meet the National Ambient Air Quality Standards established by EPA under the CAA and is in a nonattainment area for $PM_{2.5}$. A new gas-fired generating plant developed at the TMI-1 site would need to comply with the new source performance standards set forth in 40 CFR 60 Subparts D(a). The standards establish limits for particulate matter and opacity, SO_2, and NOx.

Pennsylvania and most other eastern states had been subject to requirements of 40 CFR 51.121(e), "Findings and requirements for submission of State implementation plan revisions relating to emissions of oxides of nitrogen," and the total amount of NOx emissions allowed for the Pennsylvania State implementation plan was 257,928 t (233,988 MT) for the 2007 ozone season, and would have been subject to ozone-controlling elements of the Clean Air Interstate Rule (CAIR) had CAIR not been vacated by the D.C. Circuit Court in July of this year. On September 24, 2008, EPA filed for a rehearing of the D.C. Circuit Court decision. Until EPA, Congress, or the courts act, future NOx regulatory approaches remain uncertain.

As noted in 8.2.1, NOx is typically the pollutant of greatest concern for natural-gas-fired power plants. Like the plant in 8.2.1, this gas-fired portion of this alternative relies on dry, low-NOx burners, as well as selective catalytic reduction (SCR) to reduce NOx emissions.

For the combination alternative only one gas-fired unit would be built. Emissions of SOx, NOx, mercury, and particulate matter would be approximately 37 percent of those detailed in Section

10 The S107FB unit considered here is slightly less efficient than the S207H units considered in Section 8.2 (heat rate of 5950 btu/kWh for the S107FB versus 5690 btu/kWh for the S207H; GE 2007). We've calculated air quality impacts in the following sections accordingly.

8.2.1. A natural gas-fired plant would also have unregulated CO_2 emissions; a single-unit gas-fired facility would emit approximately 728,000 t (660,000 MT) of CO_2 per year.

As noted in 8.2.1, EPA has determined that natural gas-fired power plants emit arsenic, formaldehyde, and nickel. Unlike coal and oil-fired plants, EPA did not determine that emissions of hazardous air pollutants from natural gas-fired power plants should be regulated under Section 112 of the CAA.

Construction activities for the gas-fired unit as well as retrofits at existing dams would also result in some air effects, including those from temporary fugitive dust, though construction crews would employ dust-control practices to limit this impact. Exhaust emissions would also come from vehicles and motorized equipment used during the construction process, though these emissions are likely to be intermittent in nature and would occur over a limited period of time. Construction stage impacts would, therefore, be SMALL.

The overall air-quality impacts of the combination alternative—based largely on the impacts from a new, single-unit, natural gas-fired combined cycle plant sited at TMI-1—would be SMALL to MODERATE.

8.4.2 Ground Water Use and Quality

If the onsite gas-fired plant continued to use ground water for drinking water and service water, the total usage would likely be much less than TMI-1 uses, because many fewer workers are onsite, and because the gas-fired unit would have fewer auxiliary systems requiring service water. The current permitted withdrawal rate is 225,000 gpd, and pumping tests indicate this rate would not cause an effect on nearby supply wells. A reduction in this withdrawal rate means that impacts of the combination alternative would remain SMALL.

8.4.3 Surface Water Use and Quality

Using a combined alternative with conservation as a major component will reduce the amount of surface water consumed for cooling purposes. The maximum consumptive use would be reduced to a fraction of the 18 mgd used by the current nuclear plant. This represents less than 0.1 percent of the average annual flow rate in the river. The impact of this withdrawal would be SMALL.

8.4.4 Terrestrial and Aquatic Ecology

Terrestrial Ecology

Impacts to terrestrial ecology would be SMALL. ROW maintenance would continue, although no additional transmission lines would be necessary. The only construction activities that would occur for the combination alternative are the construction of a combined-cycle gas-fired power plant and any retrofit-related construction (largely internal) at existing dams. These activities would be confined to previously disturbed areas at the TMI-1 site, and would be relatively limited at dam sites. Some habitat fragmentation impacts on the southern part of the island may occur.

Aquatic Ecology

Aquatic ecology would actually benefit from the combination efficiency/conservation, hydroelectric power plant uprates, and gas-fired power plant alternative, as the combined-cycle plant would reject significantly less heat to the environment than the existing TMI-1, thus requiring less water. Impacts to aquatic resources would be SMALL, but positive, as withdrawals from and discharges to the Susquehanna River would be significantly less. Energy conservation and efficiency would likewise result in less withdrawals and discharges corresponding to a decreased demand for power generation as discussed in Section 8.3. Uprates to hydroelectric power plants to compensate for loss of power generation at TMI-1 could lead to slight increases in entrainment and impingement impacts at these hydroelectric plants, but these impacts would be regulated and likely SMALL.

