Geothermal/Ground-Source Heat Pump Application Opportunities Under the MCP

MassDEP/LSPA Training Course

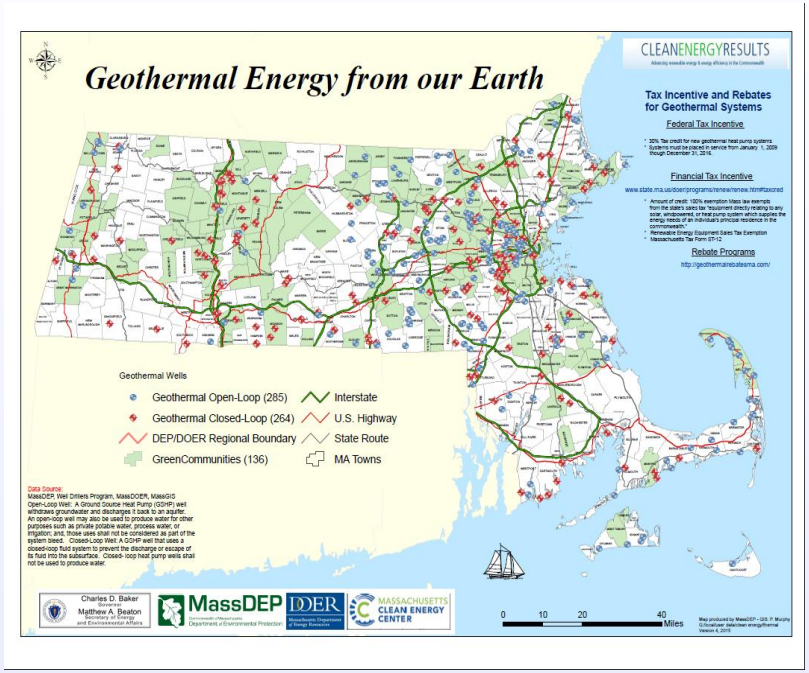
Tuesday, May 5th — Westborough, MA

Thursday, May 7th — Taunton, MA

Thomas M. Potter, Clean Energy Development Coordinator

WORKSHOP OBJECTIVE

- Foster the Development of Renewable Thermal Technologies in MA
- Engage LSPs in the technology and its development through their sphere of influence



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Agenda - AM

TIME	PRESENTATION	SPEAKER
8:00 – 8:05	**Introduction**	Thomas Potter
8:05 – 8:45	**Understanding GSHP:** Principles, Technology and Types of GSHP Systems	Stephen Sakakeeny
8:45 – 9:15	**DOER:** Renewable Thermal Technologies and Regulations	Bram Claeys
9:15 – 10:00	**MassCEC:** Financing and Grants	Josh Kessler
10:00 – 10:15	**BREAK**	
10:15 – 11:15	**MassDEP BWR:** GSHP Regulations and Guidance	Joseph Cerutti
11:15 – 11:45	**MassDEP BWSC:** Greener Cleanups / GSHP's at Contaminated Sites	Thomas Potter
11:45 – 12:15	**MassDEP BWSC:** Feasibility Study on Thermal Technology at Baird McGuire	Dorothy Allen
12:15 – 1:15	**LUNCH**	

Agenda - PM

TIME	PRESENTATION	SPEAKER
1:15 – 2:15	**GEOLOGY & ENGINEERING:** Geological, Engineering and Feasibility Considerations when using GSHP at Contaminated Sites	Don Maggioli & Mark Worthington
2:15 – 3:00	**REMEDIAL APPLICATIONS:** GSHP as a Component of Remediation Systems	Larry Lessard
3:00 – 3:15	**BREAK**	Stephen Sakakeeny
3:15 – 3:45	**CASE STUDY:** Conventional GSHP – Isabella Stuart Gardner Museum	Stephen Sakakeeny
3:45 – 4:15	**CASE STUDY:** Implementation of GSHP at a Contaminated Site	Don Maggioli & Mark Worthington
4:15 – 4:45	**CASE STUDY:** Conceptual use of GSHP to Enhance Remediation	Larry Lessard
4:45 – 5:00	**WRAP-UP AND Q&A**	

Understanding GSHP – Principles, Technology, and Types of Systems

Presented by:
Stephen A. Sakakeeny, LSP, LEP, CHMM, CPG
SAK Environmental, LLC
www.sakenvironmental.com

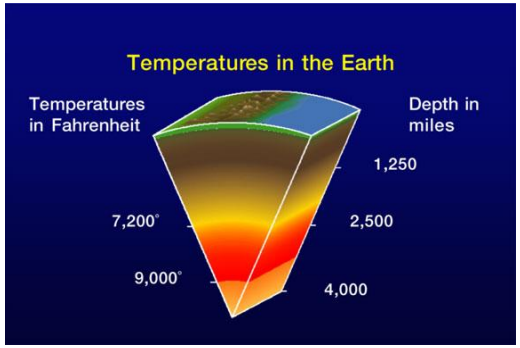
sak Environmental, LLC
advise ◆ remediate ◆ sustain

What This Module Is About

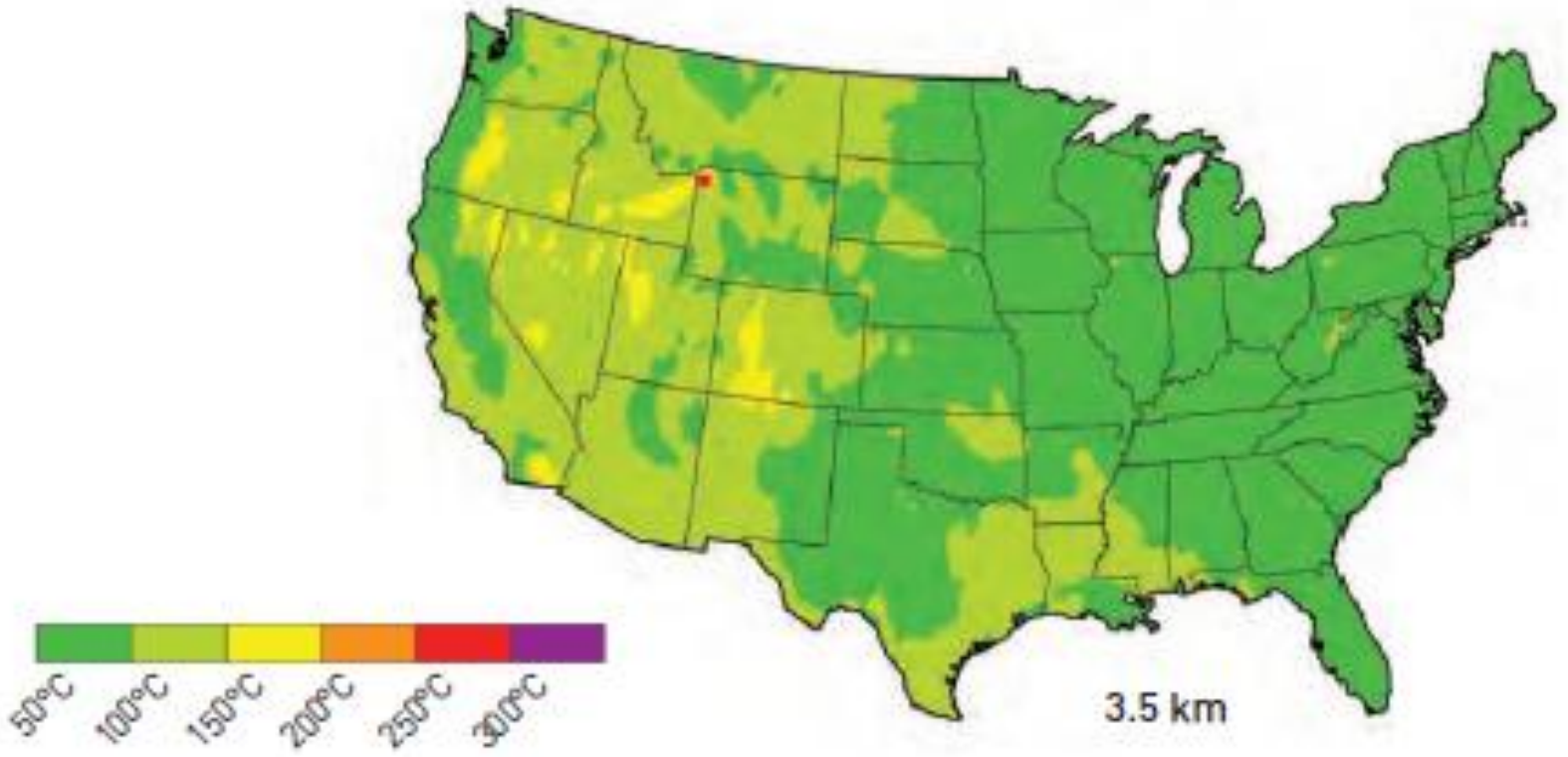
- What is geothermal?
- How it works
- Types of systems
- Typical applications

