Seasonal Thermal Energy Storage Program

**Legal and Regulatory
Issues Affecting the Aquifer
Thermal Energy Storage Concept**

**Prepared for the U.S. Department of Energy
Office of Advanced Conservation Technologies
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**Pacific Northwest Laboratory
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LEGAL AND REGULATORY ISSUES
AFFECTING THE AQUIFER THERMAL
ENERGY STORAGE CONCEPT

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SUMMARY

This document examines a number of legal and regulatory issues that potentially can affect implementation of the Aquifer Thermal Energy Storage (ATES) concept. This concept involves the storage of thermal energy in an underground aquifer until a later date when it can be effectively utilized. Either heat energy or chill can be stored. Potential end uses of the energy include district space heating and cooling, industrial process applications, and use in agriculture or aquaculture. Issues are examined in four categories: regulatory requirements, property rights, potential liability, and issues related to heat or chill delivery.

Initiation of an ATES project will necessarily involve compliance with certain permits and regulatory requirements. In most western states and some eastern states, a permit to withdraw ground water will be required from the appropriate state water resources agency. Most states have requirements related to well drilling, construction, and abandonment. In many states, a separate permit to reinject the thermally altered ground water will be required from the appropriate pollution control agency. A few states prohibit such reinjection, and a variance will be necessary if an ATES project is to be implemented. Eventually, a permit from a state agency or the U.S. Environmental Protection Agency under the Underground Injection Control (UIC) Program established by the Safe Drinking Water Act of 1974 will be required. This requirement will supersede existing underground injection requirements. Final UIC requirements for the well classification likely to include ATES wells will probably not be issued for several years. An ATES project may also trigger the need for an environmental impact statement (EIS). Table 1 is a summary of potential regulatory requirements.

A central concern of the ATES operator will be assurance of the ability to store, protect, and recapture the thermal energy when desired. An associated concern is the need to conduct these activities without incurring liability. At a minimum, the ATES operator will need to purchase or when necessary condemn (assuming statutory authority) sufficient surface property rights to provide site access, drill needed wells and provide adequate spacing from nearby

TABLE 1. Areas of Regulation Potentially Applicable to an ATEs Project

Activity	Level of Control		
	Federal	State	Local
EIS	Required by NEPA for projects with significant Federal activity and environmental impacts	Required in about 20 states, requirements can often be satisfied by a NEPA EIS	
Land Use		Permit may be needed in certain states that regulate key facilities	Compliance with applicable zoning and land use plans
Well Drilling		Most states have requirements	
Ground Water Withdrawal		Permit needed in most western and some eastern states	Units of local government regulate withdrawal in a few states, e.g., Calif.
Ground Water ReInjection	By about 1984, UIC permit will be needed from EPA in states without UIC program authority	Permit currently needed in about half of states. By about 1984, permit required under UIC program from states that receive UIC program authority from EPA	Certain local governments (e.g., Kern County, Calif. have injection requirements

land use activities. Acquisition of a subsurface energy storage easement may be needed if significant liability is foreseen or if intentional interference with the ATEs operation by another aquifer user is considered possible. Both of these contingencies are more likely if a relatively shallow aquifer is utilized for storage, although the likelihood of each can be rendered very small by careful aquifer selection. Liability from ATEs operations is most likely for interference with existing users of an aquifer as a potable water source. Alleged interference would most likely be for increased water temperature, although it is also possible that an ATEs operation could lead to some chemical or biological contamination of ground water. Liability is also

possible to other existing ground-water users, to potential ground-water users in states recognizing overlying ground-water rights, and to mineral rights holders if mineral (including oil and gas) interests are interfered with. The possibility that someone could drill with impunity into the energy storage bubble with the major purpose of capturing stored energy and/or interfering with an ATES operation is remote. This is true even if the ATES operator has not acquired any property interests. It seems possible to conclude that an ATES operator can assure the right to store, protect, and recapture the energy and to adequately limit the possibility of future liability. It is also likely that this assurance can be provided at a reasonable cost, especially in relation to total ATES costs.

A variety of legal, institutional, and regulatory issues will occur at the stage of heat or chill delivery. A principal issue is locating an entity with sufficient incentive to construct and operate an ATES and delivery system. It may be difficult to find an investor owned entity with sufficient economic incentive and consequently the responsibility may fall to a public body. A variety of other issues related to financing, rate setting, service areas, taxation, and other areas will require resolution. These issues are likely to be most complex for a residential district heating system.

CONTENTS

SUMMARY	iii
ACRONYMS	ix
1.0 INTRODUCTION	1
2.0 REGULATORY REQUIREMENTS PRIOR TO OPERATION	7
2.1 GROUND-WATER WITHDRAWAL AND DRILLING REQUIREMENTS	7
2.2 INJECTION REQUIREMENTS	10
2.3 ENVIRONMENTAL POLICY ACTS	14
2.4 SITING REQUIREMENTS	15
3.0 STORAGE AND RECOVERY OF THE ENERGY RESOURCE	19
3.1 BACKGROUND	19
3.1.1 Ownership of Underground Space	19
3.1.2 Ground-Water Rights	22
3.1.3 Aquifer Characterization	23
3.2 PROPERTY RIGHTS NEEDED FOR STORAGE AND RECOVERY	24
3.3 EXERCISE OF EMINENT DOMAIN	28
4.0 POTENTIAL LIABILITY FROM AQUIFER THERMAL ENERGY STORAGE OPERATIONS	31
4.1 THEORIES FOR LIABILITY	31
4.2 SUBSURFACE ACTIVITIES	33
4.3 SURFACE ACTIVITIES	36
5.0 INSTITUTIONAL AND FINANCIAL ISSUES APPLICABLE TO HEAT OR CHILL DELIVERY	39
5.1 POTENTIAL END USERS	39
5.2 INSTITUTIONAL ISSUES	40

5.3 FINANCIAL AND REGULATORY ISSUES RELATED TO DISTRICT HEATING	.	41
5.4 HEAT DELIVERY ISSUES		44
REFERENCES		47
ACKNOWLEDGMENTS		53

ACRONYMS

ATES	aquifer thermal energy storage
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EA	environmental assessment
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
NEPA	National Environmental Policy Act
NPDES	National Pollution Discharge Elimination System
NTIS	National Technical Information Service
ORNL	Oak Ridge National Laboratory
PNL	Pacific Northwest Laboratory
SEPA	state environmental policy act
STES	seasonal thermal energy storage
UIC	underground injection control
USCA	United States Code Annotated

LEGAL AND REGULATORY ISSUES AFFECTING THE AQUIFER THERMAL ENERGY STORAGE CONCEPT

1.0 INTRODUCTION

Aquifer thermal energy storage (ATES) is a relatively new concept for the storage of thermal energy in underground aquifers^(a) until the energy is needed for end uses. The concept can potentially be adapted both to the storage of heat energy or for chill. The concept is receiving increasing attention in the U.S. and abroad. The objective of this study is to examine the legal and regulatory issues associated with implementation of the concept.

This effort is one output from the Seasonal Thermal Energy Storage (STES) Program. The STES Program is managed by the Pacific Northwest Laboratory (PNL) for the Office of Advanced Conservation Technologies, Division of Energy Storage, U.S. Department of Energy (DOE). The program is one component of the DOE Thermal Energy Storage Program.

The objectives of the STES Program are to demonstrate the economic storage and retrieval of energy on a seasonal basis using heat or cold available from waste or other sources during a surplus period to reduce peak period demand on the energy source, to reduce electric utilities' peaking problems, and contribute to the establishment of favorable economics for district heating and cooling systems for commercialization of the technology. Aquifers, ponds, earth, and lakes have potential for seasonal storage. The initial thrust of the STES Program is toward utilization of ground-water systems (aquifers) for thermal energy storage. The program has the further objective of evaluating other methods of seasonal storage, both from existing literature and by following current work in other countries.

Reports issued by PNL under the STES Program to date include:

1. R. D. Allen, Thermal Energy Storage in Aquifers - Preliminary Information PNL-3062, December 1979.

(a) An aquifer is an underground zone of saturated, permeable earth material from which significant quantities of ground water can be extracted.

2. J. A. Stottlemire et al., Geochemical Equilibrium Modeling of the Auburn Thermal Energy Storage Field, PNL-3167, October 1979.
3. R. W. Reilly, A Descriptive Analysis of Aquifer Thermal Energy Storage Systems, PNL-3298, June 1980.
4. J. E. Minor, Seasonal Thermal Energy Storage Program Progress Report (April 1979 - December 1979), PNL-3322, March 1980.
5. L. S. Prater, Aquifer Thermal Energy Storage Reference Manual, PNL-3471, August 1980.

The sources and uses of stored energy can be quite varied. Sources of heat energy include waste heat from steam electric power plants and industrial plants, heat from cogeneration plants^(a) and possibly solar heated hot water. The most likely end use for the heat is district space heating, both residential and commercial. Other potential end uses are industrial process heat, agriculture, both open field and in greenhouses (actually another form of space heating), and aquaculture. The principal source of chill is water chilled by winter temperature. Winter-chilled water can be injected into an aquifer and extracted for summer air conditioning.