8.4.5 Human Health

The human health risks of a combination of alternatives include those that have already been discussed in their respective sections (i.e. energy conservation and combined cycle gas-fired alternatives). The human health risks are uncertain, but considered to be SMALL given the combination of alternatives must comply with health-based Federal and State emission standards.

8.4.6 Socioeconomics

Land Use

As discussed in Section 8.1, the GEIS generically evaluates the impacts of nuclear power plant operations on land use both on and off each power plant site. The analysis of land use impacts focuses on the amount of land area that would be affected by the construction and operation of a single natural gas-fired unit power plant at the TMI-1 site and minor renovation of dams.

Approximately 11 ac (5 ha) would be necessary to support a single natural gas-fired unit combination alternative based on Exelon Generation estimates for a discrete gas-powered alternative. By scaling the GEIS estimate, a 280 MWe plant could require up to approximately 32 ac (13 ha) of land and would encompass available space at the TMI-1 site. The NRC staff believes that the Exelon Generation estimate is reasonable. However, if additional land were necessary for a buffer around plant structures and the construction of gas pipelines at TMI-1, the NRC staff believes the GEIS estimate provides a more useful approximation. Nevertheless, land use impacts from construction would be SMALL.

In addition to onsite land requirements, land will be required offsite for natural gas wells and collection stations. The GEIS estimates that 3,600 ac (1,457 ha) would be required for wells, collection stations, and pipelines to bring the gas to a 1000-MWe generating facility. If this land requirement were scaled directly with generating capacity, the combination alternative could require up to 1,025 ac (425 ha), though actual requirements will vary significantly. As previously discussed in Section 8.2, most of this land requirement would occur on land where gas extraction already occurs. In addition, some natural gas that could be used by the new power plant may come from outside of the U.S. and would be delivered as liquefied gas. Effects from gas extraction are generally smaller than those for coal mining, as most land around a gas extraction site remains undisturbed, except for roads and collection pipe network. Site reclamation after natural gas extraction would be less involved than reclamation of land previously used for coal mining.

As previously discussed, the elimination of uranium fuel for TMI-1 could partially offset offsite land requirements. In the GEIS, the NRC staff estimated that approximately 1,000 ac (405 ha) would no longer be needed for mining and processing uranium during the operating life of a 1000-MWe nuclear power plant. For TMI-1, roughly 850 ac (344 ha) of uranium mining area would no longer be needed. Overall land use impacts from a single natural-gas-fired power plant unit under the combination alternative would be SMALL.

Socioeconomics

As discussed in Section 8.1, socioeconomic impacts are defined in terms of changes to the demographic and economic characteristics and social conditions of a region. For example, the number of jobs created by the construction and operation of a new single natural gas-fired power plant unit could affect regional employment, income, and expenditures. Job creation is characterized by two types: (1) construction-related jobs, which are transient, short in duration, and less likely to have long-term socioeconomic impacts; and (2) operation-related jobs in support of power plant operations, which have the greater potential for permanent, long-term socioeconomic impacts. Workforce requirements for power plant construction and operations for the combination alternative were determined in order to measure their possible effect on current socioeconomic conditions.

The socioeconomic impacts from constructing and operating a single unit natural-gas-fired plant and minor renovation of dams would have little noticeable effect. Compared to the coal-fired alternative, the small size of the construction and operations workforce would have little or no socioeconomic impact.

Exelon Generation indicated that a peak construction workforce of 169 workers would be required to construct this alternative (AmerGen 2008). After construction, local communities may be temporarily affected by the loss of the construction jobs and associated loss in demand for business services, and the rental housing market could experience increased vacancies and decreased prices. The impact of construction on socioeconomic conditions would be SMALL.

Following construction, a single unit gas-fired combination alternative could provide up to nine jobs, based on Exelon Generation estimates, or up to 44 jobs based on an extrapolated estimate from the GEIS. Socioeconomic impacts associated with the operation of a single unit natural-gas-fired power plant would be SMALL.

Transportation

Transportation impacts associated with construction and operation of a single unit gas-fired power plant under the combination alternative would consist of commuting workers and truck deliveries of construction materials to the TMI-1 worksite. These vehicles would increase the overall number of vehicles on local roads. Pipeline construction and modification to existing natural gas pipeline systems may also have an additional, short-term impact.

Conversely, transportation impacts would almost disappear during plant operations. The estimated number of operating personnel would be approximately nine workers, although, the GEIS indicates that as many as 44 operations workers could be required. Since fuel would be transported by pipeline, the transportation infrastructure would experience little to no increased use from plant operations. Overall, the combination alternative would have a SMALL impact on transportation conditions in the region around TMI-1.

Aesthetics

As discussed in Section 8.1, aesthetic resources are the natural and man-made features that give a particular landscape its character and aesthetic quality. The aesthetics impact analysis focuses on the degree of contrast between the power plant and the surrounding landscape and the visibility of the power plant.

