A Two-step Looping Absorption Process for Utilizing Geothermal Energy in Building Conditioning

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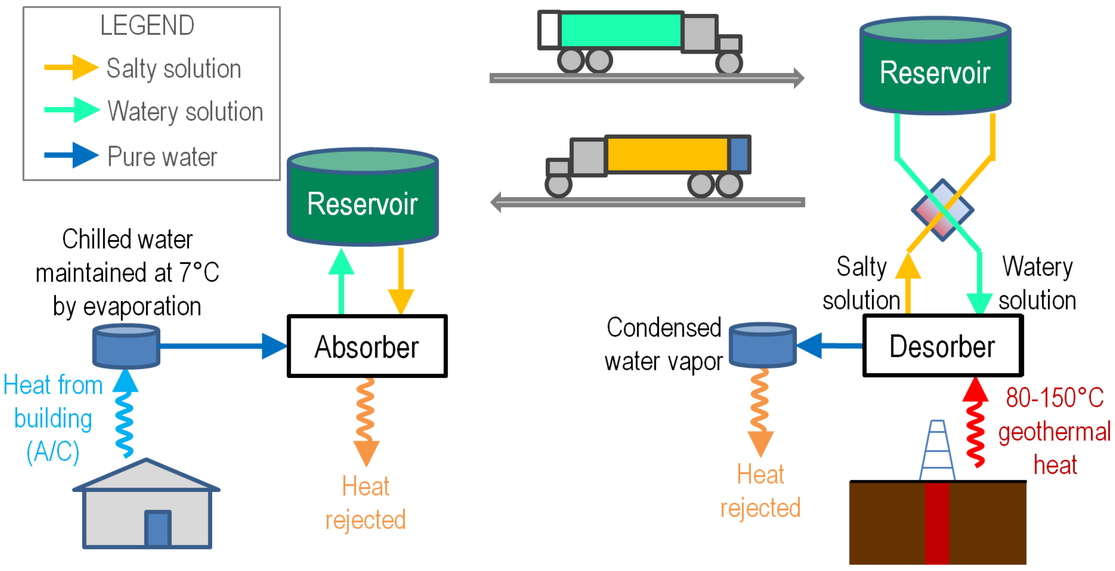
Introduction

- Geothermal resources with low temperature (below 150°C) are abundant.
- In addition to hydrothermal resources, 25 billion barrels/year of geothermal fluid (mostly water) at 80–150°C are coproduced at oil and gas wells in the US (DOE 2015).
- These geothermal resources have not been fully utilized, partly due to the distances between the geothermal resources and potential utilization sites.
- ORNL proposed the development of a system that uses low-temperature geothermal energy to provide space conditioning for buildings.

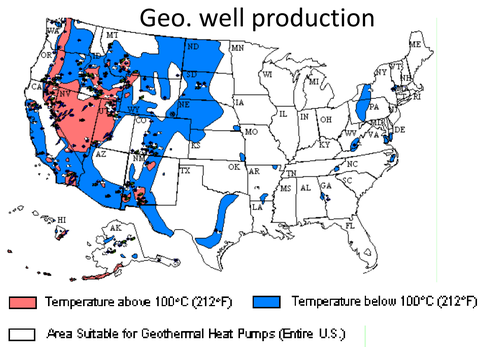
The proposed technology separates the production and regeneration of the conventional absorption cycle into a two-step process. The first step is regeneration at the geothermal resource. A weak aqueous solution of lithium bromide (LiBr) salt, or another absorbent, is heated using geothermal heat to drive off moisture from the solution. The concentrated solution is then allowed to cool to ambient temperature and transported to commercial or industrial buildings by tanker trucks (or other appropriate means including, but not limited to, trains or ships). The second step is space conditioning at the building site, where liquid water is evaporated to provide cooling and the water vapor is absorbed at low pressure by the concentrated solution, which is kept near ambient temperature. The diluted solution is then transported back to the geothermal site to regenerate (concentrate) it.

Currently, researchers at ORNL are assessing the technical challenges and the economical viability of the two-step looping absorption/adsorption technology.

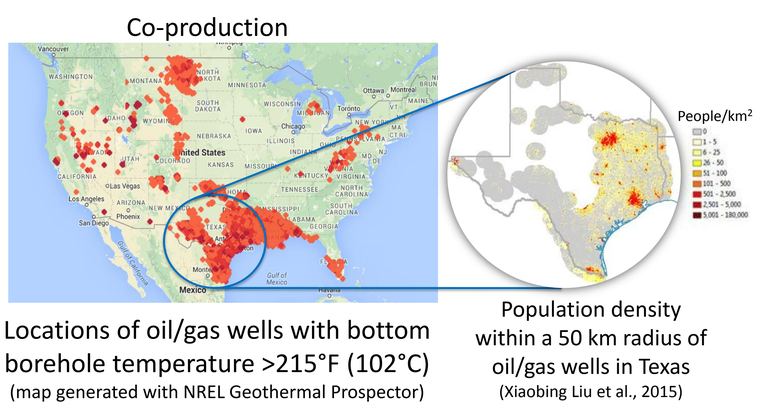


Method

- **Review available low-temperature geothermal resources**



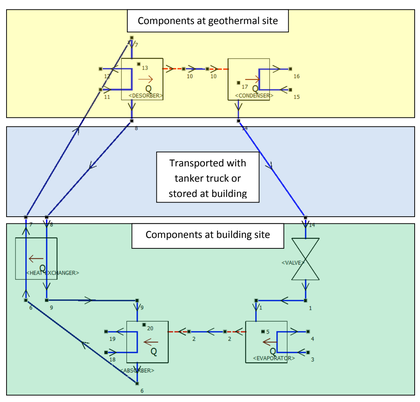
Location of geothermal resource areas
(http://geoheat.oit.edu/dusys.htm)