The ATES concept appears to be the most attractive technology available for seasonal storage of large quantities of thermal energy. Its potential for application is great. It has the potential to store energy generated during a period when it is not needed for use at a later period when it is needed at a relatively low storage cost and with few environmental impacts. For example, the waste heat from a power plant or other industrial facility that otherwise would have no value for space heating in warm weather months can be saved for cold weather months. Solar-heated water and winter-chilled water can also potentially be stored for off-season use.

(a) Cogeneration is the simultaneous production of electricity and heat in the form of hot water at the same facility. It differs from conventional power production at a central station plant by producing water at a high enough temperature (greater than 150°F) to be useful, at the expense of additional electricity generation.

The ATES concept is illustrated in Figure 1. Waste heat from the heat source is transferred to a transport fluid, probably water, by a heat exchanger located at the waste heat source. If the heat can be used immediately without storage, it travels directly to the end user, in this case a district heating system. At this point another heat exchanger may be used to extract the heat from the transport fluid. As shown in Figure 1, waste heat that cannot be immediately used travels to a heat exchanger where it is transferred to ground water pumped from the warm zone. The heated ground water is then injected into the confined storage aquifer for later recovery. The hot water warms the aquifer and surrounding underground stratum. When the heat is needed at the end use, the heated ground water is pumped up to the heat exchanger from the hot zone and the heat transferred to the transport fluid. The cooler ground water is then reinjected into the warm zone and the heated transport fluid travels to the end users.

The ATES system will normally operate so that all working fluids are kept separated from each other by the use of heat exchangers at the heat source, the well injection point, and the end use. This separation lowers overall efficiency, but minimizes the possibility of chemical reactions. This is important at the source and use points and also in the aquifer, where chemical or physical reactions could lead to well clogging. It is likely that overall heat recovery efficiencies for an ATES system in the range of 50 to 90% will prove both technically and economically feasible.

Selection of the storage aquifer is quite important. A relatively shallow (e.g., less than 1000 feet) confined aquifer with sufficient hydrostatic pressure to prevent the hot water from flashing to steam is probably most attractive. This type of aquifer will have good heat retention and relatively low pumping costs. It may, however, involve conflicts with other ground water users. In most cases, these are not likely to be too severe (see Section 4.0). Deeper aquifers may also be utilized if it is considered desirable to avoid potential aquifer use conflicts. Unconfined aquifers are also potentially feasible when suitable confined aquifers are unavailable. An unconfined aquifer is an aquifer overlain by rock of relatively high permeability. Shallow aquifers are more likely than deep aquifers to be unconfined.

FIGURE 1. Aquifer Thermal Energy Storage

The extent of suitable aquifers is not known. One potential difficulty is that a suitable aquifer must ordinarily be near a relatively large population center that will provide sufficient demand for the stored energy. Aquifers in high population areas sometimes have numerous competing users. Aquifers underlie approximately two-thirds of the land area in the U.S.,⁽¹⁾ so their potential availability is great.

The economics of the ATES concept appear attractive. The concept was considered as part of a district heating-cogeneration study for Minneapolis - St. Paul.⁽²⁾ ATES demonstrated a net energy saving of 32%. Using this energy savings, Meyer estimated that the proposed system could afford to pay up to \$76/kW thermal to implement ATES.⁽²⁾ Actual implementation costs were estimated to range from \$23 to \$50/kW thermal.

The environmental impacts of the concept currently appear to be positive on balance on a regional basis. Work on possible environmental impacts is now in progress as part of the ATES Program. The principal environmental gains are realized from conservation, i.e., reduced combustion of fossil fuels and associated impacts that otherwise would be necessary. The principal impacts will result from altering the aquifer temperature. As long as the aquifer water is not a potable water source and it is kept isolated from transport fluids, the negative aspects of altering the aquifer temperature will hopefully be manageable. Water quality will perhaps deteriorate some if greater mineral solubility is induced by the stored energy. Even if the aquifer is a potable water source, impacts should not be too excessive. The farther the aquifer user is from the ATES injection location, the less temperature change will be seen. Moreover, it is possible that other aquifer users will be able to utilize the energy stored in the aquifer available for hot water/space heating or space cooling, depending on the system, so long as the use does not materially interfere with the ATES system. Other environmental impacts will result from disruptions caused by fluid transport to and from the ATES site and the possibility of fluid spills.

The remaining chapters of this document consider legal and regulatory issues affecting ATES development in four categories. Section 2.0 examines

regulatory and permit requirements that must be satisfied prior to operation. Section 3.0 provides some background information on ownership of underground space, ground-water rights, and types of aquifers, and uses this information to examine the property rights that an ATEs operator will want to consider acquiring to ensure the ability to store and recover the energy resource. Section 4.0 examines possible areas of liability associated with an ATEs operation and possible mitigation measures. Section 5.0 identifies some of the important legal and regulatory issues that will affect delivery of the stored energy resource.

2.0 REGULATORY REQUIREMENTS PRIOR TO OPERATION

Regulatory requirements in three principal categories must be met before an ATES system can become operational. The first category is permit requirements for ground water withdrawal and requirements related to well drilling. The second category is related to reinjection of thermally altered ground water. The final category is land use requirements at the injection/storage site. Land use considerations associated with pipelines to and from the site are also quite important. Pipeline related issues are discussed in Section 5.4. Certain other permits such as a local building permit or a permit to transport drilling equipment to the ATES site over public highways may also be needed, but are not discussed in this document.

2.1 GROUND-WATER WITHDRAWAL AND DRILLING REQUIREMENTS

Implementation of the ATES concept will involve the drilling and construction of at least two wells. In most western and some eastern states a permit from the state engineer or water resources agency to withdraw ground water will be required even though the water will be reinjected rather than consumed. An additional permit to reinject the thermally altered ground water will be needed in some cases, as discussed in Section 2.2. In addition, state regulations relating to water well drilling must be complied with.

All of the 19 westernmost states except Hawaii, Nebraska, and Texas generally follow the appropriation system (see Section 3.1.2) and require a permit for ground water withdrawals.⁽³⁾ Arizona, California, and Montana, however, provide for permits and controls for certain sources of ground water or sources in particular areas only. Twelve eastern states have passed legislation regulating ground-water withdrawals.⁽⁴⁾ Delaware, Iowa, Maryland, Minnesota, and Wisconsin have state-wide regulation; Florida, Georgia, Indiana, New Jersey, New York, North Carolina and South Carolina limit regulation to certain geographic areas. North Carolina also regulates all wells within the state withdrawing over 100,000 gallons per day. Several states provide exemptions to permit requirements for wells utilized for domestic purposes or for other wells with small capacity. However, it is unlikely that an ATES well would qualify for an exemption in those states generally requiring permits.

Several western states including Arizona, Hawaii, Idaho, Montana, Nebraska, Nevada, Oregon, Texas, and Wyoming have provisions in their state codes for the designation of critical ground-water areas.⁽⁵⁾ This designation is for areas where the ground water is being withdrawn in quantities significantly exceeding recharge. After designation, new withdrawal permits may become more difficult to obtain and existing permit holders may even be told to cut back their use. Although an ATES project does not involve a consumptive ground-water use, it can be expected that obtaining a permit to withdraw water from an aquifer designated as critical will be more difficult than for a noncritical aquifer. In part, this difficulty will likely reflect that water is an emotional and political commodity, especially in the arid west.

The critical ground-water area designation may provide an analogy to preclude additional ground-water withdrawal permits in the proximity of an ATES project. The ground water surrounding the project might be designated a critical energy storage area and be closed to further withdrawal. Such a designation would normally require legislative authority. In permit states, such a designation may not be necessary because water rights administrators often have discretion to deny ground-water withdrawal applications that will impair existing water rights from the aquifer.⁽⁶⁾

Withdrawal of ground water from an aquifer that has been designated by the Environmental Protection Agency (EPA) or possibly a state agency as the sole or principal drinking water source for an area may be somewhat more difficult than from an aquifer not so designated. The EPA has authority under the Safe Drinking Water Act to designate sole source aquifers. Once it has made a designation, no subsequent commitments of Federal financial assistance may be made to projects that EPA determines may contaminate the aquifer so as to create a significant hazard to public health.⁽⁷⁾ Federal financial assistance is broadly defined to include contracts, grants and loan guarantees.⁽⁸⁾ A significant hazard to public health is one that causes an aquifer to exceed any maximum contaminant level established by the National Primary Drinking Water Standards,⁽⁹⁾ adversely affects human health, or requires additional treatment by a public water system to prevent adverse effects.⁽¹⁰⁾

The six aquifers designated as sole source through 1979 include: the Edwards Underground Reservoir near San Antonio, Texas; the Spokane Valley-Rathdrum Prairie Aquifer near Spokane, Washington; Nassau-Suffolk Counties, Long Island, New York; the northern ground-water system of the island of Guam; Fresno County, California; and the Biscayne Sole Source Aquifer, Florida. Other applications for sole source status are pending before EPA. One of the ATEs demonstration projects is located on the campus of the State University of New York at Stony Brook. The Nassau-Suffolk sole source aquifer will be utilized for the demonstration and, consequently, EPA must find that the project will not contaminate the aquifer. This finding is pending.