A single natural gas-fired unit located at TMI-1 could be approximately 100 ft (30 m) tall, with an exhaust stack of at least 175 ft (53 m) tall. The impact would be moderated as higher elevations and vegetation along the river valley could make it difficult to see or hear the power plant outside of the river valley. The alternative power plant infrastructure would generally be smaller and less noticeable than the current TMI-1 containment and cooling tower. The mechanical draft cooling towers would be markedly shorter than the natural-draft towers located at TMI-1, but they would also generate condensate plumes and operational noise. Noise during power plant operations would be limited to industrial processes and communications.

In addition to the power plant structures, construction of natural gas pipelines would have a short-term impact. Noise from the pipelines could be audible offsite near compressors.

In general, aesthetic changes would be limited to the immediate vicinity of TMI-1; therefore aesthetic impacts would be SMALL.

Historic and Archaeological Resources

As discussed in Section 8.2.6, depending on the resource richness of the site ultimately chosen for the gas-fired single unit as part of the combination alternative, impacts will range from SMALL to MODERATE.

Environmental Justice

The environmental justice impact analysis evaluates the potential for disproportionately high and adverse human health and environmental effects on minority and low-income populations that could result from the construction and operation of a single unit natural gas-fired power plant and uprates to existing hydroelectric dams. Adverse health effects are measured in terms of the risk and rate of fatal or nonfatal adverse impacts on human health. Disproportionately high and adverse human health effects occur when the risk or rate of exposure to an environmental hazard for a minority or low-income population is significant and exceeds the risk or exposure rate for the general population or for another appropriate comparison group. The minority and low-income populations are subsets of the general public residing around the site, all of whom are exposed to the same hazards generated from power plant operations.

Minority and low-income populations could be affected by the construction and operation of a new single unit natural gas-fired combined-cycle generation power plant at TMI-1. Some of these effects have been identified in resource areas discussed in this section. Effects on minority and low-income populations in the vicinity of TMI-1 would vary from construction to operations. Increased localized rental housing demand during construction in some locations could disproportionately affect low-income populations. Overall though, the impacts on minority and low-income populations from the combination alternative would likely be SMALL, as the

NRC staff finds that the potential for adverse impacts is smaller than for the gas-fired alternative, and any disproportionate impacts from implementing conservation are unlikely to be adverse.

8.4.7 Waste Management

As discussed in Sections 8.2.7 and 8.3.7, NRC staff concluded in the GEIS that gas-fired technology waste generation would be minimal (NRC 1996) and the waste impacts would be SMALL for a natural gas-fired combined-cycle plant sited at TMI-1 or at an alternate site; and impacts from a conservation alternative would be SMALL. Overall, the waste impacts from the combination alternative would be SMALL.

8.5 Purchased Power

Exelon Generation participates in the PJM Interconnection. This restructured energy supply system allows for the sale of energy across parts of 13 States and the District of Columbia (PJM 2008). Across the PJM, coal is the predominant fuel used for generation, accounting for 55.3 percent in 2007, followed by nuclear (33.9 percent), natural gas (7.7 percent), hydroelectric (1.7 percent), oil (0.5 percent), solid waste (0.7 percent), and wind (0.2 percent) (PJM 2008). Many of PJM's gas-fired units are actually able to burn fuel oil, as well, although gas utilization is much higher due to lower costs and emissions. Given the size and flexibility of PJM, the NRC staff considers it likely that purchased power could reasonably replace TMI-1.

Impacts would likely be similar to those of the above options located at alternate sites. If power purchases cause currently existing capacity to operate at higher capacity factors, however, rather than triggering new construction, then construction stage impacts would be eliminated. It is likely, then, that purchased power would come from older, less efficient plants than those considered in this chapter, from plants with once-through cooling, or from plants without modern emissions controls. Accordingly, impacts are difficult to quantify, although they are likely similar to those of other alternatives considered in Sections 8.2 through 8.4 in this supplemental EIS, as well as in the GEIS.

Given the location of TMI-1, it is unlikely that purchased power from outside the U.S. could replace TMI-1 capacity, regardless of whether or not either country has sufficient existing export capacity.

Since purchased power may come from a variety of generating resources, including coal, natural gas, nuclear, hydroelectric, and perhaps oil-fired installations (where impacts in previous NRC documents, including the supplemental EIS and the GEIS, were determined to be similar to or larger than those of natural-gas fired generation), NRC staff evaluation indicates that impacts from the purchased power alternative would be greater than the impacts of license renewal, and within the range of other alternatives considered in this chapter.

8.6 Alternatives Considered but Dismissed

In this section, the NRC staff presents the alternatives it initially considered for analysis as alternatives to license renewal of TMI-1, but later dismissed due to technical, resource availability, or commercial limitations that currently exist and that the NRC staff believes are likely to continue to exist when the existing TMI-1 license expires. Under each of the following technology headings, the NRC staff indicates why it dismissed each alternative from further consideration.

