San Juan Basin Action Plan

ALTERNATIVES TO THE PROJECT

for the
Environmental Impact Statement
on Public Service Company of New Mexico's
Proposed New Mexico Generating Station
and Possible New Town

United States
Department
of the Interior

Bureau of Land Management
New Mexico State Office
Santa Fe, New Mexico

October 1982

Report 3 of 22

March 3, 1849

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
NEW MEXICO STATE OFFICE
P.O. BOX 1449
SANTA FE, NEW MEXICO 87501

IN REPLY REFER TO
NM30840EIS
1792.73(934A)

October 1982

Dear Interested Citizen:

Attached is one of twenty-two technical reports developed as a basis for writing the Environmental Impact Statement on Public Service Company of New Mexico's Proposed New Mexico Generating Station and Possible New Town (NMGS EIS). (A list of the technical reports is attached.)

These technical reports provide detailed information on the existing environment, methods used for the impact analysis, and related data supportive of the analysis and conclusions presented in the EIS. These reports should be retained for use with the Draft and Final EIS and other documents related to BLM's San Juan Basin Action Plan (SJBAP).

The Draft NMGS EIS will be filed with the Environmental Protection Agency and released for public review on November 30, 1982. Comments on the Draft EIS will be due by close of business February 7, 1983, at the BLM New Mexico State Office. Because of the large volume of material presented in the technical reports, the BLM is distributing these reports in advance of the Draft EIS to provide sufficient time for public review. The technical reports will be available for public review at the places indicated on the attached list. Copies will also be available from the BLM New Mexico State Office, U.S. Post Office and Federal Building, Santa Fe, for a copy fee.

Informational public meetings are scheduled for December 1982 to provide a public forum to clarify questions and concerns about the SJBAP proposals and the related environmental documents, which will all have been issued by that time. The meetings are scheduled as follows:

- December 14, Civic Center, Farmington, 3 to 9 PM
- December 14, Convention Center, Albuquerque, 3 to 9 PM
- December 15, Chapter House, Crownpoint, 3 to 9 PM
- December 16, Holiday Inn, Gallup, 3 to 9 PM
- December 16, Kachina Lodge, Taos, 3 to 9 PM

In addition, formal public hearings will be held in January 1983 to solicit public comments on the SJBAP Proposals. These meetings are scheduled as follows:

- January 10, Chapter House, Crownpoint, beginning at 1:00 PM
- January 12, Civic Center, Farmington, beginning at 9:00 AM
- January 14 (and 15th if necessary because of the number of registrants), Four Seasons Motor Lodge, Albuquerque, I-40 and Carlisle Blvd., beginning at 9:00 AM (each day)

Questions on the public meetings, hearings, and the technical reports themselves should be directed to:

Leslie M. Cone
NMGS Project Manager
BLM, New Mexico State Office
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6184 FTS 476-6184

Sincerely yours,

Charles W. Luscher

Charles W. Luscher
State Director, New Mexico

List of Technical Reports

1. Purpose and Need
2. Project Description
3. Alternatives to the Project
4. Site Alternatives
5. Permit Reconnaissance
6. Air Quality
7. Geologic Setting
8. Mineral Resources
9. Paleontology
10. Soils, Prime and Unique Farmlands
11. Hydrology
12. Water Quality
13. Vegetation
14. Wildlife and Aquatic Biology
15. Threatened and Endangered Species
16. Cultural Resources
17. Visual Resources
18. Recreation Resources
19. Wilderness Values
20. Transportation
21. Social and Economic Conditions
22. Land Use Controls and Constraints

Availability of Technical Reports for Public Review

Individual copies of the technical reports can be obtained for a copy fee. Inquiries should be directed to:

Bureau of Land Management, New Mexico State Office
Title Records and Public Assistance Section (943B)
U.S. Post Office and Federal Building
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6107 FTS 476-6107

Copies of the reports are available for public review at the locations listed below. [Formal and informal cooperating agencies are denoted by an asterisk (*).]

BUREAU OF LAND MANAGEMENT OFFICES

New Mexico State Office

NMGS Project Staff (934A)
Room 122, Federal Building
Cathedral Place
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6184 FTS 476-6184

San Juan Energy Projects Staff (911)
Room 129, Federal Building
Cathedral Place
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6226 FTS 476-6226

Public Affairs Staff (912)
Room 2016
U.S. Post Office and Federal Building
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6316 FTS 476-6316

Division of Resources (930)
509 Camino de los Marquez, Suite 3
P.O. Box 1449
Santa Fe, NM 87501
(505) 988-6212 FTS 476-6212

Albuquerque District Office
3550 Pan American Freeway NE
P.O. Box 6770
Albuquerque, NM 87107
(505) 766-2455 FTS 474-2455

Farmington Resource Area Headquarters
900 La Plata Road
P.O. Box 568
Farmington, NM 87401
(505) 325-3581

Taos Resource Area Office
Montevideo Plaza
P.O. Box 1045
Taos, NM 87571
(505) 758-8851

Socorro District Office
198 Neel Avenue
P.O. Box 1219
Socorro, NM 87801
(505) 835-0412 FTS 476-6280

Las Cruces District Office
1705 N. Valley Drive
P.O. Box 1420
Las Cruces, NM 88001
(505) 524-8551 FTS 571-8312

Roswell District Office
1717 W. Second Street
P.O. Box 1397
Roswell, NM 88201
(505) 622-7670 FTS 476-9251

Carlsbad Resource Area Headquarters
114 S. Halagueno Street
P.O. Box 506
Carlsbad, NM 88220
(505) 887-6544

USDI, Bureau of Land Management
Division of Rights-of-Way (330)
18th and C Streets, NW
Washington, D.C. 20240
(202) 343-5441 FTS 343-5441

USDI, Bureau of Land Management
Denver Service Center (D-460)
Technical Publications Library
Denver Federal Center, Bldg. 50
Denver, CO 80225
(303) 234-2368 FTS 234-2368

NEW MEXICO STATE AGENCIES

New Mexico State Environmental Improvement Division*
725 St. Michaels Drive
P.O. Box 968
Santa Fe, NM 87503
(505) 827-5217, ext. 2416

New Mexico Energy and Minerals Department*
525 Camino de los Marquez
P.O. Box 2770
Santa Fe, NM 87503
(505) 827-3326

New Mexico Historic Preservation Bureau*
State Historic Preservation Officer
505 Don Gasper Avenue
Santa Fe, NM 87503
(505) 827-2108

New Mexico Natural Resource Department*
Villagra Building
Santa Fe, NM 87503
(505) 827-5531

New Mexico Public Service Commission*
Bataan Memorial Building
Santa Fe, NM 827-3361
(505) 827-3361

New Mexico State Engineer's Office*
Bataan Memorial Building
Santa Fe, NM 87503
(505) 827-2423

New Mexico State Planning Office*
505 Don Gasper Avenue
Santa Fe, NM 87503
(505) 827-5191

OTHER ORGANIZATIONS

Public Service Company of New Mexico
Alvarado Square
P.O. Box 2268
Albuquerque, NM 87158
(505) 848-2700

Woodward-Clyde Consultants, Inc.
3 Embarcadero Center, Suite 700
San Francisco, California 94111
(415) 956-7070

PUBLIC AND UNIVERSITY LIBRARIES

Reading copies of the NMGS EIS and associated technical reports will be available at the following public and university libraries:

State and Public Libraries

Albuquerque Public Library
501 Copper Avenue NW
Albuquerque, NM 87102

Aztec Public Library
201 W. Chaco
Aztec, NM 87401

Crownpoint Community Library
c/o Lioness Club, P.O. Box 731
Crownpoint, NM 87313

Cuba Public Library
Box 5, La Jara
Cuba, NM 87027

Farmington Public Library
302 N. Orchard
Farmington, NM 87401

Gallup Public Library
115 W. Hill Avenue
Gallup, NM 87301

Mother Whiteside Memorial Library (Public)
525 W. High Street
P.O. Box 96
Grants, NM 87020

New Mexico State Library
325 Don Gaspar Avenue
Santa Fe, NM 87503

OTHER DEPARTMENT OF THE INTERIOR AGENCIES

Bureau of Indian Affairs*
Albuquerque Area Office
123 4th Street
P.O. Box 2088
Albuquerque, NM 87198
(505) 766-3374 FTS 474-3374

Bureau of Indian Affairs*
Eastern Navajo Agency
P.O. Box 328
Crownpoint, NM 87313
(505) 786-5228

Bureau of Indian Affairs*
Navajo Area Office
Box M - Mail Code 305
Window Rock, AZ 86515
(602) 871-5151 FTS 479-5314

Bureau of Reclamation*
Upper Colorado Regional Office
125 S. State Street
P.O. Box 11568
Salt Lake City, UT 84147
(801) 524-5463 FTS 588-5463

Minerals Management Service*
South Central Region
505 Marquette Avenue NW, Suite 815
Albuquerque, NM 87102
(505) 766-1173 FTS 474-1173

Minerals Management Service*
Resource Evaluation Office
411 N. Auburn
Farmington, NM 87401
(505) 327-7397 FTS 572-6254

National Park Service*
Southwest Regional Office
1100 Old Santa Fe Trail
Santa Fe, NM 87501
(505) 988-6375 FTS 476-6375

National Park Service*
Environmental Coordination Office
Pinon Building, 1220 St. Francis Drive
P.O. Box 728
Santa Fe, NM 87501
(505) 988-6681 FTS 476-6681

U.S. Fish and Wildlife Service*
Field Supervisor, Ecological Services
3530 Pan American Highway, Suite C
Albuquerque, NM 87107
(505) 766-3966 FTS 479-3966

U.S. Geological Survey (WRD)*
505 Marquette Avenue, Room 720
Albuquerque, NM 87101
(505) 766-2810 FTS 474-2817

OTHER FEDERAL AGENCIES AND ORGANIZATIONS

Environmental Protection Agency*
Region VI
1201 Elm Street
Dallas, TX 75270
(214) 767-2716 FTS 729-2716

Navajo Tribe*
c/o Division of Resources
P.O. Box 308
Window Rock, AZ 86515
(602) 871-6592

Pueblo of Zia*
General Delivery
San Ysidro, NM 87053
(505) 867-3304

Soil Conservation Service*
424 N. Mesa Verde
Aztec, NM 87410
(505) 334-9437

U.S. Corps of Engineers*
P.O. Box 1580
Albuquerque, NM 87103
(505) 766-2657 FTS 474-2657

USDA, Forest Service*
717 Gold Avenue
Albuquerque, NM 87102
(505) 474-1676 FTS 474-1676

USDA, Forest Service*
District Ranger
Mt. Taylor Ranger District
201 Roosevelt Avenue
Grants, NM 87020
(505) 287-8833

Harwood Foundation Library
(Public)
25 LeDoux
P.O. Box 766
Taos, NM 87571

University/College Libraries

University of New Mexico
General Library
Albuquerque, NM 87131

Navajo Community College Library
Shiprock Branch
P.O. Box 580
Shiprock, AZ 87420

Northern New Mexico Community College
P.O. Box 250
Espanola, NM 87532

New Mexico State University
San Juan Campus
4601 College Blvd.
Farmington, NM 87401

University of New Mexico, Gallup Campus
Learning Resources Center
200 College Road
Gallup, NM 87301

New Mexico State University/Grants
1500 Third Street
Grants, NM 87020

New Mexico Highlands University
Donnelly Library
National Avenue
Las Vegas, NM 87701

College of Santa Fe
Fogelson Memorial Library
St. Michaels Drive
Santa Fe, NM 87501

ALTERNATIVES TO THE PROJECT

for the

Environmental Impact Statement on Public Service Company of New Mexico's Proposed New Mexico Generating Station and Possible New Town

Prepared by

Woodward-Clyde Consultants

for the

**U.S. Department of the Interior
Bureau of Land Management**

CONTENTS

FIGURE AND TABLES

1.0
INTRODUCTION

This technical report presents supporting analyses and discussions related to alternatives to the proposed project as described in Chapter 1 of the New Mexico Generating Station (NMGS) Environmental Impact Statement (EIS). In accordance with the regulations promulgated by the Council on Environmental Quality [1]* regarding the implementation of the National Environmental Policy Act of 1969, the Bureau of Land Management (BLM), acting as the federal lead agency for the preparation of the NMGS EIS, has a responsibility to prepare an EIS which "shall inform decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment." In accordance with guidance from the Council on Environmental Quality [2], "reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant."

This technical report considers alternatives that would provide for the electrical need that NMGS is designed to supply and that would involve something other than building a single conventional coal-fired central-station steam electric plant. Both alternatives that would

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*Numerals in brackets refer to the numbered list of references at the end of this report.

supply the electrical need and alternatives that would reduce the need are considered. Another technical report analyzes the reasonableness of the applicant's statement of purpose and need [3].

This report is organized as follows: Section 2.0 is a summary of methods and results, Section 3.0 provides a detailed description of the selection of alternatives, and Section 4.0 presents the analysis of alternatives. Supporting material is provided in two appendices.

The reader who is interested in a summary of the methods used to select and analyze alternatives will find this in Section 2.0. This summary also contains references to appropriate sections of the report which contain more details concerning each step in the selection and analysis. The selection of alternatives is reviewed in detail in Section 3.0, and supporting information on every alternative is contained in the appendices.

