Summary 1

The U.S. Air Force operates a seismic observatory on Burnt Mountain in Alaska to help verify compliance with nuclear test ban treaties. Data from the unattended station, located in a remote area about 60 miles north of the Arctic Circle, are used to ascertain whether or not seismic activity has been caused by nuclear explosions. The data collection and communications equipment at the station is powered by 10 nuclear batteries, called radioisotope thermoelectric generators (RTGs). Each RTG is fueled with between 1.2 and 3.9 pounds of strontium-90 (Sr-90), a highly radioactive material. RTGs are used because of their high reliability and low maintenance requirements.

In August and September 1992, a tundra fire encroached on the Burnt Mountain site. It damaged some data cables, but did not disturb the monitoring, communications, and power equipment. The fire raised public concern among nearby inhabitants about the safety of using a radioactive material as the power source at the station. To address this concern, Senator Murkowski of Alaska asked the Air Force to inspect the site, conduct public meetings to discuss the risks and advantages of RTGs, and analyze alternative potential power sources for the station. Additionally, Senator Stevens of Alaska along with Senator Murkowski requested that the Office of Technology Assessment (OTA) undertake an independent evaluation of alternative power technologies for the site. The objective of the assessment was to identify a remote power source technology that presents the lowest health and safety risk to nearby populations and equipment technicians at an acceptable life-cycle cost. The Senators' letter stated specifically that the health, safety, and environmental aspects of the system were to be given precedence over cost considerations. This background paper examines the safety of using RTGs at Burnt Mountain and assesses the viability of using alternative power sources at the station.

There are three principal issues that must be resolved with regard to the Burnt Mountain Seismic Observatory and its power system. First, should the observatory continue to operate; i.e., is the station still necessary given the changed face of world security coming with the end of the Cold War? The Air Force has recently been given the responsibility y for monitoring compliance with a worldwide comprehensive test ban treaty in addition to its previous treaty monitoring duties. Fully monitored stations such as the one at Burnt Mountain are important to this new assignment. The Air Force considers the data from Burnt Mountain to be critical. Thus, this background paper assumes that the station will remain operational. Second, assuming that the station continues to operate, when should the RTGs be replaced? Should the RTGs remain in place until the end of their useful power production at the station or should they be replaced at an earlier time? The current RTGs could conceivably fully power the observatory until 2009. Several of the units could power their associated equipment until 2018 or later. Third, what power system could be used to eventually replace the RTGs? Leading candidate technologies include: modified RTGs, propane-fueled thermoelectric generators (TEGs), and photovoltaic (PV) systems.

AIR FORCE FINDINGS

The Air Force, at the request of Senator Murkowski, conducted a study of RTGs and alternative power technologies for the Burnt Mountain station.[1] The study concluded that:

> . . . continued use of the RTGs is clearly the safest, most reliable, and most economical approach to supplying electrical power to the Burnt Mountain Seismic Observatory. . . . [The RTGs] should continue to be operated until the end of their useful power life. The first unit falls below the required power level in 2009. For an added margin of safety it is recommended that combustible materials be cleared annually from the equipment sites.
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> A logical plan would be to phase out the RTGs as they reach the end of their useful lifetimes. This approach would also provide the opportunity to field test replacement systems without jeopardizing the reliability of the observatory operations. . . . [A]t this time, propane-fueled TEGs appear to be the best candidate for immediate replacement of the RTGs. However, by the end of the projected useful lifetime of the RTGs other, emerging technologies may prove more economical and safe than the TEGs.

The Air Force's preference for TEGs stems from their proven track record in applications with climate conditions and energy requirements similar to those at Burnt Mountain. In addition, TEGs could be deployed in a dispersed configuration similar to that used by the RTGs now.

A PV system was found to be the next most viable option. A major design issue with such a system is how to deliver adequate power during the dark winter months in the Arctic. The Air Force examined PVS with two different power backup systems for the winter--batteries and TEGs. The stand-alone PV/battery system was judged less desirable, because of the expense of the large number of batteries required. The high cost covers not only the initial purchase of the batteries, but also their transport to Burnt Mountain. Several other power technologies were examined for the application, but were considered too costly, too unreliable, or unproven.[2]

[1] Wright Laboratory, Aeropropulsion and Power Directorate, Aerospace Power Division, "Power System Assessment for the Burnt Mountain Seismic Observatory, " report prepared for the Air Force Technical Applications Center, Patrick Air Force Base, FL, May 1994.

[2] Considered too costly or too unreliable by the Air Force were: fuel cells, aluminum-air batteries, gasoline-powered combustion-engine-driven generators, wind turbine with battery storage, commercial power with a land-line connection. Considered too unproven were: combustion thermionic generators, thermal photovoltaic generators, combustion-driven stirling generators, microwave power beaming, hydrogen thermoelectric converters, and alkali metal thermoelectric converters.