8.6.1 Coal-Fired Integrated Gasification Combined-Cycle

While utilities across the U.S. have considered or are considering plans for integrated gasification combined-cycle (IGCC) coal-fired power plants, few IGCC facilities have yet been constructed. All facilities constructed in the U.S. to date have been smaller than TMI-1.

The technology, however, is commercially available and essentially relies on a gasifier stage and a combined-cycle turbine stage. Existing combined-cycle gas turbines (like the ones considered in Section 8.2) could be used as part of an IGCC alternative.

EIA indicates that IGCC and other advanced coal plants may become increasingly common in coming years (EIA 2008a, 2008b), though uncertainties about construction time periods and commercial viability in the near future leads NRC staff to believe that IGCC is an unlikely alternative to TMI-1 license renewal. For plants whose licenses expire at later dates, IGCC (with or without carbon capture and storage) may prove to be a viable alternative, though NRC did not evaluate IGCC as an alternative to TMI-1 license renewal.

8.6.2 New Nuclear

In its ER, Exelon Generation indicated that it is unlikely that a nuclear alternative could be sited, constructed and operational by the time the TMI-1 operating license expires in 2014 (AmerGen 2008). Sources in the nuclear industry have recently indicated that reactor projects currently under development are likely eight or nine years from completion (Nucleonics Week 2008), or possibly online in the 2016-2017 timeframe. While several new reactor proposals currently under development or undergoing NRC review are within the footprint of PJM, they are unlikely to be available prior to the expiration of the TMI-1 operating license. Further, potential plant owners or operators wishing to submit a new proposal specifically to offset the capacity of TMI-1 would require additional time to develop an application. Given the relatively short time remaining on the current TMI-1 operating license, NRC staff has not evaluated new nuclear generation as an alternative to license renewal.

8.6.3 Wind Power

Wind power, by itself, is not suitable for large baseload capacity. As discussed in Section 8.3.1 of the GEIS, wind has a high degree of intermittency and low average annual capacity factors (up to 30 to 40 percent). Wind power, in conjunction with energy storage mechanisms or another readily dispatchable power source, like hydropower, could serve as a means of providing baseload power. Current energy storage technologies are too expensive for wind power to serve as a large baseload generator.

The Commonwealth of Pennsylvania is mostly a wind power Class 1 region, although some areas, particularly along ridgelines, may provide wind classes ranging from 4 to 6 (DOE 2003).

Wind turbines are economical in wind power Classes 4 through 7, which have average windspeeds of 12.5 to 21.1 miles per hour (20 to 34 kilometers per hour) (DOE 2007).

Through the end of 2007, operators had installed 294 MWe in Pennsylvania (DOE 2008). While installed wind power capacity is relatively low, wind power installation in Pennsylvania has accelerated in recent years. As noted by the NRC staff in the supplemental EIS for the Susquehanna Steam Electric Station, PJM has a maximum potential of 6,658 MWe of wind capacity with an achievable potential of 665 MWe to 1,995 MWe. Given that this capacity will function at a 30–40-percent capacity factor, it is unlikely that there will be sufficient wind power potential to replace TMI-1.

Therefore, the NRC staff does not consider wind power to be a stand-alone alternative to TMI-1 license renewal.

8.6.4 Solar Power

Solar technologies use the sun's energy to produce electricity. Currently, the TMI-1 site receives approximately 4 to 4.5 kWh per square meter per day (approximately 0.4 kWh of solar radiation per square foot per day), as does much of Pennsylvania (NREL 2008), for solar collectors oriented at an angle equal to the installation's latitude. Since flat-plate photovoltaics tend to be roughly 25 percent efficient, a solar-powered alternative will require at least 3,590 to 4,040 ac (1,450 to 1,640 ha) of collectors to provide an amount of electricity equivalent to that generated by TMI-1. Space between parcels and associated infrastructure increase this land requirement. This amount of land, while large, is consistent with the land required for coal and natural gas fuel cycles. In the GEIS, the NRC staff noted that, by its nature, solar power is intermittent (i.e., it does not work at night and cannot serve baseload when the sun is not shining), and the efficiency of collectors varies greatly with weather conditions. A solar-powered alternative will require energy storage or a backup power supply to provide electric power at night. Given the challenges in meeting baseload requirements, the NRC staff did not evaluate solar power as an alternative to license renewal of TMI-1.

8.6.5 Wood Waste

In 1999, DOE researchers estimated that Pennsylvania has biomass fuel resources consisting of urban, mill, agricultural, and forest residues, as well as speculative potential for energy crops. Excluding potential energy crops, DOE researchers projected that Pennsylvania had 5,090,000 tons (4,617,570 metric tons) of plant-based biomass available at $50 per ton delivered (Walsh et al. 2000; costs are in 1995 dollars). The Bioenergy Feedstock Development Program at Oak Ridge National Laboratory estimated that each air-dry pound of wood residue produces approximately 6,400 Btu of heat (ORNL 2007). Assuming a 33 percent conversion efficiency, using all biomass available in Pennsylvania at $50 per ton—the maximum price the researchers considered—would generate roughly 6.3 terawatt hours of electricity. This is roughly the same as the amount of electrical energy produced by TMI-1 operating at 85 percent capacity for one year.