2.0
SUMMARY OF METHODS AND RESULTS

2.1 SELECTION OF ALTERNATIVES

A four step process was used to select alternatives to NMGS:

1. Review applicant's statement of purpose and need, and identify selection concerns: Identify the appropriate analysis concerns for the selection of alternatives for the NMGS EIS.

2. Determine potential energy options: Include the full range of options that might be relevant to meeting PNM's need for power.

3. Screen energy options: Select those energy options that have the potential to meet a significant portion of PNM's energy needs during the NMGS planning period.

4. Develop alternatives: From the energy options selected, develop alternatives to NMGS.

The relationships among the various steps are shown in Figure 2-1. A distinction has been drawn here between options, which are individual ways of generating or saving electrical energy, and alternatives, which are total methods for meeting the needs for

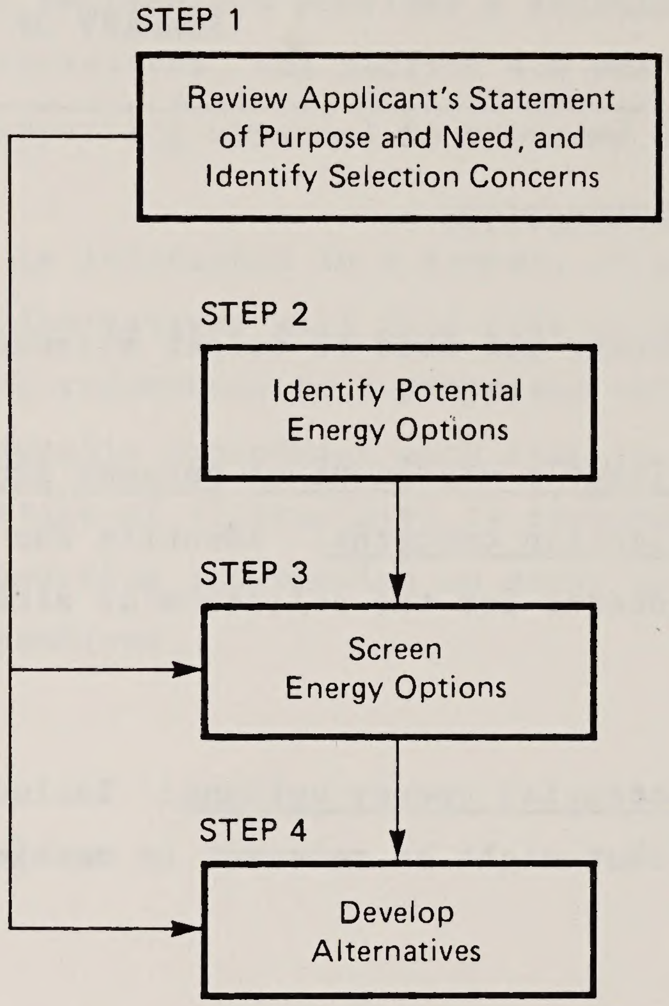

Figure 2-1. PROCESS FOR SELECTING ALTERNATIVES TO NMGS

electric energy that PNM proposes to meet with NMGS. Thus an alternative might consist of one or several options. Each selection step, and its results, is summarized below. Additional details are given in Section 3.0.

Step 1: Review Applicant's Statement of Purpose and Need, and Identify Selection Concerns

PNM has stated [4] that the purpose of the NMGS project "is to provide the management of the Public Service Company of New Mexico (PNM) with sufficient information to assess the benefits and risks of developing a coal-fired generating station ... evaluated against a full range of options to meet the electrical energy needs of PNM's customers in the 1990s and beyond." (PNM's complete statement of purpose is included in Section 3.0.) PNM's assessment of need [5] states that the first 500-MW unit of NMGS could be needed in May 1990, with full production from all four 500-MW units occurring as early as 1998.

Council on Environmental Quality regulations [1] specify the following concerns for selecting alternatives:

- Identify reasonable alternatives that will avoid or minimize adverse impacts or enhance the quality of the human environment.
- For alternatives that are eliminated from detailed study, briefly discuss the reasons for their being eliminated.
- Include the alternative of no action.
- Include a reasonable number of example alternatives covering the full spectrum of possibilities.

The following steps of the selection process address these concerns while also focusing on the applicant's purpose and need.

Step 2: Identify Potential Energy Options

The potential energy options were identified by reviewing a variety of sources, including PNM planning documents, other EISs, government energy planning documents, and material furnished by interested private groups. All specific options identified in the scoping analysis and public involvement summary [6] prepared by the BLM for NMGS were included. A total of 39 different specific energy options were identified in the following 11 categories: coal, oil/gas, geothermal, hydroelectric, direct solar, wind, biomass, nuclear, out-of-state, non-generation (conservation, load management), and miscellaneous. The options and the sources which suggested each one are shown in Table 3-2.

Step 3: Screen Energy Options

The potential energy options were screened to retain those that are likely to make a significant contribution to the need that NMGS would meet within the planning period of NMGS. Specific criteria were defined to screen the potential energy options to assure they were:

- In accord with national energy policy.
- Technically feasible.
- Capable of meeting or eliminating a significant portion of the electric need that PNM proposes to meet with NMGS. The criterion used was that an option had to be able to supply or eliminate the need for at least 5 percent of the yearly energy NMGS would supply.

The candidate options retained after the screening in this step are shown in Table 2-1.

Table 2-1. CANDIDATE OPTIONS RETAINED AFTER SCREENING

Category	Candidate Energy Option
Coal	● Central-station steam electric (NMGS) ● Decentralized steam electric ● Coal conversion plus generation
Geothermal	● Hot water (high-temperature liquid-dominated)
Hydroelectric	● Large (central-station)
Direct Solar	● Central-station thermal electric ● Central-station photovoltaic ● Decentralized photovoltaic ● Point-of-use solar heating
Wind	● Central-station
Biomass	● Agricultural and forestry wastes ● Wood
Nuclear	● Water-cooled fission reactor
Out-of-State Power Source	● Purchase contract ● Equity participation
Non-generation	● Conservation
Miscellaneous	● Fuel cells

Step 4: Develop Alternatives

This step assembled the candidate options identified in Step 3 into a set of alternatives for meeting or eliminating the electrical needs that would be met by NMGS. (Note that an alternative must be able to meet or eliminate the need for all of the electricity that NMGS would provide while the options identified in Step 3 only have to be able to meet or eliminate a portion of the need that NMGS would meet.) This was done by applying the following selection guidelines:

- Include as an alternative any candidate reasonable option that could by itself meet or eliminate the electrical need that NMGS would meet.
- Include every candidate option as part of at least one alternative.

The resulting alternatives are shown in Table 2-2.

2.2 ANALYSIS OF ALTERNATIVES

The analysis summarized above shows that six potentially viable alternatives are available: a decentralized coal-fired steam electric system, a coal conversion plant, a geothermal plant, a nuclear plant, an out-of-state power source, and a renewable resource alternative. The environmental issues associated with these are briefly summarized below and presented in more detail in Section 4.

Decentralized Coal-Fired Steam Electric System

Since each individual plant in a decentralized system would be smaller than NMGS, the local environmental effects would be less than with NMGS, assuming comparable equipment and local conditions. However, the overall cumulative environmental loading for the whole

Table 2-2. ALTERNATIVES

Alternative	Description
Coal-fired central-station steam electric plant	The applicant's proposed action (NMGS).
Decentralized coal-fired steam electric system	Two or more small coal-fired plants with the same combined capacity as NMGS, built at different locations.
Coal conversion plant	A coal gasification facility in conjunction with either a combined-cycle or fuel-cell generating plant. This would probably not be commercially available until the mid-1990s. In the event that PNM's higher-load-growth scenarios occur, power purchase would be necessary for several years.
Geothermal plant	A generating plant using steam from underground high-temperature (>150°C) hot water reservoirs.
Nuclear plant	A light-water fission reactor plant. Operation of such a plant could probably not commence until the mid-1990s. In the event that PNM's higher-growth scenarios occur, power purchase would be necessary for several years.
Out-of-state power source	This alternative would rely on either contract purchase of out-of-state power or equity participation in one or more out-of-state generation projects.
Conservation and renewable resource alternative	This is a combination strategy involving conservation and a variety of renewable generation resources, possibly including large hydroelectric, central-station solar-thermal electric and photovoltaic, decentralized photovoltaic, point-of-use solar heating, central-station wind, agricultural and forestry wastes, and wood-fired generation. Energy storage might be required with this alternative.

system should be at least comparable to that for NMGS. Each plant in the decentralized system would require a corridor for delivery of coal and an electric transmission corridor. In addition, depending on the water sources, a water supply corridor might be required. The environmental effects of a decentralized coal-fired steam electric system are reviewed further in Section 4.1.

Coal Conversion Plant

The environmental effects in the immediate vicinity of a gasification facility are anticipated to be more pronounced than for direct coal combustion. The primary concern is the safe disposal of the large quantities of solid wastes that would be produced. Air pollution issues and treatment of liquid-waste streams are also important environmental issues. Current projections are that a coal conversion plant would be more complex than a conventional coal-fired plant. Hence, it would probably require a larger construction and operating work force than NMGS. The environmental effects of a coal conversion plant are reviewed further in Section 4.2.

Geothermal Power

Major environmental issues are airborne emissions, solid wastes, brine disposal, induced seismicity, subsidence, water use, and hydrologic changes. Other issues include noise, chemical or thermal pollution of surface and ground waters, increased land and ecosystem disturbance (e.g., erosion, sedimentation), and short-term climate disturbances. The environmental effects are highly site-dependent. The environmental effects are reviewed further in Section 4.3.

Nuclear Power

Nuclear power plants produce radioactive isotopes that may escape into the reactor cooling system. Also, structural and other materials are made radioactive during reactor operation, and liquid radioactive wastes are produced. Small quantities of short-lived radioactive gases and airborne particulates are released.

Decommissioning of a nuclear power plant must be done in a way that protects public health and safety. Spent fuel from a reactor is highly radioactive and requires shielding and permanent isolation from the human environment. The safety of nuclear power plants during an accident is a public concern. The environmental effects of nuclear power are reviewed further in Section 4.4.

Out-of-State Power Source

Potential out-of-state sources of electricity are likely to be either coal-fired or nuclear power plants. In the absence of unusual local situations, the environmental effects should be similar to those for similar plants located in New Mexico. Out-of-state power sources are reviewed further in Section 4.5.

Conservation and Renewable Resource Alternative

This would involve use of a combination of conservation, large hydroelectric, central-station solar-thermal electric or photovoltaic, decentralized photovoltaic, point-of-use solar heating, central-station wind, agricultural and forestry wastes, and wood-fired generation. Environmental issues associated with conservation are minor. Hydroelectric environmental issues include passage of fish around dams, water-level fluctuations and downstream flow changes, water quality, and dredging. The reservoir behind a dam will destroy the resources, ecosystems, and human uses of land in the area innundated. Central-station solar systems require large land areas with potential for land-use conflicts and disturbance of local ecosystems. Environmental issues associated with decentralized photovoltaic and point-of-use solar heating are minor. Central-station wind plant issues include safety, electromagnetic interference, noise, aesthetic, and land use problems. Agricultural and forestry waste environmental issues include erosion due to removal of wastes that would otherwise hold the soil in place, airborne pollutants, and waste disposal. Environmental issues associated with wood-fired generation are similar. The environmental effects of the conservation and renewable resource alternative are reviewed further in Section 4.6.

3.0

SELECTION OF ALTERNATIVES

The process described below selects alternatives to NMGS. The alternatives-selection process consisted of the four steps which are diagramed in Figure 2-1 and briefly summarized in Section 2.1. Each step is described in more detail below.

Step 1: Review Applicant's Statement of Purpose and Need, and Identify Selection Concerns

The purpose of this step is to establish general guidelines for the selection of alternatives.

The applicant's statement of purpose [4] is as follows:

> 1. STATEMENT OF PURPOSE
>
> The purpose of this phase of the New Mexico Generating Station (NMGS) Project is to provide the management of the Public Service Company of New Mexico (PNM) with sufficient information to assess the benefits and risks of developing a coal-fired generating station. This risk and benefit analysis will be evaluated against a full range of options to meet the electrical energy needs of PNM's customers in the 1990s and beyond. Among the options considered by PNM are nuclear, geothermal, solar, hydro, conservation, and others. In order to make the best decision, PNM management requires information related to the feasibility and availability of such coal-related resources as land, water, and fuel. Additionally, PNM management requires information regarding the suitability of the proposed project's impact on the human and natural environments in accordance with the NEPA process.

As set forth in the July 10, 1981, letter from PNM to BLM, the proposed project consists of a coal-fired generating station with up to four 500-MW units. The units will be placed in service in the 1990s, with the first unit possibly as early as May, 1990. Associated with the generating station are two 500-kV transmission lines to Albuquerque, a 500-kV tie to the Four Corners-Ambrosia 500-kV lines, and two water pipelines from San Juan River to the generating station.

2. BACKGROUND

Planning and constructing new power generation facilities is a complex and dynamic process. Multiple objectives must be satisfied within the limits of technological and economic feasibility. The chief planning objective is to match the supply of power with the customer's demand.

Given the omnipresent uncertainty of the future and the long time period, often in excess of ten years, that it takes to plan and construct a facility, additional complexity is added. The human, financial, and physical resources committed to such planning are enormous.

