The Use of Geothermal Energy in U.S. Military Operations: Challenges and Potential

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Agenda

• Key military energy challenges
  – Installations
  – Field Operations
• Geothermal energy in the solution mix
  – Advantages
  – Challenges
• Potential technological advance
• Conclusions
Key military energy challenges – Installation Dependence on the Grid

• 2008 Defense Science Board conclusion:
  “Almost complete dependence of military installations on a fragile and vulnerable commercial power grid and other critical national infrastructure places critical military and Homeland defense missions at an unacceptably high risk of extended disruption.”

• What are the threats?
  – Natural disasters that cause long-lasting damage
  – Cyber attacks on the SCADA
  – Direct attacks on large transformers

• DSB proposed solution – Where cost effective, “island” the installations with respect to energy supply
Economic Perspective on Installation Islanding

• Cost of reduced reliance on grid is that of the least expensive locally supplied means to do so:
  – Energy efficiency
  – Windmills
  – Solar power
  – Mini-nuclear power plant
  – Geothermal energy?
Key Military Challenges – Supplying Energy to Operations in the Field
Sometimes Bad Things Happen…….
Economic perspective on Energy Supply to Field Operations

• “Fully Burdened Cost of Fuel”
  – Takes account of:
    • Logistics assets needed to move fuel from point of purchase to the front
      – Trucks, pipelines, personnel, etc.
    • Defense assets needed to protect fuel convoys
      – Helicopters, armored vehicles, soldiers
    • Attrition
      – Fuel, personnel, equipment

• Fully Burdened Cost of Power
  – Includes costs of:
    • Generating equipment, maintenance & repair, support personnel, fuel, transport, backup source
<table>
<thead>
<tr>
<th>Conflict Conditions</th>
<th>5 kW generator</th>
<th>60 kW generator</th>
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<tbody>
<tr>
<td>Peacetime (Bosnia)</td>
<td>2.33</td>
<td>.73</td>
</tr>
<tr>
<td>Low intensity conflict (Iraq)</td>
<td>3.55</td>
<td>1.44</td>
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<tr>
<td>Medium intensity conflict (Afghanistan)</td>
<td>3.99</td>
<td>1.71</td>
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Source: “DARPA Workshop on Geothermal Energy for Military Operations”, LMI Report DRP90T1, March 2010
Some Implications

• The military faces considerably higher costs of energy than does the civilian sector. This means that energy options that are not cost effective commercially might be in a military setting. By implication:

  – The DoD is willing to consider technological options that would be of little interest to the commercial sector.
  – The DoD is willing to invest in R&D to develop new energy supply technologies of practical military use
  – If geothermal could successfully address some of the military’s energy challenges, there would be strong DoD interest
A Basic Geothermal Energy System

How a geothermal system works
Stages of Production

• Resource characterization
  – Mapping
  – Seismology
  – Temperature gradient hole

• Drilling
  – Production well
  – Injection well

• Power system
  – Turbine
  – Generator
  – Cooling towers
Geothermal Power has a Number of Advantages

• Provides baseload power
  – Non-interruptible, unlike many other renewable sources

• Relatively clean
  – Low GHG emissions
  – Once built, no particulate or hydrocarbon emissions

• Well-established technology
  – Basic technology has been understood for decades

• Virtually inexhaustible
  – Will last for many years and heat will regenerate
The Military Already Uses Geothermal Energy

- US Navy operates Coso geothermal field in California
- Investigating other sites in California, Nevada & Arizona
But Several Challenges to the use of Geothermal Energy by the Military

• Common challenges for anyone:
  – Need a good-sized heat reservoir and an attractive heat gradient
  – Uncertainty exactly where heat is located underground
    • Drilling is risky and expensive – may yield only a dry hole
  – Require water or other medium to transfer heat into steam
    • May have to import from elsewhere
  – Much of earth is not mapped for geothermal energy

• Specific challenges to the Military
  – Forces go anywhere on earth
  – Once set up, need power quickly
  – Need to minimize logistics
  – Face possible enemy actions to disrupt energy production
Technical Advances Would Ease the Challenges

• **Enhanced geothermal systems (EGSs)**
  – Improved underground fracture mapping
  – More effective rock fracturing
  – More accurate directional drilling
  – Measurement while drilling
    • Realtime information on reservoir characteristics and heat gradient

• **Improved drilling technology**
  – Spallation drilling – use high pressure water to fracture rock
  – Stronger drill pipe & longer lasting bits

• **More efficient energy conversion**
  – Only 10% of heat energy content is converted into power
    • More effective heat transfer fluids, improved heat exchanger material, more effective waste heat use, e.g., for water purification
What Advanced Geothermal Technology Would and Would not Achieve from a Military Perspective

• It would achieve:
  – Better understanding of the worldwide resource base
  – Broader geographic application of the technology; not just where ideal resources exist
  – More rapid, less risky access to geothermal sources

• But it would not much resolve:
  – Need for quick access to power in the field
  – Heavy reliance on logistics – cement, drill pipe, etc.
  – Vulnerability of above-ground equipment (e.g., cooling towers) & personnel

• May therefore be more suitable for installations than for field use
DOE is Investing in Geothermal Energy, Largely Through ARRA

![Bar Chart]

- **Enhanced Geothermal System Component R&D**
- **Induced Seismicity, Planning, Analysis, Intl and other**
- **Ground Source Heat Pump**
- **Geothermal Data Development, Collection Maintenance**
- **Enhanced Geothermal System Demonstration**
- **Coproduction and other Low Temperature**
- **Innovative Exploration Technology**
Of ARRA expenditures, over $50M for Ground Source Heat Pump R&D

- Actually a storage medium rather than a heat source
- Makes use of moderate underground air temperature
- May be immediately applicable in a military encampment or installation setting
- May be especially suitable for a Forward Operating Base, which sometimes is set up on a layer of gravel
- USMC experimenting with this application at Occoquan
A Few Conclusions

• Military has a pressing desire for energy options to reduce installation vulnerability, cost of energy delivery in the field
  – Economics of energy to the military is different than to the civilian sector and allows more options to be considered
• Geothermal energy is on the table and has many attractive qualities, but also many drawbacks from a military perspective
• In the near term, military will continue to develop conventional geothermal at western U.S. installations; experiment with ground source heat pump applications
• Longer term, military likely will follow technology development, look for opportunities to apply at installations or field operations where cost effective to do so