# GEOTHERMAL RESOURCE ASSESSMENT

for

# THE MX MISSILE SYSTEM

in

# NEVADA AND UTAH

## A PRELIMINARY PROGRAM PLAN

by

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# GEOTHERMAL RESOURCE ASSESSMENT

## PROGRAM SUMMARY

It is estimated that geothermal energy could supply between 20 and 100 percent of the electrical needs and between 10 and 30 percent of the space heating needs of the MX system and associated support facilities. An agressive resource assessment program would be needed to locate and prove enough resources to accomplish this. The geothermal resource assessment program will consist of a number of interdependent elements designed to provide both electrical power generation and direct space and process heat for the new MX ICBM Missile system installation. It is nearly certain that geothermal electrical power could be furnished to one of the two planned Operating Bases through further testing and development of the high-temperature hydrothermal resource at Roosevelt Hot Springs, near Milford, Utah PROVIDED THAT AN EARLY DECISION COULD BE MADE BY DOD[1]. The Roosevelt hydrothermal system resource could at the same time supply electrical power to clusters and shelters through tie-ins to appropriate electrical transmission lines. In fact, the Roosevelt resource is estimated to be large enough to supply the entire 120 MWe average continuous load requirement. In addition, waste heat from an electrical generating plant could be used for process and space heating for nearby installations.

1

Phillips Petroleum, operator of the Roosevelt Unit, intends to move ahead with trying to sell geothermal steam. They maintain that utilities they have contacted would require commitment of the complete resource if agreement to produce electricity is reached. If DOD wants to use the Roosevelt geothermal resource, they would have to reach agreement with Phillips before Phillips commits to a utility (Bill Berge, Phillips Petroleum Co., personal communication).

It would be highly desirable to establish existence of a geothermal resource capable of electrical power generation in Nevada. Presently there are no known candidate sites within the planned Deployment Area. However, several potential sites lie north and west of the Deployment Area, and one or more of these could be utilized by transmission line construction if the viability of the resource could be established. A portion of the proposed program is addressed to establishing viability of one of the western Nevada high temperature resources.

Many of the warm wells and springs of Nevada and Utah occur in the valley areas. It is certain that some portion of the cluster loops would be located near one of these lower-temperature resources, and that some space heating could thereby be provided. In addition, support facilities could be colocated with selected ones of these resources in order to take advantage of geothermal and process space heating energy available there.

The inventory of geothermal resource areas is not complete in Utah or Nevada. Through intensive efforts this inventory could be completed between 1980 and 1983, and detailed resource testing could begin in late 1980 to establish the viability of low temperature geothermal resources in this area.

The program outlined below is designed to:

1. Establish by November 1981 sufficient resource at Roosevelt Hot Springs, Utah to generate at least 33 MWe of electrical power (the operating base requirement). THIS ASSUMES THAT AN AGREEMENT CAN BE REACHED BETWEEN DOD AND PHILLIPS PETROLEUM CO.

2. Determine the additional potential at Roosevelt Hot Springs beyond 33 MWe.
3. Search for one or more sites in Nevada within the Deployment Area that could furnish at least 33 MWe of electrical power.
4. Perform an intensive and timely inventory of the low- to moderate-temperature geothermal resource base in western Utah and eastern Nevada in order to locate areas suitable for a space-heating quality resource.
5. Perform detailed surface exploration and drill testing of selected areas resulting from (4) above; and
6. Provide production well testing, hydrogeological studies and geothermal reservoir engineering for successful wells resulting from (1-6) above.

In this program, UURI would provide program management assistance and coordination to DOE/IDO for geothermal resource assessment, and would in addition perform a portion of the earth science studies and exploration. Principal assistance would be given to UURI by the Nevada Bureau of Mines and Geology (NBMG) and the Utah Geological and Mineral Survey (UGMS), both of whom are present contractors to DOE for geothermal resource assessment. Drilling expertise would be provided to the program by DOE/NVO. Reservoir engineering expertise would be provided to the program by Lawrence Berkeley Laboratory and by EG&G, Idaho, Inc. Use would be made of consultants in reservoir engineering, hydrology, and drilling. Ties with industry (who own land and geothermal rights to the principal high-temperature resource areas) would be maintained through DOE's Industry Coupled Program, currently operating in both Nevada and Utah. It is assumed that industry would cost-share some of the exploration on their lands.