PNM's long-range planning program is conducted pursuant to the New Mexico Public Utility Act and regulation by the N.M.P.S.C. The company's planning for future generation needs is consistent with its corporate mission to provide adequate and reliable electric service at the lowest reasonable cost to the ratepayer while providing a reasonable return to PNM investors.

To accomplish this mission, PNM employs state of the art econometric modeling programs and forecasting techniques. The data deriving from those tools are incorporated into studies which indicate a range of future load growth. The impact of the increased energy prices, natural gas deregulation, energy and demand conservation, solar energy applications, innovative rate design, and direct load control techniques, are among the various factors accounted for in these analyses.

For more than twenty years, PNM has evaluated and, in some cases, pursued various options for meeting customer energy requirements. Such options have included:

1. Coal - Four Corners Project
   San Juan Project
2. Nuclear - Arizona Nuclear Power Project
3. Geothermal - Baca Geothermal Project
4. Hydro - Pumped Storage Project
5. Solar - Solar Hybrid Repowering Project
6. Conservation and Load Management Programs

These options, along with such technologies as wind, refuse burning, coal gasification, and fuel cells, are being continuously measured against:

- Commercial availability of the technology required for the option
- Availability of the required resources
- Environmental and social impacts
- Capital investment required
- The ability of the corporation to successfully implement the option in the time frame and dollars required.

Load growth in New Mexico is such that a combination of options is required to meet anticipated demand. No single option can meet all needs. Based upon current load growth forecasts, it is anticipated that additional base load generating capability will be required between 1990 and 2000. Therefore, PNM has established the New Mexico Generating Station Project. This project is intended to place emphasis on the coal option for meeting anticipated needs. In examining this option, the company is assessing the feasibility and availability of required resources (land, water, and fuel), and the probable impact on the environment from pursuing such a course. PNM views coal as the best available option for meeting part of the energy requirements of the 1990s. Accordingly, the company has chosen to subject the risks and benefits from coal development to detailed analysis. This analysis will be conducted in conjunction with continued study of the other options presently in use in the generating system.

In summary, the hallmark of system planning must be flexibility. Flexibility is required by the rapidly changing demands for electrical energy and by the rapid changes in the power supply options available to the company. This flexibility must be especially evident in planning new generation facilities. The eight to twelve years required to bring a coal station into commercial operation makes it difficult to establish a "date certain". Nevertheless, the same long lead-time from conception to commercial operation required that the company start very early to assess the risks and weigh the benefits of a given option. This process takes place while new data and altered circumstances dictate the need to accelerate or slow down the potential completion dates due to changes in the load and resource picture.

3. NEW MEXICO GENERATING STATION EIS

To assess the NMGS Project as the next potential coal option for the 1990s, PNM has requested the Bureau of Land Management (BLM) to consider the issuance of right-of-way grants for any

> proposed water conveyance system and transmission lines associated with the project.
>
> In response to PNM's application for those facilities, BLM, New Mexico State Office, was designated as the federal lead agency to prepare the EIS for the project in accordance with the NEPA process.
>
> Depending on the outcome of NEPA/EIS process, and the land, water, and fuel resource acquisitions, PNM recognizes that there are many other regulatory and permit requirements that would have to be met. These include construction permit, location permit, numerous environmental approvals by state and federal agencies, and a certificate of convenience and necessity by the New Mexico Public Service Commission, before any construction would be allowed to begin.

The general concerns for selection of alternatives are laid out in federal regulations regarding environmental impact statements. Table 3-1 presents the overall selection concerns. This selection step specifies both the applicant's purpose and need and the general selection concerns to be addressed under federal regulations so the reader will understand the BLM's statutory responsibilities with regard to analysis of alternatives to NMGS. In particular, federal regulations [1] require that the BLM "identify reasonable alternatives that will avoid or minimize adverse impacts or enhance the quality of the human environment" and that the analysis "focus on significant environmental issues and alternatives." Thus, the emphasis for the selection and analysis of alternatives is on environmental questions. In particular, economic and engineering issues are addressed only to the extent this is needed to assure that reasonable alternatives are "practical or feasible from the technical and economic standpoint" [1].

Step 2: Identify Potential Energy Options

The purpose of this step is to identify the full range of energy options that might contribute to meeting PNM's electric energy and power needs. These options were suggested by listings in a variety of sources; in addition, they include all specific options identified in

Table 3-1. OVERALL SELECTION CONCERNS

1. Identify reasonable alternatives[a] that will avoid or minimize adverse impacts or enhance the quality of the human environment (Ref. A, Sec. 1502.1).
2. For alternatives that are eliminated from detailed study, briefly discuss the reasons for their being eliminated (Ref. A, Sec. 1502.14).
3. Include the alternative of no action[b] (Ref. A, Sec. 1502.14).
4. Include a reasonable number of example alternatives covering the full spectrum of possibilities (Ref. B, p. 18027).
5. Focus on significant environmental issues and alternatives rather than the accumulation of extraneous background data (Ref. A, Sec. 1502.1).

References:

A. Office of the Federal Register, "Code of Federal Regulations, Title 40, Part 1502--Environmental Impact Statement," 1980.

B. Council on Environmental Quality, "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," Federal Register, Vol. 46, No. 55, pp. 18026-18038 (March 23, 1981).

Notes:

[a] Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint rather than simply desirable from the standpoint of the applicant (Ref. 2, p. 18027). Include reasonable alternatives not within the jurisdiction of the lead agency (Ref. A, Sec. 1502.14).

[b] "No action" means that the proposed activity would not take place. Where a choice of "no action" by the agency would result in predictable actions by others, this consequence of the no-action alternative should be included in the analysis (Ref. B, p. 18027).

the scoping analysis and public involvement summary prepared by BLM for the NMGS EIS, and in the project description prepared by PNM. These electric energy options and the sources that suggested each are summarized in Table 3-2. It should be emphasized that potential options need only be capable of contributing to PNM's needs, not necessarily meeting them alone.

Step 3: Screen Energy Options

The purpose of this step is to retain for further study, from among those identified in Step 2, the options that could be likely to make a significant contribution to meeting the need that NMGS would meet. Three general considerations were addressed in making this selection; options retained must be:

- In accord with national energy policy
- Technically feasible
- Capable of meeting or eliminating the need for a significant portion of the electric need that PNM proposes to meet with NMGS (see Table 3-3, No. 3, for an exact statement of this criterion)

This step was carried out by defining specific screening criteria based on the above requirements, and applying these criteria to the potential energy options identified in Step 2. Those options that satisfied all criteria were retained.

The specific screening criteria, and the rationale for each, are shown in Table 3-3. Further description of the energy options and screening results is presented in Appendix A.

Step 4: Develop Alternatives

The purpose of this step is to assemble the energy options, including those identified in the public scoping process, into a

Table 3-2. POTENTIAL ENERGY OPTIONS

		Source					
Category	Potential Energy Option	AWV	CEC	CPUC	PNM	Scope	Other
Coal	Central-station steam-electric (NMGS)	x	x	x	x		
	Decentralized steam-electric	x					
	Retrofit of existing oil/gas units	x	x		x	x	
	Coal conversion plus generation	x	x	x	x	x	
Oil/Gas	Steam turbine		x		x		
	Combustion turbine		x	x	x		
	Combined cycle		x	x	x		
Geothermal	Dry steam		x	x			
	Geopressured			x			
	Hot water		x	x	x		x
	Hot dry rock			x			
Hydro-electric	Large (>25 MW)	x	x		x	x	
	Small (including low-head)	x	x	x	x	x	x
Direct Solar	Central-station thermal-electric		x	x	x	x	x
	Solar-thermal repowering of existing units			x	x		
	Central-station photovoltaic		x	x	x	x	x
	Decentralized ("rooftop") photovoltaic		x	x	x	x	x
	Point-of-use solar heating			x		x	
	Solar-power satellite	x					
	Solar ponds	x	x				
Wind	Central-station ("windfarm")		x	x	x	x	x
	Decentralized ("backyard")		x	x		x	
Biomass	Municipal solid waste		x	x	x	x	
	Agricultural and forestry wastes		x	x	x	x	
	Wood			x		x	
	Nonwood energy crops		x	x		x	
Nuclear	Water-cooled fission reactor	x	x	x	x		x
	High-temperature gas-cooled fission				x		
	Breeder fission				x		
	Fusion				x		
Out-of-State	Purchase contract	x	x	x	x	x	
	Equity participation	x					

Table 3-2. POTENTIAL ENERGY OPTIONS (concluded)

Category	Potential Energy Option	Source					
		AWV	CEC	CPUC	PNM	Scope	Other
Non-generation	Conservation	x	x	x	x	x	x
	• Rate structure						
	• Volunteer (assistance/information)						
	• Mandatory (legislative/regulatory)						
	Load management			x	x		
	• Rate structure						
	• Direct control at point of use						
Miscellaneous	Cogeneration		x	x	x	x	x
	Fuel cells		x	x	x		

Sources:

AWV	Bureau of Land Management, "Allen-Warner Valley Energy System Environmental Impact Statement," November 1980.
CEC	California Energy Commission, "Electricity Tomorrow, 1981 Final Report to the Governor and the Legislature," January 1981.
CPUC	California Public Utilities Commission: • C.E. Rixford, "Conventional Utility Supply Options," Appendix 8 to the Summary Report of the Allen-Warner Project Team, August 1980. • C. Ford and L. Huen, "Non-conventional Energy Resources," Appendix 9 to the Summary Report of the Allen-Warner Project Team, August 1980.
PNM	Public Service Company of New Mexico, "Description of the Proposed Project: New Mexico Generating Station," 1980.
Scope	Bureau of Land Management, New Mexico State Office, "Scoping Analysis and Public Involvement, Summary for the Proposed New Mexico Generating Station Environmental Impact Statement and the San Juan Basin Action Plan Cumulative Overview," May 1981.
Other	Dave Marcus, "Need for NMGS: PNM's Exercise in Deception," Southwest Research and Information Center, November 1981.

Table 3-3. CRITERIA FOR SCREENING POTENTIAL ENERGY OPTIONS

Screening Criteria	Rationale for Screening Criteria
1. For an option to be selected, it must be consistent with U.S. policy to reduce dependence on petroleum and natural gas.	The Powerplant and Industrial Fuel Use Act of 1978 and other actions of the U.S. government establish that it is U.S. policy to reduce the use of oil and natural gas for electric power generation.
2. For an option to be selected, it must be projected that the option could be commercially available, licensed, and in operation by the end of the planning period for NMGS.[a]	If an option would not be available until after the planning period for NMGS, it cannot be included in an alternative to NMGS. Since some units of NMGS would not be built until late in the planning period, an option might serve as part of an alternative to NMGS even if the option would not be available at the time PNM proposes to build the first unit of NMGS.
3. For an option to be selected, it must be projected to be capable of providing, or eliminating the need for, at least 5 percent of the annual energy output proposed for NMGS,[b] beginning at some time during the planning period.[a]	The objective of the alternatives selection is to identify reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment. If an option would meet less than 5% of the need PNM proposes to supply with NMGS, the option would not significantly reduce the need for NMGS or the environmental impacts associated with NMGS. Hence, such an option would not meet the objectives of the alternatives selection. The very small number (5%) is used in order to be conservative and not eliminate an option simply because it could not meet most of PNM's projected need by itself.

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[a] The end of PNM's planning period for NMGS is 1998.

[b] The annual energy output from NMGS at a 65 percent capacity factor would be 2000 MW x 8760 hr/yr x 0.65 = 11,388 GWh/hr; 5 percent of this is 569.4 GWh/hr.

set of alternatives for meeting or eliminating the energy and power needs that would be met by NMGS in a way that would permit a clear environmental analysis in the EIS. The step was carried out by defining and applying specific selection guidelines consistent with the concerns identified in Step 1. These guidelines are listed, along with the rationale for each, in Table 3-4. Brief summaries of the resulting alternatives are given in Table 2-2. The application of the selection guidelines is described further in Appendix B.

Table 3-4. GUIDELINES FOR DEVELOPING ALTERNATIVES

Guideline	Rationale for Guideline
1. Include as a distinct candidate alternative any energy option that could, <u>by itself</u>, meet or eliminate the power and energy needs that NMGS at full production would meet,[a] and that could do so no later than PNM's projected start of full NMGS production.[b] The remaining options are to be included in combinations so that together they fulfill the above requirements, with similar resources grouped together where possible.	This guideline ensures that, to the extent possible, subsequent analysis of environmental impacts in the EIS will not be clouded by a multiplicity of diverse technologies, some of which would be of such small size and impact to have very little influence on the overall environmental effects of any alternative to NMGS.
2. Include every energy option as part of at least one alternative.	The process of assembling specific alternatives to NMGS from general energy options should not by itself eliminate possible methods from consideration.

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[a] PNM plans that full production for NMGS would be 2000 MW at 65 percent capacity factor.

[b] PNM states that full production from NMGS could start in 1998.

4.0
ANALYSIS OF ALTERNATIVES

The analysis in Section 3.0 and Appendices A and B shows that the applicant has six potentially viable alternatives to NMGS for meeting the identified need: a decentralized coal-fired steam electric system, a coal conversion plant, a geothermal plant, a nuclear plant, an out-of-state power source, and a renewable resource alternative. For each of these, a summary is provided below of environmental effects and uncertainties. Numerous different estimates have been made of the cost of electricity for different generation technologies (see, for example, references 7-11). Costs for technologies which are not yet in commercial use are uncertain. In addition, costs for all technologies are dependent on the specific situation in which they are utilized. For these reasons we have not provided cost estimates for the various alternatives.