Walsh et al. (2000), go on to note that these estimates of biomass capacity contain substantial uncertainty, and that potential availability does not mean biomass will actually be available at the prices indicated or that resources will be usably free of contamination. Some of these plant wastes already have reuse value, and would likely be more costly to deliver because of competition. Others, such as forest residues, may prove unsafe and unsustainable to harvest on a regular basis. As a result, the available resource potential is likely less than the estimated totals in Walsh et al., and the total resource is not likely to be sufficient to substitute for the capacity provided by TMI-1. As a result, the NRC staff has not considered a wood-fired alternative to TMI-1 license renewal.

8.6.6 Conventional Hydroelectric Power

According to researchers at Idaho National Energy and Environmental Laboratory, Pennsylvania has an estimated 2,217 MW of technically available, undeveloped hydroelectric resources at 104 sites throughout the State (INEEL 1997). This amount occurs primarily in small installations generating 10 MWe or less, though one site in Pennsylvania is capable of providing at least 100 MWe. These sites are scattered widely across the state, with a significant number in the Susquehanna River Basin region. The NRC staff notes that the total available hydropower potential is greater than the capacity considered for the other alternatives to license renewal of TMI-1, although INEEL indicates that many sites may not be available for development for a variety of reasons. Given the large numbers of individual installations needed to replace the TMI-1 capacity and the uncertainty surrounding available resource potential, the NRC staff did not evaluate hydropower as an alternative to license renewal. The NRC does, however, consider that the portion of this potential capacity that is available through uprates at existing hydroelectric facilities could play a role in a combination alternative in Section 8.4.

8.6.7 Wave and Ocean Energy

Wave and ocean energy has generated considerable interest in recent years. Ocean waves, currents, and tides are often predictable and reliable. Ocean currents flow consistently, while tides can be predicted months and years in advance with well-known behavior in most coastal areas. Most of these technologies are in relatively early stages of development, and while some results have been promising, they are not likely to be able to replace the capacity of TMI-1 by the time its license expires. The NRC staff has previously evaluated the potential for wave or ocean energy to provide an alternative to license renewal for the Oyster Creek Nuclear Generating Station (OCNGS) in New Jersey, also part of PJM and located on the coast. In 2007, the NRC staff concluded that wave and ocean energy could not provide a feasible alternative to license renewal at OCNGS, a smaller plant than TMI-1 (NRC 2007). While testing of new technologies to produce electricity from the ocean continues, the NRC has not yet seen technological advances significant enough to consider wave and ocean energy as an alternative to TMI-1 license renewal.

8.6.8 Geothermal Power

Geothermal energy has an average capacity factor of 90 percent and can be used for baseload power where available. However, geothermal electric generation is limited by the geographical availability of geothermal resources (NRC 1996). As illustrated by Figure 8.4 in the GEIS, no feasible eastern location for geothermal capacity exists to serve as an alternative to TMI-1. The NRC staff concluded that geothermal energy is not a reasonable alternative to license renewal at TMI-1.

8.6.9 Municipal Solid Waste

Municipal solid waste combustors incinerate waste to produce steam, hot water, or electricity. Combustors use three types of technologies—mass burn, modular, and refuse-derived fuel. Mass burning is currently the method used most frequently in the United States and involves no (or little) sorting, shredding, or separation. Consequently, toxic or hazardous components present in the waste stream are combusted, and toxic constituents are exhausted to the air or become part of the resulting solid wastes. Currently, approximately 89 waste-to-energy plants operate in the United States. These plants generate approximately 2,700 MWe, or an average of approximately 30 MWe per plant (Integrated Waste Services Association 2007). More than 25 average-sized plants will be necessary to provide the same level of output as the other alternatives to TMI-1 license renewal.

Estimates in the GEIS suggest that the overall level of construction impact from a waste-fired plant will be approximately the same as that for a coal-fired power plant. Additionally, waste-fired plants have the same or greater operational impacts than coal-fired technologies (including impacts on the aquatic environment, air, and waste disposal). The initial capital costs for municipal solid-waste plants are greater than for comparable steam-turbine technology at coal-fired facilities or at wood-waste facilities because of the need for specialized waste separation and handling equipment (NRC 1996).

The decision to burn municipal waste to generate energy is usually driven by the need for an alternative to landfills rather than energy considerations. The use of landfills as a waste disposal option is likely to increase in the near term as energy prices increase; however, it is possible that municipal waste combustion facilities may become attractive again.

