Center for Energy and Environment

# The Thermal Balancing Act

## Evaluating Heat Pump Opportunities for Industries in Minnesota

# Q: What do we need to have for industrial heat pumps to succeed in Minnesota?

# A: Collaboration!

Center for Energy and Environment

Graphet DATA MINING
<Empowering Energy Efficiency>

# THANK YOU

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www.mncee.org

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# What information is useful?

What?

Who?

How?

Where?

When?

# Study Structure

- Products and Processes ⟵ What?
- Stakeholder Interviews ⟵ Who?
- “Design Guide” ⟵ How?
- Site Characterizations & State Technical Potential ⟵ Where?
- Roadmap ⟵ When?

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**A longer memory, and a sterner sense of justice than we do.**

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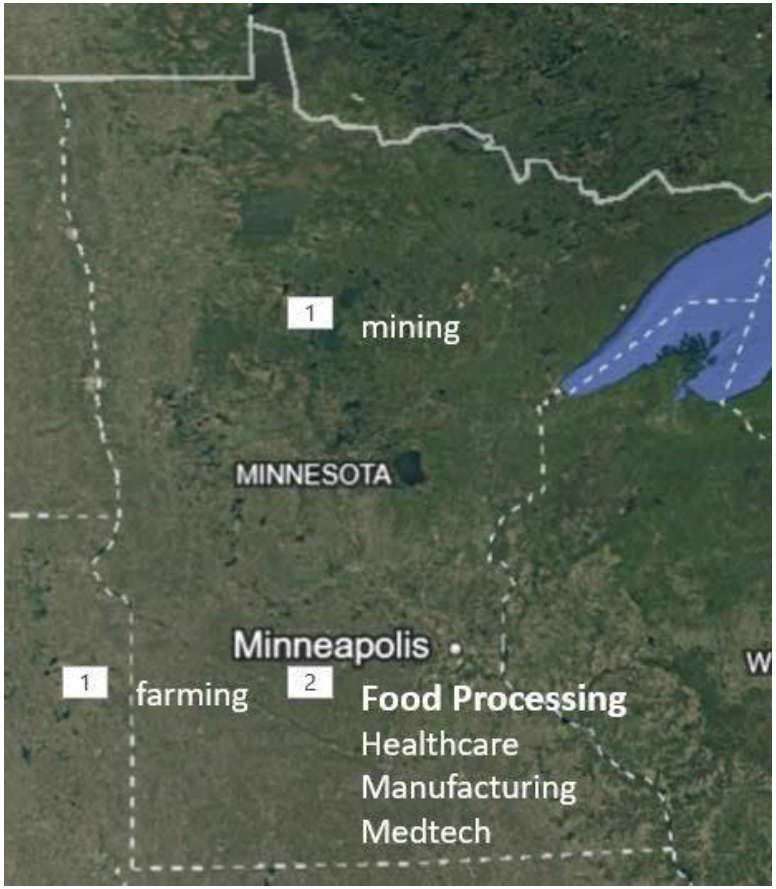
mining
milling
farming


**0.5 Quads Gas**
**0.2 Quads Elec**




## Total Gas: 0.5 Quads

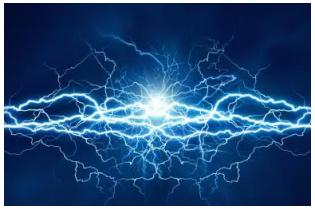
*Dutiyampi…*

# Q: What do we need to have for industrial heat pumps to succeed in Minnesota?

# A: Balance

# Balance…

# Balance… Fuel Cost!

$\eta_C$

customer

$COP = \frac{Q_{out}}{W}$

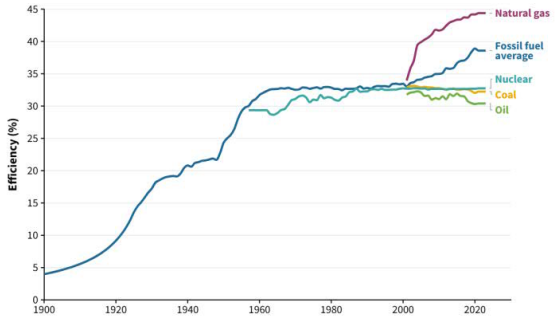
# Balance… Utility Cost with Grid Greening!

# Balance… Energy!

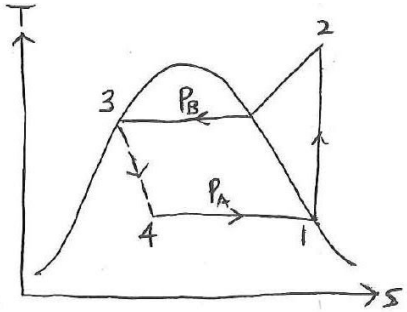
$$\text{Heat Rate} = \frac{\text{Thermal Energy In}}{\text{Electrical Energy Out}}$$

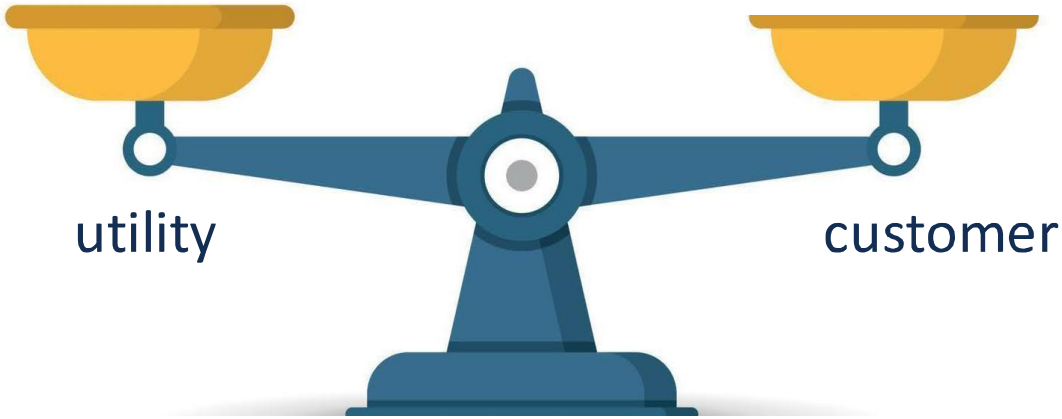
**Thermal power plant efficiency in the United States**

Efficiency is the heat content of a kilowatt-hour (kWh) of electricity divided by the heat rate of the plant, which is the amount of energy used to generate one kWh of electricity.