4.1 DECENTRALIZED COAL-FIRED STEAM ELECTRIC SYSTEM

Environmental Effects

Since each individual power plant in the decentralized system would be smaller than NMGS, the local environmental effects around each plant site would be less than with NMGS, assuming comparable equipment and local conditions. However, the overall cumulative environmental loading for the whole system with regard to air quality, water use and quality, and solid-waste disposal should be at least comparable to that for NMGS. This is because the total electric energy generated would be similar for the two alternatives, and operating experience shows that smaller plants are generally less efficient than larger plants [69]. Hence, more coal would need to be utilized to generate the same amount of electricity as NMGS. If the rate of emissions of pollutants is the same for the coal combustion at the smaller plants as at NMGS, the total emission of pollutants will be greater for the total decentralized system, since more coal would be burned.

Each plant in the decentralized system would require a corridor for delivery of coal and an electric transmission corridor. In addition, depending on the water sources, a water supply corridor might be required. The environmental effects of these corridors would depend on the specific number and locations of the plants; however, the required multiple corridors would likely have more severe impacts than the smaller number of corridors associated with the single NMGS site. This is particularly true since NMGS would be located near its expected coal supplies and hence would have a short coal delivery corridor.

Uncertainties

Since the technology associated with coal-fired power plants is well established, there are relatively few engineering or environmental uncertainties. The major uncertainties are whether or not PNM could locate, acquire, and license sites and associated corridors for the multiple power plants.

4.2 COAL CONVERSION PLANT

Environmental Effects

The major environmental effects of a coal conversion plant are discussed in a recent U.S. Department of Energy Environmental

Information Handbook, Energy Technologies and the Environment [12]. This handbook concludes that the environmental effects in the immediate vicinity of gasification facilities would be more pronounced than for direct coal combustion. The primary concern is the safe disposal of the large quantities of solid wastes that would be produced. Trace elements and trace organics in the ash or sludge might be toxic or carcinogenic. However, more research work would be needed to fully define the scope of the environmental problems.

In addition, major air pollution issues for a coal conversion plant include the evolving environmental regulations and the mitigation controls they necessitate, siting with regard to prevention of significant deterioration, nonattainment, characterization of discharges and control of their ecological and health impacts, and acid rain. Few data exist on the composition of gas discharge streams from a gasification process. Even qualitative information about the presence of various chemical species in certain streams is somewhat speculative. However, the gaseous streams of greatest environmental concern are probably flue gas from power and stream generation and the primary acid gas streams.

The treatment of liquid-waste streams is also an important environmental issue in coal gasification. Ash quench water and process condensate (raw gas liquor), together with waste solvents and reagents from gas purification, are major concerns.

Although a full-scale coal conversion plant has not yet been built, current projections are that such a plant would be more complex than a conventional coal-fired plant. Hence it would probably require a larger construction and operating work force than NMGS. Thus the social and economic effects on the surrounding region would be more intense for the coal conversion plant. Land and water requirements would be similar for the two types of plants.

Uncertainties

Because this technology has not been used in a full-scale power plant, there are uncertainties about what the exact environmental effects would be. Costs, construction difficulties, and operating reliability are also uncertain.

4.3 GEOTHERMAL PLANT

Environmental Effects

The U.S. Department of Energy [12] says that the major environmental issues in geothermal power production are airborne emissions, solid wastes, brine disposal, induced seismicity, subsidence, water use, and hydrologic changes. Other issues include noise, chemical or thermal pollution of surface and ground waters, increased land and ecosystem disturbance (e.g., erosion, sedimentation), and short-term climatic disturbances. The environmental effects are highly site-dependent.

The airborne emissions of greatest concern are hydrogen sulfide and the trace metals. Hydrogen sulfide has an extremely offensive smell and is very toxic at high concentrations. Its release has been a historical problem at geothermal plants.

The management of spent hydrothermal fluids is a key issue, since most are very saline and cannot be discharged into surface or ground waters. The anticipated disposal scheme is to inject the spent fluids back into the geothermal reservoir, but scaling and plugging are sometimes a problem with very saline fluids. Treatment of the spent fuel would produce large quantities of sludge, which would require careful disposal.

The removal of large quantities of fluid from a geologic formation may result in subsidence, or sinking of the land. Also, the withdrawal and injection of geothermal fluids may increase the rate of microseismic events.

Uncertainties

Although there are substantial geothermal resources in New Mexico, PNM reports [13] that there have been substantial difficulties in well field development for its Baca Ranch project. PNM now believes that large-scale development might be very costly and has abandoned the project [14].

4.4 NUCLEAR POWER PLANT

Environmental Effects

Nuclear power plants produce radioactive isotopes (fission products) [12]. Some of these could escape into the reactor cooling system because of defects in the cladding material. Also, structural materials, coolant-borne materials, and corrosion products are made radioactive by radiation produced during the fission process. Liquid radioactive wastes are produced from excess reactor coolant, collected drainage, leaky valve stems and pump seals, and so forth. In normal operation, these and other wastes are packaged and disposed of in accordance with safety regulations. Normal operation of commercial light water reactors results in release of small quantities of short-lived radioactive gases and airborne particulates.

Decommissioning of a nuclear power plant must be done in a way that protects public health and safety. The primary ways of decommissioning a facility are (1) "mothballing," which involves removing all fuel and selected radioactive components and placing the facility in protective storage; (2) entombment, which consists of removing all fuel and selected components and sealing the remaining major radioactive components within the shielding structure; and

(3) removal/dismantling, which consists of removing from the plant site all fuel and components having radioactivity above predetermined levels.

Spent fuel from an operating nuclear reactor is highly radioactive and requires shielding. In addition, the spent fuel generates a large amount of heat, necessitating cooling. Because spent fuel is highly radioactive and its radioactivity persists for a very long time, it requires permanent isolation from the human environment. Current national policy is to develop mined geologic repositories to provide this isolation. This would involve placing the spent fuel in deep, geologically stable rock formations. No such repositories are currently in operation. Currently, spent fuel is being accumulated in on-site storage at commercial power plants across the country. Within the next 5 years, the U.S. Department of Energy [12] estimates that some plants will run out of storage space.

The safety of commercial nuclear power plants during an accident has been of concern since the first plants were built in the 1950s. The Three-Mile Island accident in March 1979 drew additional attention to this, although no one was killed or physically injured. Commercial power reactors in the United States have compiled several hundred reactor-years of operation without any member of the public being killed or seriously injured.

Uncertainties

Current estimates of the total time for regulatory studies, licensing, construction, and startup of a nuclear power plant range from 12 to 14 years [5,15-18]. Thus, if PNM's need for electricity grows at a rate near the high end of its current estimates, the company would need to obtain power from an out-of-state source for several years until its nuclear plant was ready. In addition, current uncertainties about future regulation of nuclear power plants make it difficult to plan for a new nuclear power plant [19].

4.5 OUT-OF-STATE POWER SOURCE

Environmental Effects

Potential out-of-state sources of electricity are likely to be either coal-fired or nuclear power plants. In the absence of unusual local situations, the environmental effects should be similar to those for such plants located in New Mexico.

Uncertainties

PNM states [20] that it is likely that an out-of-state power supply may not have the same long-term availability as a PNM-operated NMGS. However, long-term contractual arrangements that provide for reliable supplies of electricity from out-of-state sources are common in the electrical utility industry. For example, PNM is a partial owner of the Palo Verde Nuclear Generating Station in Arizona and plans to meet some of its future electrical needs from this source. Thus, in the BLM's judgment, the uncertainties for an out-of-state power plant would be similar to those for a plant of the same type located in New Mexico.

4.6 CONSERVATION AND RENEWABLE RESOURCE ALTERNATIVE

Environmental Effects

This combination strategy would involve use of some combination of the following: conservation, large hydroelectric, central-station solar-thermal electric or photovoltaic, decentralized photovoltaic, point-of-use solar heating, central-station wind, agricultural and forestry wastes, and wood-fired generation. The environmental effects of each of these is discussed below.

Environmental issues associated with conservation are minor. However, this could only provide for a fraction of the energy that NMGS would supply.

For hydroelectric plants, four environmental issues are likely to require detailed site-specific analyses [12]: (1) the need for upstream and downstream passage of certain species of fish around dams, (2) the effects of water-level fluctuations and downstream flow changes, (3) water quality, and (4) the environmental effects of dredging.

The primary determinants of whether fish passage will be a significant issue at a particular site are the fish species, habitat conditions upstream from the dam, and regulatory requirements. For those fish species whose life cycle includes migration for spawning, blocking migration by a dam can have significant consequences.

Water-level fluctuations resulting from releases required for peak power can adversely affect both reservoir and downstream ecosystems. Potential water quality issues include alteration of temperature regimes, reduced turbidity, changes in dissolved oxygen, increases in certain dissolved metals, and altered nutrient and organic matter regimes. Potential adverse impacts due to dredging include loss of primary production and stress to fish from increased turbidity and destruction of bottom aquatic habitat, and secondary effects on aquatic biota.

PNM states [21] that "in northern New Mexico, institutional barriers appear to inhibit hydropower development. Especially concerns expressed by the Indian Nations and the New Mexico Department of Game and Fish severely limit new hydroelectric developments. Some parts of the Chama River (from Heron Dam to Abiquiu) come under restrictions from the Wild and Scenic Rivers Act and are, therefore, difficult if not precluded from development."

Central-station solar-thermal electric or photovoltaic systems would require construction over relatively large areas of land, with potential for land use conflicts and disturbance of local ecosystems.

Environmental issues associated with decentralized photovoltaic and point-of-use solar heating are minor. However, these could only provide for a fraction of the energy that NMGS would supply.

Environmental issues associated with central-station wind plants are relatively minor [12]. The main ones are (1) safety, both public and occupational, during construction and operation; (2) electromagnetic interference, particularly to nearby television receivers, (3) noise; and (4) the aesthetic and land use problems of siting very large towers. Minor issues include bird collisions, ice-throwing, lightning danger, and potential aircraft hazards.

Agricultural and forestry wastes might be directly burned or converted to a liquid fuel such as alcohol. The environmental effects of direct burning would be similar to those for wood-fired generation, which is discussed below. Environmental issues associated with biomass-derived alcohol fuel arise from biomass production, conversion to alcohol, and electricity production [12].

The most significant potential problem related to biomass production is erosion due to removal of wastes that would otherwise help to hold soil in place. Erosion depletes soil fertility and affects air quality, water quality, and ecological communities.

Conversion of biomass to alcohol by biochemical or thermochemical means produces various emissions that may cause environmental problems. Thermochemical process emissions include particulates, nitrogen and carbon oxides, ammonia, and hydrocarbons; as well as oils, phenols, and polynuclear aromatic hydrocarbons. Biochemical processes produce sludges with high biochemical oxygen demand. If applied to the land, these can introduce unconverted organic material, minerals, and inorganic salts into local water supplies and cause a buildup of salts in the soil. However, much of this sludge can be dried and sold as cattle feed.

The environmental, health, and safety issues related to <u>wood-fired generation</u> are not well known [12]. Areas of particular concern are gaseous and particulate pollutants, residue disposal, and safety. Other issues related to harvesting, transportation, handling, and storage systems include nutrient depletion in forest lands, emissions during wood handling, leachate from wood storage, soil erosion, stream sedimentation, impact on ecosystems, land use competition, and occupational accidents in wood harvesting.

Many factors influence the atmospheric emissions from wood burning, but the pollutants of concern include particulates, carbon monoxide, nitrogen oxides, hydrocarbons, polycyclic aromatic hydrocarbons, phenols, aldehydes, potassium, calcium, and aluminum.

<u>Uncertainties</u>

The estimates of available renewable resources in New Mexico are based on preliminary figures. Further study may show that insufficient resources are available to meet PNM's needs. In addition, certain of the renewable resource technologies are not yet commercially available.

4.7 NET ENERGY ANALYSIS

A net energy analysis is a comparison between the energy that goes into a facility such as NMGS and the energy that comes out in a usable form. In a coal-fired power plant system the main flow of energy is from raw coal in the ground through a mining and preparation process through transportation to the power plant and conversion to electricity, and through distribution of the electricity to end users. At each stage of the process, energy is added to the system in various forms (e.g., diesel fuel to power mining equipment) and energy is irretrievably lost (e.g., heat energy lost up the stack at the power plant). In addition there are second- and third-order energy uses, such as the energy used in constructing the plant boiler or the energy used by plant personnel in driving to work.

Net energy analysis is further complicated by the differing qualities of different types of energy. Thus, a Btu of electricity is different from a Btu of energy in coal. In order to give a clear picture of the energy flows in a complicated system, the analysis should present both the type of energy and the amounts being used.

The net energy analysis for NMGS begins with mined and processed coal as an input and ends with electricity output to the electric transmission system.

Three major systems will be discussed:

- Coal transportation
- Water transportation
- Electricity generation

The major emphasis of this analysis was on the primary energy flow (coal to electricity) with some discussion of major ancillary energy inputs and energy used in construction.

Coal Transportation

Since NMGS is a minemouth plant, no long-distance transportation of coal would be needed. Coal would be delivered to the plant site as part of normal mine operations, thus energy use for coal transportation would be negligible.