Finally, it is possible that in the future all ground waters will be classified in some manner. EPA is considering a three-tiered ground-water classification system.⁽¹¹⁾ The three classifications being considered include:

1. ground water that serves a highly valuable human use or ecological function warranting the most stringent level of control
2. ground water potentially usable as drinking water and requiring usual levels of protection
3. ground water areas where limited and defined contamination would be allowed for certain contaminants.

Incentives would likely be offered to encourage states to adopt the classification system ultimately selected. EPA is currently reviewing internally the extent to which their proposed strategy should allow degradation of existing ground-water quality. Publication of a draft strategy is planned for later this year. The ultimate strategy selected will very likely affect ground-water uses and withdrawal requirements and hence ATEs location possibilities. Some states already have ground-water classification systems and associated water quality standards. Examples include New York, New Jersey, and New Mexico,⁽¹²⁾ Maryland, and Minnesota.

In addition to a withdrawal permit, compliance with state well drilling regulations will be required.^(a) Regulations, some of which go into considerable detail, may include requirements concerning:

- information to obtain a permit
- location
- well design and construction
- well drilling equipment and materials
- pump and other equipment
- testing
- maintenance
- abandonment.⁽¹³⁾

Most states license water well drillers. Some have inspection requirements and require that log data and/or a well completion report be filed. Chemical and bacteriological analyses may also be required.

Ground-water withdrawal permit requirements, well construction and drilling regulations, and injection requirements are often regulated at the state level. Sometimes this authority is delegated to a county or municipal governmental body, such as a local health department. Certain local entities have their own regulations, and they can sometimes be more strict than state requirements.⁽¹⁴⁾ Local regulations can significantly affect ATEs implementation and must be examined. For example, a local ordinance in Kern County, California specifies that water injected into an aquifer shall not cause the temperature of adjacent ground water to increase more than 8 F.⁽¹⁴⁾

2.2 INJECTION REQUIREMENTS

In many instances a permit for reinjection of thermally altered ground water will be required. Currently permit requirements are based on state law and differ substantially among states. As the Kern County example suggests, injection requirements can also potentially differ significantly within a

(a) A summary of state requirements, regulatory agencies and citations to appropriate state code and regulation sections is in J. D. Ritchey and J. D. Miller, National Water Well Association, Compendium of State Laws and Regulations Affecting Water Well Drilling, Worthington, Ohio, 1979.

state. By 1985, requirements under the Underground Injection Control (UIC) Program authorized by the Safe Drinking Water Act of 1974⁽¹⁵⁾ are likely to provide uniform guidelines for underground injection associated with ATES and other nonhazardous injection practices.

Many states currently regulate underground injection of pollutants in some manner. States are required to have authority to issue permits that control the disposal of pollutants into wells as a precondition to approval by the EPA of their operation of the National Pollution Discharge Elimination System (NPDES).⁽¹⁶⁾ At least 33 states have received approval from EPA to operate the NPDES system.⁽¹⁷⁾ In many of these states, a permit for reinjection of thermally altered ground water will be required. The terms of the permit are likely to be determined by negotiation between the parties rather than by predetermined and published regulations or rules.

The National Water Well Association is investigating ground-water reinjection requirements as part of a study on ground-water heat pumps conducted for the U.S. Department of Energy. They have determined that reinjection of ground water from ground-water heat pumps would require a permit in 21 states and that 7 states would prohibit the reinjection unless a special variance is obtained.⁽¹⁸⁾

Minnesota is one state where discharges to an aquifer are prohibited unless a variance is obtained from the State Pollution Control Agency.⁽¹⁹⁾ The Agency has effectively classified all underground waters in the state as potential potable water supply. Another of the DOE ATES demonstration projects is located at the St. Paul campus of the University of Minnesota. A variance for the first phase of the demonstration project has been granted by the Pollution Control Agency.

The major Federal environmental statute that will affect the storage function of ATES systems is the Safe Drinking Water Act of 1974.⁽¹⁵⁾ The Clean Water Act⁽²⁰⁾ has some existing impact that will diminish as the Safe Drinking Water Act is phased in. The two statutes operate similarly. Under each, the EPA sets minimum standards for certain discharge practices and provides an overseeing function to ensure compliance. Those states that adopt

permit, monitoring, and enforcement programs acceptable to EPA and agree to enforce the EPA standards are delegated authority to operate their own programs, thus removing EPA from a direct role.

The principal objective of the Safe Drinking Water Act is to protect ground water currently being used or potentially of use as drinking water. The Act directs the EPA to:

- publish minimum national requirements for effective state UIC programs
- make grants to states for development and implementation of those programs
- review proposed state programs and approve or disapprove them
- implement Federally controlled programs for those states choosing not to participate in the program.

Regulations establishing the technical criteria and standards for use by EPA and the states in the development and implementation of state UIC programs became effective July 18, 1980.⁽²¹⁾ With certain exceptions relating to underground injection of hazardous waste, within the meaning of the Resource Conservation and Recovery Act,⁽²²⁾ the new regulations do not establish requirements for owners of injection wells. Rather, they establish requirements for states to use in developing their UIC programs, which, in turn, will establish enforceable requirements.

In its new regulations under the UIC program, EPA has divided injection wells into five categories. Examination of the classifications and preliminary discussion with the EPA Region 10 Office suggest that an ATEs well will probably fall into Class V, the catch-all classification for wells not defined in the first four categories. Examples of Class V wells given in the regulations include those for water table recharge, cooling water return flow, ground-water heat pump return flow, subsidence control, and geothermal wells used for heating and aquaculture.⁽²³⁾ Class V wells will likely be the last to be regulated, in part because little is known about their potential health risks and environmental implications. The regulations direct owners/operators of these wells to submit a description of the well and its status to the state within one year of the effective date of a state UIC program. Within 3 years

of the effective date, the state must submit to EPA information on the construction features of Class V wells, an assessment of their contamination potential, available corrective actions and their economic and environmental consequences, and recommendations for regulatory actions.⁽²³⁾ Final requirements for injections from Class V wells will thus probably not be published for 3 or 4 years. It is likely that the final requirements will not present a serious obstacle to ATEs. Rather, it is possible they will require such things as an injection permit; perhaps a fiscal responsibility element; and careful controls on aquifer selection (including aquifer depth and boundary materials), well construction materials and techniques, injection practices, and well abandonment.

If ATEs wells are construed by EPA to come under Class I (industrial waste injection) wells or Class III (wells that use injection for extraction of minerals or energy), which is unlikely, regulation will be more intense and will occur sooner. Use of an aquifer that is an underground source of drinking water will probably not be possible in this case.

The Clean Water Act requires that, before pollutants can be discharged into the waters of the United States, a NPDES permit must be obtained. Heat is included within the definition of pollutants.⁽²⁴⁾ The principal intent of the Act seems to have been protection of surface waters; however, control of underground discharges is indirectly addressed. States are required to control the disposal of pollutants into wells as a precondition to EPA approval of their NPDES program.⁽¹⁶⁾ The authority of EPA to require an NPDES permit for underground pollutant injection has been litigated in at least three cases. Two cases have held that EPA does not have the requisite authority.⁽²⁵⁾ One case has held that it does.⁽²⁶⁾

The EPA has also recently promulgated regulations to consolidate permit requirements under several programs including UIC and NPDES permit requirements.⁽²⁷⁾ The regulations encourage, but do not mandate, that states with permit-issuing authority adopt consolidation procedures. Under the consolidated regulations, UIC and NPDES requirements relating to underground injection can potentially be satisfied by a single permit under the UIC program if either the state or the EPA administers both programs.

2.3 ENVIRONMENTAL POLICY ACTS

It is entirely possible that an environmental assessment (EA) or an environmental impact statement (EIS) will be required prior to implementing an ATES project either by the National Environmental Policy Act (NEPA) or a state environmental policy act (SEPA). The NEPA requires Federal agencies to prepare a detailed EIS for each major Federal action significantly affecting the quality of the human environment.⁽²⁸⁾ Two questions must be answered before a determination of whether an EIS under NEPA would be required for any particular ATES project. The first question is whether there is a major Federal action. A typical ATES development will not require Federal licensing. It may in some cases require a UIC permit from EPA,^(a) however, or receive a demonstration grant from an agency such as DOE. It is also possible that an injection/storage site could be located on land leased, exchanged, or purchased from a Federal agency. Any of these Federal actions could possibly trigger the NEPA requirement for an EIS. The second question is whether the environmental impacts of the ATES project are significant. Impacts may be significant even if on balance there is a positive environmental impact. Given the extent of impacts that arise during the generation, transportation, storage and end use of energy it seems probable that an ATES project of more than minimal size will be construed to have significant impacts.