# STORAGE SYSTEMS RESOURCE ASSESSMENT

## PROGRAM SUMMARY

### Thermal Aquifers

In order for an aquifer to be useful for thermal storage it should be shallow (for ease on drilling access) and should accept and give up fluids easily (to cut down pumping costs). In addition it is required that the thermal fluids be neither diluted or disbursed. Hydrologic surveys and drill testing would be performed to locate such aquifers.

It is assumed that UURI would provide management assistance to DOE and that the principal work would be done by private contractors through government procurements.

### Pumped Hydro

These are two aspects of this program:

1. Hydrologic surveys to locate large volumes of ground water which would be available for pumping into a storage dam.
2. Geologic surveys of prospective dam sites.

The proposed program addresses both of these aspects. The hydrlogic problem is different from that in the thermal aquifer storage project. In this project we would be looking for large-extent, unconfined, very high productivity aquifers.

The principal project work would be done by private contractors through government procurements.

Compressed Air Storage

The two principal components of this program are:

1. Location of caves in the Paleozoic and Mesozoic carbonate rocks of western Utah and eastern Nevada and geologic mapping in selected caves to determine potential for leakage and loss of compressed air, and
2. Pressure testing selected caves.

The principal work would be performed by the Utah Geological and Mineral Survey and the Nevada Bureau of Mines and Geology.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Geothermal Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.111 TITLE Reservoir Documentation-Roosevelt Hot Springs, UT.

Description (Include deliverables):

Establish cooperative agreement with Phillips Petroleum Co., operator of the Roosevelt Hot Springs Unit, to purchase steam. Examine Unit well test and flow records to document capability of reservoir to produce minimum of 20 MWe. Examine options for power plant construction. PHILLIPS REQUIRES AN EARLY DECISION TO COMMIT (Mid-1980).

Benefit to Program:

Development of electrical power generation from a liquid-dominated geothermal resource. Economic and operational data from this experience would be useful in facilitating similar development at other sites.

Benefit to MX Project:

Development of 20 MWe to power one operating base. Subsidiary, cascaded use of the steam condensate and of unflashed geothermal fluid could provide space heating for operating base.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Geothermal Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.112 TITLE Exploration - Roosevelt Hot Springs, UT.

Description (Include deliverables):

Perform further surface exploration aimed at helping to define reservoir limits. Drill up to 50 shallow (200-500m) thermal gradient wells. Drill 10 production well tests to attempt to increase known productive capacity of reservoir. Perform well flow tests and reservoir engineering studies on wells. (It is assumed that the Roosevelt Hot Springs Unit participants will contribute 70% to the costs of drilling, testing and reservoir engineering.)

Benefit to Program:

Development of a high-capacity liquid-dominated geothermal resource. Development of electrical power generation from a liquid-dominated geothermal resource. Economic and operational data from this experience would be useful in facilitating similar development at other sites.

Benefit to MX Project:

If successful, this activity could develop as much as 150 MWe additional electrical power production capability from the Roosevelt Hot Springs geothermal system. This power would be sufficient for the entire MX system.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Geothermal Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.113 TITLE Resource Inventory - Deployment Area

Description (Include deliverables):

Perform intensive geothermal resource inventory and reconnaissance exploration studies in the MX Deployment Area. Measure temperatures in all wells and hot springs. Map surface geology with emphasis on geothermal features. Collect and analyze hydrologic data to determine subsurface water availability. Accumulate a detailed data base for use in site selection. Deliverables will be measured values of fluid temperatures in wells and springs and geologic and hydrologic data.

Benefit to Program:

Accelerated resource assessment in about 25,000 sq mi in western Utah and eastern Nevada. These resources could be used in other applications if the MX system is not built.

Benefit to MX Project:

1. Resources suitable for space heating of shelters, clusters and other support facilities would be located.
2. Resources suitable for electric power generation may be located.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Geothermal Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.114 TITLE Site Exploration - Deployment Area

Description (Include deliverables):

Using the data base of (3.113), select specific sites for detailed exploration and drill testing. Perform site geological, geochemical, geophysical and hydrologic studies. Drill temperature gradient holes. Locate production well sites and drill production wells. Perform flow tests and reservoir engineering analyses on production wells. Deliverables would be 1) geothermal waters suitable for space heating an estimated 25 clusters and/or other support building, and 2) a 20% probability that temperatures would be found at 2 sites that would be high enough for electrical power generation.