Regulatory structures that once supported municipal solid waste incineration no longer exist. For example, the Tax Reform Act of 1986 made capital-intensive projects such as municipal waste combustion facilities more expensive relative to less capital-intensive waste disposal alternatives such as landfills. Also, the 1994 Supreme Court decision C&A Carbone, Inc. v. Town of Clarkstown, New York, struck down local flow control ordinances that required waste to be delivered to specific municipal waste combustion facilities rather than landfills that may have had lower fees. In addition, environmental regulations have increased the capital cost necessary to construct and maintain municipal waste combustion facilities.

Given the small average installed size of municipal solid waste plants and the unfavorable regulatory environment, the NRC staff does not consider municipal solid waste combustion to be a feasible alternative to TMI-1 license renewal.

8.6.10 Biofuels

In addition to wood and municipal solid-waste fuels, there are other concepts for biomass-fired electric generators, including direct burning of energy crops, conversion to liquid biofuels, and biomass gasification. In the GEIS, the NRC staff indicated that none of these technologies had progressed to the point of being competitive on a large scale or of being reliable enough to replace a baseload plant such as TMI-1. After reevaluating current technologies, the NRC staff believes other biomass-fired alternatives are still unable to reliably replace the TMI-1 capacity. For this reason, the NRC staff does not consider other biomass-derived fuels to be feasible alternatives to TMI-1 license renewal.

8.6.11 Oil-Fired Power

EIA projects that oil-fired plants will account for very little of the new generation capacity constructed in the United States during the 2007 to 2030 time period. Further, EIA does not project that oil-fired power will account for any significant additions to capacity (EIA 2008a).

The variable costs of oil-fired generation tend to be greater than those of the nuclear or coal-fired options, and oil-fired generation tends to have greater environmental impacts than natural-gas-fired generation. In addition, future increases in oil prices are expected to make oil-fired generation increasingly more expensive. The high cost of oil has prompted a steady decline in its use for electricity generation. Thus the NRC staff did not consider oil-fired generation as an alternative to TMI-1 license renewal.

8.6.12 Fuel Cells

Fuel cells oxidize fuels without combustion and its environmental side effects. Power is produced electrochemically by passing a hydrogen-rich fuel over an anode and air (or oxygen) over a cathode and separating the two by an electrolyte. The only byproducts (depending on fuel characteristics) are heat, water, and CO_2. 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.

At the present time, fuel cells are not economically or technologically competitive with other alternatives for baseload electricity generation. EIA projects that fuel cells may cost $5,374 per installed kW (total overnight costs) (EIA 2008b), or 3.5 times the construction cost of new coal-fired capacity and 7.5 times the cost of new, advanced gas-fired, combined-cycle capacity. In addition, fuel cell units are likely to be small in size (the EIA reference plant is 10 MWe). While it may be possible to use a distributed array of fuel cells to provide an alternative to TMI-1, it would be extremely costly to do so. Accordingly, the NRC staff does not consider fuel cells to be an alternative to TMI-1 license renewal.

8.6.13 Delayed Retirement

Neither Exelon Generation nor its parent company, Exelon, has any plans to retire generating capacity within PJM (AmerGen 2008). As a result, delayed retirement is not a feasible alternative to license renewal. Other generation capacity may be retired within PJM prior to the expiration of the TMI-1 license, but this capacity is likely to be older, less efficient, and without modern emissions controls.

8.7 No-Action Alternative

This section will examine the environmental effects that will occur if NRC takes no action. No action in this case means that the NRC does not issue a renewed operating license for TMI-1, and the license expires at the end of the current license term, in April 2014. If the NRC takes no action, the plant will shutdown at or before the end of the current license. After shutdown, plant operators will initiate decommissioning according to 10 CFR 50.82, "Termination of License." Table 8-5 below contains a summary of the environmental impacts of the no-action alternative compared to continued operation of TMI-1.

We note that no action is the only alternative that we consider in-depth that does not satisfy the purpose and need for this supplemental EIS, because it does not provide power generation capacity. Furthermore, it would not meet the needs currently met by TMI-1, or the alternatives evaluated in sections 8.1 through 8.4. Assuming that a need currently exists for the power generated by TMI-1, the no-action alternative would require the appropriate energy planning decisionmakers to rely on an alternative to replace the capacity of TMI-1 or reduce the need for power.

In this section, we address only those impacts that arise directly as a result of plant shutdown. The NRC already addressed— in several other documents— environmental impacts from decommissioning and related activities. These documents include the *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*, NUREG 0586, Supplement 1 (NRC 2002); the license renewal GEIS (Chapter 7; NRC 1996); and Chapter 7 of this supplemental EIS. These analyses either directly address or bound the environmental impacts of decommissioning whenever Exelon Generation ceases operating TMI-1.

We note that, even with a renewed operating license, TMI-1 will eventually shut down, and the environmental effects we address in this section will occur at that time. Since these effects have not otherwise been addressed in this supplemental EIS, we will address the impacts in this section. We expect that— as with decommissioning effects— shutdown effects will be similar whether they occur at the end of the current license or at the end of a renewed license.