OTA FINDINGS

OTA, with help from Future Resources Associates, examined the safety and environmental characteristics of RTGs and alternative power technologies under several accident scenarios.[3] The use of RTGs presents risks to people and the environment through the possible release of Sr-90. However, the probability of any accident--with the exception of dedicated vandalism--causing a release of radioactive material to the environment is very low. No natural disaster presents much risk of causing a release of radioactive material to the environment, and most accidents associated with human activities present little risk of contamination. In the event that radioisotope material is released, there would probably be minimal long-range dispersal, so that cleanup activities would be able to remove the bulk of the material in the units. Residual radioisotopes in the environment would remain embedded in a fairly inert ceramic material, with minimal uptake by plants and incorporation into the food chain. It appears reasonable to conclude that continued operation of the RTGs at Burnt Mountain presents minimal risk to the surrounding area and population.

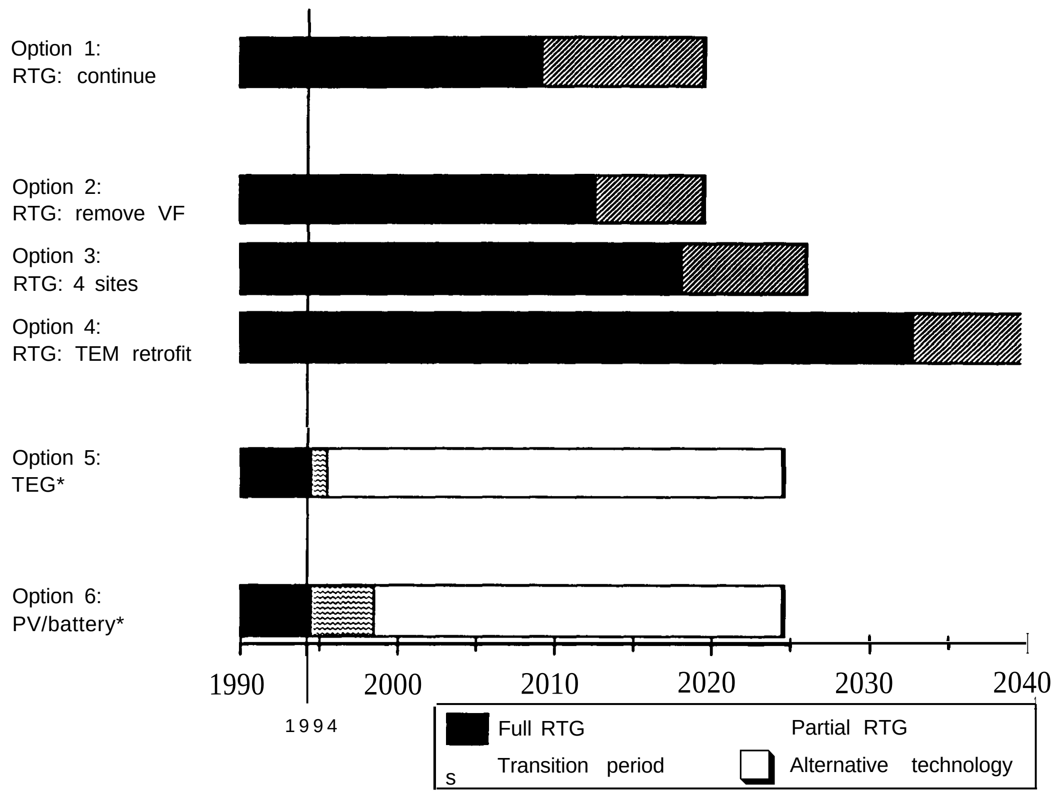
The use of TEG power systems at Burnt Mountain would introduce different risks to the facility. In the event of an accident, TEGs are more likely than RTGs to damage the station's equipment and less likely to harm people and the environment. Propane fuel is flammable and explosive (in certain mixtures with air), and its use would subject the seismic equipment to a variety of risks due to fires and explosions. Accidents could arise in delivering propane fuel to the remote Burnt Mountain site, and in distributing fuel on the ground at the site, Propane accidents during unattended operation of the observatory can be caused either by natural events, like offsite fires and earthquakes, or by vandalism. The TEG power systems would not present any substantial risks to nearby populations, except in the event that a propane fuel accident ignites a fire that spreads offsite--an unlike] y occurrence given the cleared area around the seismic facilities,

PV energy systems present minimal risks for the environment during routine operation, maintenance, and transportation. There are, however, potential safety and environmental problems associated with PVs--particularly the batteries--in accident situations. Releases of toxic heavy met - als into the environment is a potential problem Annual maintenance visits are recommended for PV/battery systems, but no annual fuel deliveries are necessary, Of course, if TEGs were used as the winter backup for the PV system, there would be additional risks of the sort mentioned earlier. However, since the fuel requirements would be smaller, the risk would be somewhat lower than for a stand-alone TEG system.

