# Thermoelectric Heat Recovery: Ranking Methodology and On-Campus Case Studies


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Path to Zero Net Energy, Spring 2015

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## Abstract

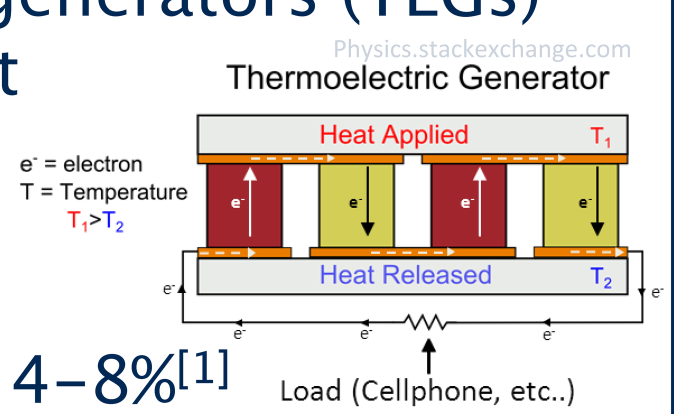

Thermoelectric heat recovery is a promising technology for heat recapture and efficiency increase where traditional heat recapture is infeasible. We developed a ranking methodology for the potential of locations for thermoelectric implementation that accounts for the accessibility of the heat source, visibility of the project, cost of power generated, on-site demand for power, and commercial relevance of the application. We applied this metric to a range of on-campus heat sources, and determined the extent to which we recommend implementing this technology on a pilot scale. These results contextualize the potential for thermoelectric heat recovery in achieving campus-wide zero net energy by 2025.


## Purpose

- Achieve zero net energy campus-wide by 2025
- Develop generalizable methodology for ranking heat sources
- Apply methodology to campus resources
- Determine role of thermoelectric heat recovery in campus facilities infrastructure

## Background

- Thermoelectrics generators (TEGs) convert waste heat directly to electricity




- Efficiency usually 4–8%[1]
  - Dependent on temperature: higher T = higher %
  - Topic of ongoing research and improvement
- Potentially useful where
  - Traditional heat exchange infeasible
  - Electricity can be readily used
  - Heat is otherwise unrecovered

## Methodology

- List criteria for a promising heat source
- Develop evaluative matrix for ranking
  - Score = Criterion Weight * Value Formula
  - Based on projected costs and benefits
  - Determined through site visits, interviews, data analysis
- Visit potential application sites
  - Photograph areas
  - Measure temperatures with
  - infrared thermometer
  - Interview staff, employees, managers
- Apply matrix to on-campus heat sources

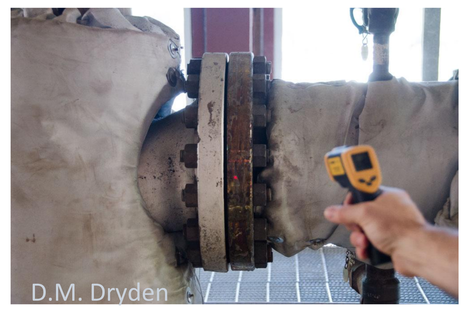
| Criteria | Criterion Weight | Value Formula |
|---|---|---|
| Accessibility | 10 | Qualitative, 0-10 |
| Image/Visibility | 10 | Qualitative, 0-10 |
| Annual Energy Recovered per $ | 8 | kWh annual /$ *2.5 |
| Demand for Power Generated | 4 | Qualitative, 0-10 |
| Commercial Relevance | 4 | Qualitative, 0-10 |

## Results

| Criteria | Criterion Weight | Steam Plant | Facility Closet | Campus Fleet | Fleet (Car) | Fleet (Truck) | Pilot Brewery |
|---|---|---|---|---|---|---|---|
| **Accessibility** | **10** | 4 | 6 | 0 | 3 | 3 | 10 |
| **Image/ Visibility** | **10** | 0 | 0 | 6 | 4 | 4 | 10 |
| **Annual Energy Recovered per $** | **8** | 10 | 7 | 10 | 0 | 0 | 1 |
| **Demand for Power Generated** | **4** | 0 | 5 | 10 | 10 | 10 | 5 |
| **Commercial Relevance** | **4** | 0 | 0 | 10 | 10 | 10 | 7 |
| **Total Score** | **--** | **120** | **136** | **130** | **150** | **150** | **256** |

### Steam Plant

- Low-quality heat: max 175 °C
- Limited area for application
- No substantial power demand
- Heat needed as heat: better insulation
- Already extremely efficient!


### Facilities Closets

- Low-quality heat: max 160 °C
- No substantial power demand
- Heat needed as heat: better insulation
- Asbestos hazard poses health risks

### Fleet Services

- High temperature
- "True" waste heat
  - Cannot be recovered as heat usefully
  - 40% of total fuel power wasted[2,3]
- Difficult, expensive to implement
  - Cost per vehicle: \$3000–6000/kW[2]
- Low direct visibility, but good press
- Substantial savings
  - ~5% increase in fuel economy[3]
  - 17,000 gallons of fuel saved
  - 170 tons of $CO_2$ emissions offset per year[4]
- Large data set eases further analysis



### Pilot Brewery

- Low-quality heat: max 100 °C
- Low duty cycle limits power generated
- Excellent visibility
  - Classes
  - Extension classes
  - Industry contacts
  - Well-known and prestigious facility
- Easy to implement
  - Simple installation
  - Highly conductive surface
- High commercial relevance
  - Directly transferrable to small breweries


## Recommended Actions

- Implement pilot brewery TEGs
  - High visibility
  - Ease of access
  - Transferable directly to industry
- Explore automotive implementation
  - Directly offsets Category 1 emissions
  - Work with existing research projects (e.g. GM)
  - Seek grant money to cover costs
- Develop less expensive technology
  - Efficiency/\$ must improve for economic justification
  - Need ~10-fold cost reduction for automotive[1]

## Conclusions

- Limited implementation feasible
  - Fleet Services
  - Pilot Brewery
- Technology still immature
- Extreme efficiency of existing facilities limits opportunities for implementation

## Acknowledgments


Josh Morejohn, Facilities Management
Prof. Chris Simmons, Food Science
Dan McCann, Fleet Services
David Franklin, Fleet Services
Sweta Agarwal, Facilities Management


## References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