Water Transportation

NMGS would require approximately 35,000 ac-ft/yr of water for the four 500-MW units. This water would be transported to the plant through a pipeline with static lift of 1280 feet. To accomplish this would require roughly 2.01×10^{11} Btu, assuming electric pumps with 65 percent efficiency. This is equivalent to 5.89×10^{4} MWh/yr.

Plant Operations

NMGS would use 7.5×10^{6} t/yr of Bisti coal. PNM estimates this coal to have a heating value of 8300 Btu/lb, so NMGS use would be 1.25×10^{14} Btu/yr, or 3.65×10^{7} MWh/hr. Assuming an annual capacity factor of 65 percent and 2000 MW total capacity, NMGS would generate a total amount of electricity of 1.14×10^{7} MWh/yr (3.90×10^{13} Btu/yr), thus implying an overall plant efficiency of 31 percent. NMGS would have other energy inputs. The plant would use 2.2×10^{6} gal/yr of diesel fuel per unit (8.8×10^{6} gal/yr total). This is equivalent to 1.18×10^{12} Btu/yr. In addition, energy would be needed to construct the plant. Reference 21b estimates that 3.29×10^{-2} Btu of energy invested in materials would be needed for every Btu of electricity produced on an annual basis. Thus 1.28×10^{12} Btu/yr of energy in materials can be estimated as appropriate for NMGS. Thus the total yearly energy balance for NMGS can be summarized as follows:

Annual Inputs	Nominal Units	Btu Equivalent
Coal	7.5×10^6 t	1.25×10^{14}
Diesel fuel (at plant)	88×10^6 gal	1.18×10^{12}
Water pumping	5.89×10^4 MWh	2.01×10^{11}
Materials	-	1.28×10^{12}
Total inputs	-	1.28×10^{14}
Annual Output		
Electricity	1.14×10^7 MWh/yr	3.90×10^{13}
Ratio of Output to Input	-	0.305

Energy Use of Plant Alternatives

Most of the alternatives to the proposed action that were analyzed in detail would have a negligible effect on the energy use of NMGS. Those that would affect the energy use are discussed below.

Alternatives

The analysis in Section 3 identified alternatives available to PNM. Table 4-1 lists the major alternatives, their primary fuels, and their efficiencies at converting these fuels to electricity. Energy in materials and ancillary energy inputs are not included in these calculations.

Other Coal Sources

NMGS would use 7.5×10^6 t/yr of coal for four 500-MW units. If sources other than minemouth coal were used, coal would be transported to the plant by truck. The maximum distance is estimated to be 30 miles one way. Energy use for truck transportation of coal is estimated to be 966 Btu/ton-mile [21c]. So a total of 2.17×10^{11} Btu/yr would be needed. This is equivalent to 1.62×10^6 gal/yr of diesel fuel [21b]. Coal losses during transportation are assumed to be negligible.

Table 4-1. ENERGY USE OF ALTERNATIVES

Alternative	Primary Fuel	Percent Efficiency in Conversion to Electricity
Geothermal	Hot water	Less than 22[a]
Nuclear	Uranium	17[b]
Hydroelectric	Hydraulic head	75 - 80[c]
Solar	Sunlight	1 - 20[d]
Wind	Wind	5 - 7[e]
Biomass	Wood, agricultural wastes	35 - 38[c]

Note: Out-of-state power source was not considered in this analysis because the primary fuel is unknown.

[a] Percentage of recovered resource only [21c].

[b] Percentage of in-situ uranium resource [21a] (DOE).

[c] Ref. 21c.

[d] 1 percent for solar ponds, 20 percent for solar thermal [21c].

[e] For entire wind farm [21c].

Electrostatic Precipitator for Particulate Control

Electrostatic precipitators require more energy than the proposed bag house. The amount of additional energy requirements would depend on the exact design.

Water Source: Alternative (20,000 ac-ft/yr from San Juan River, 15,000 ac-ft/yr from well field)

Using groundwater as a water source would require additional electricity for pumping. The exact amount would depend on the characteristics of the well field and the pumping system design.

Appendix A

SCREENING OF POTENTIAL ENERGY OPTIONS (SELECTION STEP 3)

Option: CENTRAL-STATION COAL-FIRED STEAM-ELECTRIC (NMGS, the applicant's proposed action)

DESCRIPTION

The proposed action is to construct and operate a 2000-MW coal-fired steam electric generating plant south of Farmington, New Mexico, and a related 500-kV transmission system [5]. The plant would consist of four units; each unit would contain a 500-MW nominally rated, single-reheat turbine generator, installed in a plant building with a condenser and other station auxiliaries. The boiler, with air heaters, fans, and auxiliaries, would be located semi-outdoors.

The primary fuel would be coal from Sunbelt Mining Company's Bisti mine, located adjacent to the proposed plant site. The primary source of water would be the San Juan River. The power plant would be designed and operated as a zero-discharge plant [5]. Commercial operation of Unit 1 could begin in 1990, Unit 2 in 1993, Unit 3 in 1995, and Unit 4 in 1998 [4].

SCREENING RESULTS: RETAINED

The screening criteria were developed to identify options that are generally comparable to the proposed action. Hence, by design, the proposed action meets all screening criteria and is retained for further study.

Option: DECENTRALIZED COAL-FIRED STEAM-ELECTRIC

DESCRIPTION

This option is to construct two or more coal-fired steam electric generating plants at different locations, with a combined capacity of approximately 2000 MW. Each plant would consist of one or more units. In addition, coal and water delivery systems and an appropriate transmission system would be constructed.

SCREENING RESULTS: RETAINED

Since the technology involved is similar to the proposed action, this option meets all the screening criteria.

Option: COAL RETROFIT OF EXISTING OIL OR GAS UNITS

DESCRIPTION

This option is to convert oil- or gas-fired units to the use of coal. This might lead to additional generation capacity if the oil- or gas-fired units would otherwise be retired from use or operated at lower capacity factors.

SCREENING RESULTS: REJECTED

This option was removed from further consideration because it does not meet the criterion that it "must be . . . capable of providing . . . at least 5 percent of the annual energy output proposed for NMGS, beginning . . . during the planning period."

PNM and New Mexico Electric Company currently have 475 MW of gas/oil installed generating capacity, and they have no plans to retire any of this during the planning period for NMGS [5]. Converting some or all of this equipment to coal use might result in additions to the total energy produced by these plants, if either the capacity factors or the rating of the generating units could be increased. Part of any such increase would be consumed by operation of additional pollution control or fuel conversion equipment that would be required for coal-fired units.

Since the total 475 MW of installed gas/oil generating capacity is less than 20 percent of the proposed capacity of NMGS, no reasonable modifications could be made to the existing plants that would result in adding as much as 5 percent of the annual energy output proposed for NMGS.

Option: COAL CONVERSION PLUS GENERATION

DESCRIPTION

An alternative to burning coal is to convert the coal to medium-Btu gas and burn it in a combined-cycle gas turbine/steam turbine system, with the steam turbine using steam produced from the hot gas-turbine exhaust. The major advantages of the system are simplified pollution control (pollutants can be removed at the coal conversion stage) and high overall energy efficiency (34-40 percent in advanced designs) [23]. Both synfuels and combined-cycle technology are available commercially, although the combined system has never been tested in a utility setting. The optimum design for electric utility purposes appears at present to be a high-temperature (2400°F) gas turbine with a Texaco gasification system [23], but neither of these technologies is currently available. Thus, to be implemented in the near future, a system would have to use off-the-shelf components in a less than optimum design.

SCREENING RESULTS: RETAINED

A. "Must be consistent with national policy to reduce dependence on petroleum and natural gas." Yes. The intent of national policy, as evidenced by the Powerplant and Industrial Fuel Use Act of 1978, is to reduce the use of oil and natural gas for electrical power generation. Since synthetic fuels are produced from coal, their use is consistent with national policy.

B. "Must be commercially available, licensed, and in operation by the end of the planning period." Yes. Although no plants are in operation, there are demonstration plants in the design/early construction phase. The California Energy Commission predicts commercial availability by 1987 and earliest commercial operation in 1992 [8]. Other sources give later dates, but commercial operation should be possible by the end of the NMGS planning period in 1998.

C. <u>"Must be capable of supplying at least 5 percent of the annual energy output of NMGS</u>." Yes. Most designs are for baseload generation in the 1000-MW range. Thus this system could replace all or part of the projected NMGS load.

Option: OIL- OR GAS-FIRED ELECTRIC GENERATION

DESCRIPTION

This option covers all types of electric generating units (including steam turbine, combustion turbine, combined-cycle, and diesel-engine units) which might be alternatives to NMGS and which use oil or natural gas as fuels.

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be consistent with national policy to reduce dependence on petroleum and natural gas."

The Powerplant and Industrial Fuel Use Act of 1978 [24] has as one of its purposes "to conserve natural gas and petroleum for uses, other than electric utility or other industrial or commercial generation of steam or electricity, for which there are no feasible alternative fuels or raw material substitutes." The act states that it is U.S. policy to avoid construction of new baseload generation facilities that use oil or natural gas. Although various exemptions are possible from the prohibitions against new oil- and gas-fired units, none are particularly relevant to the situation of PNM. An attempt by PNM to build an oil- or natural gas-fired unit would violate U.S. policy.

Option: GEOTHERMAL

DESCRIPTION

This option entails the generation of electricity using steam from a geothermal reservoir, and encompasses several types, as described below. For some of these there are known resources in New Mexico; for others, there are not.

A. Vapor-dominated: No known resource in New Mexico [25].

B. Geopressured: No known resource in New Mexico [25].

C. Hot Water (hydrothermal convection):

1. Moderate- and low-temperature (less than 150°C) liquid-dominated: Several resources are known in southern and western New Mexico [25]. These are, however, best suited for direct-heating applications [12,25,26]. There are no U.S. development plans for electric generation [26], although the technology does exist (for example, a binary system in the USSR produces power with an 80°C reservoir [26]).

2. High-temperature (150°-250°C): Valles Caldera is the primary area in New Mexico with high-temperature resources [25], although others may be considered as being within this category [27]. USGS has estimated Valles Caldera to be capable of 2700 MW(e) for 30 years [25]. Other sources, all apparently using USGS raw data and various methods of calculation, estimate 2030 MW [28], 1990 MW [29], and 1900 to 2000 MW [27] (reference 27 also estimates other high-temperature resources that might be commercially feasible in the 1990s, at 20-250 MW). Union Oil

Co., PNM, and the U.S. Department of Energy began development for a 50-MW(e) pilot plant at Baca Ranch, with estimated start-up in 1982 [24,27,28], but well-field difficulties have led to termination of the project [13,14]. The Baca Ranch DEIS estimated [13] a possible 400 MW of development in this area. Other exploration is also underway [13,31].

D. Hot Dry Rock: Known resources exist in the Valles Caldera area [25]. Los Alamos Scientific Laboratory has a pilot project, with tentative plans for an eventual 3 to 10 MW [13]. Original projected date was 1986-1987, but that may be postponed [13]. The first electric production (60 kW with binary cycle) was achieved in May 1980 [31]. Fracture techniques and other problems remain to be solved [12].

Available electric-generation technologies are:

- Flashed steam cycle--Commercially available within PNM's planning period [7]. Suitable only for low-salinity fluids; probably suitable for Valles Caldera hot-water resource [32].

- Binary (heat transfer) cycle--Commercially available within PNM's planning period [7].

- Total flow--Technology is uncertain in the near term.

SCREENING RESULTS

A. Vapor-dominated: Rejected. This option is removed from further consideration because it does not meet the criterion that it "must be . . . capable of providing . . . at least 5 percent of the annual energy output proposed for NMGS."

B. Geopressured: Rejected (see A).

C. Hot Water

1. Moderate- and low-temperature liquid-dominated: Rejected. This option is removed from further consideration because it does not meet the criterion that it "must be . . . commercially available . . . by the end of the planning period." Availability is in doubt due to the lack of development plans for electric generation technology [26].

2. High-temperature liquid-dominated: Retained. This option meets all screening criteria and is thus retained for further consideration.

D. Hot Dry Rock: Rejected. Technology for access to thermal reservoirs is uncertain [7]. Thus, although the thermal resource is abundant, its reliable availability at the surface cannot be counted on within PNM's planning period.

Option: HYDROELECTRIC

DESCRIPTION

Hydroelectric power generation is a well established technology. It is reliable and suitable for both baseload and peaking generation. Its disadvantages are that it is limited to suitable sites, its availability fluctuates from year to year due to rainfall variations, and it often conflicts with recreational and other uses of rivers.

SCREENING RESULTS: LARGE--RETAINED; SMALL--REJECTED

A. "Must be consistent with national policy to reduce oil/gas dependence": Yes.

B. "Must be available by the end of the planning period": Yes.

C. "Must be capable of providing at least 5 percent of NMGS energy": The U.S. Army Corps of Engineers' preliminary estimate [33] of hydroelectric potential in New Mexico indicates that small and intermediate hydro plants could supply a total of 313 GWh/yr of electricity. This is less than 5 percent of the proposed NMGS load.

The same study indicates that large (greater than 25 MW) hydro plants could supply 1883 GWh/yr (both incremental and new development). Although these preliminary estimates may be optimistic, there seems to be sufficient potential for further consideration. Potential sites include:

Site	Power (MW)	Energy (GWh/yr)
San Juan River (Navajo Dam to Farmington)	155	332
San Juan River (Farmington to Shiprock)	135	291
San Juan River (Shiprock to Upper Limit Bluff)	68	479
Cochiti (Rio Grande)	88	185

PNM disagrees with the Corps of Engineers' estimate [20] and states that social and political issues, regulatory lead times, and ownership questions place the availability of significant hydroelectric capacity after the planning period for NMGS. In addition, PNM believes the assumed stream flows used to calculate the available capacity are highly optimistic.

Option: CENTRAL-STATION SOLAR-THERMAL ELECTRIC

DESCRIPTION

The station would consist of banks of heliostats (mirrors) keeping sunlight continually focused on a central receiver ("power-tower"), where heat would boil water or other heat-transfer fluid to drive a conventional turbine [34]. An alternative would use multiple receivers, but the central-receiver concept is mechanically simpler overall, most resembles conventional systems, and thus is most well developed [13]. Another alternative would use distributed stations to reduce weather-caused discontinuities [34]; thermal or other storage could also reduce this problem, and technologies are expected to be available. Land requirement would be roughly 1 to 2 square miles for every 100 MW(e) [7,34]. DOE and EPRI have separate test programs, aiming for 50 to 100 MW demonstration by mid to late 1980s [7]; a 10-MW prototype is now under construction at Barstow, California [7,34,35]. The California Energy Commission [7] projects a potential commercial operation date of 1995 and estimates a lead time, including advance planning and regulatory matters, of 8 years [15].

SCREENING RESULTS: RETAINED

Although this technology is still considered a "calculated risk" [34] and appears dependent on continuing research and development support by DOE, it meets all screening criteria and is retained for further consideration.

Option: SOLAR THERMAL REPOWERING OF EXISTING OIL/GAS-FIRED UNITS

DESCRIPTION

The technology is the same as that for central-station solar-thermal electric [34]. In this option such a plant would be built adjacent to an existing peaking or intermediate source, such as an oil- or gas-fired plant, and would share the same turbine/generator and other back-end equipment [5]. Conventional fuel would be burned when sunlight was unavailable, thus making the total facility a baseload candidate, reducing use of oil and gas, and eliminating the need for storage with the solar component.

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be . . . capable of providing . . . at least 5 percent of the annual energy output proposed for NMGS . . . during the planning period."

PNM and New Mexico Electric Company currently have 475 MW of gas/oil-fired installed capacity, with no plans to retire any of this capacity during the NMGS planning period [5]. Since this total capacity is already less than 20 percent of the proposed capacity of NMGS, no reasonable modifications could be made to the existing plants as part of solar thermal repowering that would result in adding as much as 5 percent of the proposed energy output of NMGS.

Option: CENTRAL-STATION SOLAR PHOTOVOLTAIC

DESCRIPTION

This station would consist of banks of photovoltaic (PV) panels, converting sunlight directly to DC current; and units for converting this to AC. The major physical limitation on total output is the availability of land; 1 square mile would yield roughly 300 MW(e). Output is mainly for peaking or intermediate applications [5,36]. Some of the output can be considered firm capacity, since it reliably follows peak demand [34]; weather-related interruptions could be partially dealt with by short-term storage or geographically distributed photovoltaic units. Longer-term storage would increase capacity factors, and will probably be available. However, oil/gas units would constitute a suitable backup in most cases [34], apparently without violating PIFUA [24]. Technology and adequate raw material (silicon) exists now, though costs are not yet competitive. Increasing petroleum prices and methods/materials research may make this option competitive with oil-fired generation, for oil-dependent utilities in the Sunbelt (especially the Southwest), by the mid to late 1980s [34,37]. Taking account of licensing and construction times [38], some sources estimate a central PV plant could be operational in the early 1990s [7,34], although other sources give later dates [15].

SCREENING RESULTS: RETAINED

This option meets all screening criteria and is thus retained for further consideration.

Option: DECENTRALIZED PHOTOVOLTAIC

DESCRIPTION

Decentralized photovoltaic systems would generate electricity using arrays of photovoltaic cells installed on residential and commercial buildings. The electricity would be used during daylight hours, with backup power coming from the electric grid. Surplus energy could be sold to the grid or stored.

Generally speaking, decentralized photovoltaic systems are less developed than solar-heating systems. However, costs of these systems have been rapidly decreasing [38]. Recent studies have indicated that residential photovoltaic arrays could become economically competitive if the U.S. Department of Energy (DOE) 1986 cost goal of $0.50/peak watt can be met. A DOE representative stated in 1980 that residential photovoltaics will be economically competitive in 1984 with no additional technological breakthroughs [39].

In order for dispersed solar photovoltaics to be broadly implemented, many technical and political problems must be resolved. These include [36,39]:

- solar access
- high initial cost
- market development problems (production, sales, installation)
- building codes and ordinances

In addition, there are problems of interfacing with utilities; these include:

- valuation of energy produced
- electric utility load interface
- need for power conditioning and control equipment

The resolution of these questions will determine the degree of penetration of decentralized solar photovoltaic systems.

SCREENING RESULTS: RETAINED

The technology is not commercially available today, but the consensus is that it will be, well within the planning period for NMGS.

Assuming 10-kW installations at 21 percent capacity factor, installations would be needed on approximately 31,000 homes to provide 5 percent of NMGS's annual energy output. This is approximately 9 percent of the total residential customers predicted for 1996 in PNM's 1981-2001 forecast of energy sales and peak demands [40]. Note that PNM would have more residential customers than this forecast under the strong-growth scenario in the Project Description [5].

Dispersed photovoltaic systems are therefore retained for further consideration.

Option: POINT-OF-USE SOLAR HEATING

DESCRIPTION

Decentralized solar-heating systems would be designed to reduce electric demand by producing space heat, hot water, or industrial process heat. Many different configurations are possible, ranging from passive solar design (e.g., south-facing windows) to flat-plate collectors to solar concentrator systems.

Solar systems are currently technologically feasible and available. Demand is being spurred through the use of tax credits and other incentives, particularly in California. California had 38,000 solar systems installed in 1979 [39]. Thus the industry should be mature by 1990.

SCREENING RESULTS: RETAINED

PNM's forecasts do not explicitly identify the type of heating and cooling used. Most of PNM's current housing stock is gas-heated, although the use of all-electric heating is expected to increase. If a new home uses solar instead of gas heating, its total electric bill could increase if electric backup is used. If gas backup is used, its electric bill should not change significantly. Thus savings will occur only if solar heating is chosen over all-electric heating. PNM expects about 200,000 new residential customers between 1981 and 2001. If half of these customers choose all-electric heating and half of the all-electric customers insulate to SMART standards [41], the additional demand due to these customers will be 1667 GWh per year. If all of these customers were to use solar heat, each customer would use an average of 5172 fewer kilowatthours per year (using PNM's current estimate of use by various types of customers). This represents a savings of 517.2 GWh for 100,000 homes.

At the end of 1981, PNM had 195,722 existing residential customers [42]. Many of these customers currently use gas heating; however, to be conservative, assume that approximately half of these, or 100,000, currently have all-electric heat and would convert to solar heating. Then, by the calculation above, 517.2 GWh per year of electric energy would be saved per year from conversion by current residential customers. Combining current residential customers with new customers results in a savings of 2 x 517.2 GWh/yr = 1034.40 GWh/hr. This is more than 5 percent of the annual energy output for NMGS.

PNM also had 21,164 commercial customers, 458 industrial customers, and 180 other customers at the end of 1981 [42]. These customers, as well as new customers in these categories, could reduce their electrical use through point-of-use solar heating.

Thus the total achievable savings for all categories, based on the reasoning above, would be more than 5 percent of the annual energy output of NMGS. Hence, this option is retained.

Option: SOLAR-POWER SATELLITE

DESCRIPTION

This option would make use of one or more solar-power electric generating plants in orbit around the earth. The generated power would be transmitted to the earth's surface by either microwave radiation or laser beams.

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be projected to be commercially available . . . by the end of the planning period." Two recent studies, one by the National Academy of Sciences and the other by the Office of Technology Assessment, have examined solar-power satellites [43]. Both studies agree that because of the cost and numerous technical, social, and political problems, the development of solar-power satellites is several decades in the future.

Option: CENTRAL-STATION WIND GENERATION

DESCRIPTION

Wind-powered turbine generators have the potential for making significant contributions to fuel displacement in the relatively near future. Large-scale single units of up to 2.5 MW are now being built and tested [44,45]. Utility-scale wind farms are now in the final planning stages [46]. Thus the technology is available, if not completely proven. The most well developed designs seem to be horizontal axis wind machines with a capacity of 1-4 MW. Studies funded by the Electric Power Research Institute (EPRI) have found that capacity value can be assigned to wind plants but that their main value is in energy displacement.

PNM states that wind generators cannot be considered firm capacity due to their intermittent nature. Variability of the resource and lack of appropriate site-specific data are also cited. Other problems are the lack of operating experience with wind farms, uncertain cost and reliability, and concerns about spinning reserve requirements [47]. Costs of wind turbine systems are currently relatively high but are expected to come down as experience increases [48]. A study by the Southwest Research Institute found that wind energy can be cost-effective at a relatively small scale if costs for fossil fuels keep rising [47].

Under a Department of Energy program, a 200-kWe wind energy conversion system has been installed at Clayton, New Mexico [49]. This had problems in mid-1978 related to blade stress and loss of rivets. The blades have been modified and repaired, and since then the turbine has operated more than 1500 hours without further malfunction. A primary goal of the Department of Energy program is to study the impact of the intermittent nature of wind generators on utility networks. In addition, the installations provide for technical evaluation, verification of simulation studies, and determination of maintenance and operating costs.

SCREENING RESULTS: RETAINED

A. "Must be consistent with national policy to reduce oil and gas use": Yes.

B. "Must be commercially available . . . by the end of the planning period": Yes. All components are now commercially available. Demonstration plants have been working satisfactorily, and the first production facilities are being built.

C. "Must be capable of providing 5 percent of the annual energy output proposed for NMGS": Yes. Assuming a capacity factor of 35 percent this would require a 185-MW installation. Installations of 80 MW and over 200 MW are being built in Hawaii and California. Costs, capacity factors, and energy production are all highly dependent on site location. Vigorous monitoring programs would be needed to identify optimum sites in New Mexico. According to PNM estimates [13] based on EPRI studies, a capacity credit of approximately 40 percent could potentially be applied to a system of this size (8.5 percent of PNM's planned 1990 system). This would represent 74 MW of effective capability. This figure would be highly site- and system-dependent.

This option meets all screening criteria and is thus retained for further consideration.

Option: DECENTRALIZED WIND GENERATION

DESCRIPTION

Dispersed wind generators would be installed on the property of individual customers and used to supply them with power. During periods when the customer's demand is low, extra power could be sold to the utility through the grid. In periods of low wind the customer could use electricity from the grid as backup power. The most desirable types of application would be those in which only intermittent power from the wind turbine is required, for example, on a farm pumping water into a holding pond.

Dispersed wind turbines have several significant disadvantages that may prevent their widespread adoption [50,51]. First, most homes are not located in areas of high wind; indeed, most developers would try to avoid windy areas if possible. Second, if wind power is to be used for conventional appliances or sold to the grid, expensive power conditioning equipment will be needed. Location of turbines in residential areas would exacerbate environmental impacts such as television interference, low-frequency noise, and safety hazards. Finally, costs would be increased due to the necessity for many wind monitoring programs and for having to work through equipment retailers rather than wholesalers. While dispersed wind turbines may be very effective for certain applications in rural areas, the preceding considerations make it unlikely that they could supply a significant fraction of the need for NMGS.

SCREENING RESULTS: REJECTED

This option does not meet the criterion that it "must be capable of providing, or eliminating the need for, at least 5 percent of the annual energy output proposed for NMGS." It is therefore removed from further consideration.

Option: BIOMASS

DESCRIPTION

"Biomass" refers to the conversion of natural organic materials to fuels, or directly to energy. Potential resources include [34,52, 53]:

- Agricultural and forestry (mill and logging) wastes
- Municipal solid waste (MSW)
- Noncommercial timber
- "Energy farms" (crops grown specifically for energy production)

The major advantage of these resources is their renewability; their major drawbacks (insofar as electric generation is concerned) appear to be their seasonality; their low energy density and resulting need for extensive transportation from remote and scattered sources; and the difficulty in obtaining reliable, long-term source contracts [34, 53,54].

Near- or middle-term technologies include [12,34,52,53]:

- Direct combustion, to produce heat
- Thermal decomposition under low-oxygen conditions, to produce pyrolysis oil (pyrolysis) and low- and medium-Btu synthesis gas (gasification)
- Bioconversion, to produce medium-Btu methane gas (anaerobic digestion) and alcohols (fermentation)

With some exceptions, most of these techniques could be applied to most of the above resources, though not all are equally practical. Other technologies exist, but are generally considered too immature for consideration in the NMGS planning period [53].

Not all the above processes are best suited for electric generation at utility scales. Gaseous and liquid biofuels tend to have preferred cash uses, such as chemical feedstocks (alcohols, synthesis gas), auto fuels (alcohols), and conversion to natural gas substitutes (methane, synthesis gas) [34,49,53,55]. As potential fuels for electric generation, they represent a more roundabout, less energy-efficient, and generally more costly alternative than direct combustion, although low-Btu synthesis gas and pyrolysis oil may be useful in certain limited backup or peaking applications. Direct combustion is considered to have the greatest near-term commercialization potential for electric generation [52]. Only direct combustion is considered here.