An EA may be needed if it is unclear whether an EIS should be prepared, to facilitate preparation of an EIS, or to aid an agency's compliance with NEPA when no EIS is necessary.⁽³⁰⁾

As of 1978, 18 states had enacted state environmental policy acts.⁽³¹⁾ These acts typically require an EIS for state actions significantly affecting the environment. Since one or more state permits (e.g., a UIC permit) will almost surely be needed, a SEPA EIS could be required in these states if the environmental impacts are determined to be significant. Generally a SEPA EIS will not be required if a NEPA EIS has already been prepared.⁽³²⁾

(a) EPA has indicated that it anticipates that EPA-issued UIC permits will be exempt from formal NEPA requirements. The reason for the exemption is EPA reliance on court decisions recognizing that its regulatory actions constitute the functional equivalent of NEPA.⁽²⁹⁾

2.4 SITING REQUIREMENTS

The injection/storage site must naturally comply with applicable land use and facility siting requirements. In most cases, this will simply involve selecting a site with industrial or commercial zoning or zoning that will otherwise permit the storage activity as a special use. The zoning/land use decision will ordinarily be made at a local level of government.

During the last 10 years, a number of states including Arkansas, Florida, Connecticut, Montana, New Hampshire, Ohio, Wyoming, Vermont, Oregon, Washington and Nevada, have enacted siting controls at the state level for projects defined in some manner to be for large or key facilities.⁽³³⁾ Certain of these states, e.g., Florida, Nevada, Oregon, Vermont, and Wyoming, and other states including Hawaii, Maine, Maryland, Minnesota, and North Carolina also have controls at the state level for siting in areas defined to be critical because of their uniqueness, fragile resources, or for other reasons.⁽³⁴⁾ Depending on its size and location, an ATEs facility could conceivably fall into the category of a project requiring state siting approval. A common format for industrial siting is to establish a council made up of state agencies having regulatory control over the permit and siting process. The council is generally given authority to develop a unified state position and either grant or deny the necessary permits. Electric power plants are invariably included within the scope of this "one-stop" siting process and some states limit the process to these plants.^(a) Other states such as Washington include all significant energy related projects, or, like Wyoming, all significant industrial facilities. The Washington statute applies to specific energy and transmission facilities, but an ATEs facility is not included within the statutory definition of energy facility.⁽³⁵⁾ The Wyoming statute applies to all industrial facilities with an estimated construction cost of \$50 million or more.⁽³⁶⁾ An ATEs facility could approach \$50 million or more if extensive piping from the source to the user is included as part of the cost. The energy storage portion itself is likely to be substantially less than \$50 million.

(a) An ATEs project combined with a cogeneration plant would likely be included within the scope of these statutes. An ATEs facility by itself would not.

If the storage site is owned by the storing entity, the site use requirements are simplified. If access to the storing site is to be by lease or easement, the consent of the land owner in addition to that of the land use regulatory body is required. This issue is discussed further in Section 3.2.

Certain Federal land use related programs could potentially affect site selection.⁽³⁷⁾ Two programs are the National Flood Insurance Program, and coastal land use controls encouraged by the Coastal Zone Management Act. The National Flood Insurance Program,⁽³⁸⁾ enacted by Congress in 1968, and the Flood Disaster Protection Act⁽³⁹⁾ have effectively led to local land use control for all land theoretically subject to a 100-year flood. Participation by Federally chartered financial institutions in loans for these areas is prohibited unless the local community adopts and enforces minimum land use restrictions and Federal flood insurance is purchased. Construction of ATEs wells in a flood-prone area would not be desirable except in unusual cases, because of the possibility of damage to above-ground equipment and well contamination.

The Coastal Zone Management Act of 1972⁽⁴⁰⁾ provides monetary incentives for states to implement land use management in a coastal zone.^(a) In part because of this incentive, all coastal states have now adopted legislation to protect coastal resources.⁽⁴¹⁾ The legislation typically establishes a permit system to control land use. Section 307 of the Act requires that applicants for permits from Federal agencies must certify that the proposed activity complies with the state coastal zone management program if the state program has been approved by the Office of Coastal Zone Management in the National Oceanic and Atmospheric Administration. The Coastal Zone Management Act was amended in 1976 to provide grants to states to manage the siting and operation of coastal energy projects.⁽⁴²⁾ It is not entirely clear whether an ATEs project is within the scope of energy project as defined in the Act. It is likely though that siting of an ATEs project in a coastal area will be more difficult than at an inland location.

(a) The coastal zone is defined according to state and local laws. It is generally confined to a narrow band within the immediate vicinity of the coastline.

Two Executive Orders issued by the President and applicable to all Federal agencies could also potentially affect siting. Executive Order 11988, issued May 24, 1977, requires each agency to establish regulations and procedures to ensure that the potential effects of any action it may take in a flood plain are evaluated and consideration is given to flood hazards and flood plain management. Executive Order 11990, also issued May 24, 1977, requires all Federal agencies to ensure consideration of wetlands protection. Any Federal agency participating in or authorizing an ATES project will need to comply with these orders.

If an ATES project involves dredging, filling, or construction on virtually any water body or adjacent wetlands, a permit from the U.S. Army Corps of Engineers will be required. Applicable regulations are found at 33 CFR 323. A permit application is circulated for review to all concerned Federal and State agencies; consequently, the review process can be lengthy. The U.S. Fish and Wildlife Service is likely to be especially concerned if any filling of wetlands is proposed. Application for a dredge and fill permit from the Corps can potentially trigger the need for an EIS under NEPA.

3.0 STORAGE AND RECOVERY OF THE ENERGY RESOURCE

In addition to receiving necessary regulatory permits, the ATES owner/operator also requires assurance that he has the right to store, protect, and recapture the energy resource. For successful implementation, he also needs assurance that he will not be subject to liability for trespass or interference with others rights. In this section, the issues of storage and recovery are considered. In Section 4.0, the potential areas of liability are considered.

3.1 BACKGROUND

Before examining the specific issue of how the ATES owner/operator can be assured of the right to store, protect, and recapture the resource, it will be helpful to consider some background information on ownership of underground space, ground-water law, and the technical alternatives for aquifer utilization.

3.1.1 Ownership of Underground Space

Under the English common law, a surface land owner was considered to also own everything vertically upward and downward from his land. This rule first appeared in an English case in 1586, but had its origins in other law systems several hundred years earlier.⁽⁴³⁾ As applied to air space, the rule began to break down with the coming of airplanes. The U.S. Congress in the Air Commerce Act of 1926 and the Civil Aeronautics Act of 1938 declared a public right to freedom of transit within the navigable air space. The landowner did not lose all above-ground property rights, however. In a leading 1946 case, the Supreme Court required compensation to be paid to a landowner who suffered damage to his poultry business because of low-flying government aircraft.⁽⁴⁴⁾ The Court stated that "the landowner owns at least as much of the space above ground as he can occupy or use in connection with the land."

The law for underground space has not developed to the same extent as that for above-ground; however, it appears to be heading in the same direction. For example, several court cases in New York State have awarded only minimal damages to surface owners for subway tunnels constructed at considerable depth (e.g., more than 100 feet) under their land.⁽⁴³⁾ Another case found no

invasion of property rights for a sewer 150 feet below the surface.⁽⁴⁵⁾ Mining law generally provides that the owner of the rights to the highest point of a mineral vein owns the entire vein even if it extends beyond the horizontal boundaries of the original claim.⁽⁴³⁾ These cases support the notion that vertical ownership is not absolute, but rather is conditioned on what space the surface owner can actually make use of.

Underground storage rights in oil and gas law provide an interesting analogy for thermal energy storage. The current prevailing rule appears to be that gas can be stored under another's ground as long as compensation is paid.

Three possible theories for relating underground oil and gas to the property rights of the surface owner have been advanced:⁽⁴⁶⁾

1. nonownership - Oil and gas are incapable of ownership until reduced to possession.
2. qualified ownership - Landowners have correlative rights in an underground oil and gas reservoir.
3. ownership in place - The nature of the surface owner's interest in oil and gas is the same as for solid minerals.

All of the theories have been advanced by state courts at one time or another; however, the decisions are not always consistent. The most common theory is 3 followed by 1 and then 2. Under theory 1, an early Kentucky case concluded that natural gas stored under another's property was not a trespass, but that the gas was subject to capture.⁽⁴⁷⁾ More recent cases have rejected this view and held that gas artificially stored underground is not subject to capture.⁽⁴⁸⁾ In the latter instance, however, compensation must be paid to the surface and/or mineral owner for the right to store.^(a) Oil and gas law thus seems to be developing similarly to the law of air space. Ownership of the space beneath the surface owner's land is recognized. However, the surface owner cannot interfere with a reasonable underground use such as gas storage. He is, however, generally entitled to compensation for use of the underground

(a) Case law is mixed on whether the surface or mineral owner or both is entitled to payment.⁽⁴⁹⁾

space. Unlike the air space, sewer, and subway cases this is apparently true even when the surface owner cannot make effective use of the storage space.

Underground storage of water also provides an interesting analogy for the ATES concept. Underground water storage has been utilized in California for many years, and the law there is considerably more developed than in other states.⁽⁵⁰⁾ At least for public water agencies, the law in California now permits the storage of water underground and the right to protect and recapture the stored water. Moreover, these rights can be exercised without paying compensation to overlying landowners. The most important case establishing these rights is Niles v. Alameda Water District.⁽⁵¹⁾ In this case the plaintiff, Niles, sued the defendant Water District for damages caused by impairment of quarry operations due to ground-water storage. The California Court of Appeal found for the Water District and based its decision on the existence of a public servitude for ground-water storage and conservation. The court also found that the storage operations were a noncompensable exercise of the district's police power. The court did suggest, however, that compensation would have been appropriate if the water level had risen above the historical water table. The Niles decision is especially remarkable because California had codified the common law rule that the surface landowner owns subsurface space. The California Civil Code (Section 829) provides that "the owner of land in fee has the right to the surface and to everything permanently situated beneath or above it." Another section of the Code (Section 659) defines land as including "free or occupied space for an indefinite distance upwards as well as downwards."