Table 8-5. Summary of Environmental Impacts of the No Action Alternative Compared to Continued Operation of TMI-1.

	No Action		Continued TMI-1 Operation
	At TMI-1 site	At alternate site	
Air Quality	SMALL	N/A	SMALL
Ground Water	SMALL	N/A	SMALL
Surface Water	SMALL	N/A	SMALL
Aquatic and Terrestrial Resources	SMALL	N/A	SMALL
Human Health	SMALL	N/A	SMALL
Socioeconomics	SMALL to MODERATE	N/A	SMALL
Waste Management	SMALL	N/A	N/A

8.7.1 Air Quality

When the plant stops operating, there will be a reduction in emissions from activities related to plant operation, such as use of diesel generators and employees' vehicles. In Chapter 4, the NRC staff determined that these emissions would have a SMALL impact on air quality during the renewal term. Therefore, if the emissions decrease, the impact to air quality would also decrease and would be SMALL.

8.7.2 Ground Water Use and Quality

The use of ground water would diminish as plant personnel are removed from the site and operations cease. Some consumption of ground water may continue as a small staff remains onsite to maintain facilities prior to decommissioning. Overall impacts would be smaller than during operations, but would remain SMALL.

8.7.3 Surface Water Use and Quality

The rate of consumptive use of surface water would decrease as the plant is shut down and the reactor cooling system continues to remove the heat of decay. Wastewater discharges would also be reduced considerably. Shutdown would reduce the already SMALL impact on surface water resources and quality.

8.7.4 Aquatic and Terrestrial Ecology

<u>Terrestrial Ecology</u>

Terrestrial ecology impacts would be SMALL. No additional land disturbances on or offsite would occur.

<u>Aquatic Ecology</u>

If the plant were to cease operating, impacts to aquatic ecology would decrease, as the plant would withdraw and discharge less water than it does during operations. Shutdown would reduce the already SMALL impacts to aquatic ecology.

8.7.5 Human Health

Human health risks would be smaller following plant shutdown. The plant, which is currently operating within regulatory limits, would emit less gaseous and liquid radioactive material to the environment. In addition, following shutdown, the variety of potential accidents at the plant (radiological or industrial) would be reduced to a limited set associated with shutdown events and fuel handling and storage. In Chapter 4 of this supplemental EIS, the NRC staff concluded that the impacts of continued plant operation on human health would be SMALL. In Chapter 5, the NRC staff concluded that the impacts of accidents during operation were SMALL. Therefore, as radioactive emissions to the environment decrease, and as the likelihood and variety of accidents decrease following shutdown, the NRC staff concludes that the risks to human health following plant shutdown would be SMALL.

In addition, the no-action alternative would require TMI-1 to initiate decommissioning activities. Environmental impacts from the activities associated with the decommissioning of any reactor before or at the end of an initial or renewed license are evaluated in the *Generic Environmental Impact Statement for Decommissioning of Nuclear Facilities*: Supplement 1, *Regarding the Decommissioning of Nuclear Power Reactors*, NUREG-0586, Supplement 1 (NRC 2002). The NRC's evaluation of the environmental impacts of decommissioning presented in NUREG-0586, Supplement 1, identifies a range of impacts for each environmental issue including human health risks. Based on information in the GEIS (NRC 1996) along with the information in Chapter 7 of this supplemental EIS, the Commission found that doses to the public will be well below applicable regulatory standards regardless of which decommissioning method is used. Occupational doses would increase no more than 1 person-rem caused by buildup of long-lived radionuclides during the license renewal term. Therefore, the human health risks to an occupational worker and to a member of the public, from the decommissioning of TMI-1, due to the no-action alternative, would be SMALL.

8.7.6 Socioeconomics

Land Use

Plant shutdown will not affect onsite land use. Plant structures and other facilities will likely remain in place until decommissioning. Most transmission lines at TMI-1 will remain in service after the plant stops operating. Maintenance of most existing transmission lines will continue as before. The NRC staff expects the impacts on land use from plant shutdown to be SMALL.

Socioeconomics

Plant shutdown will have a minimal impact on socioeconomic conditions in the region around TMI-1, primarily because of the plant's proximity to the Harrisburg-Carlisle metropolitan statistical area and its relatively small contribution to local services. Plant shutdown will eliminate up to 525–695 jobs and will reduce tax revenue in the region, though the TMI-1 contributions to local taxing jurisdictions are a small percentage of total revenue for each of the jurisdictions discussed in Chapter 4 of this supplemental EIS. The loss of these contributions, which may not entirely cease until after decommissioning, will have a SMALL impact, although job losses could increase the impact level slightly. Overall, the staff expects the impacts of plant shutdown to be SMALL to MODERATE. See Appendix J to NUREG 0586, Supplement 1 (NRC 2002), for additional discussion of the potential socioeconomic impacts of plant decommissioning.