SCREENING RESULTS

A. Municipal Solid Waste: Rejected. This option is removed from further consideration because it does not meet the criterion that it "must be . . . capable of providing . . . at least 5 percent of the annual energy output proposed for NMGS." Our estimates of the total annual resource in PNM's service area (based on references 12 and 28) indicate 1 to 3 percent of the proposed energy output of NMGS.

B. Agricultural and Forestry Wastes: Retained. The estimated total available (not committed to other uses) agricultural and forestry wastes in New Mexico amount to 15 to 20 percent of the projected energy output of NMGS, with agricultural wastes accounting for about 3/4 of the total [13,56,57]. In the case of forestry wastes, uncertainties exist as to future U.S. Forest Service policies, according to PNM [13]. No account has been taken here of the available capacity to transport these wastes to power plants; this may be the major limitation on this resource [13,34, 53]. This option meets all screening criteria and is retained for further consideration.

C. Wood: Retained. This option consists of the direct combustion (central, distributed, or end-point) of available, replenishable, standing growth of the following types:

- Annual surplus commercial growth (net annual commercial growth, minus commercial removals)
- Annual mortality (commercial trees killed by infestations, disease, or fire)
- Annual surplus from noncommercial forest land

This resource is estimated to be capable of a steady production equivalent to at least 45 percent of projected NMGS energy production [54], although it is not known whether all of this resource would be economically obtainable for such a use. The techniques of silviculture (wood farming) may be capable, in general, of additional output [53], but New Mexico's climate and available rainfall, even in the northern part of the state, do not appear to be adequate [53,54].

Wood-fired steam electric generation is a currently available technology at scales up to 50 MW(e), and may be competitive with coal-fired generation, in the conversion of older oil/gas-fired units [12,52,53].

This option meets all screening criteria and is retained for further consideration.

D. Nonwood Energy Crops: Rejected. This option is removed from further consideration beause it does not meet the criterion that it "must be projected to be capable of providing . . . at least 5 percent of the energy output proposed for NMGS." Estimates indicate that 100 MW of generation capacity would require roughly 100 square miles of land for cultivation [53]. However, little additional water is available in New Mexico for irrigation [53,55]. New Mexico's severe winters would also restrict potential cultivation time.

Option: WATER-COOLED FISSION REACTOR

DESCRIPTION:

The plant would consist of a light-water reactor (of a type now in use, either boiling-water or pressurized-water coolant) as heat source; heat-transfer system; turbine generator; and control, safety, and other systems [58]. Fuel is uranium, with enriched U-235/U-238 ratio. The technology is available now. The major issue, in the context of this screening, is lead time: current estimates of the total time for regulatory studies, licensing, construction, and startup range from 12 to 14 years [5,15-18].

A design (CANDU) using deuterium-substituted ("heavy") water as moderator and primary coolant permits the use of unenriched uranium fuel, and is commercially available in Canada [5,59]. In other respects, the CANDU system resembles a light-water reactor. Licensing periods may be longer than those for a light-water reactor.

SCREENING RESULTS: RETAINED

Although the technology exists now, this option is constrained by lead times, which dictate that the earliest such a plant could be operating is 1994-1996. The option meets all screening criteria and is retained for further consideration.

Option: HIGH-TEMPERATURE GAS-COOLED REACTOR

DESCRIPTION

This reactor design uses helium gas, rather than water, as the core coolant and primary heat transfer medium [13,58]. Among the consequences of this are: (a) a wider range of possible fuels (Th-232, U-233, U-235); (b) higher process temperatures, which lead to higher efficiencies; (c) possibility of gas turbine use and cogeneration applications; (d) lower water use and thus better siting flexibility; and (e) possibly lower generating costs, compared with light-water reactors. A small number of prototypes are now in use in the United States; government support is minimal [58].

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be projected to be commercially available, licensed, and in operation by the end of the planning period." PNM materials [13] indicate availability no sooner than 1999; elsewhere PNM predicts that some types could be available around 1995-1998 [5]. Other sources cite an "indeterminate" availability date [7], or doubt that this type of reactor will ever pass the prototype stage [18].

Option: FAST BREEDER REACTOR

DESCRIPTION:

As with the light-water reactor (LWR), the fast breeder reactor uses a U-238 fuel matrix, but the fissile material is plutonium (Pu-239) rather than U-235 from enrichment. The design of the fuel elements, and the fact that U-238 itself is eventually converted to Pu-239, results in an extremely efficient use of the original U-238 resource (to the point that uranium supply ceases to be a limitation), and a net creation of Pu-239 as further fuel [58,60]. Most of the U-238 would come from LWR fuel cycle by-products, and all Pu-239 would come from reprocessing of spent fuel from LWRs and the breeders themselves [58,60]. Because of the requirement for fast neutrons, a different moderator/primary coolant than water is necessary; all designs now under development use liquid sodium metal [60]. Advantages include highly efficient resource use, fuel production, and high operating efficiencies. Disadvantages include plutonium toxicity, potential diversion of plutonium for weapons, and sodium reactivity [58, 60]. The technology is feasible now. Current administration policy is to permit resumption of fuel reprocessing for Pu-239 production, accelerate development and construction of the 375-MW Clinch River demonstration reactor (perhaps to begin operation in 1989 or later), and reduce licensing delays [16]. Major problems with this technology are uncertainties associated with licensing times and with public and congressional acceptance, particularly because Pu-239 is also potential weapons material.

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be . . . commercially available, licensed, and in operation by the end of the planning period." Even under favorable conditions, the Clinch River demonstration reactor is not expected to be operational before 1989 [60].

Licensing times seem likely to exceed those for LWRs, and no reliable predictions can be made about reductions in these lead times. This puts commercial operation well past the planning period. The California Energy Commission cites an "indeterminate" commercial availability date [7].

Option: NUCLEAR FUSION

DESCRIPTION

In this option, a steam electric generating system would derive its thermal energy from the energy released in the fusion of certain light nuclei (first-generation systems would use deuterium and tritium, isotopes of hydrogen) [58,60]. Advantages include the extreme abundance of fuels, reduced radioactive inventories, and probably fewer radioactive wastes [58]. Two fusion processes are under development: inertial confinement (laser implosion) and magnetic confinement (reactants, in high-temperature plasma state, confined within "shaped" magnetic fields); the latter is presently at a more promising development stage [58,60]. However, no fusion technology has yet been proven feasible. A national goal is completion of a demonstration magnetic-confinement reactor by 2000.

SCREENING RESULTS: REJECTED

This option is removed from further consideration because it does not meet the criterion that it "must be . . . commercially available . . . by the end of the planning period."

<u>Option</u>: OUT-OF-STATE POWER SOURCE

DESCRIPTION

This option would involve obtaining the electricity needed by the customers of PNM from outside New Mexico, either through purchase contracts or equity participation in an out-of-state generation project. Thus a new generating plant would not be built within New Mexico.

SCREENING RESULTS: RETAINED

This option meets all screening criteria and hence is retained for further study. It is difficult to assess the degree of availability of out-of-state power during the 1990s because of the uncertainties about events so far in the future. However, the three references cited below indicate that the potential exists for obtaining reasonably large amounts of power from out of state.

Examples of potentially available projects include:

- From reference 61:
  --Allen-Warner Valley Project (early 1990s): 2500 MW
  --California Coal Project (early 1990s): 1500 MW
  --Unnamed nuclear project (mid- to late 1990s): 1050 MW
  --White Pine Project (early 1990s): 1500 MW
- From reference 62:
  --Southwest Project
  --Intermountain Power Project
  --Sierra Pacific Thousand Springs Project
- From reference 34 (Appendix 8):
  --Unspecified Utah projects
  --Colorado-Ute Project

Option: CONSERVATION

DESCRIPTION

Conservation is probably the most effective of all energy options, since each Btu saved does not have to be generated and transmitted. Conservation measures such as insulation, weatherstripping, and so on, can significantly reduce a home's heating requirements. PNM estimates that a home built to PNM's SMART standards [41] consumes up to 50 percent less heating energy than a conventional home. A SMART home is defined as one that has a heat loss of less than 6.5 watts per hour per square foot.

SCREENING RESULTS: RETAINED

PNM states that a SMART home consumes 2750 kWh less per year than a conventional home. PNM expects about 200,000 new residential customers from 1981 to 2001. If half of these homes are electrically heated, 275 GWh per year could be saved if all of them were to switch from non-SMART to SMART conservation standards.

As mentioned in the discussion of point-of-use solar heating, only existing homes which currently use electric heating can significantly reduce their heating-related electrical use by conservation. A maximum estimate is that PNM could have 100,000 existing customers who could reduce their electrical use by 2750 kWh/yr by retrofitting their homes to SMART standards. Thus the total savings from retrofitting could amount to an additional 275 GWh/yr, and the total achievable savings due to conservation in existing and new homes would be approximately 2 x 275 GWh/yr = 550 GWh/yr. This is slightly less than 5 percent of the annual energy output from NMGS.

Load management measures such as time-of-use rates or interruptible service can shift peak energy requirements to non-peak times. However, since NMGS is being planned as a baseload (continuously operating) plant, these measures will not affect the need for NMGS.

More stringent conservation is possible if more strict standards are set than the SMART construction guidelines. In addition, conservation is possible for existing and new commercial, industrial, and other customers. Thus, at least 5 percent of the annual energy output of NMGS could be provided for through conservation. Hence, this option is retained.

Option: LOAD MANAGEMENT

DESCRIPTION

Load management refers to the shifting of electric energy use from peak to off-peak periods. This can be accomplished in many ways, including time-of-use rate structures, interruptible load agreements, and central switches for shutoff of certain appliances. The effect of these approaches is not to reduce the total energy used in a given period but to reduce the peak power demand. This will tend to flatten a utility's load duration curve and could create a need for more baseload power (and less peaking power) than without load management. Thus load management would not reduce the need for a baseload facility like NMGS.

SCREENING RESULTS: REJECTED

Load management would not reduce baseload energy demand. It therefore fails to meet the criterion that it "must provide, or eliminate the need for, at least 5 percent of the annual energy output proposed for NMGS." Thus, this option is removed from further consideration.

Option: COGENERATION

DESCRIPTION

Cogeneration refers to the use of industrial or commercial waste heat for the generation of electricity, or the use of electric generation waste heat for industrial or commercial processes. The combination of electric generation and process heat production can be more efficient than when these activities are performed separately. In a submittal to the New Mexico Public Service Commission [63], PNM lists cogeneration as having ninth priority among 14 different conservation-related activities they expect to be engaged in over the next 5 years. For reference, these 14 activities in order of priority are:

1. Time-of-Use Rates
2. Advertising
3. Solar Promotion
4. Solar Advice
5. New SMART Homes
6. Direct Load Control
7. Customer Energy Storage
8. Residential Conservation Service
9. Cogeneration
10. Appliance Advice
11. Commercial Audits
12. Energy Management in Action
13. Youth Education
14. Adult Education

PNM has also filed with the NMPSC documents giving existing and potential cogenerators information on tariff and rates, proposed interconnection and safety standards, and a proposed standard-sized service contract [64].

In September 1980, PNM reported the results of an interruptible rates/cogeneration/self-generation survey of commercial/industrial customers with a monthly demand over 500 kW [65]. The survey was initiated by sending letters to 111 PNM commercial/industrial customers with monthly demand over 500 kW, requesting their help with the survey. Fifty-four of these responded positively and were sent the questionnaire. Forty-seven of these were ultimately contacted and interviewed by either a PNM representative or a representative from the New Mexico Attorney General's Office. These customers consisted of 16 general power customers, 28 large power customers, 1 large industrial power customer, and 2 special contract customers.

Of the respondents, 47 percent have their own standby electrical generating equipment. Six percent stated that they had considered cogeneration. Eighty percent of the respondents with plans for new or additional electrical generating equipment were aware of the sections of the Public Utility Regulatory Policies Act (PURPA) concerning small power production and cogeneration facilities. Forty percent of the total respondents indicated interest in obtaining information on the relevant sections of PURPA. Only one respondent had a facility or plans for a facility that would be deemed qualified as a small-power-production or cogeneration facility under PURPA.

PNM concluded in its submittal to the NMPSC [63] that only three of its larger customers are willing to begin cogenerating in the foreseeable future, and that these three could reduce their contribution to PNM's peak electrical load by 1.5 MW in 1981 and by 3.1 MW in 1982 through 1985. PNM estimated that their electrical energy consumption will decline 9 GWh in 1981 and 19 GWh in 1982 through 1985. PNM further noted that its involvement in cogeneration has so far involved surveys, meetings with potential cogenerators to assess their plans, in-house meetings, and other work to develop standards cogenerators must meet, advising cogenerators, and work on developing a rate design to accommodate those cogenerators.

More recently PNM stated [21]: "At present, there is a limited amount of near-term potential qualifying facility (QF) [small power plant or cogeneration] development in PNM's service area. With the burgeoning interest in wind, solar, and low head hydro, however, this potential could significantly increase in the mid- to late-1980s. Geothermal energy offers larger-scale opportunities in certain areas of New Mexico." In this EIS, these specific methods of generation are each considered individually in other sections.