Benefit to Program:

Accelerated resource assessment in about 25,000 sq mi in western Utah and eastern Nevada. These resources could be used in other applications if the MX system is not built.

Benefit to MX Project:

1. Resources suitable for space heating of shelters, clusters and other support facilities would be located.
2. Resources suitable for electric power generation may be located.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Geothermal Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.115 TITLE High Temperature Site Exploration - Western Nevada

Description (Include deliverables):

Select 3 of the most promising, known high-temperature areas in western Nevada for accelerated exploration. Perform surface geological, geophysical, geochemical and hydrologic surveys and drill temperature gradient holes. Select sites for production test wells. Drill up to 4 production test wells in each site in a staged program such that as soon as geothermal fluid of high enough quality for electrical power generation is discovered, effort is concentrated at that site. Deliverables would be at least one area where at least 20 MWe of electrical power production can be achieved. (It is assumed that the company who presently own property in these areas would share 70% of the exploration costs.)

Benefit to Program:

Accelerated resource assessment in about 25,000 sq mi in western Utah and eastern Nevada. These resources could be used in other applications if the MX system is not built.

Benefit to MX Project:

Electrical power would be available to the MX project by wheeling along commercial transmission lines.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Thermal Aquifer Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.116 TITLE Thermal Aquifer Hydrologic Surveys

Description (Include deliverables):

Perform detailed hydrologic studies (in conjunction with 3.113 Geothermal Resource Inventory-Deployment Area) aimed at defining aquifers suitable for storage of hot fluids: studies would be concentrated in areas of clusters and of support buildings. Drill test wells to determine aquifer characteristics. Perform geological and geophysical well logging. Deliverables would be maps and reports demonstrating location and characteristics of aquifers suitable for thermal fluid storage.

Benefit to Program:

Hydrologic studies would benefit the geothermal resource assessment programs of DOE (State Coupled and Industry Coupled) and of the USGS.

Benefit to MX Project:

Availability of aquifers for storage of thermal fluids.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Pumped Hydro Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.117 TITLE Hydrologic Surveys

Description (Include deliverables):

Assess ground water resources of Deployment and surrounding areas to locate reserves of groundwater suitable for storing behind dams for later generation of hydro power. Couple these hydrologic studies with 3.113 - Geothermal Resource Inventory-Deployment Area and with 3.116 Thermal Aquifer Hydrologic Studies. Deliverables would be maps and reports identifying large potential groundwater supplies.

Benefit to Program:

Hydrologic studies would benefit the geothermal resource assessment programs of DOE (State Coupled and Industry Coupled) and of the USGS.

Benefit to MX Project:

Ground water supplies suitable for dam storage for later hydropower generation.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Pumped Hydro Resource Assessment

For each activity please fill out the following:

ACTIVITY NO. 3.118 TITLE Dam Site Geologic Studies

Description (Include deliverables):

At selected dam sites, perform geologic studies and drilling to determine suitability of the site for dam construction and water storage with low loss.

Benefit to Program:

Increase in general geologic knowledge.

Benefit to MX Project:

Identification of geologically viable dam sites.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Compressed Air Storage

For each activity please fill out the following:

ACTIVITY NO. 3.119 TITLE Geologic Surveys

Description (Include deliverables):

Search available geologic literature to locate potential sites for compressed air storage. Western Utah and eastern Nevada contains many caves in carbonate rocks. Perform geologic mapping of selected caves to locate faults and fractures. Evaluate anticipated rates of compressed air loss based on geologic work. Deliverables would be maps and reports of caves deemed suitable for compressed air storage.

Benefit to Program:

Increase in general geologic knowledge.

Benefit to MX Project:

Identification of compressed air storage areas.

MX-RES PROJECT WBS NO. 2

PROGRAM: 3.11
Compressed Air Storage

For each activity please fill out the following:

ACTIVITY NO. 3.1110 TITLE Cavity Testing

Description (Include deliverables):

Select cavities from results of 3.119. Seal cavities and perform tests on storage capability including volumes and rates of loss.

Benefit to Program:

None

Benefit to MX Project:

Identification of compressed air storage areas.