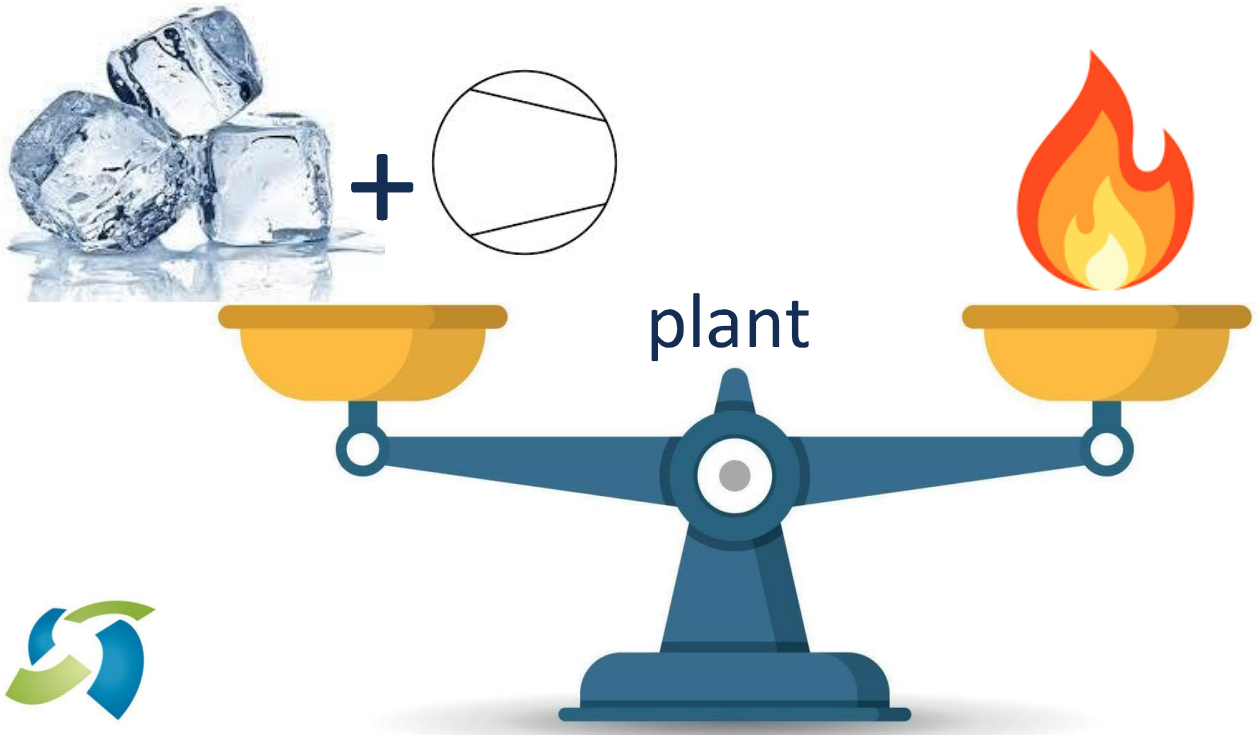



$$COP = \frac{Q_{out}}{W}$$



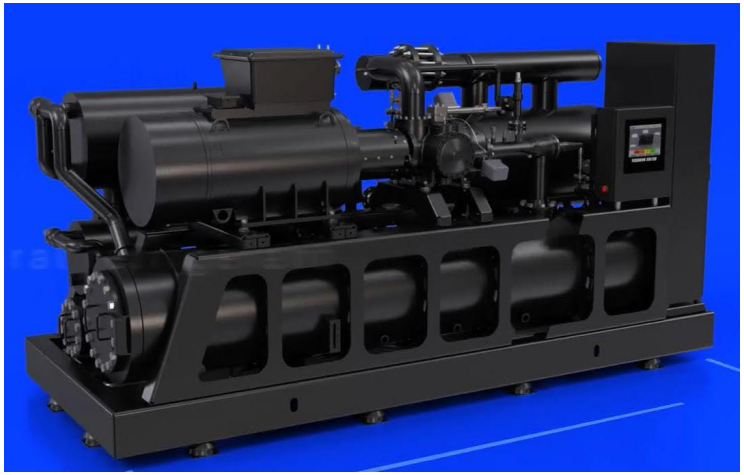



# Balance…  Thermal Loads!

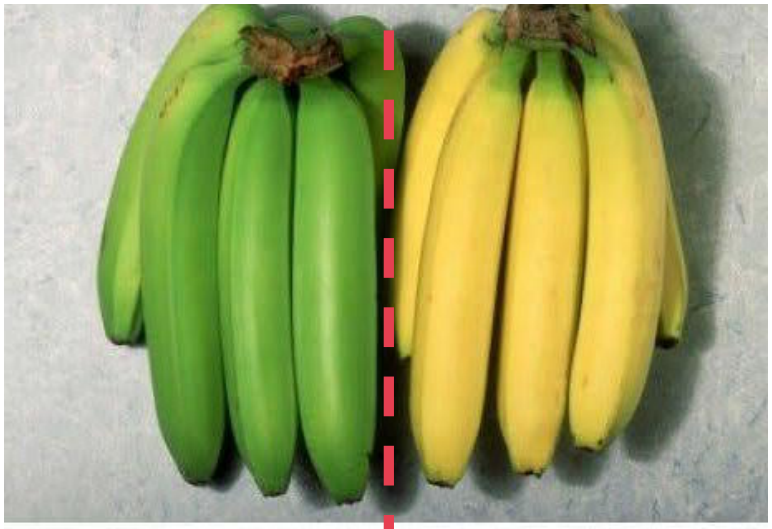


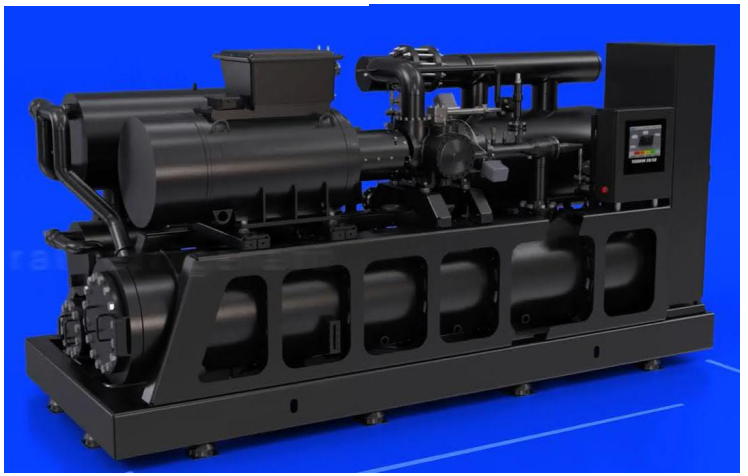
# Balance… Products and Applications!