Locations of oil/gas wells with bottom borehole temperature >215°F (102°C)
(map generated with NREL Geothermal Prospector)

Population density within a 50 km radius of oil/gas wells in Texas
(Xiaobing Liu et al., 2015)

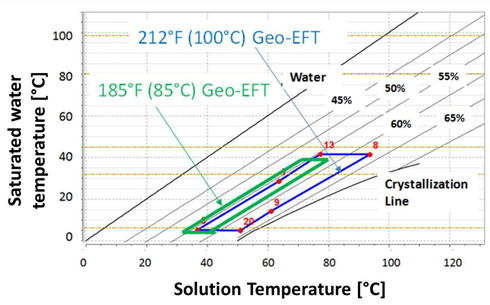
- **Design proposed system for target commercial building markets**



Determined design parameters for proposed system based on simulation results using ORNL's SorpSim program

Design parameters for major components of a 900 ton (3,165 kW cooling) two-step geothermal absorption chiller

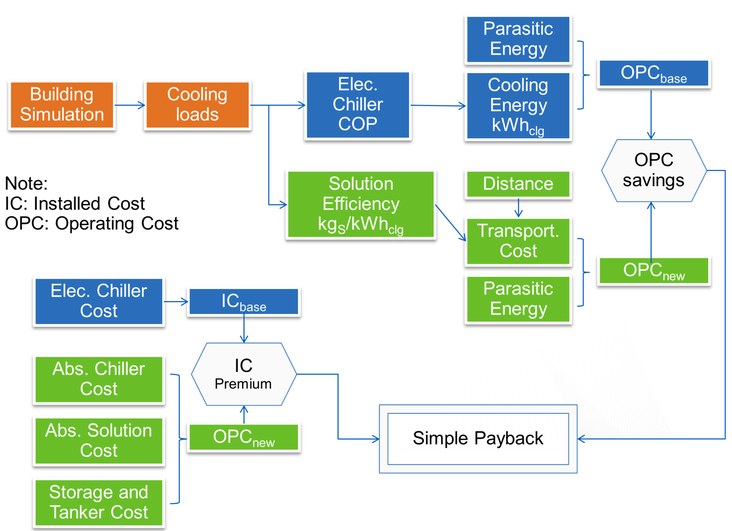
Component	UA value [kW/°C]	NTU [-]	Effectiveness [-]	Closest approach [°C]	LMTD [°C]	Heat load [kW]
Evaporator	600	1.2	0.712	2.7	5.3	3189
Internal heat exch.	25	1.2	0.573	24.2	27.1	677
Desorber	425	1.6	0.721	6.3	10.4	4411
Condenser	1000	1.5	0.776	1.5	3.4	3414
Absorber	375	1.3	0.654	7.4	11.2	4186



- **Economic analysis**

Key performance metrics:

- Simple payback period
- Energy efficiency: cooling provided per unit primary energy consumed:
  - Transportation fuel
  - Parasitic electric loads
- National/regional technical potential energy savings vs. baseline systems



Energy Consumption of Commercial Buildings In Target Regions

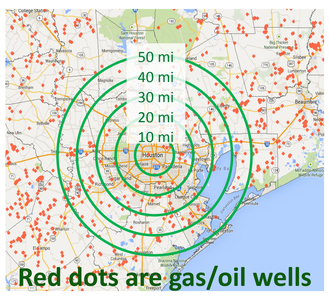
- Target buildings have:
  - favorable size and cooling load (in warm climate) and
  - reasonable proximity to geothermal sites.
- Schools, hospitals, and large office buildings are identified as target buildings

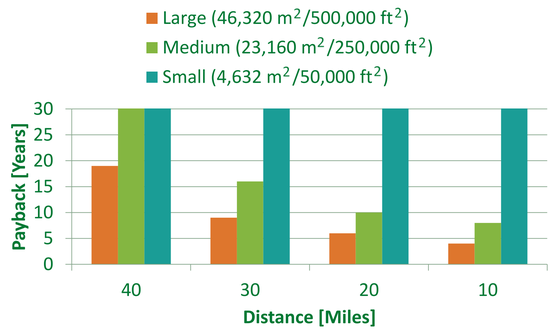
	Schools	Hospitals	Large office buildings (≥ 25,000 ft²)
Total stock floor area [Billion ft²]	8.1	1.6	8.2
Cooling energy [Trillion BTU]	65	30	73
Heating energy [Trillion BTU]	319	224	269

(Source: 2009 DOE Building Energy Data Book)

Preliminary Results

Case study of proposed system in Houston, TX office buildings: promising results





Technical challenges:

- Identify most cost effective working fluid pair
- Design of two new semi-open, "half-absorption systems" (hardware, controls)
- Reduce required volume of absorption working fluid
- Maintain vacuum at components
- Adapt to varying production and sparse distribution of geothermal resources

Conclusions

- The proposed two-step looping absorption technology has potential to utilize low-temperature geothermal energy to provide space cooling to buildings at some distance from the geothermal resources.
- It can reduce fossil fuel consumption, peak electric demand, and avoid using refrigerants with high potentials for global warming and ozone depletion.
- Further study is ongoing for the economical viability of the two-step looping absorption technology.

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