There are many timing variations associated with the implementation of altternative power sources at the Burnt Mountain observatory. Figure 1-1 illustrates several timing possibilities for deploying the three major candidate power systems at the station. The simplest from a logistics viewpoint is continuing to operate the RTGs (Option 1). Without any changes whatsoever. RTGs could fully power the station until 2009--another 15 years. There are also methods for extending the life of the RTGs. In this vein, the Air Force has considered: discontinuing the use of noncrucial communications equipment--specifically the voice frequency responder--at the sta-

[3] Future Resources Associates, "Power System Assessment for the Burnt Mountain Seismic Observatory, " OTA contractor report, January 1994.

FIGURE 1-1: Timeline of Power Options for the Burnt Mountain Seismic Observatory



KEY:
RTG = radioisotope thermoelectric generators
VF = voice frequency responder
TEM = thermoelectric module
TEG = propane-fueled thermoelectric generators
PV/battery = photovoltaic array with battery backup

*Earliest implementation of replacement technology. Later deployment is also viable.

The black region ■ indicates the time period in which RTGs fully power the observatory. The patterned region indicates the time period when RTGs can only partially power the observatory. The patterned region ❑ indicates the transition and/or testing period between RTGs and the replacement power technology. Note that in this period the RTGs are still onsite. The white region indicates the period in which replacement technologies fully power the observatory and the RTGs have been removed. The RTGs are removed at the end of the patterned regions.

SOURCE: Office of Technology Assessment, 1994.

tion (Option 2); allowing one of the station's five monitoring devices to shut down (Option 3); and refitting the RTGs with improved thermoelectric modules (Option 4).[4] These changes could extend the life of the RTGs by three to 23 years and could be implemented any time up until 2009 with minimal degradation of effectiveness. Propane-fueled TEGs could be implemented very quickly, possibly by next year (Option 5). The RTGs could not be removed as soon, because they would be needed as backup during the startup and associated troubleshooting of the TEG systems. PV/battery systems (Option 6) would require more time to put in place at Burnt Mountain, because more extensive testing and troubleshooting is needed. However, if testing were started in the near future, a reliable PV/battery system could probably be operational in three to four years. Assuming that arrangements could be made for the long-term storage of the RTGs, they could be removed shortly after the PV testing was complete.

CONCLUSIONS

Continued use of RTGs at Burnt Mountain bears low risk for the safety of maintenance workers and local populations and for the environment. In addition, it minimizes costs and further environmental disruption to the site. The Air Force's recommendations for the clearing of combustible materials from the equipment sites on a yearly basis are sound. Other useful precautions that should be considered are:

- Installing equipment to protect the sites from lightning strikes.
- Performing a periodic check of the structural integrity of the RTG units, assuming that useful nondestructive testing can be performed onsite. Such testing would monitor any degradation of materials within the RTGs due to long-term exposure to radiation.
- Installing intrusion monitors at the station that would alert Air Force personnel at Fort Yukon and authorities in nearby villages to possible problems with vandals or terrorists. This would help reduce the risk of radiation releases caused by dedicated vandalism by allowing quick response to the situation by Air Force personnel and civilian law enforcement authorities.

Looking to the eventual replacement of the RTGs at Burnt Mountain, the interrelated factors of substitute power technologies and replacement timing must both be considered. If the RTGs were required to be removed immediately, the only viable replacement power source would be propane-fueled TEG systems. TEGs are the only replacement technology that could be installed without extensive testing. The deployment of TEGs would introduce the risk of damage to the equipment at the station. In addition, there is the high cost of installing TEGs and of transporting the fuel.

If use of the RTGs could be tolerated for three or four more years or possibly until the end of their useful lives, other power technologies may prove viable replacements. Several years of onsite testing would probably be adequate to prove the suitability of alternative power technologies that do not require ongoing fuel deliveries. At present, PV/battery systems appear to be the most viable nonfuel replacements for the RTGs. PV power generation, which is accomplished without fuel or moving parts, is inherently more reliable than power generation with technologies that use conventional hydrocarbon fuels. PV systems currently provide reliable power for remote, unattended applications in polar Alaska and Antarctica. However, only a survey of the solar and weather conditions at Burnt Mountain and onsite testing of prototype PV designs can establish the viability of a PV power system for the observatory.

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4. Terry A. Schmidt, Technical Operations Division, McClellan Air Force Base, letter to the Air Force Technical Applications Center on the status of Burnt Mountain radioisotope thermoelectric generators, 1992.

The process of investigating the suitability of PV systems as an alternative could begin soon, to develop adequate onsite experience to ensure system reliability. The specific system to be tested should be a stand-alone, decentralized PV/battery system. In addition, onsite testing of low-power seismic monitoring and data communication electronics would be helpful. System electronics with decreased power demand would facilitate the use of alternative power systems. They would also extend the life of the RTGs if their continued use at Burnt Mountain were deemed the proper course of action.