A second California case, City of Los Angeles v. City of San Fernando,⁽⁵²⁾ established the right of a public water agency to store water underground and to recapture the water later. This right exists regardless of whether there was prior recapture intent, whether the water to be recaptured can be identically traced to the water stored, or whether the storing agency actually serves the area overlying the underground basin.

In a 1971 report for the National Water Commission, one commentator advocated a similar result to the California cases and concluded that the law in most jurisdictions would support the result.⁽⁵³⁾ Specifically, he concluded:

1. A can store water under B's land without acquiring a right to do so whether or not A is a public agency. A must, however, indemnify B for damage.
2. B cannot extract the water which A has stored beneath B's soil.

The two California cases provide an interesting and potentially valuable precedent for implementation of the ATEs concept. If the cases were to be followed and extended to thermal energy, it is possible that a public agency ^(a) could store energy in an aquifer and be assured of the exclusive right to recapture the energy without compensating overlying landowners.^(b) This possibility is discussed further later in this section and in Section 5.0.

3.1.2 Ground-Water Rights

There are four principal types of ground-water rights: 1) appropriative, 2) overlying, 3) prescriptive, and 4) pueblo.⁽⁵⁴⁾ The latter two are of limited importance. Prescriptive rights are vested rights to use a limited ground-water supply acquired after continuous use of the water for a period established by statute, often 7 to 10 years. Pueblo rights are the rights of communities in the southwest as successors to Spanish or Mexican pueblos to use waters naturally present within the old pueblo limits.

Appropriative ground-water rights exist in most western states. The rights are generally acquired by permit from a state water agency. The rights are allocated on a first in time-first in right basis as is the case with surface appropriative rights. In times of water shortage, the junior appropriator in time is the first to have his water right cut back.

Overlying rights predominate in the eastern and midwest states. They derive from the common (judge-made) law and exist in three forms: the English rule of absolute ownership, the American rule of reasonable use, and the rule of correlative rights. The English rule of absolute ownership is analogous to

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- (a) The right can potentially be extended to private storage entities if the conclusions reached by the commentator⁽⁵³⁾ are recognized.
 - (b) Compensation may be required if an existing use of the aquifer is impaired.

the nonownership rule in oil and gas law. Under this rule the overlying landowner has unlimited access to water under his land, but does not own it until capture. Only a few states accept this rule. The American rule of reasonable use is more common and is similar to the English rule with the added provision that the water cannot be unreasonably extracted or unreasonably harm the underground aquifer. Correlative rights stem from a 1903 California case,⁽⁵⁵⁾ and provide that the rights of every water user are to be correlative with the rights of every other user. The correlative rights rule is not entirely limited to California. Several other states following the American rule have added a sharing requirement to the reasonable use doctrine. The reasonable use and correlative rights rules are analogous to the qualified ownership rule of oil and gas law.

3.1.3 Aquifer Characterization

Aquifers are beds of saturated permeable rock or unconsolidated sediments that contain and conduct water and from which significant quantities of water can be extracted. Most are of sedimentary origin and are relatively horizontal. They can range from depths of several meters below the surface to several kilometers, with thicknesses occurring in the same range.

Aquifers can be characterized by several different attributes. These include the depth, thickness, temperature, size, pressure, fluid migration rate, and water quality. Aquifers suitable for implementation of the ATES concept can potentially have wide variation in these features. Ideally, however, the aquifer will have several important properties. The volume should be sufficiently large that end use demands can be accommodated. The fluid migration rate should be relatively low to facilitate energy recovery. The ideal heat or chill bubble will have minimum surface area to volume ratio.⁽¹⁾ A sphere best meets this criterion; however, this is not technically feasible. A cylinder with height equal to diameter is a desirable alternative. Consequently, aquifer thickness should be sufficient to permit this formation. A confined aquifer (one bordered by impervious materials) is desirable to minimize heat loss. A confined aquifer is probably less important for chill storage, although the stored chill energy resource could be more susceptible to warming in unconfined storage. Sufficient hydrostatic pressure to preclude the

possibility of the hot water flashing to steam is needed. Flashing could lead to poor pump performance through the formation of gas pockets. Finally, relatively high water quality is desirable to minimize the possibility of equipment corrosion. Ideally, water quality should not degrade after introduction of the thermal energy into the aquifer. Generally, water quality is higher in shallow aquifers. Moreover, a shallow aquifer has lower associated pumping costs. However, a shallow aquifer is more likely to be unconfined and often will have other users. An ideal aquifer will seldom be found. An adequate and economically attractive aquifer, however, may often be available.

3.2 PROPERTY RIGHTS NEEDED FOR STORAGE AND RECOVERY

The introductory paragraph to Section 3.0 posed a central concern to the ATES owner/operator. He needs assurance that he has the right to store, protect, and recapture the stored energy resource. The property rights that must be acquired to achieve this assurance are the subject of this section.^(a) The answer will not always be clear, and is likely to depend on how the bundle of ownership rights to the land has been broken up, the applicable state law and the extent of uncertainty in the law, and the relative cost of acquiring the desired property rights. In most cases it seems likely that the ATES owner/operator will be able to obtain the desired property rights and that acquisition will not be a major obstacle to ATES development.

The bundle of property rights associated with a surface parcel of land can be divided in a variety of ways. If the landowner retains all possible property rights he is said to have a fee simple absolute interest. Out of this interest he may carve out such interests as easements, leaseholds, mineral rights,^(b) air space rights, and future interests in the property.

(a) In some cases it may also be considered desirable to purchase property interests to avoid future liability from ATES operations. This possibility is discussed in Section 4.3.

(b) Most state courts consider oil and gas rights to be included in a grant of mineral rights. In this study, mineral rights are also assumed to include oil and gas rights.

The minimum property right the ATES owner/operator will need to acquire is sufficient surface rights for injection and heat exchanging equipment.^(a) Ordinarily this will involve purchase of a fee simple property interest sufficiently large to accommodate all equipment and assure access to the site. It may also be possible to obtain the desired interest by purchase of an easement or through exercise of a lease agreement. In all cases it will be necessary to include the right to drill one or more wells and to be assured that the property rights acquired extend into the future at least as long as the planned life of the project. If acquisition of the surface right will interfere with a prior lease agreement or the implied surface access interest of a mineral estate holder, access must also be purchased from these parties.

Under one set of facts, the surface property interest may be all that needs to be acquired. The first condition for this desirable result is utilization of a deep aquifer where there is minimal possibility of interference by another driller and/or interference with other aquifer users. A relatively shallow aquifer with no other existing users may also meet this condition. Under this condition damages for trespass for introducing thermal energy under another's land should be nominal in the unlikely event an action is brought. The second condition is either acquisition of mineral rights along with surface rights or reaching the conclusion that there exists little or no possibility of mutual interference with a mineral rights holder. As discussed further in Section 4.0, if the injected thermal energy damages a mineral rights holder by, for example, displacing a valuable resource, the minerals rights must be purchased or the ATES owner/operator will be subject to a claim for damages. The uncertain and probably remote possibility of damages may be cheaper and consequently preferred to purchasing mineral rights. The ATES owner/operator will also want assurance that the legitimate exercise of mineral rights will not interfere with energy storage.

If a relatively shallow aquifer (e.g., less than 1000 feet deep) is utilized for energy storage, the potential for conflicting interests is greater.

(a) Pipeline access will also be needed. Acquisition of pipeline easements is discussed in Section 5.4.

The principal concern is likely to be interference with other aquifer users. The ATES owner/operator will not want other drillers utilizing the aquifer waters because of the possibility of losing the stored energy, the possibility of pressure gradients altering desired water flow patterns, and because consumptive use of aquifer water could conceivably lower the hydrostatic pressure sufficiently to cause a flashing problem. Other users of the aquifer may not want to use thermally altered ground water, especially if the well is being used as a source of potable water.

There are several possible solutions to the potential problem of conflict between an ATES project and other property owners. The first would be for the ATES owner/operator to purchase all surface property rights and associated ground-water rights for the area overlying the energy storage bubble. Land areas sufficiently outside the bubble to minimize the possibility of wells affecting the stored energy resource may also have to be purchased. The energy resource could potentially be drawn outside the intended bubble by pressure gradients created by a nearby well. The feasibility of surface land purchase depends on the cost and the willingness of owners to sell (unless the power of eminent domain can be exercised). The cost is directly related to the amount of land that must be purchased. Preliminary calculations have been made at PNL to suggest the maximum likely boundary of the thermal bubble. The calculations indicate that the diameter of the bubble that may need protection for an ATES system supplying district heating or cooling for 26,500 single-family units from a 40-foot thick aquifer can approach 1 mile. This suggests that nearly a section of land may have to be purchased for complete protection in this case. In most urban areas this will be either unfeasible or prohibitively expensive. This will be especially true in the likely event of multiple land owners. A more likely diameter for the thermal bubble in a commercial ATES project would be on the order of 1000 feet. In this case land purchase will be more feasible. In more rural areas land purchase will also be more feasible, especially if the surface land not being utilized by the ATES operator can be leased for activities not requiring ground water.