# Products

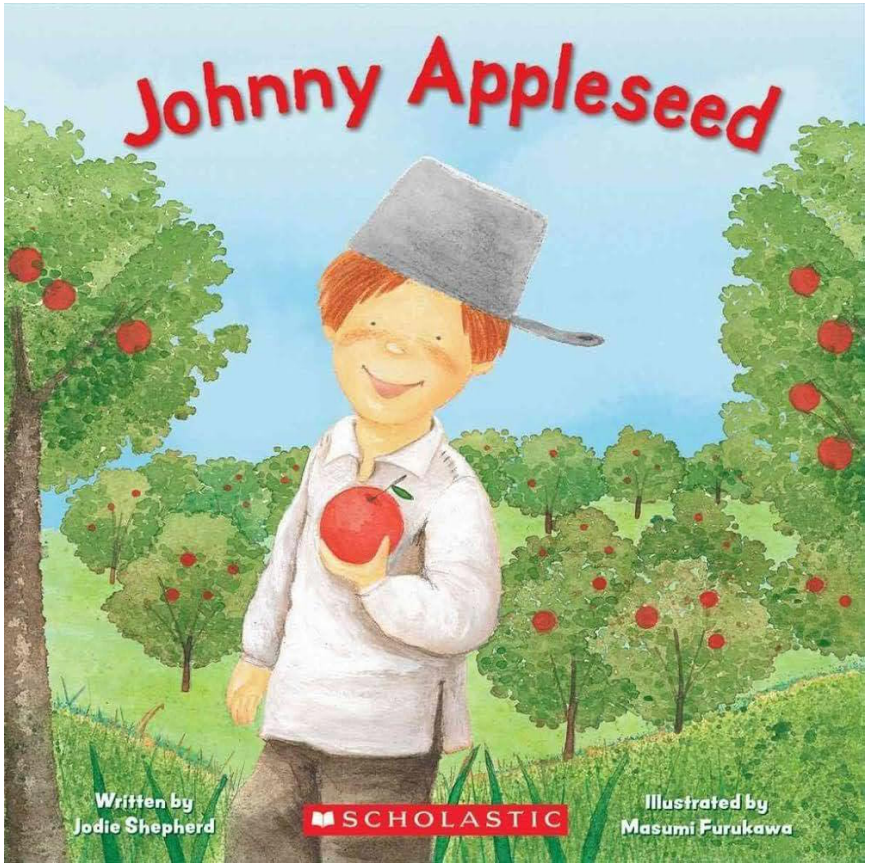


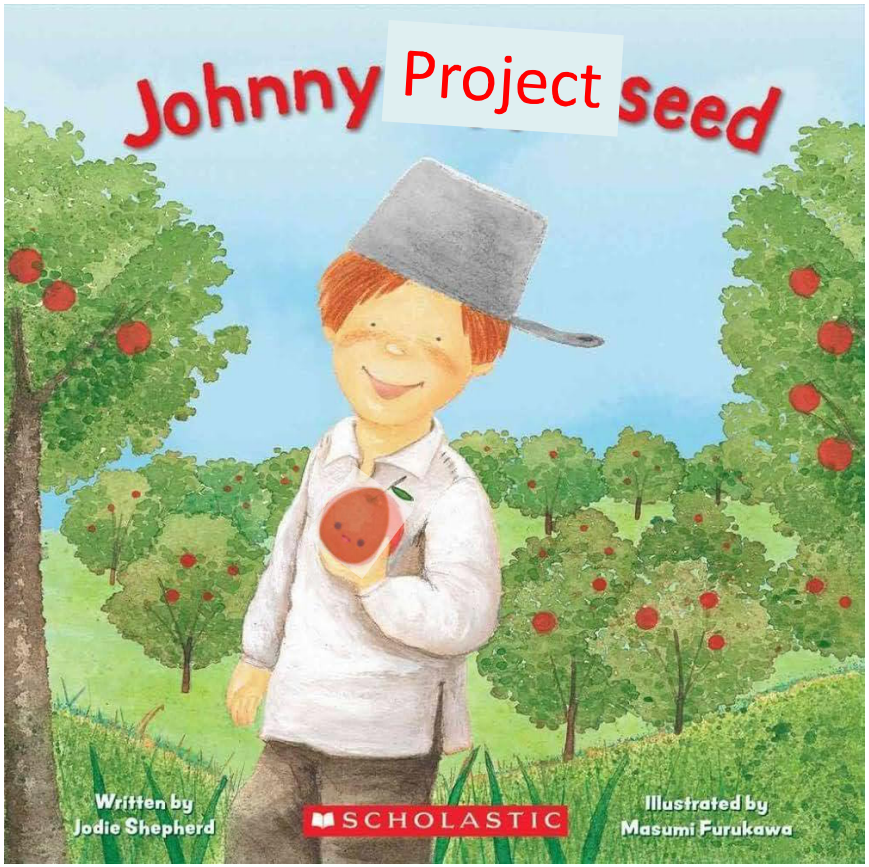
# Products





# The life cycle of a potential application


Johnny Appleseed
Written by
Jodie Shepherd
SCHOLASTIC
Illustrated by
Masumi Furukawa




=

IHP ALLIANCE

Decision Making

# The life cycle of a potential application

RTC Tool Zero?

RTC Tool 1, 2, 3

Analysis

# The life cycle of a potential application

Analysis

Decision making

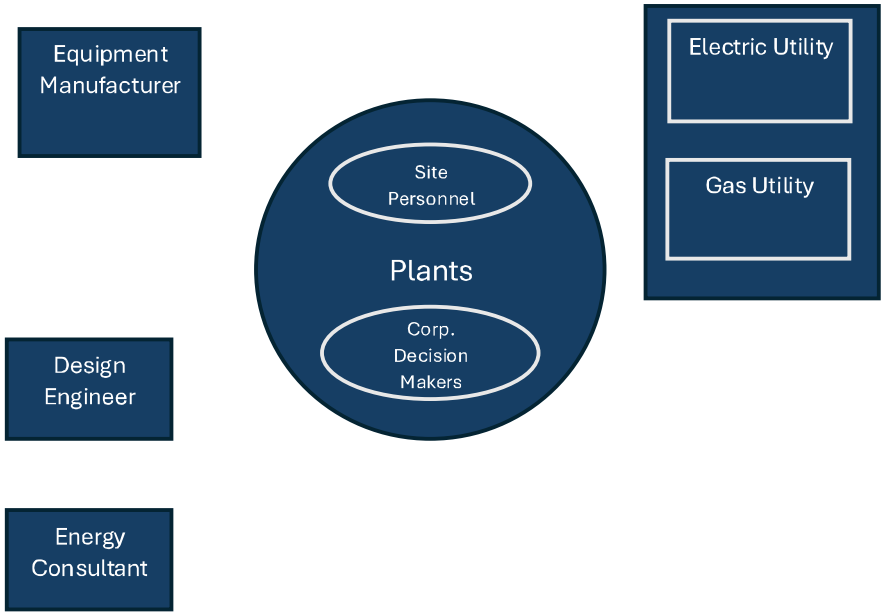
# Vectors of Influence

Site Personnel

Plants

Corp. Decision Makers

# Vectors of Influence

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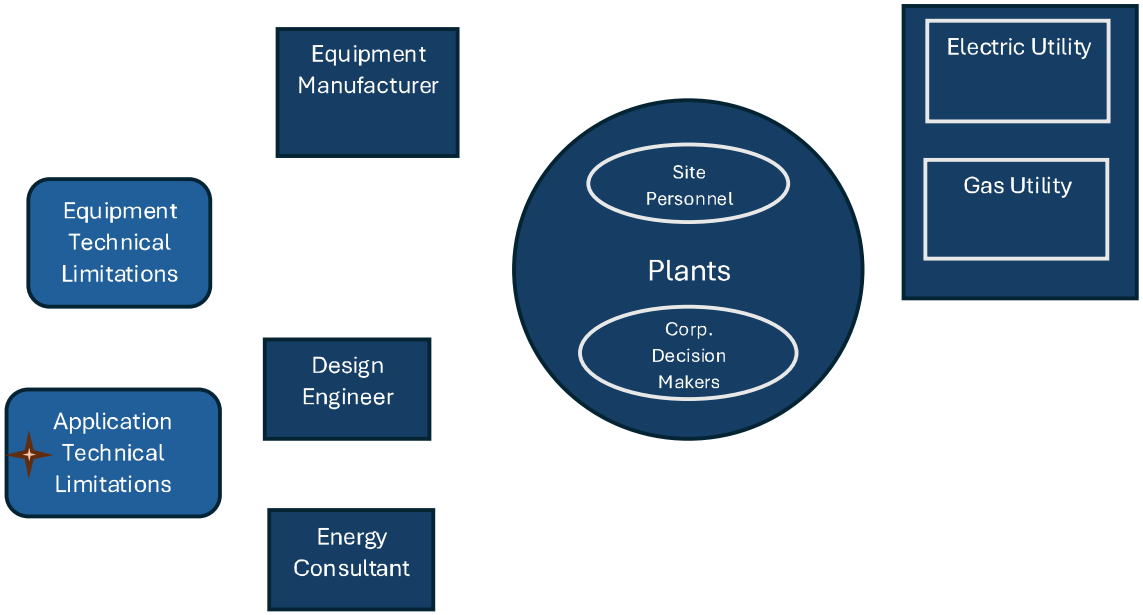


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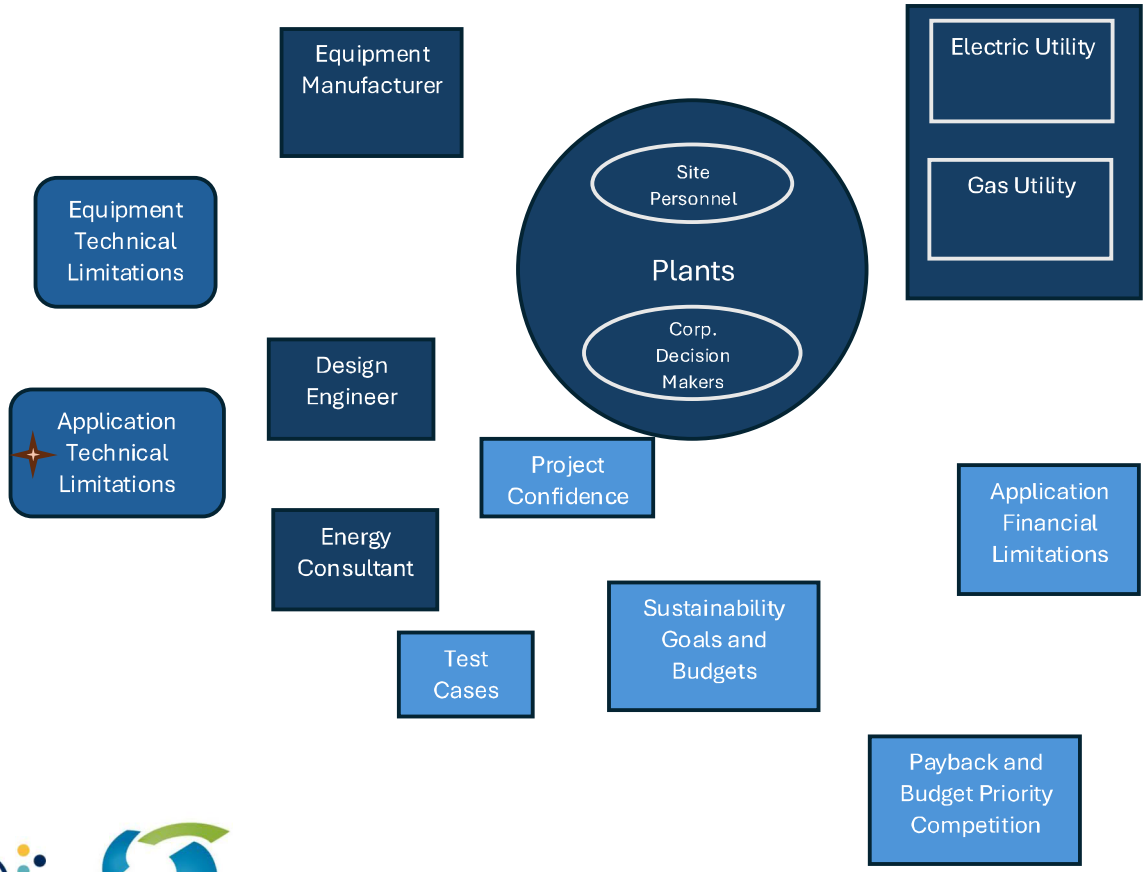
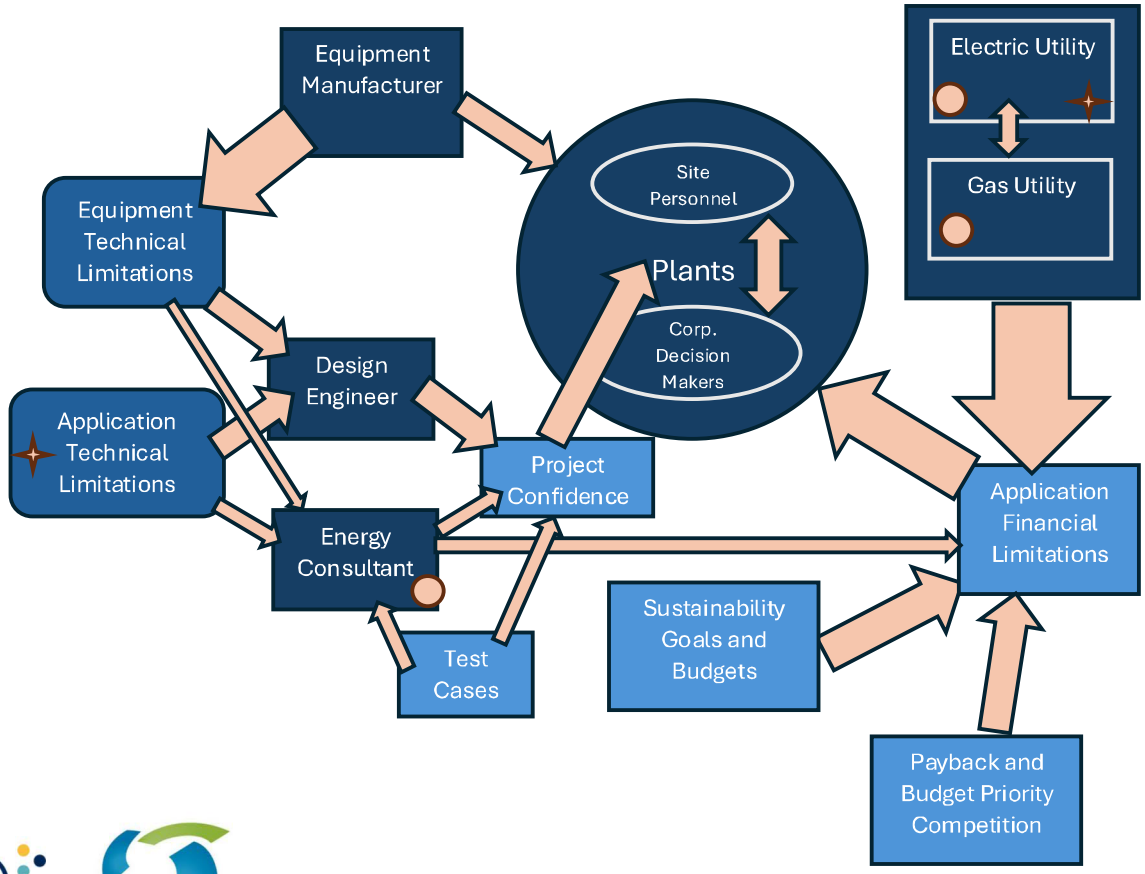



Decision Making

# Vectors of Influence

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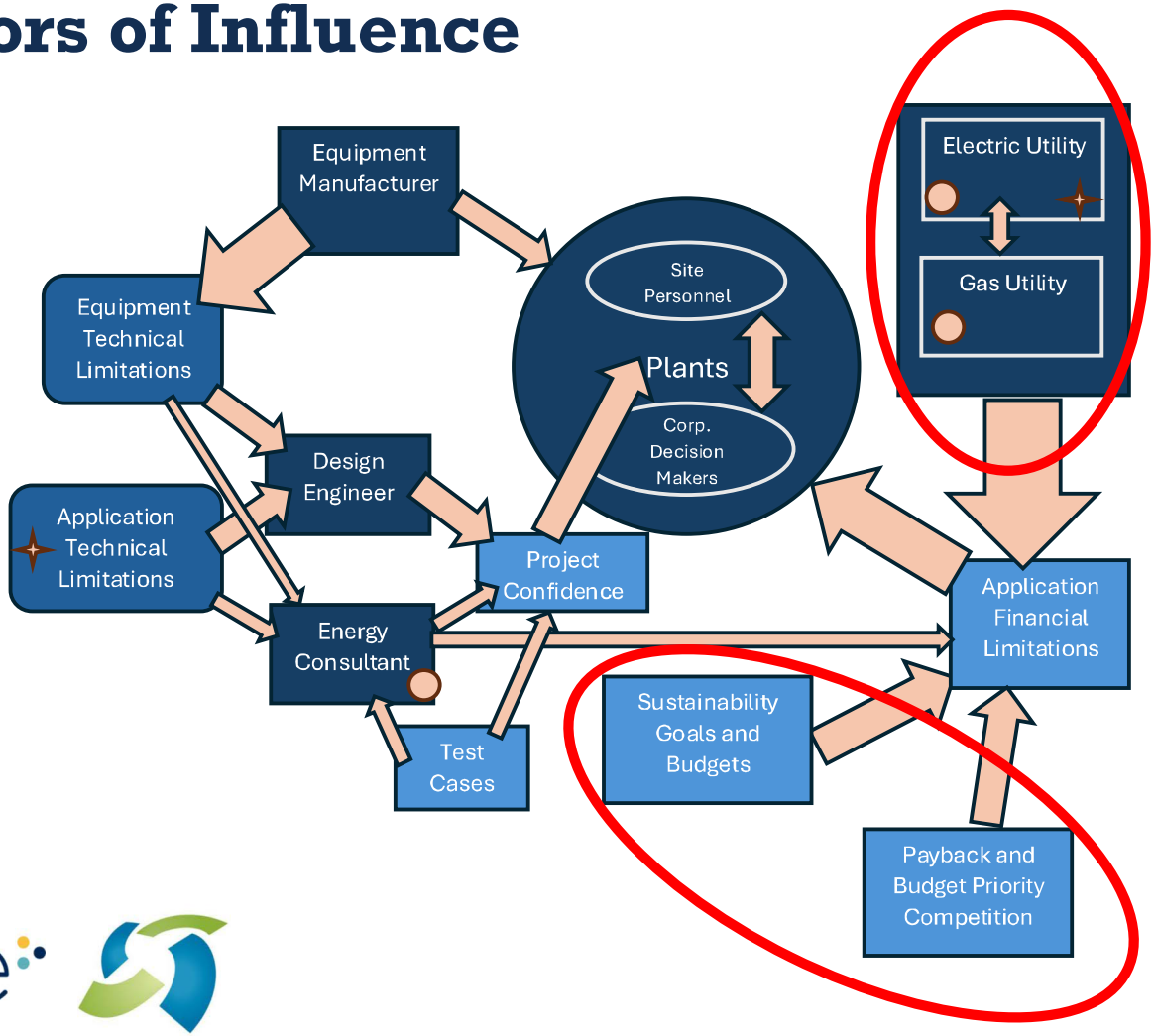


Decision Making

# Vectors of Influence

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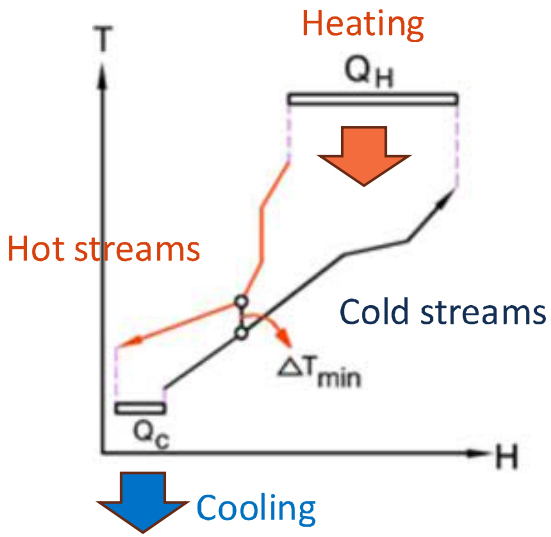
Application
Technical
Limitations

# Zoom-in

Application Technical Limitations

# Leveraging Available Heat Sources

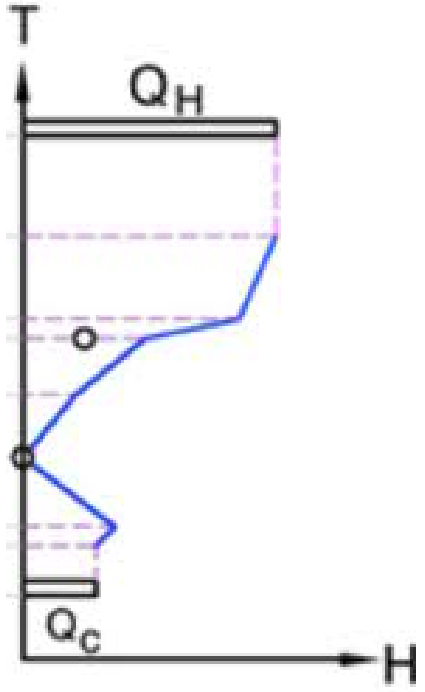
- Recover waste energy
- Upgrade waste energy with heat pumps



# Finding Optimal Solutions

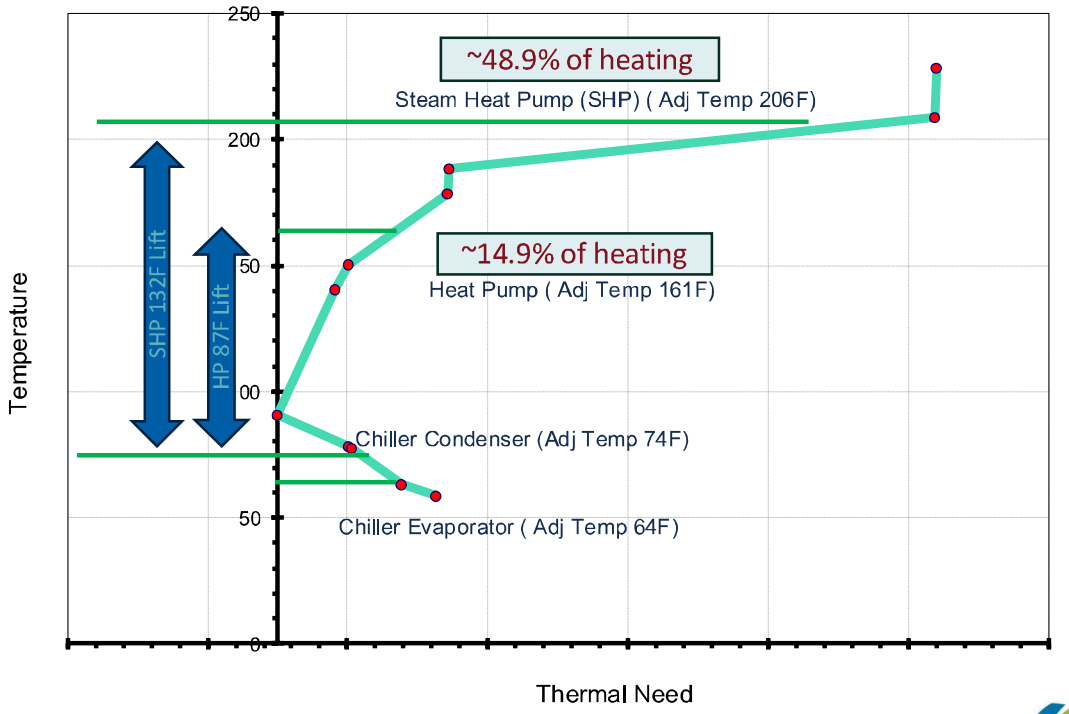
- Identify Sources and Sinks – process streams and plant utility

- Pinch Analysis Process
  - Common in high-impact heat exchanger networks (refinery, power plant)

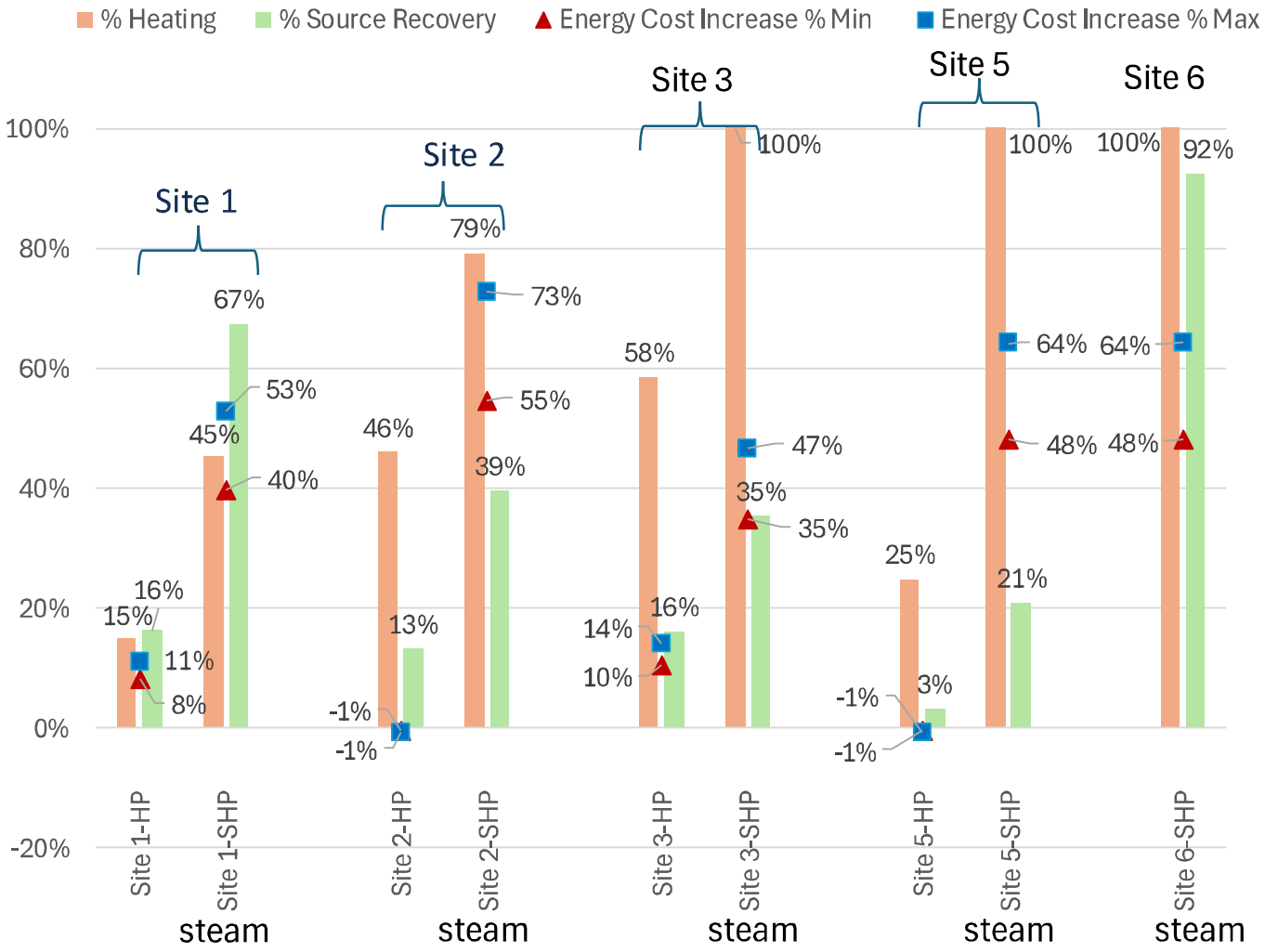


# Opportunities – Site 1

*Grand Composite Curve*



# Comparison of Heat Pump Opportunity across Sites



*Tatiyampi…*

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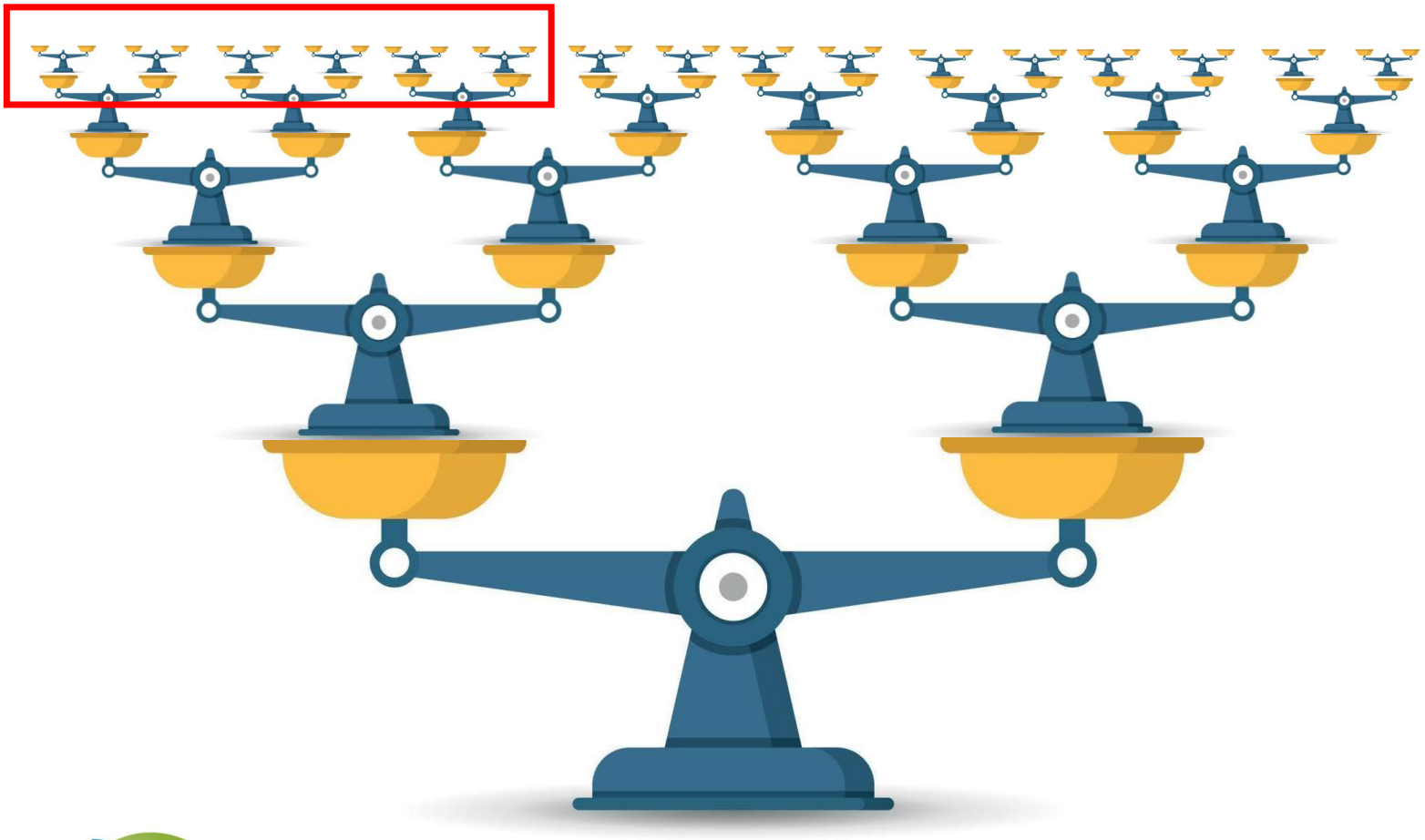

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# Appendix (Interviews)

Table 6. Interview Respondents Summary

| Stakeholder Type | Quantity Interviewed | Industries Active | Region Active | Base of Operations |
|---|---|---|---|---|
| Plant Staff | 7 | Food, Cosmetics, Medical Devices | MN | MN |
| Design Engineer, and Energy Consulting Firm | 2 | All | National | OH, WI |
| Manufacturer | 2 | Refrigeration, Space Heating and Cooling, Industrial Heat, District Energy | Europe, North America | Finland, U.S. |
| Utility Representative | 4 | Electric and/or Natural Gas Utility | MN (SD, ND, WI) | MN |