What is Geothermal?

- Two types of geothermal energy:
  - High-Grade Geothermal: One from earth's deep internal heat generation (i.e. used for power generation).
  - Low-Grade Geothermal: The other from solar energy stored in the earth's surface (i.e. used for heating & cooling)



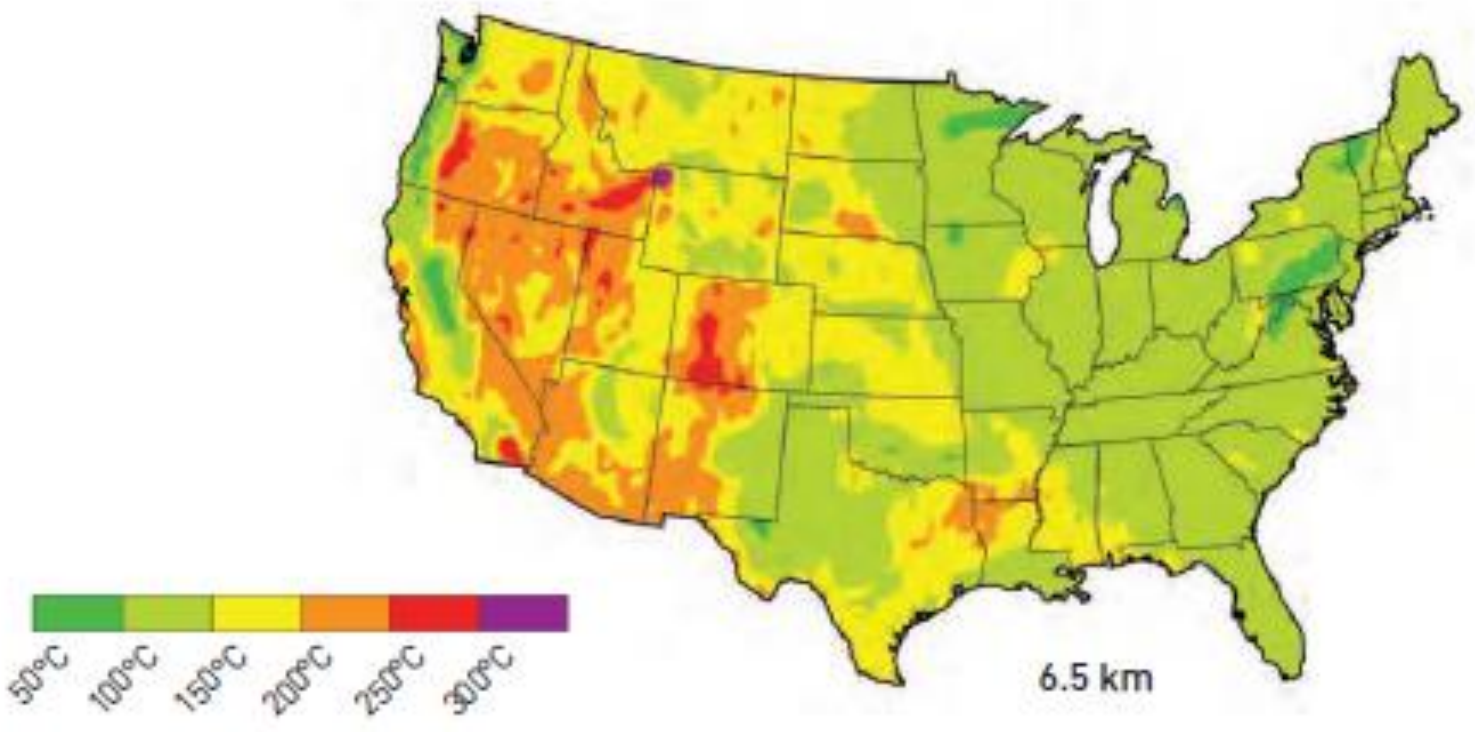
High Grade Geothermal



122F – 572F

Taken from Idaho National Laboratory, USDOE, The Future of Geothermal Energy, 2006

High Grade Geothermal



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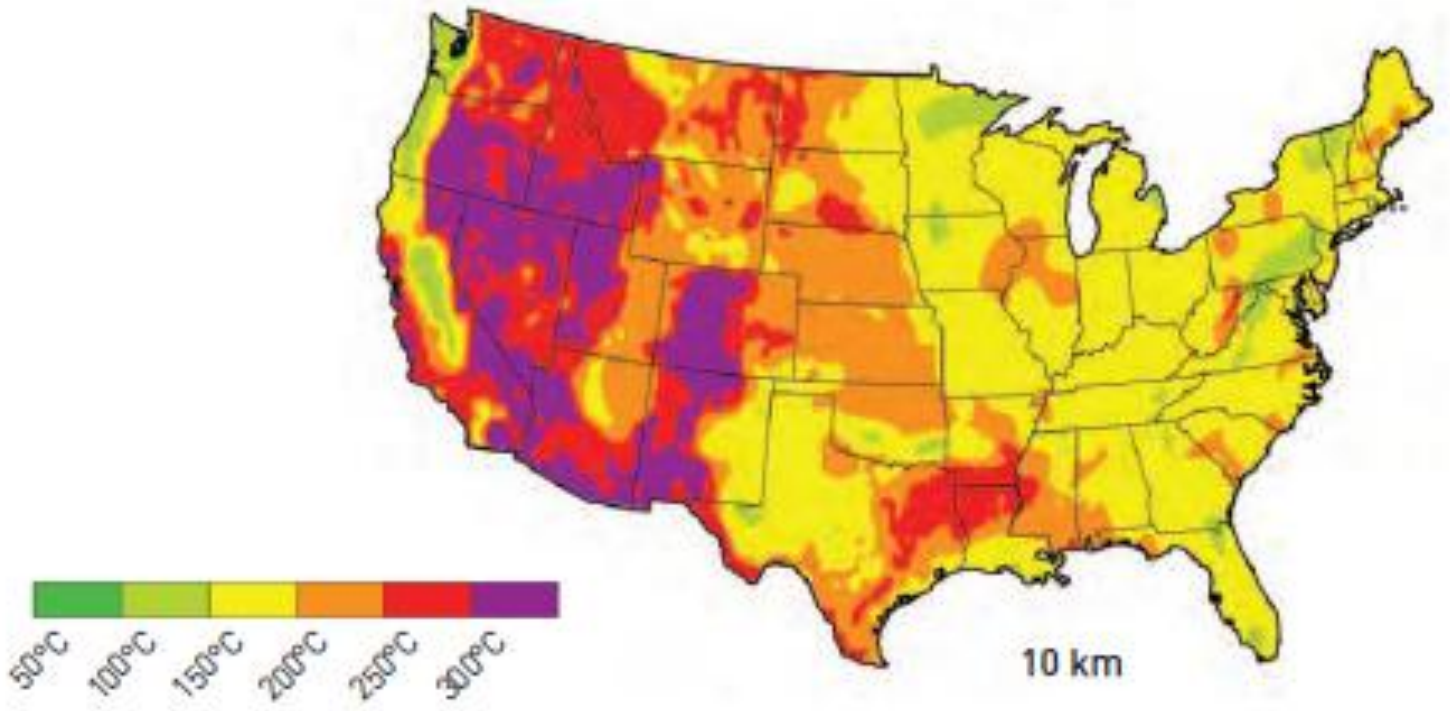

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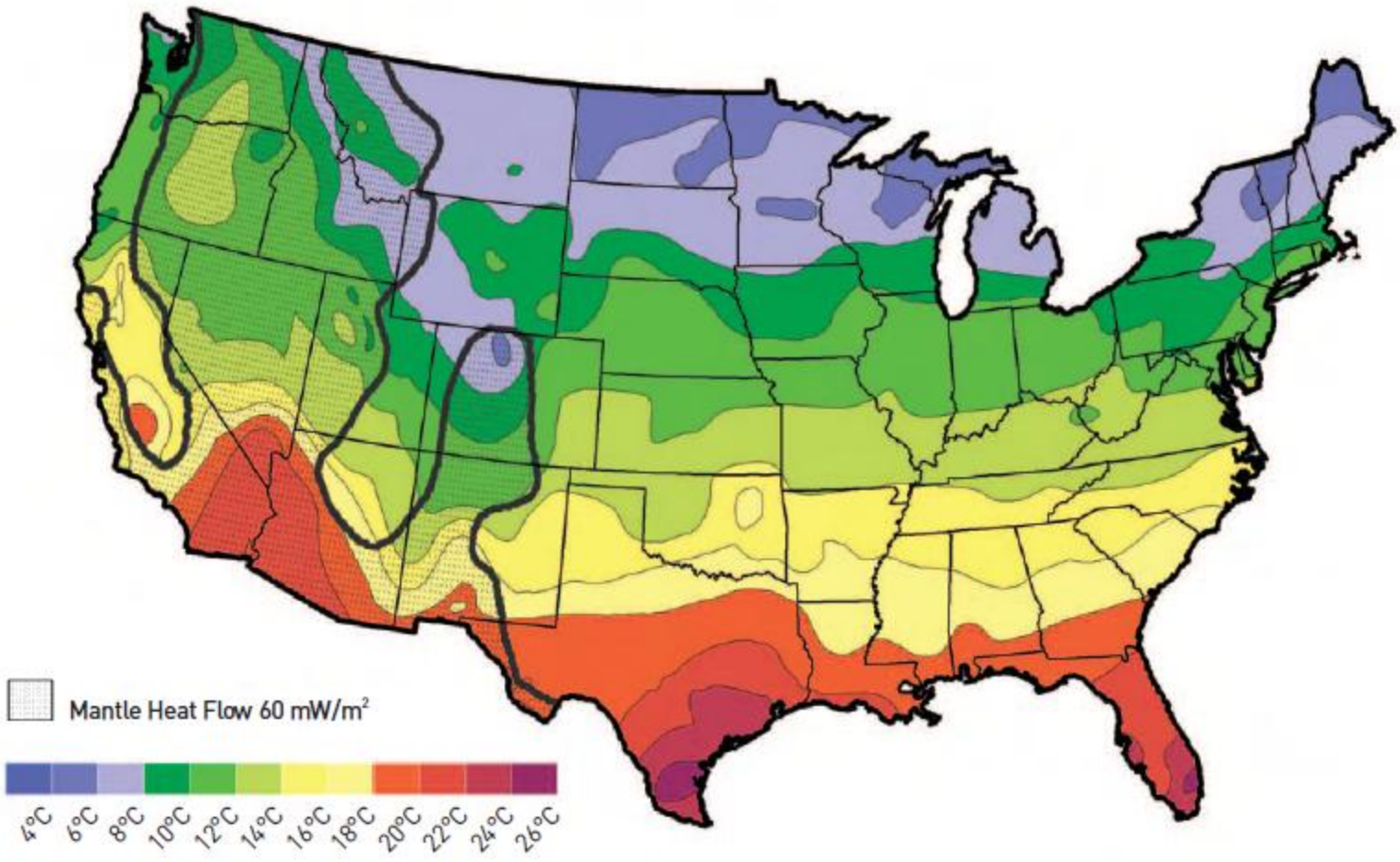
Average Surface Temperatures



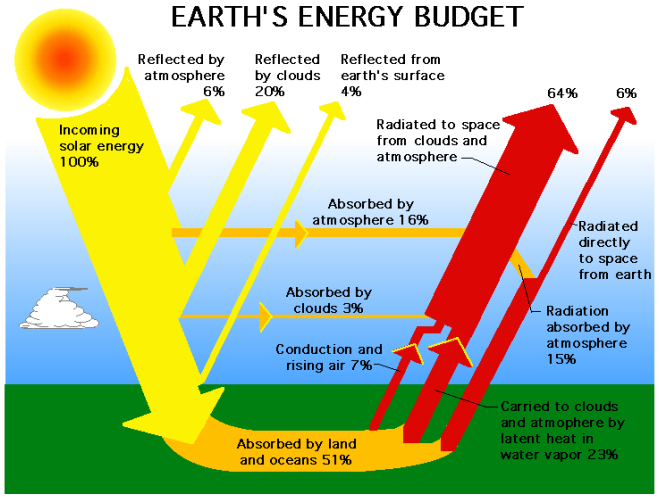
40F – 80F

Taken from Idaho National Laboratory, USDOE, The Future of Geothermal Energy, 2006

High-Grade Geothermal

- From earths internal heat
- Energy producing
- Renewable
- Requires temperatures >150C (300F)
- Resources <3Km (10,000 ft) to 10KM (30,000 ft)
- Developable U.S. Resources = 100 Gigawatts
- Not what this course is about

Low-Grade Geothermal



- Solar influenced heat
- Energy leveraging (not producing)
- Energy efficiency (not renewable)
- Requires temperatures 45F to 65F
- Resources <1,500 feet (commercial drilling limit of technology)
- Subsurface functions as heat-source in winter and heat-sink in summer.
- Needs ground source heat pump (GSHP)
- That's what we're here for

What This Module Is About

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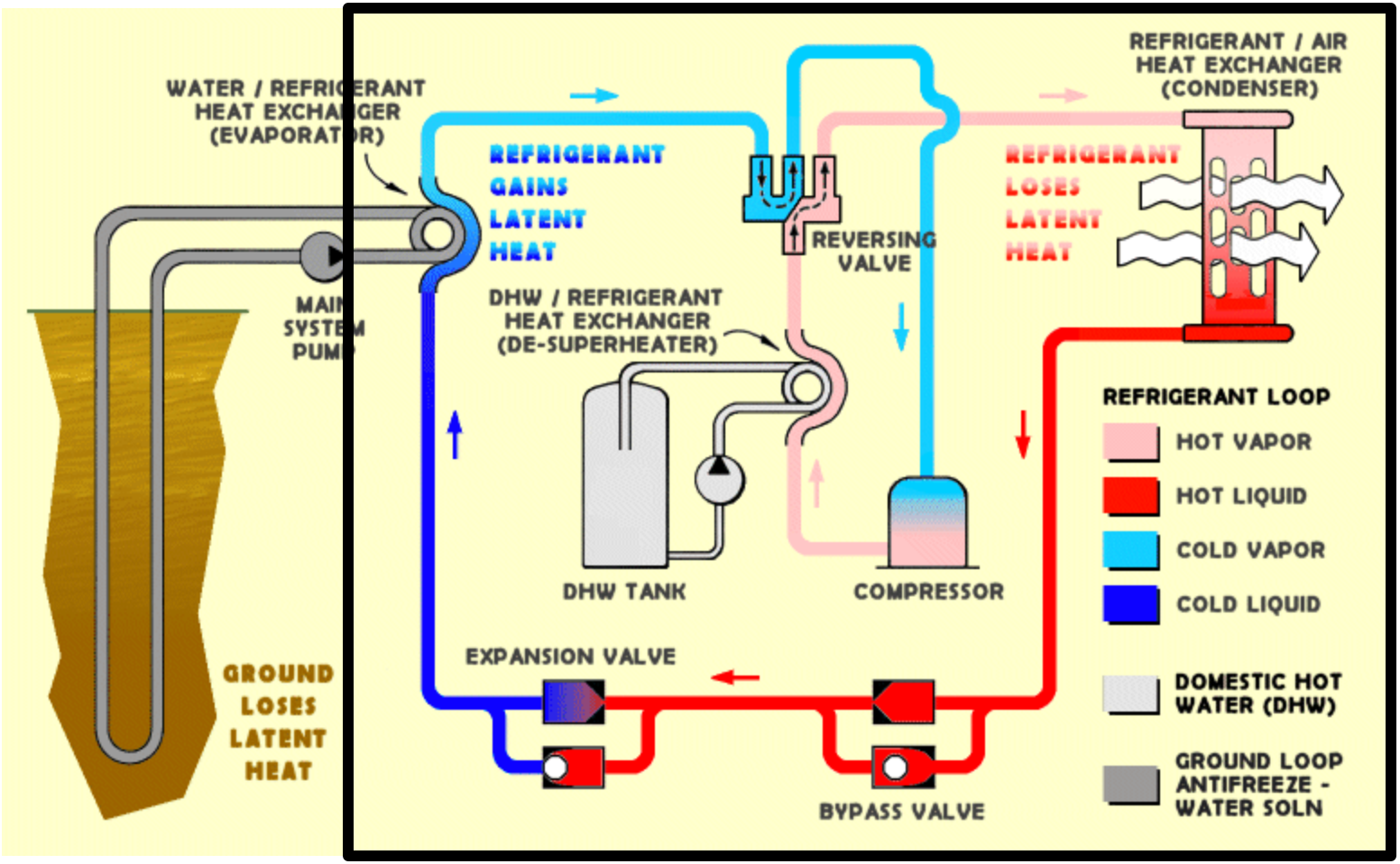
How can 50 Degree Water Heat My House to 70 Degrees?

- Think of subsurface as a thermal reservoir. Not direct heating or cooling
- Heat pump to transfer/concentrate thermal energy through refrigeration/compression process



Results in 100F-130F forced hot water heat (conventional boiler: 160F-180F)

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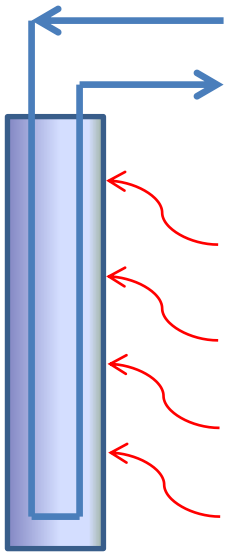
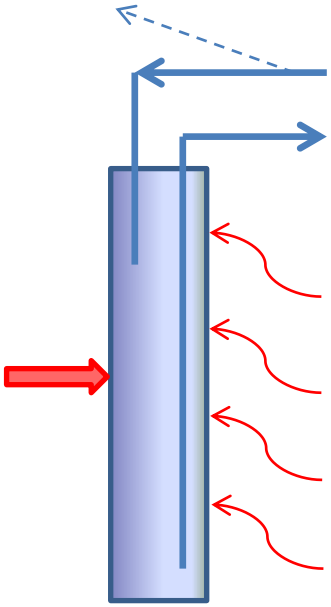
Main Geo Earth-Coupling Types

Closed Loop



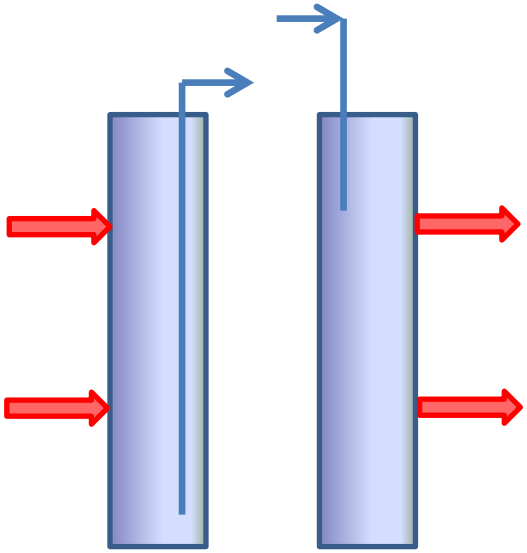
Glycol

Standing Column



Groundwater

Open to Diffusion

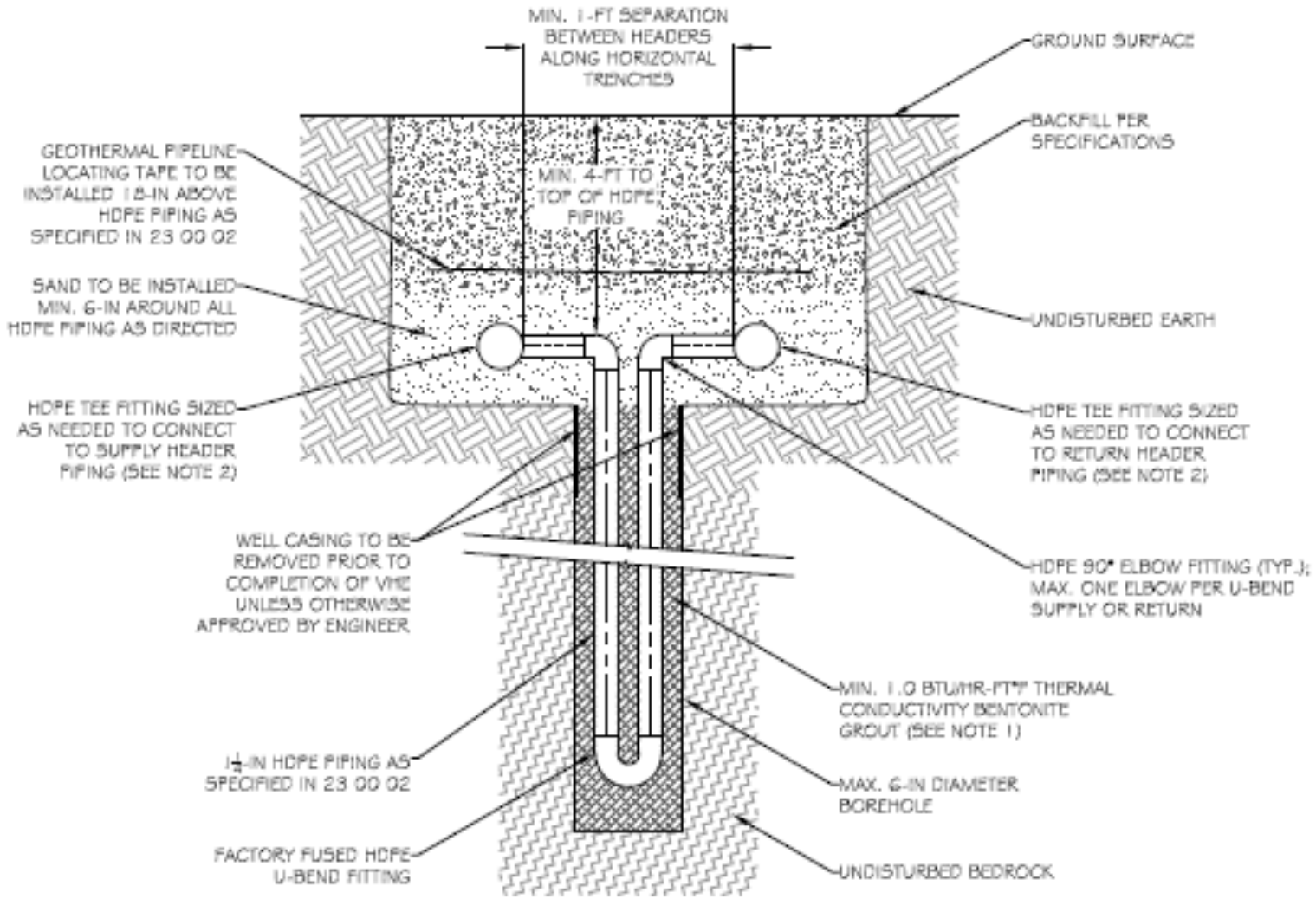


Groundwater

Closed Loop

sak Environmental, LLC
advise ◆ remediate ◆ sustain

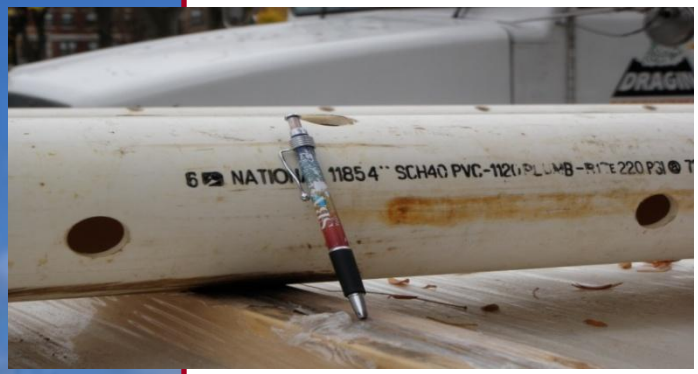
Closed Loop Vertical Borehole

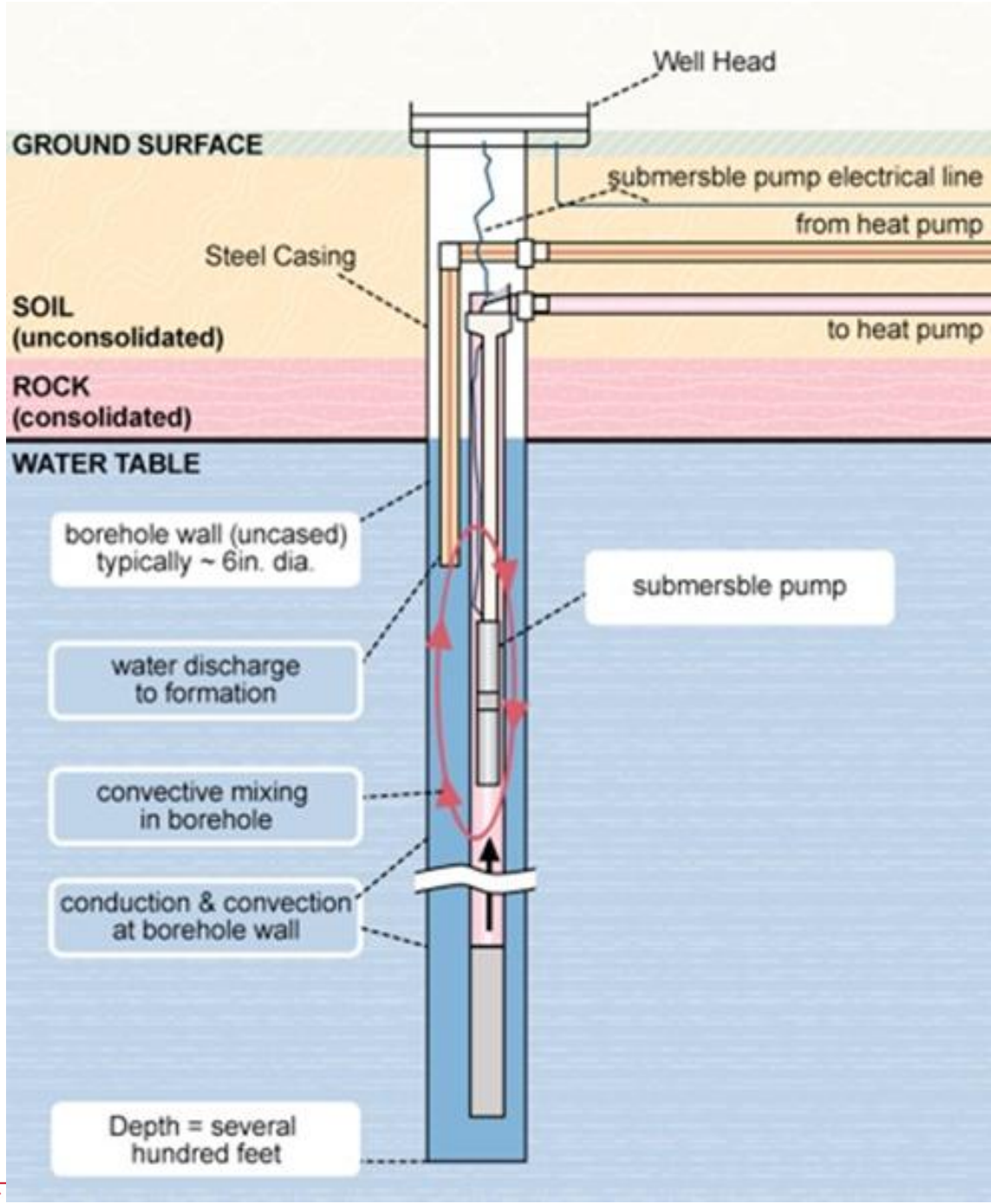


GEOTHERMAL BOREHOLE DETAIL

NOT TO SCALE

Standing Column Well





Heat Pumps

Earth-Coupling Comparison

	Closed Loop	Standing Column	Open-Diffusion
Install Cost	3	2	1
Efficiency	3	2	1
Geology	1	2	3
Maintenance	1	2	2

1 = Highest/Best Comparative Rating

Open Systems are least costly to install and most efficient, given the <u>proper</u> conditions

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Common Applications

- Individual residence
- Commercial buildings
- Replace conventional boilers, chillers, etc.
- Hybrid systems (peak demand)
- Groundwater treatment systems??

1 = Highest/Best Comparative Rating

Good Things to Know

- 500 foot deep closed loop well ~ 2 ton cooling (24,000 Btu/hr)
- 1,500 foot deep standing column well ~ 20 tons cooling (240,000 Btu/hr)
- It's about the rock column! Not groundwater
- Groundwater quality is important
- Aquifer Thermal Conductivity (Btu/hr-ft-^{o}F) is important

Questions?

Creating A Cleaner Energy Future For the Commonwealth

DOER
Massachusetts Department of Energy Resources

Renewable Thermal Technologies & Regulations

Ground Source Heat Pump Training
5/5/15 Westborough - 5/7/15 Taunton

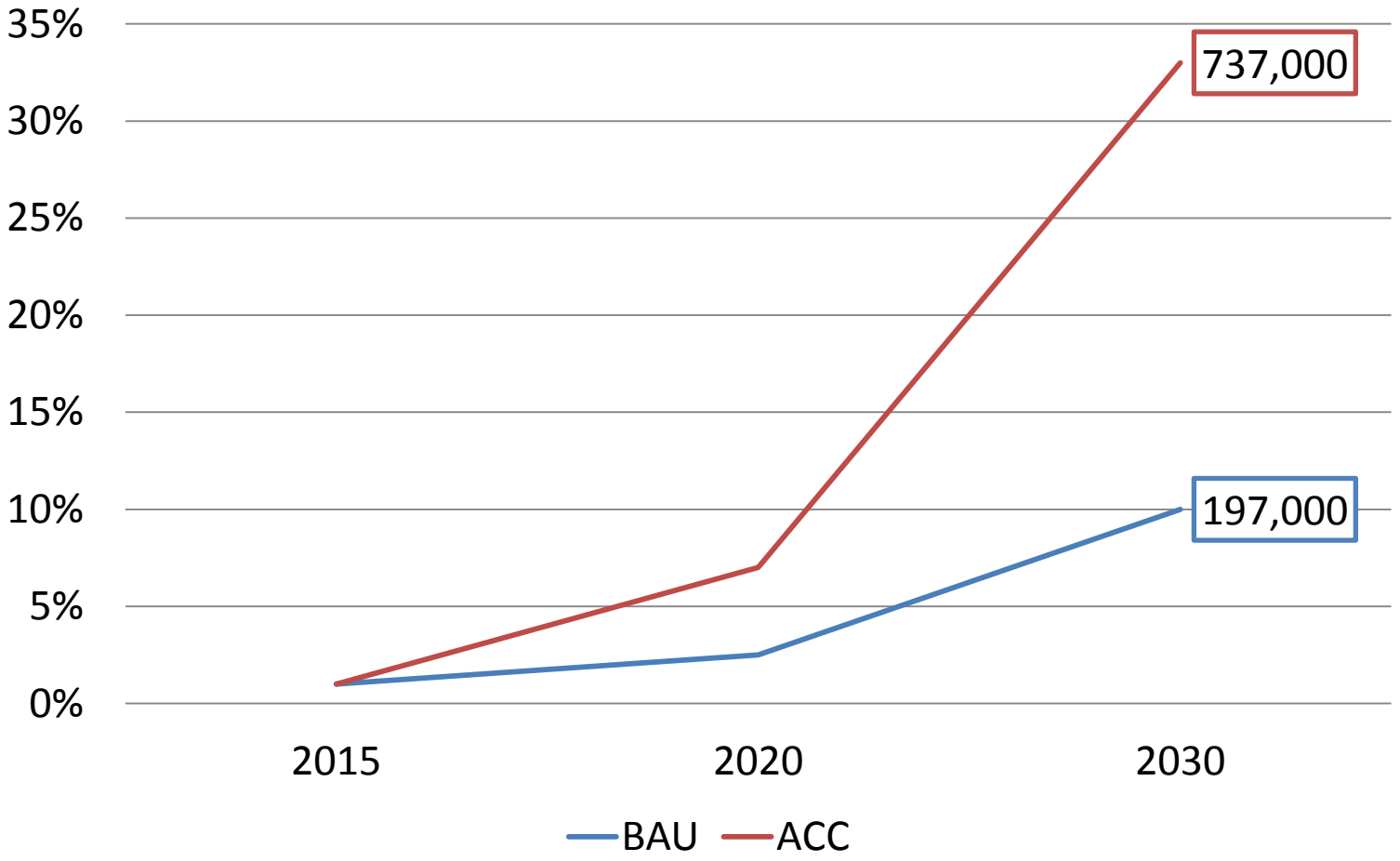
Creating A Greener Energy Future For the Commonwealth

DOER
Massachusetts Department of Energy Resources

Renewable Thermal in Massachusetts

- Clean Energy & Climate Plan 2020
- Pilot programs to kick-start market
  - Demonstrate & Communicate
- Multi-pronged market strategy
  - Customer rebates/grants
  - Market support
  - Performance based incentive

Projected Renewable Thermal Market Share



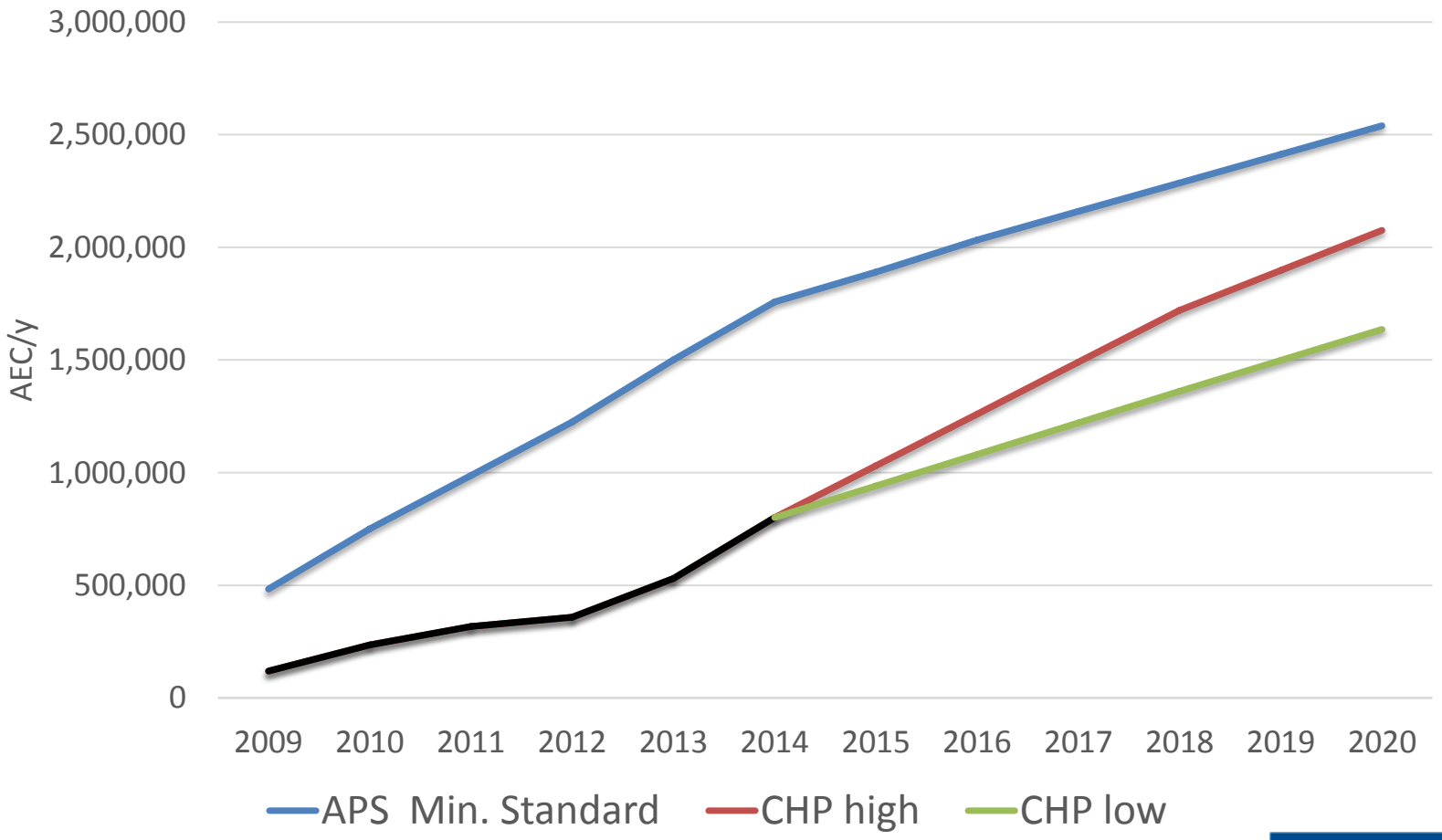
Source: CARTS Report, Navigant/Meister for DOER, January 2014

MA Alternative Energy Portfolio Standard

Regulations: 225 CMR 16.00

- Requires a certain percentage of the state's electric load to be met by eligible technologies
  - Combined Heat and Power (CHP)
  - Flywheel storage
  - *Coal gasification, carbon capture & storage, paper derived fuel (now deleted)*
- Obligation on all retail electric suppliers
  - Set at 1% in 2009
  - Increased with 1%/y until 2014, then 0.25%/y

APS evolution & trends



Technology changes – Acts 2014, Ch. 251

- Add any facility that generates useful thermal energy using:
  - Sunlight, biomass, biogas, liquid biofuel or naturally occurring temperature differences in ground, air or water
- Strike carbon capture and storage, gasification, paper derived fuel
- Additionally exclude construction & demolition debris

Energy from Ground Source Heat Pumps

- Credits for net thermal energy delivered as heating energy
  - Space heating, hot water
  - Process heat
- Cooling from heat pumps will not be credited
- Renewable heat can be used to provide cooling through absorption chillers
  - In commercial & industrial uses
  - Thermal energy delivered as process heat to the absorption chiller will be credited as useful thermal energy

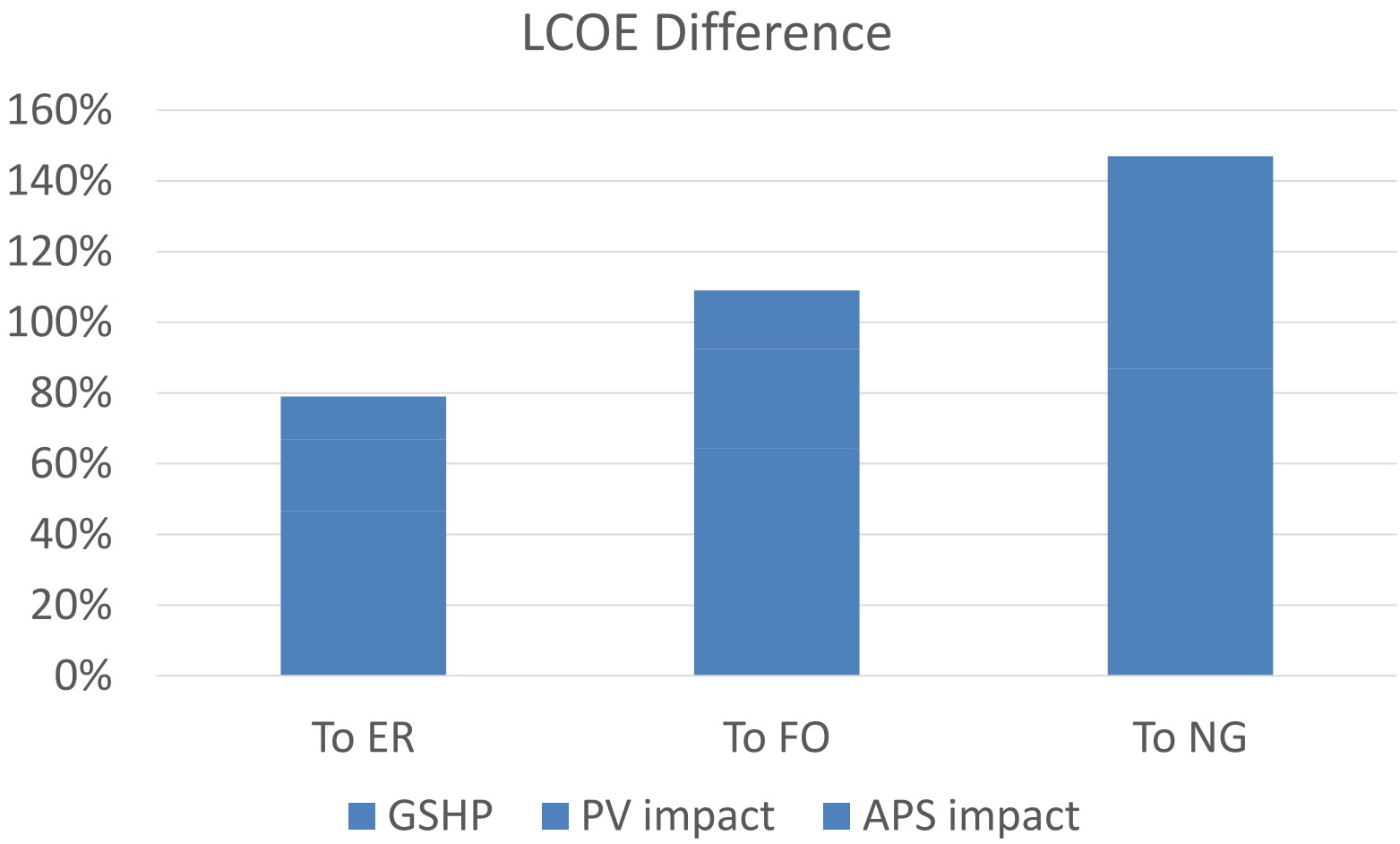
Net Energy Generation

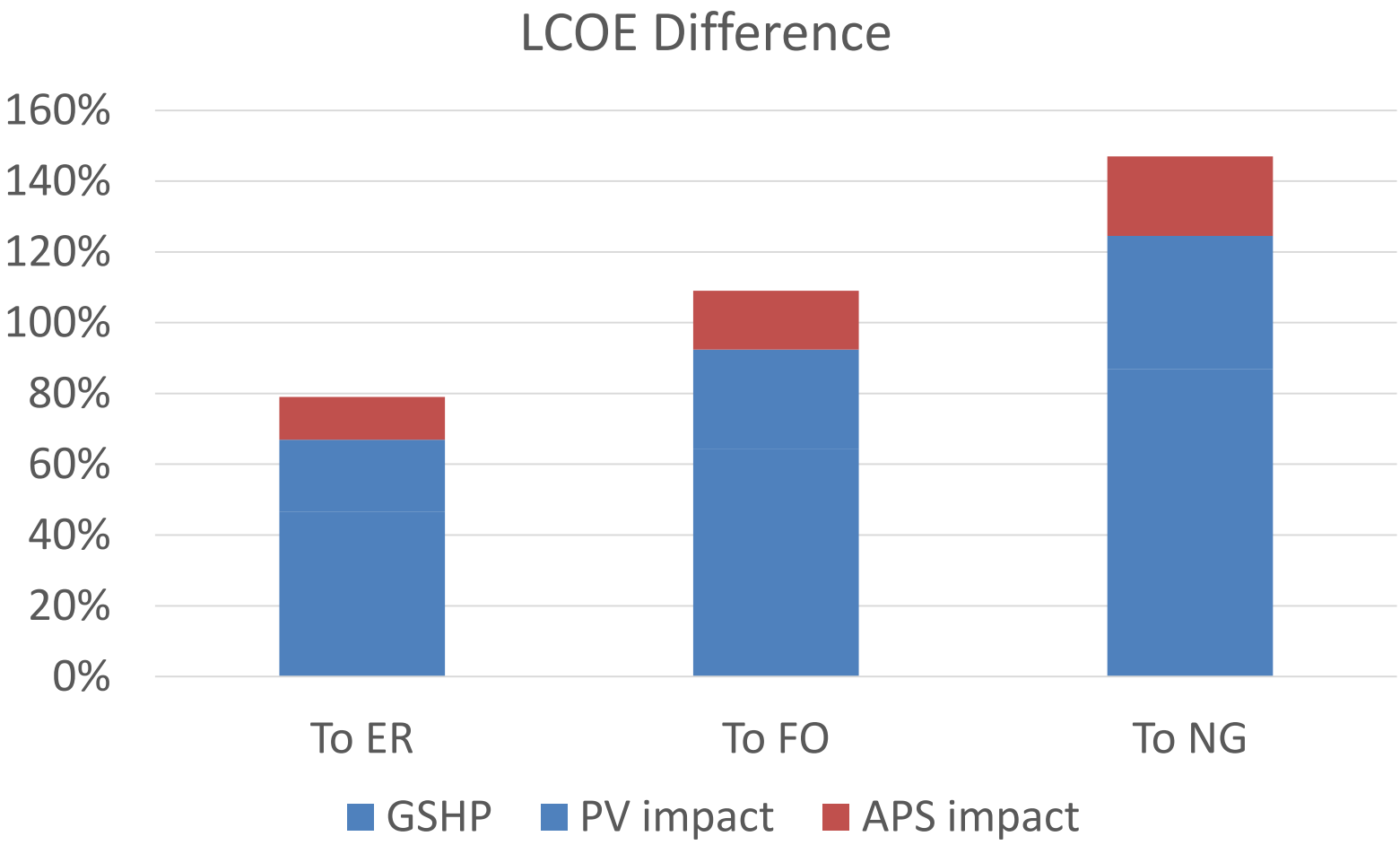
$$E_{net} = E_{thermal,\ out} - E_{non\text{-}renewable,\ in}$$

- Non-renewable energy input is calculated as primary energy, so for electricity:
  - Assume average heat rate and electric transmission/distribution losses (ISO-NE)
  - Established as 41% factor (DOER will reassess periodically)
  - $E_{non\text{-}renewable,\ in}$ = Electricity input / 0.41
  - $E_{thermal,\ out}$ = heat load served (heat transferred to a useful load)

Metering Approach

- Large systems: continuous accurate **metering** and automatic reporting
  - Available equipment / standards / industry practice
- Small systems: **calculate** projected output
  - Verification of ongoing operation through spot checks and run-time monitoring


LCOE Difference
160%
140%
120%
100%
80%
60%
40%
20%
0%
To ER
To FO
To NG
GSHP
PV impact
APS impact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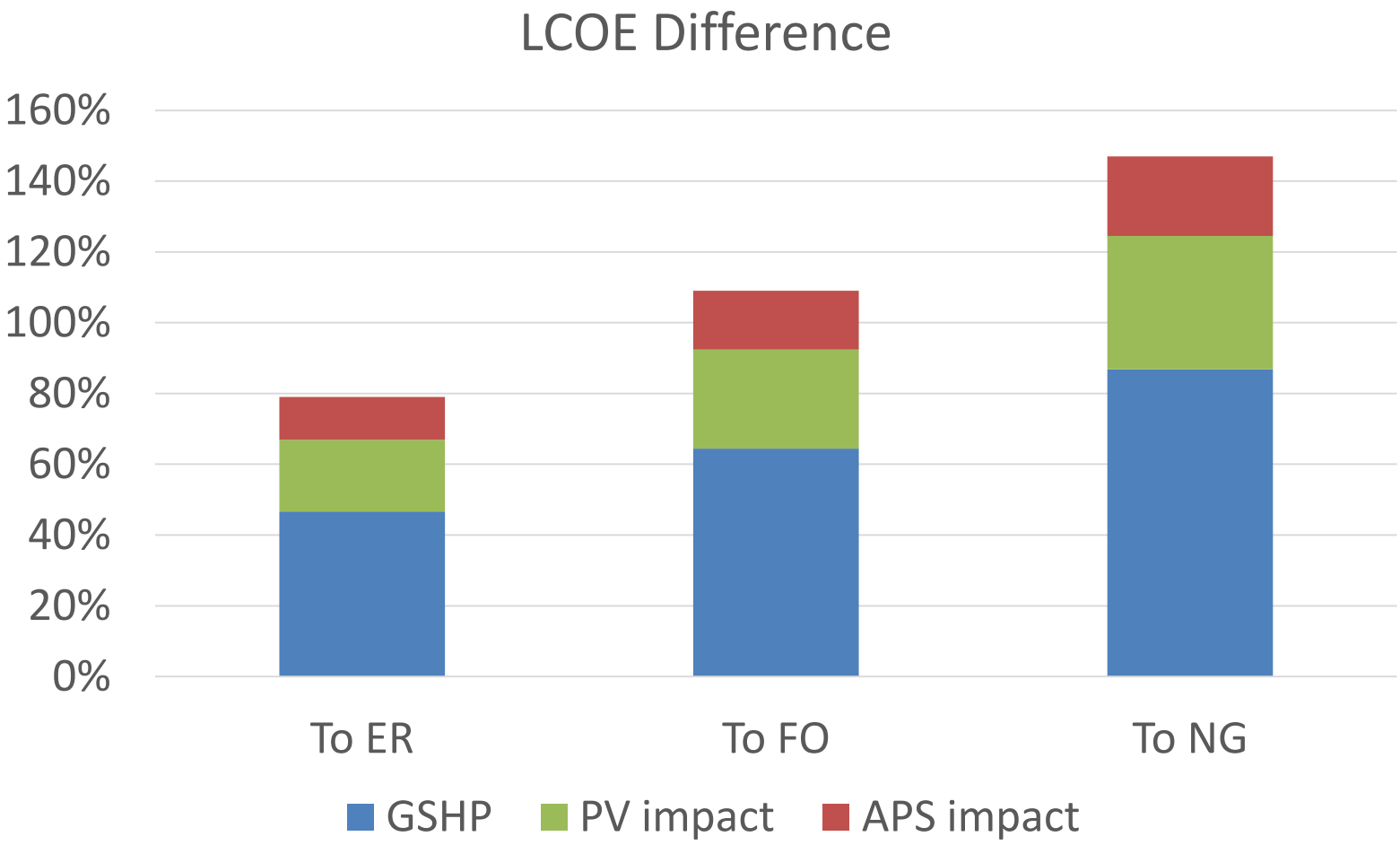
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Contact information

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- APS regulatory proceeding to include thermal