If mineral rights have been severed from surface rights, the mineral rights may also have to be purchased if there is a possibility of damage to

the stored energy resource by exercise of a mineral right or the unlikely possibility of damage to underground minerals caused by the ATES project. Simply drilling through an aquifer in search of oil, gas, or hard rock minerals should not damage the aquifer or ATES project as long as proper casing is utilized.

A second possible approach to ameliorating aquifer use conflicts would be for the ATES owner/operator to purchase (or possibly condemn) an underground energy storage easement or negotiate a lease agreement with the surface owner and possibly the mineral rights holder. The lease or easement would ordinarily be structured to include a covenant by the surface owner not to utilize aquifer waters. The advantage of this approach is that acquisition of the desired property rights and covenants should be considerably less expensive than outright purchase of the entire fee interest in the property. For this reason, purchase of a storage easement or perhaps negotiation of a lease agreement will generally be preferable to purchase of a fee simple interest in the desired property.

A decision on whether storage rights should be leased or an easement purchased will depend in part on Federal income tax considerations. If the land owner leases the storage capacity, rental payments will be ordinary income to him.⁽⁵⁶⁾ As long as rental payments are not paid more than 1 year in advance, they should be deductible as an ordinary and necessary business expense by the ATES owner/operator if he is subject to Federal income taxes.⁽⁵⁷⁾ If an easement is sold, the landowner will realize a capital gain, except in the unusual case where a storage easement was held for use in his trade or business.⁽⁵⁸⁾ The purchase would be a capital expense to the ATES owner/operator that can be amortized over the life of the project.⁽⁵⁹⁾

A third possibility is simply to take the least-cost option of not acquiring any property interests (other than necessary surface access) unless the possibility of interference with ATES operations or liability is too great. This alternative will be especially attractive if a relatively deep aquifer with no other existing users is utilized. It may also be attractive for a shallow aquifer with no other existing users. An existing user of the aquifer as a potable water source and states that recognize overlying ground-water

rights present the greatest obstacles to using this least-cost alternative. Unless an existing user could be convinced that the value of the energy received for space conditioning exceeded the loss associated with the change from natural temperature, compensation in some form may be necessary. In an appropriation/permit state, the ATES owner/operator could very likely convince the state to issue no new ground-water withdrawal permits in the immediate area of the energy storage project by claiming they would interfere with his existing storage right.⁽⁶⁾ In a state recognizing overlying ground-water rights, the problem of preventing new aquifer users is much more difficult. Other than compensating such an overlying owner in return for a covenant not to drill, special legislation may be the only effective way to prevent well drilling into the aquifer when the surface property is not purchased by the ATES operator. If it can be shown that a new user is intentionally tapping the stored energy resource for the heat or chill rather than for the water, the analogy of the City of Los Angeles case⁽⁵²⁾ provides a persuasive precedent for enjoining the action. That case held that a public agency may store and later recover water in an underground reservoir. As discussed in Section 3.1.1, the prevailing view in natural gas law is also that gas may be stored underground and not be subject to capture by another party.

3.3 EXERCISE OF EMINENT DOMAIN

The principal and preferred way for the ATES owner/operator to obtain needed property rights will be through negotiated purchase. For a ground-water withdrawal right, the preferred approach will be by application to the state water resources agency when a permit is required. Negotiated purchase of an existing withdrawal right is an alternative to use when a new permit is required but cannot be obtained. Negotiated purchase will be the preferred acquisition approach whether a fee simple or other property interest is purchased or a lease agreement is entered into. It also should be true whether the selling party is a private entity or a unit of Federal, state, or local government. In some cases the party owning the desired rights may not wish to sell, and exercise of the power of eminent domain, if available, may be needed.

States can exercise the power of eminent domain as an incident of their sovereign power. The Fifth Amendment to the U.S. Constitution requires the

payment of compensation for property taken. This provision is applicable to the states either through the Fourteenth Amendment or through provisions in state constitutions. States may delegate the power of eminent domain by appropriate legislation to units of local government and even to privately owned entities. All takings must be for a public use. Court interpretations of what is and is not a public use vary. However, it seems likely that, with appropriate legislative authority, property rights condemned for an ATES project would be found to be taken for a public use. The likelihood of this interpretation would increase as the number of potential end users of the stored energy increases. Publicly owned property may even be condemned, again with appropriate legislative authority, if the proposed use is superior to the existing use of the property.

In a number of states, gas utilities have been delegated the power of eminent domain for natural gas storage projects.^(a) This legislation provides an appropriate analogy and precedent for extension of the power to ATES owner/operators. The extension would require special legislation unless the owner/operator already had the necessary authority.

The power of eminent domain for water resource development already exists in many states. Examples include exercise of eminent domain for irrigation ditches and to acquire an existing water right in order to apply the water to a superior use. In many states, especially in the west, general classes of water uses are ranked in order of priority. Domestic and municipal use is typically ranked first, often followed by irrigation and then industrial use.⁽⁶¹⁾ If an ATES system is to be coupled to a municipal district heating system, the ground-water use may be considered to be for a municipal use. With such an interpretation, ground-water withdrawal rights could potentially be condemned from existing irrigators in some states without additional legislative authority.

When property is condemned, the condemnor may generally take only the interest reasonably necessary to allow the purpose of the project to be fulfilled. For subsurface storage, an easement will usually be sufficient. For surface activities a fee simple interest may be needed.

(a) A 1966 article identified 20 states that had delegated this authority.⁽⁶⁰⁾

The condemnee in an eminent domain action is entitled to just compensation. Just compensation is often defined to be the cash fair market value of the highest and best use of the property taken. It ordinarily requires that the condemnee be put in the same position monetarily as he would have been had his property not been taken. This approach effectively precludes a single private owner whose property is needed for a development from negotiating a "windfall" sale.

Condemnation of underground storage space alone may be quite inexpensive if the condemnee cannot show damage. For example, in one case a gas transmission company was able to condemn an easement in underground strata for natural gas storage for "no dollars."⁽⁶²⁾ If ground-water rights are taken, compensation will ordinarily have to be paid. A variety of problems arises in water rights valuation and several approaches to valuation are available.⁽⁶³⁾ The physical properties of the water right must first be quantified. The value of the water must then be estimated. One approach is to look at markets where water rights are traded. A second approach is to consider the value of the land with and without the water right.

4.0 POTENTIAL LIABILITY FROM AQUIFER THERMAL ENERGY STORAGE OPERATIONS

The ATES owner/operator will naturally be concerned about minimizing the possibility of liability for actions associated with his operations. Liability can potentially result from the act of thermally altering ground water, ground-water quality changes, and from surface activities such as operation of drilling, injection, and heat exchange equipment. Because thermal alteration of ground water is certain to occur, concern for liability is perhaps greatest for this activity. Degradation of ground-water quality can be minimized if both aquifer selection and injection operations are conducted carefully. The surface activities are fairly routine in nature, and while an incident leading to liability is possible, it is not likely if proper care is taken.

The possibility of liability is real, but must be kept in perspective. In most cases, an ATES project will be compatible with other aquifer uses. Liability, if it does occur, is not likely to be significant in relation to total project costs.

4.1 THEORIES FOR LIABILITY

A variety of different legal theories can potentially lead to liability in a particular situation. These theories include negligence, nuisance, trespass, breach of duty imposed by a statute or regulation, and willful misconduct. In unusual cases strict liability may also be imposed for inherently dangerous activities such as blasting or, in some cases, breach of a statutory duty. Of most concern for an ATES operation are the common law theories of negligence, nuisance and trespass, or some combination of the three. Hopefully, liability for damage caused by breach of a statutory duty or for willful misconduct would not occur.

An action based on the negligence of the ATES operator would attempt to show his failure to meet an obligation or duty to conduct his operations in a manner to protect others against unreasonable risks. The plaintiff in such an action would have to show that failure to meet this duty or obligation led to his actual loss or damage.⁽⁶⁴⁾ Negligence would be a likely theory for damage covered by surface operations of an ATES operator.

A nuisance theory is the most flexible theory available to a plaintiff damaged by an ATES operation. A nuisance is a substantial harm to a right of another. Nuisances are classified as public or private. A public nuisance is an unreasonable interference with a right common to the general public. A private nuisance is unreasonable interference with the use and enjoyment of a property right.^(a) To constitute a nuisance, the interference must be substantial and unreasonable. Intentional or negligent interference need not be shown. It is often difficult to predict whether a particular activity will cause substantial and unreasonable harm. However, the case law suggests that the presence of the following elements will increase the likelihood of recovery:⁽⁶⁴⁾

1. The harm is continuous or produces long-lasting effects.
2. The harm would have been incurred by anyone in the plaintiff's position, i.e., the plaintiff is not peculiarly vulnerable.
3. The plaintiff's use of his property right preceded the ATES operation.