Transportation

Traffic volumes on the roads in the vicinity of TMI-1 will decline after plant shutdown. Most of the reduction in traffic volume will be associated with the loss of jobs. The shipment of material to and from the plant will be reduced before decommissioning. Transportation impacts will be SMALL as a result of plant shutdown. Transportation impacts will increase if a new reactor or alternative energy facility is constructed on the TMI-1 site or in the immediate vicinity. Such impacts will be SMALL to MODERATE, but of short duration.

Aesthetics

Plant structures and other facilities will likely remain in place until decommissioning, although plumes from the plant's cooling towers are likely to disappear entirely. Noise caused by plant operation will cease. The NRC staff concludes that the aesthetic impacts of plant closure will be SMALL.

Historic and Archaeological Resources

Impacts from the no-action alternative would be SMALL, since TMI-1 would be decommissioned with no alternative power plant to replace it. A separate environmental review would be conducted for decommissioning. That assessment will address the protection of historic and archaeological resources.

Environmental Justice

Plant shutdown is unlikely to disproportionately affect minority and low-income populations. Impacts to all other resource areas would be SMALL to MODERATE. The communities in the immediate vicinity of TMI-1 do not have large populations of minority or low-income residents. Minority and low-income populations are generally concentrated in the urban areas of Harrisburg, Lancaster, and York. Thus, impacts from plant shutdown are likely to be SMALL. See Appendix J of NUREG 0586, Supplement 1 (NRC 2002), for additional discussion of these impacts.

8.7.7 Waste Management

After implementation of the no-action alternative, generation of high-level waste would stop and generation of low-level and mixed waste would decrease. Impacts from implementation of the no-action alternative are expected to be SMALL.

8.8 Alternatives Summary

In this chapter, we considered the following alternatives to TMI-1 license renewal: supercritical coal-fired generation, natural gas combined-cycle generation, energy conservation and energy efficiency, and a combination alternative. We also considered no action by the NRC and the effects it would have. The impacts for all alternatives are summarized in Table 8-6 on page 8-47.

The environmental impacts of the proposed action (issuing a renewed TMI-1 operating license) would be SMALL for all impact categories, except for the Category 1 issues of collective offsite radiological impacts from the fuel cycle, high level waste (HLW), and spent fuel disposal. The NRC staff did not assign a single significant level to these impacts, but the Commission determined them to be Category 1 issues nonetheless.

The coal-fired alternative is the least environmentally favorable alternative due to impacts to air quality from nitrogen oxides, sulfur oxides, particulate matter, PAHs, carbon monoxide, carbon dioxide, and mercury (and the corresponding human health impacts); and construction impacts to aquatic, terrestrial, and potential historic and archaeological resources. The gas-fired alternative would have slightly lower air emissions, and impacts to aquatic, terrestrial, and historic and archaeological resources would vary depending upon location of the plant. Purchased power would likely have operational impacts that would include aspects of coal-fired, gas-fired, and existing nuclear generation.

The NRC notes that the energy conservation/energy efficiency alternative has SMALL impacts in all categories evaluated, and upon shut down of TMI-1, current operating impacts of TMI-1 would cease. Therefore, the energy conservation/energy efficiency alternative is the environmentally preferred alternative to license renewal. All other alternatives capable of meeting the needs currently served by TMI-1 entail potentially greater impacts than the proposed action of license renewal of TMI-1. The no-action alternative does not meet the purpose and need of this supplemental EIS, however if it triggers the energy conservation/energy efficiency action to replace the capacity currently supplied by TMI-1, it could result in an overall SMALL impact, as well.

Table 8-6. Summary of Environmental Impacts of Selected Alternatives Compared to Continued Operation of TMI-1.

Alternative	Impact Area						
	Air Quality	Ground Water	Surface Water	Aquatic and Terrestrial Resources	Human Health	Socioeconomics	Waste Management
License Renewal	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Supercritical coal-fired alternative at a new site	MODERATE	SMALL	SMALL	SMALL to LARGE	SMALL to MODERATE	SMALL to LARGE	SMALL to MODERATE
Gas-fired alternative at the TMI-1 site	MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
Gas-fired alternative at a new site	MODERATE	SMALL	SMALL	SMALL to LARGE	SMALL	SMALL to MODERATE	SMALL
Energy Conservation/ Energy Efficiency	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL
Combination of Alternatives	SMALL to MODERATE	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL
No Action Alternative	SMALL	SMALL	SMALL	SMALL	SMALL	SMALL to MODERATE	SMALL

8.9 References

10 CFR 50. *Code of Federal Regulations*, Title 10, *Energy*, Part 50, "Domestic Licensing of Production and Utilization Facilities."

10 CFR 51. *Code of Federal Regulations*, Title 10, *Energy*, Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions."