Campus Energy 2023:

Case Study – Western Michigan University

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Topics for Discussion

1 Introduction & Background

2 Decision

3 SGT-A05HE Performance

4 Commercial

5 Installation Complete

1. Introduction & Background

Combined Heat and Power for Campus and Hospital

Western Michigan University:

- Located in Kalamazoo, Michigan
- 16,643 students, 864 full-time academic staff
- 1 of 133 public institutions classified as high research university[1]
- Top 100 in the nation for six graduate programs[2]
- Excellence in Diversity Award[3]
- 100+ study abroad programs in 40 countries
- WMU Broncos compete in NCAA Division I Athletics

Kalamazoo Psychiatric Hospital

- 201 staffed bed facility, opened in 1859, and operated by Michigan Department of Health and Human Services

Western Michigan University

Western Michigan University

Kalamazoo Psychiatric Hospital

[1] Carnegie Foundation, [2] US News and World Report, [3] Insight into Diversity

1. Introduction & Background

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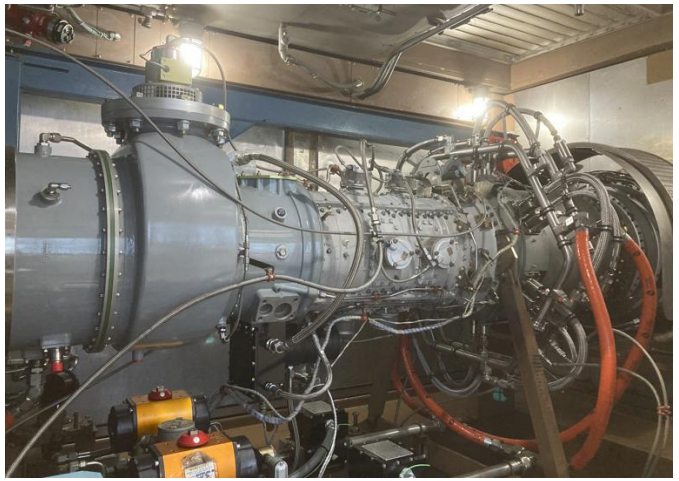


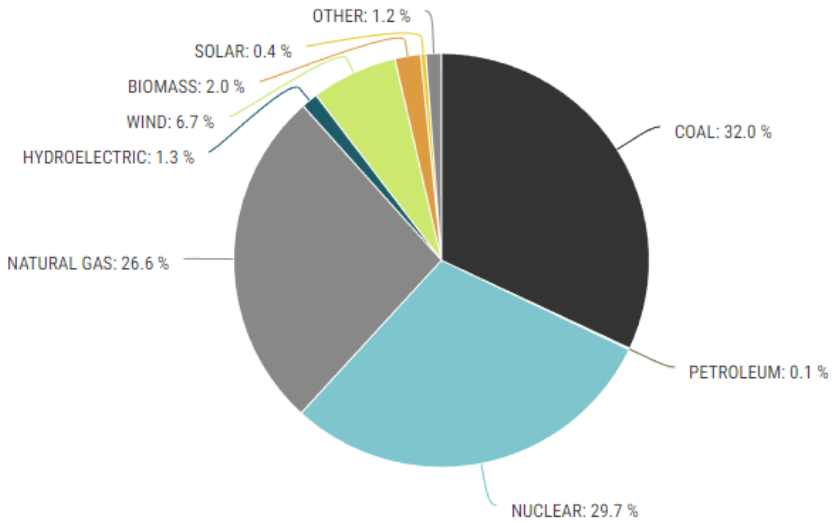
- Fuel input:
  - 275 psig high pressure natural gas, purchased from Consumers Energy
- Main operating hardware (excluding black-start and backup systems):
  - Two Siemens Energy SGT-A05 5+ MW gas turbines
  - One 900 kW steam turbine
  - Three boilers and two heat recovery steam generators
- Output:
  - Electricity is distributed to campus at both 13.8 kV and 2.4 kV, and to the Kalamazoo Psychiatric Hospital at 2.4 kV.
  - Steam is generated at 200 psig, 480 ºF

1. Introduction & Background

U.S. Energy Information Administration

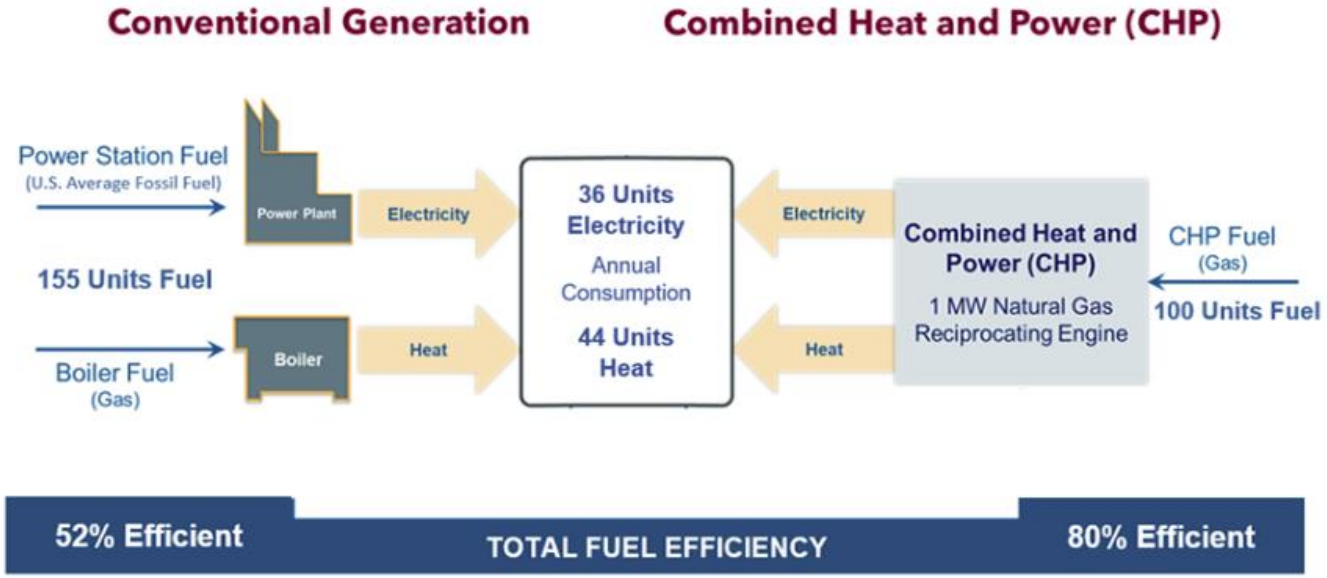
Michigan State Energy Profile

2021 Net Annual Electricity Generation by Fuel Type



Total GWh: 115,728
source: U.S. Energy Information Administration, Open Data API, Electricity: Net Generation by Fuel Type

Conventional Generation vs. CHP: Overall Efficiency



https://www.epa.gov/chp

- **Conventional** heat and power generation: 155 units of energy inputs to produce 80 units of useable output (efficiency of ~50%)
- **Combined** heat and power generation: 100 units of energy inputs to produce the 80 units of usable output (efficiency of ~80%)
- **Simple-cycle** gas turbine follows the Brayton Cycle and makes no use of waste heat (electrical efficiency of ~30%)

2. Decision – New SGT-A05 KB7HE

+ Pro

1. All parts have zero hours.
2. One-year parts and labor warranty.
3. HE engine is more efficient than KB7.
4. More reliable; 25 years of product improvement.
5. Demonstratable lower cost of ownership; lower parts cost.
6. 50% to 100% turndown at 25ppm NO_x and 50ppm CO.
7. Upgradeable to ultra-low emissions technology (15ppm NO_x and 25ppm CO; with 50% to 100% turndown.)
8. Sets WMU foundation for next 20+ years.

Sets foundation for future partnership between Siemens Energy and WMU for upcoming "Green Initiatives".

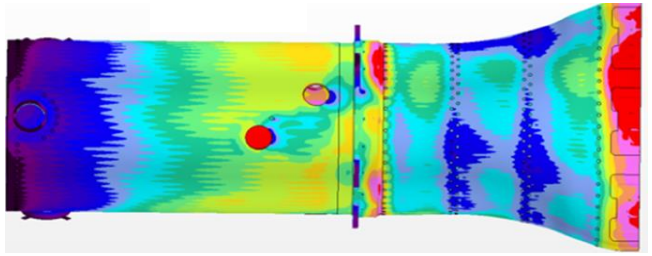
– Con

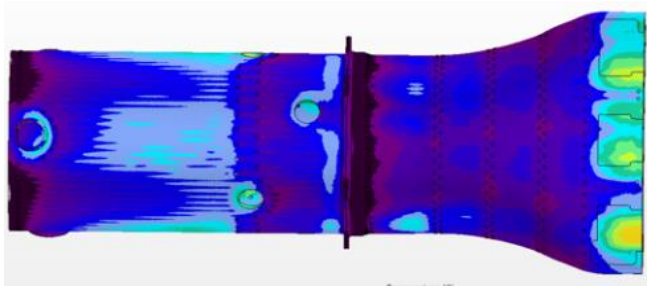
1. HE engine will require some berth modifications.
2. Potential need for emissions re-permitting[1].
3. (Potentially) higher capital investment.

[1] It was soon determined that per Michigan Department of Environment, Great Lakes, and Energy (EGLE), repermitting would not be required since the SGT-A05 KB7HE is a variant of the KB7 engine.

3. SGT-A05HE Performance

Other SGT-A05 Modernization Enhancements



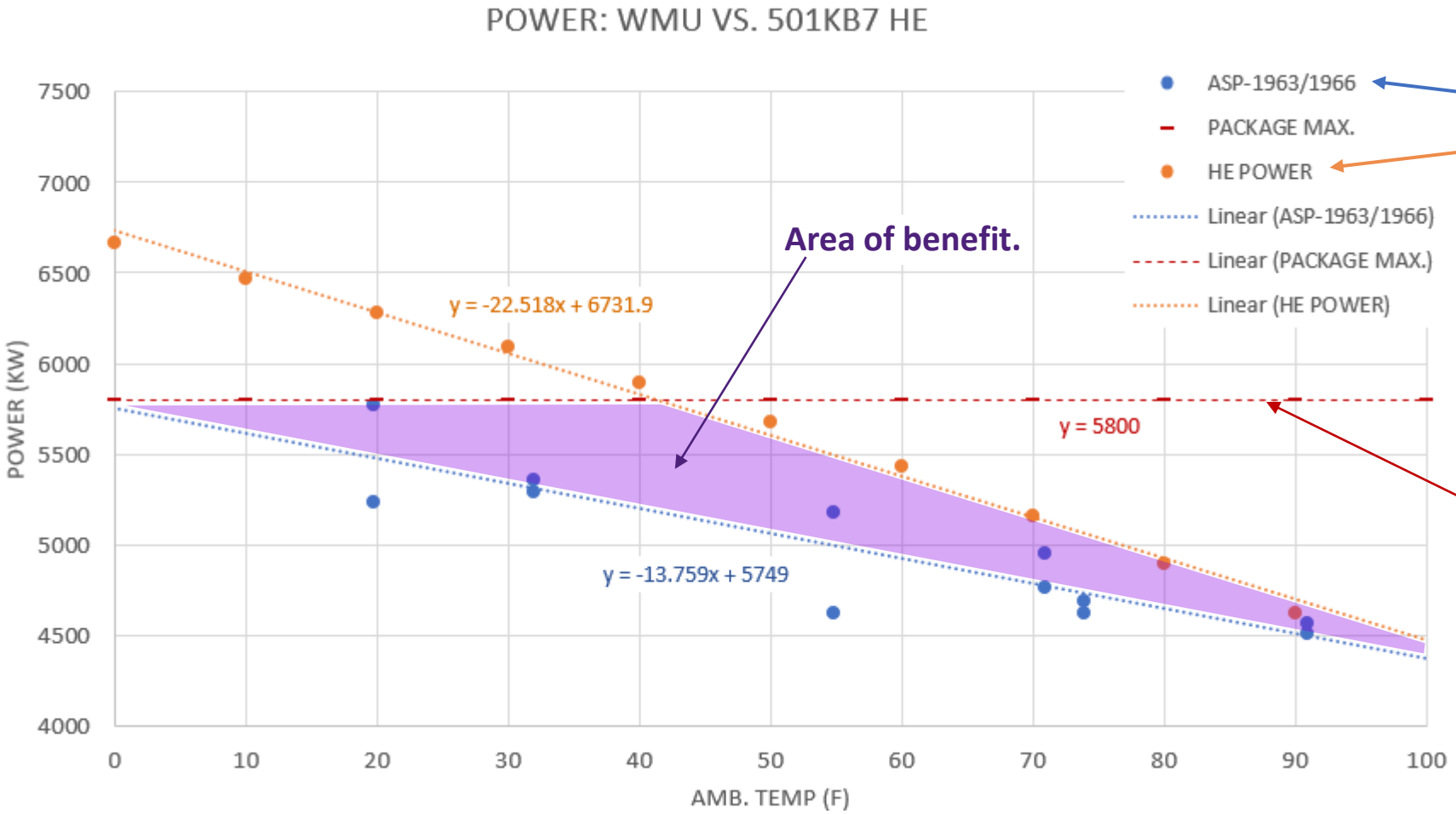


1. Compressor Module
   - Improved air sealing: higher performance and efficiency.
   - Redesigned vanes: improves reliability and resiliency.
   - Hybrid ceramic bearings: improves reliability and resiliency.
2. Combustion Module