The review above shows, in our judgment, that the realistic potential for replacing a significant portion of NMGS with more conventional types of cogeneration facilities is low. PNM does not appear from the record to have pursued cogeneration as aggressively as some other approaches to supplying electrical needs. However, their activities show that likely cogenerators are aware of the potential for cogeneration, and are generally not interested in doing it.

SCREENING RESULTS: REJECTED

Although limited data exist, the realistic potential for cogeneration appears limited in New Mexico. This option is removed from further consideration because it does not appear "capable of providing, or eliminating the need for, at least 5 percent of the proposed annual energy output of NMGS."

Option: FUEL CELLS

DESCRIPTION

A battery or cell makes use of two materials with differing electrochemical properties (electrodes) and an electrolyte medium between them that allows electrical charge to move from one electrode to the other under the influence of electrochemical forces. In time the electrodes degrade and the battery "runs down." A fuel cell is a battery with electrodes that can be steadily replenished (the fuel), and can thus be operated essentially as long as fuel is available. At present the technologically preferred fuel combination is oxygen and hydrogen gas, the oxygen being obtained from air and the hydrogen from the reforming of petroleum-based fuels [52]. A power plant would consist of fuel processing to obtain hydrogen-rich gas; banks of fuel cells; and a unit to convert the cells' DC current to AC for conventional use [13,52]. Advantages include an efficiency which is potentially very high and not strongly dependent on unit size or load characteristics; and few environmental drawbacks [5,13,58]. Technology options [13,52], on a size scale of interest for utility applications, are the following:

A. First generation, now in pilot stage: acid electrolyte, using naphtha by-product from petroleum technologies, and eventually other light distillates. Possibly available by late 1980s or early 1990s [5,7,13], mainly for peaking or intermediate applications on a small scale [13,52]. Could be used in conjunction with coal gasification system [66].

B. Second generation, now in development stage: advanced acid electrolyte and molten-carbonate electrolyte, using light petroleum- or coal-based distillates, for baseload central-station applications. Possibly available mid- to late 1990s [13], possibly in combination with coal gasification plants [7,67].

C. Third generation, now in laboratory stage: solid-oxide electrolyte. Available by late 1990s at the earliest [13].

Long-term usefulness of fuel cells will apparently depend on their combination with coal conversion technologies [13], due to the phasing out of oil and gas [24], or with other (as yet undeveloped) techniques for hydrogen production. The California Energy Commission predicts [7] that fuel cells could be producing power for utilities as early as 1991.

SCREENING RESULTS: RETAINED

It appears that technologies (first generation) depending on petroleum or natural gas derivatives would not be in violation of PIFUA [7,24]. The only other technology projected to be available in the planning period for large-scale application is the combination of second-generation molten-carbonate cells with coal conversion plants [13,66]. This option is retained for further consideration.

Option: SOLAR PONDS

The solar pond is a developing technology that would allow the sun's energy to be used to produce baseload energy. A solar pond is a relatively shallow salt-gradient pond which could store large amounts of hot water for long periods. A solar pond would consist of three layers or zones. The lowest zone would be of high salinity (5-6 times that of sea water) and would accumulate and store the sun's energy as hot water (180°-190°F). In the middle zone the salinity would increase with depth. The purpose of this zone is to insulate the storage zone. The top zone guards the integrity of the two lowest levels from outside influences and has relatively low salinity.

Electricity is generated by pumping hot brines from the lowest layer through a heat exchanger to drive a low-temperature turbine. The overall efficiency of the process is about 2 percent. Estimates of the potential power that could be produced by solar ponds in the western United States are up to 40,000 MW [39].

Currently all demonstration solar ponds contemplate using existing high-salinity water bodies (e.g., Salton Sea, Dead Sea). It may be possible to create artificial solar ponds, but this has not yet been demonstrated.

SCREENING RESULTS: REJECTED

The technology is in the early demonstration phases and it has not been determined whether large facilities (e.g., $\geq$ 50 MW) will be feasible. The technology is promising and could provide a cheap and reliable source of centralized baseload power if development efforts are successful; however, the option is removed from further consideration because it does not meet the criterion that "it must be ... commercially available ... by the end of the planning period."

SALINITY GRADIENT SOLAR PONDS

The solar pond is a technology that would allow the use of energy [illegible] to produce baseload energy. A solar pond is a [illegible] pond [illegible] [illegible] [illegible] energy at the bottom [illegible] would [illegible] with depth. The purpose of this zone is to insulate the storage zone. The top zone shields the [illegible] of the lower layers from external influences and has relatively low salinity.

Electricity is produced by [illegible] heat from the storage zone through a heat exchanger to drive a low-temperature turbine. [illegible] that is produced by solar ponds [illegible].

Currently all demonstration solar ponds contemplate using [illegible] low-salinity water bodies (e.g., Salton Sea, Dead Sea). It may be possible to create artificial solar ponds, but this has not yet been demonstrated.

[illegible]

The technology is in the early demonstration phases and it has not been determined whether large facilities (e.g., [illegible]) will be feasible. This technology is promising and could provide a [illegible] and reliable source of [illegible] baseload power if development efforts are successful. However, the option is removed from further consideration [illegible] the estimation that "it will not [illegible] commercially available [illegible] by the end of the planning period."

Appendix B

DEVELOPMENT OF ALTERNATIVES

(SELECTION STEP 4)

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[illegible]

Table 2-1 lists the energy options retained after screening in Step 3 of the alternatives selection. These are assembled to form a set of alternatives in Step 4. Table 3-4 presents the guidelines used in this process. Guideline 1 states that any option capable, by itself, of meeting the energy needs that NMGS would ultimately meet should be included as a distinct alternative. Based on the analysis reviewed in Appendix A, the following options thus qualify as distinct alternatives:

- Central-station steam electric (NMGS)
- Decentralized steam electric
- Coal conversion plus generation*
- Geothermal: Hot-water (high-temperature liquid-dominated)
- Nuclear: Water-cooled fission reactor*
- Out-of-state power source

The alternatives indicated by an asterisk (*) would not be available for operation until the mid-1990s. In the event that PNM's higher-growth scenarios occur, power purchase would be necessary for several years until the plants are operational.

Guideline 1 also directs that options that cannot by themselves clearly meet the energy needs proposed to be met by NMGS should be combined in such a way that the combination(s) themselves do so. In this category are (from Table 3-4) large hydroelectric, direct-solar, central-station wind, biomass, fuel cells, and conservation.

Fuel cells do not represent a complete energy technology, as they require a fuel. Because the most commercially promising near-term fuel source for this technology is coal-derived gases, the fuel cell option was included along with direct combustion, as a second power generation technique in the "Coal Conversion" alternative.

The remaining options are conservation and several others that are directly or indirectly based on solar energy:

- Solar-thermal electric
- Solar photovoltaic
- Solar heating
- Wind
- Hydroelectric
- Agricultural and forestry wastes
- Wood

These were combined into a single "conservation and renewable resource" alternative. The reasoning used in this process is described below.

Guideline 2 of Table 3-4, that every energy option must be included as part of at least one alternative, may be seen to be satisfied if a comparison is made between Table 2-1 and Table 2-2, which present the energy options and alternatives.

DEVELOPMENT OF THE CONSERVATION AND RENEWABLE RESOURCE ALTERNATIVE

There are technical difficulties involved in developing an alternative using solar and wind options because these options provide power only when the sun is shining or the wind is blowing. Thus, to provide continuous and reliable electric service some type of backup must be used. There are three general ways this backup can be provided:

1. Conventional generation technologies

2. Designing a mix of renewable technologies that compensate for one another's power supply limitations

3. A combination of overbuilding renewable resource generation capacity and storage

The first approach essentially uses solar and wind as "fuel-savers" to reduce the need for conventional oil, gas, coal, or nuclear fuels. This approach is not useful for PNM, since its system contains little oil or gas generation. Thus the backup system would be coal or nuclear. However, coal and nuclear systems have high capital costs and low fuel costs. Thus it makes sense to run these plants as much as possible. Little savings would result from using intermittent power along with coal and nuclear units that are not run continuously. If the plants are run continuously, the renewable resources are not needed.

The second approach would use renewable technologies as backups for one another. Probabilistic analysis shows the degree to which electricity from a given system of renewable resources is likely to be available when needed at the time of the system peak load. This analysis is done by running a system simulation model and identifying how much load can be served at a given loss of load probability (LOLP). Then the simulation is run again with the wind and solar technologies included. Any additional load that can be served at the chosen LOLP is called the "capacity credit" that can be assigned to wind and solar. Studies have found that the capacity credit that may be assigned to wind and solar diminishes as these technologies form a higher and higher percentage of the total system capacity. PNM states [13] that at 10 percent penetration, wind generation might be assigned an effective capability of around 38 percent. An EPRI study [13] did a similar calculation for solar and found that at 10-20 percent penetration, a 42 percent capacity credit could be achievable in Arizona. It is not clear how these credits would be affected by different system configurations (e.g., centralized vs decentralized wind farms). More utility experience is needed to answer these questions.

The third way to integrate solar and wind is to provide an electric storage system to save electricity generated during sunny or windy periods. Studies have found [36,47] that systemwide storage facilities are more cost-effective than storage dedicated to individual generation facilities. Possible storage technologies are hydroelectric pumped storage, batteries, and compressed air. The most promising of these is pumped storage, which is commercially available. In fact, PNM had planned until recently to build a pumped storage facility for cycling use in the 1990s [68]. PNM states [20] that a site approximately 45 miles west of Albuquerque was selected as the development site for the 600 MW of pumped storage hydro. The proposed plant would consist of four 150-MW units. Under PNM's current system-expansion plans, PNM believes this resource may not be needed until the late 1990s.

For purposes of the NMGS EIS analysis, we assumed a combination of strategies 2 and 3; that is, use of capacity credits as much as feasible, supplemented with storage. For comparative analysis purposes, a specific reference system is developed below based on this approach. Other systems are possible, and selection of the preferable one would require detailed studies.

The renewable alternative must meet PNM's 1998 projections for peak demand and for total energy demand (2875 MW and 17,503 GWh, respectively). PNM's currently planned projects will supply 1849 MW and 10,364 GWh by 1986. Thus the remaining need is 1026 MW and 7139 GWh. First, nonintermittent resources were considered. These were included as follows:

Alternative	Maximum Available	Used in Alternative	Capacity Factor	Energy Generation
Large Hydro	690 MW	286 MW	0.38	957 GWh
Wood	900+ MW	100 MW	0.70	613 GWh
Wastes	400 MW	100 MW	0.70	613 GWh
Total		486 MW		2183 GWh

(Note that in all cases less than the estimated maximum available resource is used. However, PNM has stated that it believes that the assumed large hydro potential is a very optimistic estimate.)

In addition to these options, it was assumed that PNM's previously planned 300-MW pumped-storage facility could be built. This was considered firm capacity but, of course, not given any credit for energy generation. Thus the total firm capacity of the system would be:

Existing and Planned	1859 MW
Firm Renewable	486 MW
Storage	300 MW
Total	2635 MW

This base was used to compute the penetration of solar and wind technologies. A penetration of approximately 20 percent for solar and 10 percent for wind was asssumed. This indicated that the appropriate capacity credits were 42 percent and 38 percent, respectively. Solar penetration was assumed to be 50 percent photovoltaic and 50 percent solar thermal. The following results were obtained.

Technology	Nominal Capacity	Percent of Firm Capacity	Capacity Credit Factor	Capacity Credit	Capacity Factor	Yearly Energy[a]
Solar PV	250 MW	9.5	0.42	105 MW	0.22[39]	482
Solar Thermal	250 MW	9.5	0.42	105 MW	0.30[12]	657
Wind	250 MW	9.5	0.38	95 MW	0.45[46]	986
Total	750 MW			305 MW		2125 GWh

[a](nominal capacity) x (capacity factor) x (8760 hours/year)

Therefore the total from the options considered thus far is:

Option	Power (MW)	Energy (GWh)
Existing and Planned	1849	10,364
Firm Renewable	486	2,183
Storage	300	0
Intermittent Renewable (Credit)	305	2,125
Total	2940	14,672
Needed in 1998	2875	17,503
Surplus (Deficit)	65	(2,831)

Thus there appears to be sufficient power available for peaking, but not sufficient energy.

The additional energy could be generated in a variety of ways. It was assumed for this reference system that geothermal generation would provide the needed energy. 435 MW would be needed at 75 percent capacity factor. Since this results in a 495 MW overcapacity, it was assumed that the storage facility would not be needed. Thus the final alternative looks like this:

Option	Power (MW)	Energy (GWh)
Existing and Planned	1849	10,364
Firm Renewable	486	2,183
Intermittent (Capacity Credit)	305	2,125
Geothermal	435	2,858
Total	3075	17,530
Needed in 1998	2875	17,503
Surplus	200	27

Testing the reliability of this system would require use of complicated system simulation models. It is likely that some fine tuning would be needed. Also these options tend to vary in their characteristics from site to site, so that better or worse results might be obtained.

The alternative above did not utilize conservation or point-of-use solar heating. Including these could reduce the need for some of the other resources in the conservation and renewable resource alternative. However, the review of conservation and solar heating shows that these two resources together could provide for only a portion of the energy that NMGS would supply. Whether or not conservation and solar heating are utilized, the analysis above shows that the conservation and renewable resource alternative is a potentially viable way of providing for the electrical need that NMGS would supply.

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