Each of these elements need not be present for the plaintiff to recover. Significantly, recovery under a nuisance theory may be possible even if the ATES operator is complying with all applicable regulations and permits.⁽⁶⁶⁾

A court has wide discretion in selecting an appropriate remedy in a nuisance case. A common remedy is to award monetary damages. If the defendant's activity is permitted to continue, the result in effect is a judicially conferred power of eminent domain. Another option is to force the defendant to add additional equipment or operate in such a manner that damage is reduced. In appropriate cases, the remedies can be combined.

The trespass theory is likely to be least helpful to a plaintiff. In appropriate cases, however, the theory can support and in effect coexist with a negligence and/or nuisance theory. The basis of this theory is an intentional invasion of the plaintiff's interest in the exclusive possession of property.⁽⁶⁷⁾

(a) A ground-water right is a property right.

4.2 SUBSURFACE ACTIVITIES

Potential liability from subsurface activities will be a significant concern of the ATES operation. Liability could result from temperature changes or from other impacts on ground-water quality.

Implementation of an ATES system will necessarily involve either increasing or decreasing the natural aquifer temperature. This action can potentially lead to liability in at least three ways. The most likely is interference with other aquifer users caused by changes in ground-water temperature, especially those using the aquifer as a potable water source. A second possibility is degradation of ground-water quality caused by enhanced mineral solubility or in unusual cases, biological contamination. Finally, increased solubility can potentially lead to liability to a mineral estate owner from displacement of a mineral resource. In each case, liability seems more likely if the ground-water temperature is increased rather than decreased by the ATES operation.

Liability to others for altering ground-water temperature is of some concern because, by definition, it will occur during ATES implementation. If a deep aquifer is utilized for storage, the possibility for liability is less because use conflicts are unlikely to occur. The concern will also be less for aquifers with no other users or distant users unlikely to be affected by the ATES operation. Nuisance is the most likely theory for recovery, with trespass also a possibility.

Ground-water quality can also be degraded by an ATES operation in ways unrelated to temperature changes. These include direct injection of noxious substances, contamination caused by corrosion of system components or mixing of different aquifers, and contamination by microorganisms.⁽¹⁾ All of these possibilities can be minimized by careful operating practice and aquifer selection.

An action based on a nuisance theory will likely be most attractive to a plaintiff seeking recovery for ground-water degradation. A nuisance action is based on substantial and unreasonable interference with a property right. A ground-water use permit is a property right as is the right to use ground water in a state that recognizes overlying ground-water rights. In fashioning a

possible remedy for thermally altered ground water or for changes in ground-water quality, a court would consider and balance a number of interests. If the damaged party were using the aquifer as a potable water source prior to the ATES operation, his chances for at least monetary damages would probably be quite good. If the aquifer were not being used as a potable water source or if the use were initiated after ATES implementation, recovery would be possible but less likely. Because of its social utility, it is unlikely that a court would issue an injunction barring an ATES operation. If the ATES operation were found to create a nuisance, the remedy would be the monetary amount that the ATES operation has reduced the value of the plaintiff's property plus any special damages the plaintiff can show. The damage award should theoretically be reduced by the amount the thermally altered ground water can be used by the plaintiff to reduce his space conditioning costs.

Recovery in a trespass action for thermally altered ground water or degradation of ground-water quality is also a possibility. The potential advantage to the plaintiff is that he need not show substantial and unreasonable interference as in a nuisance action. A trespass action is at least a possibility because of the traditional view discussed in Section 3.1.1, that the landowner owns everything upward and downward from his property. Moreover, a trespass does not necessarily require an actual physical invasion of property;⁽⁶⁸⁾ temperature alterations can potentially be considered a trespass. The likelihood of a trespass action succeeding is tempered by what appears to be a trend (discussed in Section 3.1.1) to reduce the vertical dimension of property ownership to the area that the surface owner can effectively utilize. Thus, use of a deep aquifer by an ATES operator is unlikely to constitute a trespass. The remedies available for a successful trespass action are similar to those for a nuisance action. In practice, a plaintiff is likely to plead both theories in stating his claim.

Liability to a mineral rights holder could also be imposed if mineral resources are displaced by the thermally altered ground water.⁽⁶⁹⁾ This liability is unlikely, but conceivably could result from changes in mineral solubility. A nuisance or trespass theory is possible.

A third possible theory for subsurface liability is negligence in drilling operations. An example would be contamination of fresh water by improper casing or inadequate chlorination.

The ATES concept does not involve a consumptive use of water. Nevertheless, it is conceivable that an ATES project could temporarily affect, or be accused of affecting, the quantity of ground water available to other users. The common law bases for liability have been incorporated into the Restatement (Second) of Torts⁽⁷⁰⁾. The Restatement formulation provides that a withdrawer of water for a beneficial purpose is not subject to liability for interference with the use of water by another unless

- a. the withdrawal of water unreasonably causes harm to a proprietor of neighboring land by lowering the water table or reducing artesian pressure, or
- b. the quantity of water withdrawn is unreasonable, or
- c. the withdrawal directly affects the quantity of water in a watercourse or lake and unreasonably harms a person entitled to the use of its water.

The questions of subsurface liability, acquisition of property interests, and even injection and extraction of water will be significantly complicated if the aquifer crosses state lines. Not only will different permitting agencies become involved, but the applicable law on these questions may be different.

The possibility of liability for subsurface actions associated with an ATES operation is real and must be considered in designing an ATES system and selecting an appropriate location. It is especially important to note that the ATES operator is not relieved from possible liability to third parties simply by complying with applicable governmental regulations. The extent of possible liability must be kept in perspective, however. If a deep aquifer is utilized, liability is highly unlikely. If a shallow aquifer is utilized to reduce pumping and drilling cost, there may be limited liability to existing ground-water users and property owners in states recognizing overlying ground-water rights. However, this liability is not likely to be significant in relation to total ATES costs. Moreover, in most cases an aquifer without

other existing users or with users sufficiently far away to be unaffected by the thermal bubble will be selected. Possible liability may be partially offset if an existing ground-water user can beneficially use the thermally altered ground water. Liability after commencement of ATES operations should not be great if the ATES operator can encourage the state (in permit states) not to issue additional ground-water permits. This result seems likely. Moreover, future ground-water users will dig their wells with notice of the ATES operation. In particular, one who buys property over the energy storage bubble after the start of ATES operations will presumably have paid less for the property if the ATES operation is in fact a nuisance. If he also is allowed to recover damages, he receives a windfall.⁽⁷¹⁾

When faced with the likelihood of liability to one or more ground water or mineral rights holders, the ATES operator has two choices. One choice is to purchase (or possibly condemn) the threatened property interest. A second choice is to proceed with the operation and negotiate damage claims only when they are presented. Each position has its advantages and disadvantages. Purchase prior to operation is equitable and may enhance public perception of the project, but is likely to be the most costly. Negotiation of damage claims is likely to be less expensive, especially since damage will not always be certain (especially for mineral rights holders) and because of the possibility of damage offsets if the thermally altered ground water is useful for certain of the ground-water users applications.

4.3 SURFACE ACTIVITIES

Liability for surface activities in conjunction with an ATES project can occur in a number of ways. Damage may result from such things as accidental release of fluids, which potentially could result in erosion and/or contamination of surface water, or noise and vibrations caused by drilling activities.⁽⁷²⁾ Liability can potentially occur for injury to people, the land surface, structures, crops, water supply, livestock, and timber. ATES drilling, injection, and fluid transport operations are normal industrial activities, however, and proper care can reduce the possibility of liability to a minimum.

Changes in the water table leading to land subsidence or surface flooding are possible sources of surface liability caused by subsurface activity. The likelihood of these results is extremely remote, however. Under normal operation, the water table in an ATEs project should fluctuate only slightly.

Negligence, nuisance, trespass, or some combination of the three are the most likely theories of recovery. For the plaintiff to recover, a causal connection between the alleged trespass, negligence or activity causing a nuisance and the alleged injury must be shown.

5.0 INSTITUTIONAL AND FINANCIAL ISSUES APPLICABLE TO HEAT OR CHILL DELIVERY

The ATES concept will prove useful only if it is economically feasible to transfer the heat or chill from the source through aquifer storage to the end user and if a variety of potential institutional and financing barriers can be overcome. Perhaps the chief barrier to implementation is recovering the large capital cost associated with the fluid distribution system. The purpose of this section is not to focus on specific economic issues, but rather to suggest some potential end users, identify some of the potential institutional and financing barriers and suggest how formidable they may be. A detailed examination of these issues will be necessary before a specific commercial ATES project can be implemented.

5.1 POTENTIAL END USERS

The potential end uses for energy stored in an ATES project are principally space heating and cooling, industrial process heat, and agriculture/aquaculture.⁽¹⁾ Space heating and cooling require water from about 50 to 100°C. Most industrial process heat requirements are for temperatures above 100°C. Agricultural applications can effectively utilize relatively low-grade heat, on the order of 30 to 50°C. Combinations of these users can potentially be served by a single ATES project by cascading different users or by altering the temperature of the fluid through predelivery thermal enhancement with boilers or heat pumps or through cooling of high temperature fluid by dilution.