PROGRAM:

Geothermal Resource Assessment

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| Reservoir Documentation-RHS | 50 | 80 | LBL | | | | March 80 | | Sept. 80 | |
| | 30 | 80 | UURI | | | | March 80 | | Sept. 80 | |
| Exploration-RHS | 1500 | 80 | Phillips Petroleum (includes drilling) | | | | June 80 | | Sept. 81 | |
| | 2500 | 81 | | | | | | | | |
| | 30 | 80 | UURI | | | | June 80 | | Sept. 81 | |
| | 50 | 81 | | | | | | | | |
| | 10 | 80 | LBL | | | | | | | |
| | 50 | 81 | | | | | June 80 | | Sept. 81 | |
| Resource Inventory | 30 | 80 | UURI | | | | June 80 | | Sept. 83 | |
| | 50 | 81 | | | | | | | | |
| | 50 | 82 | | | | | | | | |
| | 30 | 83 | | | | | | | | |
| | 100 | 80 | UGMS | | | | | | | |
| | 200 | 81 | | | | | | | | |
| | 200 | 82 | | | | | | | | |
| | 50 | 83 | | | | | | | | |
| | 100 | 80 | NBMG | | | | | | | |
| | 200 | 81 | | | | | | | | |
| | 200 | 82 | | | | | | | | |
| | 50 | 83 | | | | | | | | |

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PROGRAM:

Geothermal Resource Assessment

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| Site Exploration | 200 | 80 | UURI | | | | June 80 | | Sept. 88 | |
| | 700 | 81 | (includes gradient | | | | | | | |
| | 600 | 82 | drill costs) | | | | | | | |
| | 500 | 83 | | | | | | | | |
| | 500 | 84 | | | | | | | | |
| | 500 | 85 | -Surface explora- | | | | | | | |
| | 500 | 86 | tion project | | | | | | | |
| | 500 | 87 | coord. | | | | | | | |
| | 300 | 88 | | | | | | | | |
| | - | 80 | UGMS | | | | | | | |
| | - | 81 | -Asst. surface | | | | | | | |
| | 50 | 82 | exploration | | | | | | | |
| | 100 | 83 | | | | | | | | |
| | 100 | 84 | | | | | | | | |
| | 100 | 85 | | | | | | | | |
| | 100 | 86 | | | | | | | | |
| | 100 | 87 | | | | | | | | |
| | 50 | 88 | | | | | | | | |
| | - | 80 | NBMG | | | | | | | |
| | - | 81 | -Asst. surface | | | | | | | |
| | 50 | 82 | exploration | | | | | | | |
| | 100 | 83 | | | | | | | | |
| | 100 | 84 | | | | | | | | |
| | 100 | 85 | | | | | | | | |
| | 100 | 86 | | | | | | | | |
| | 100 | 87 | | | | | | | | |
| | 50 | 88 | | | | | | | | |

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PROGRAM:

Geothermal Resource Assessment

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| | - | 80 | NVO | | | | June 80 | | Sept. 88 | |
| | 2500 | 81 | production | | | | | | | |
| | 3400 | 82 | drilling | | | | | | | |
| | 3400 | 83 | | | | | | | | |
| | 3400 | 84 | | | | | | | | |
| | 2500 | 85 | | | | | | | | |
| | 2500 | 86 | | | | | | | | |
| | 2500 | 87 | | | | | | | | |
| | 1000 | 88 | | | | | | | | |
| | - | 80 | EG&G | | | | | | | |
| | 50 | 81 | reservoir engineer- | | | | | | | |
| | 50 | 82 | ing low temp sites | | | | | | | |
| | 50 | 83 | | | | | | | | |
| | 50 | 84 | | | | | | | | |
| | 50 | 85 | | | | | | | | |
| | 50 | 86 | | | | | | | | |
| | 50 | 87 | | | | | | | | |
| | 20 | 88 | | | | | | | | |
| | - | 80 | LBL | | | | | | | |
| | 50 | 81 | reservoir engineer- | | | | | | | |
| | 50 | 82 | ing -high temp sites | | | | | | | |
| | 50 | 83 | | | | | | | | |
| | 50 | 84 | | | | | | | | |
| | 20 | 85 | | | | | | | | |
| | - | 86 | | | | | | | | |
| | - | 87 | | | | | | | | |
| | - | 88 | | | | | | | | |

Prepared by: _____

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PROGRAM:

Geothermal Resource Assessment

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| High Temperature | 50 | 80 | UURI | | | | June 80 | | Sept. 83 | |
| Site Exploration | 200 | 81 | | | | | | | | |
| Western Nevada | 150 | 82 | | | | | | | | |
| | 100 | 83 | | | | | | | | |
| | 800 | 80 | Industry | | | | | | | |
| | 3500 | 81 | | | | | | | | |
| | 2000 | 82 | | | | | | | | |
| | 1000 | 83 | | | | | | | | |
| | - | 80 | LBL | | | | | | | |
| | 50 | 81 | | | | | | | | |
| | 80 | 82 | | | | | | | | |
| | 50 | 83 | | | | | | | | |
| | 50 | 80 | NVO | | | | | | | |
| | 100 | 81 | | | | | | | | |
| | 70 | 82 | | | | | | | | |
| | 50 | 83 | | | | | | | | |

Prepared by: _____

DATE: _____

PROGRAM:

Thermal Aquifer Resource Assessment

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| Thermal Aquifer Hydrology | 50 | 80 | UURI prog. coord., data interp. | | | | June 80 | | Sept. 83 | |
| | 150 | 81 | | | | | | | | |
| | 150 | 82 | | | | | | | | |
| | 70 | 83 | | | | | | | | |
| | 1000 | 80 | Hydrology Contractors (includes drilling) | | | | | | | |
| | 1800 | 81 | | | | | | | | |
| | 1500 | 82 | | | | | | | | |
| | 400 | 83 | | | | | | | | |

Prepared by: _____

DATE:

PROGRAM:

Pumped Hydro Resource Assess.

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT NEW | PROCUREMENT MOD | SCHEDULE START CURRENT | SCHEDULE START NEW | SCHEDULE END CURRENT | SCHEDULE END NEW |
|---|---|---|---|---|---|---|---|---|---|---|
| Hydrologic Surveys | 50 | 80 | UURI | | | | June 80 | | Sept. 83 | |
| | 150 | 81 | | | | | | | | |
| | 150 | 82 | | | | | | | | |
| | 70 | 83 | | | | | | | | |
| | 800 | 80 | Hydrology | | | | | | | |
| | 1500 | 81 | Contractors | | | | | | | |
| | 1200 | 82 | (includes drilling) | | | | | | | |
| | 100 | 83 | | | | | | | | |
| Dam Site Geologic Studies | 30 | 81 | UURI | | | | June 81 | | Sept.85 | |
| | 50 | 82 | | | | | | | | |
| | 50 | 83 | | | | | | | | |
| | 50 | 84 | | | | | | | | |
| | 50 | 85 | | | | | | | | |
| | 150 | 81 | Geologic Contractor | | | | | | | |
| | 300 | 82 | | | | | | | | |
| | 300 | 83 | | | | | | | | |
| | 300 | 84 | | | | | | | | |
| | 100 | 85 | | | | | | | | |

Prepared by: _____

DATE: _____

PROGRAM:

Compressed Air Storage

MX-RES

WBS NO. 2

| ACTIVITY | $ THOUSANDS | FY | CONTRACTOR OR LABORATORY | TECH. MONIT | PROCUREMENT | | SCHEDULE | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NEW | MOD | START CURRENT | START NEW | END CURRENT | END NEW |
| Geologic Surveys | 20 | 80 | UURI | | | | June 80 | | Sept. 83 | |
| | 50 | 81 | | | | | | | | |
| | 50 | 82 | | | | | | | | |
| | 30 | 83 | | | | | | | | |
| | 50 | 80 | UGMS | | | | | | | |
| | 150 | 81 | | | | | | | | |
| | 150 | 82 | | | | | | | | |
| | 70 | 83 | | | | | | | | |
| | 50 | 80 | NBMG | | | | | | | |
| | 150 | 81 | | | | | | | | |
| | 150 | 82 | | | | | | | | |
| | 70 | 83 | | | | | | | | |
| Cavity Testing | 100 | 82 | Engineering Contractor | | | | June 82 | | Sept. 85 | |
| | 300 | 83 | | | | | | | | |
| | 300 | 84 | | | | | | | | |
| | 200 | 85 | | | | | | | | |

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