District space heating and cooling of residential and commercial buildings is the largest potential end user of energy from an ATES project. One study estimated that 50 to 55% of the U.S. population could economically be served by a district heating system.⁽⁷³⁾ This estimate was published in 1977, prior to recent oil price increases that have enhanced the economic attractiveness of district heating. District heating in the U.S. is a relatively old, but still minor, technology. The first system began operation in 1877 in Lockport, New York.⁽⁷⁴⁾ Today there are about 200 district heating

utilities in the U.S.⁽⁷⁴⁾ The largest utility supplier is Consolidated Edison Co. in New York City, which sold nearly 33 million pounds of steam in 1978.⁽⁷⁵⁾ Virtually all district heating systems in the U.S. use steam as the heat delivery medium.

In Europe, district heating is much more extensively utilized. Czechoslovakia and the U.S.S.R. have the highest concentration of district heating in the world. Denmark has the highest concentration in the West; about 35% of Danish homes receive heat from district heating systems. District heating supplies about 20% of space heating demand in Sweden and Finland.⁽⁷⁶⁾ European systems generally utilize hot water instead of steam, principally because of its greater distribution range, lower system costs, and technical flexibility.

5.2 INSTITUTIONAL ISSUES

The principal institutional barrier facing development of an ATES system is the identification of an entity to take the initiative to begin the development. This is potentially a very significant barrier. The difficulty arises because the energy generators and end users will usually be different parties, often with different interests. The situation is simplest when there will be a single private end user or a limited number of cooperative end users (e.g., a shopping center). The economic incentive to implement the energy storage and delivery system may be sufficient to successfully complete the project in this case. With limited numbers of participants, the energy generator and end user(s) can probably negotiate directly without the intervention of a government body. The end user seems the most likely candidate to arrange for financing the pipeline delivery and the ATES system in this case.

The situation becomes considerably more complicated when there are multiple end users. A large district heating/cooling system will likely be most complicated. The difficulty here is that no one entity has a sufficient economic interest to initiate the project. What may appear to be the most likely entities, utilities, may be less than enthusiastic if they see their existing customers and/or capital equipment displaced. Also, the many

uncertainties associated with regulatory approvals and permits, financing, economic regulation and associated questions of allowable rate base and return, and reliability of energy supply, storage, and equipment are powerful dissuaders. The many inhibiting factors suggest that either a publicly owned utility would have to agree to be the energy storage and delivery entity or an adequate inducement would have to be made for a private entity by legislative action. European countries have typically used a combination of these approaches. Water delivery utilities may be the most likely district heating operators because of their expertise and their existing distribution easements. Many of these utilities are relatively small, however, and they may view energy delivery as something new and uncertain and therefore undesirable.

5.3 FINANCIAL AND REGULATORY ISSUES RELATED TO DISTRICT HEATING

These are many very significant financial and regulatory issues applicable to implementation of a district heating system in the United States. Many of these issues have not been thoroughly investigated, principally because there is no large residential district heating system in the U.S. During the past 2 years, however, several applicable studies have been published.⁽⁷⁷⁾

Table 2 suggests some of the important financial/institutional issues affecting district heating. Most of the issues are interrelated. Designation of a publicly-owned, as opposed to investor-owned, district heating entity will significantly impact all regulation and financing issues. The issues of pricing and service area are also directly related.

The issue of financing is important if residential space heating is to be one of the end uses of the stored energy. Because district heating systems are so capital-intensive, the methods of financing can vary the cost of delivered heat by up to 30%. Financing will be needed for main transmission lines, for distribution networks, and, in many cases, for retrofit of heating systems in existing houses. Costs will easily run to tens of millions of dollars for even a small- to medium-size city. General obligation or revenue bonds are the most likely funding source for the transmission and distribution system.

TABLE 2. Regulatory and Financing Issues Applicable to District Heating

Category	Subissues
ATES and Delivery System Financing	Relative amounts of debt and equity. Types of debt and equity issues.
Retrofit Financing	Available options and terms.
Service Area	Mandatory versus optional hook-up. Does the delivery utility have an obligation to serve?
Rate Setting	Full cost recovery versus initial subsidy. Allowance for funds used during construction. Rate structure.
Cogeneration	Allocation of costs and benefits between electricity and heat production.
Regulation	What governmental agencies will regulate and how? Type of regulation - rates, safety, quality of services, other?
Taxation	How will the district heating company be taxed? Should tax incentives be adopted?

Retrofit conversions can be financed in various ways, with financing provided by the marketing utility the most likely. Funds from the Department of Housing and Urban Development or FHA-insured loans are also potential financing sources. The availability of private financing will depend upon investor confidence in the commercial feasibility of the district heating system, and the potential for economic return. With the escalating price of alternative fuels, the economic attractiveness of district heating should quickly improve.

The question of mandatory hook-up to a district heating system is also a significant issue. The economics of district heating is strongly dependent upon the density of users, and it may be that virtually 100% participation is necessary for cost-effective service in many situations. To effect such participation, either the price must be significantly less than that of competing energy sources, or participation must be made mandatory. While a mandatory

hook-up policy may seem inimical to some, there are precedents. California and some local governments have begun to explore proposed regulations, ordinances and standards concerning the energy source, and the type and size of heating equipment. San Diego and Santa Barbara Counties now prohibit issuance of building permits for new residential buildings that do not use solar energy systems as the primary means of heating water.⁽⁷⁸⁾ San Diego County also requires the use of solar energy as the primary heat source for new swimming pools and existing pools when the heat source is replaced.⁽⁷⁹⁾

Pricing of the energy delivered by a district heating system is a related institutional issue. A principal distinction of district heating systems is that much of the energy cost is for retirement of fixed capital costs and that variable costs are relatively low. Consequently, heat delivery costs will almost certainly rise much more slowly than the costs of alternative space heating options. An important question, then, is whether the initial price of delivered energy should be set artificially low with planned future price increases exceeding the rate suggested by variable cost increases in order to recover early losses, or whether initial prices should be set so as to provide full cost recovery plus, where appropriate, a reasonable return to investors/owners from the outset. The former strategy might encourage virtually full participation without mandatory hook-up, but it would involve additional financing problems or government subsidy. The latter strategy could unfairly burden the original participants, who would have to carry the full fixed cost load until it is advantageous for others to participate. In both cases, estimates of the consumers' price elasticity of demand for energy would be desirable for pricing decisions.

Another important pricing issue is how heat (and electricity) from a cogeneration source should be priced. The price must be set so that neither the heat nor electricity consumer is treated unfairly. This problem has been studied, and it appears that equitable solutions can be achieved.⁽⁸⁰⁾

The question of how the district heating entity will be regulated will depend in part on whether it is publicly or privately owned. Regulation, at least at the state level, will likely be much more intense for an investor owned district heating company. A municipal utility is likely to have more latitude, subject to approval by local governing authorities.

Various other issues are also important to the development of a heat storage and delivery system. These include taxation and possible tax incentives at the Federal, state, and local levels; construction-related impacts; and the institutional mechanisms that can encourage the conversion of electrical plants to cogeneration plants. Background work has been done on all these issues plus those previously discussed. The evidence suggests that with sufficient economic incentives, none represents an insurmountable obstacle to development of ATES and heat delivery systems.

5.4 HEAT DELIVERY ISSUES

Implementation of any ATES system will require an extensive pipeline network (see Figure 1). Acquisition of appropriate permits and property rights must precede laying pipe. This will be a tedious but not insurmountable task.

Normally an easement is acquired from the surface owner for a pipeline. In unusual cases a fee simple interest may be purchased or a lease agreement entered into. Also in unusual cases, an interest from a mineral rights holder in addition to the surface owner must be acquired. The preferred approach to acquisition is negotiation; eminent domain may be available as a back-up when needed. If a private, non-utility end user is installing the delivery system, however, eminent domain will ordinarily not be available. Unless it is authorized by legislation at the state level, implementation may be significantly inhibited.

If the desired easement crosses Federal lands, the Federal land management agency must be contacted. Federal agencies are generally authorized to grant easements across lands they administer. The applicable regulations for lands administered by components of the Department of the Interior are found at 43 CFR 2873. Acquisition of an easement across Federal lands may trigger the need for an EIS under NEPA.⁽²⁸⁾ The Bureau of Land Management apparently requires reimbursement for its costs in processing right-of-way applications.⁽⁸¹⁾ A permit from the Army Corps of Engineers and/or the U.S. Coast Guard may be needed if the proposed pipeline passes near, over, or under navigable waters. Easements across Indian lands are issued by the Bureau of

Indian Affairs (BIA). This agency's practice is to require approval by the affected tribe or individual Indian in all cases.⁽⁸¹⁾

If the proposed project affects a wildlife refuge, the U.S. Fish and Wildlife Service must be consulted. If outdoor recreation or historic preservation would be affected, the U.S. Heritage Conservation and Recreation Service in the Department of the Interior must be consulted.⁽⁸¹⁾ These agencies also have counterparts at the state level in many cases.

Approval from various transportation agencies at the state and local level will almost certainly be needed if highway easements are to be used or if roadways are disrupted.

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