   - DLE combustion liners are upgradable to ULE liners offering:
   - Improved emissions: <15 ppm NOx and <25 ppm CO @ 50 to 100% load.
   - Longer life: improved channel cooling lowers combustion liner temperature
3. Turbine Module
   - Larger, more powerful and efficient turbine module.
   - Air cooled, directional solidified first stage blades: improves reliability and resiliency.

4. Future Enhancements
   - SGT-A05 engine will be future upgradeable to 100% H_2 burning capable.

4. Commercial

Power Generation: KB7 versus KB7HE

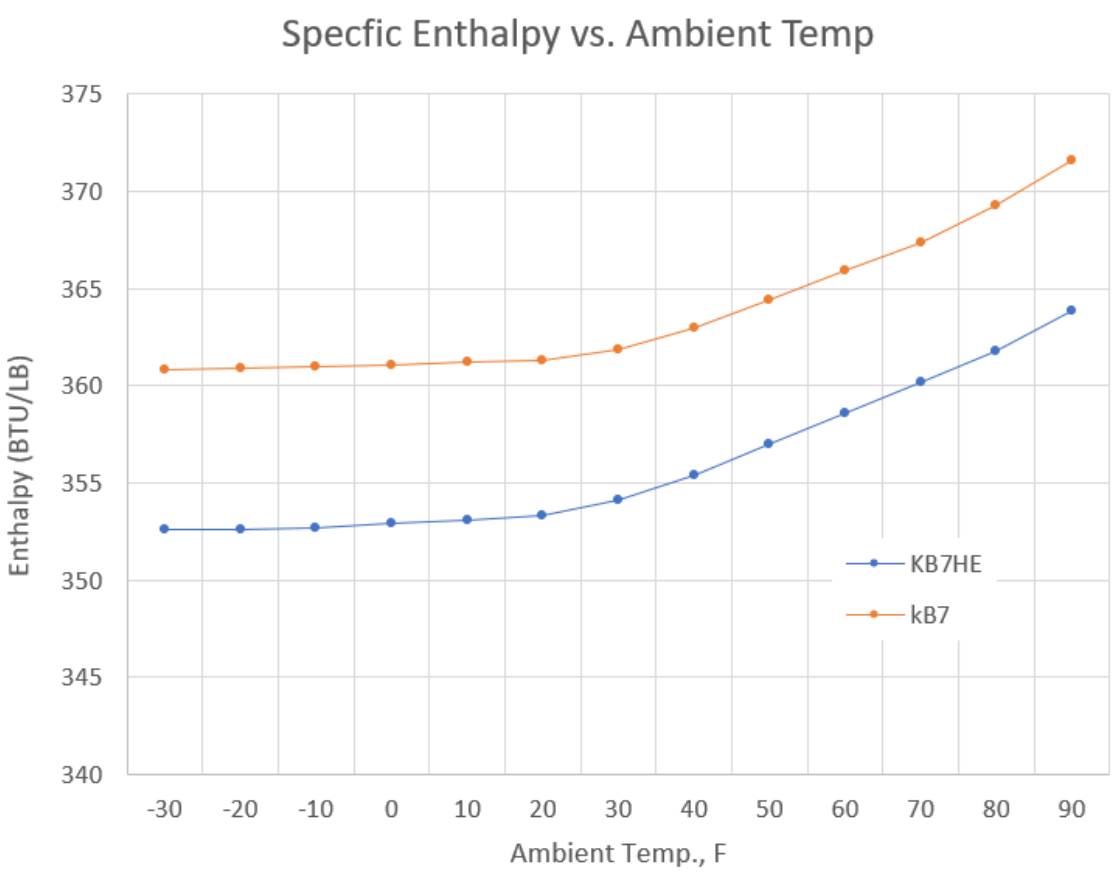


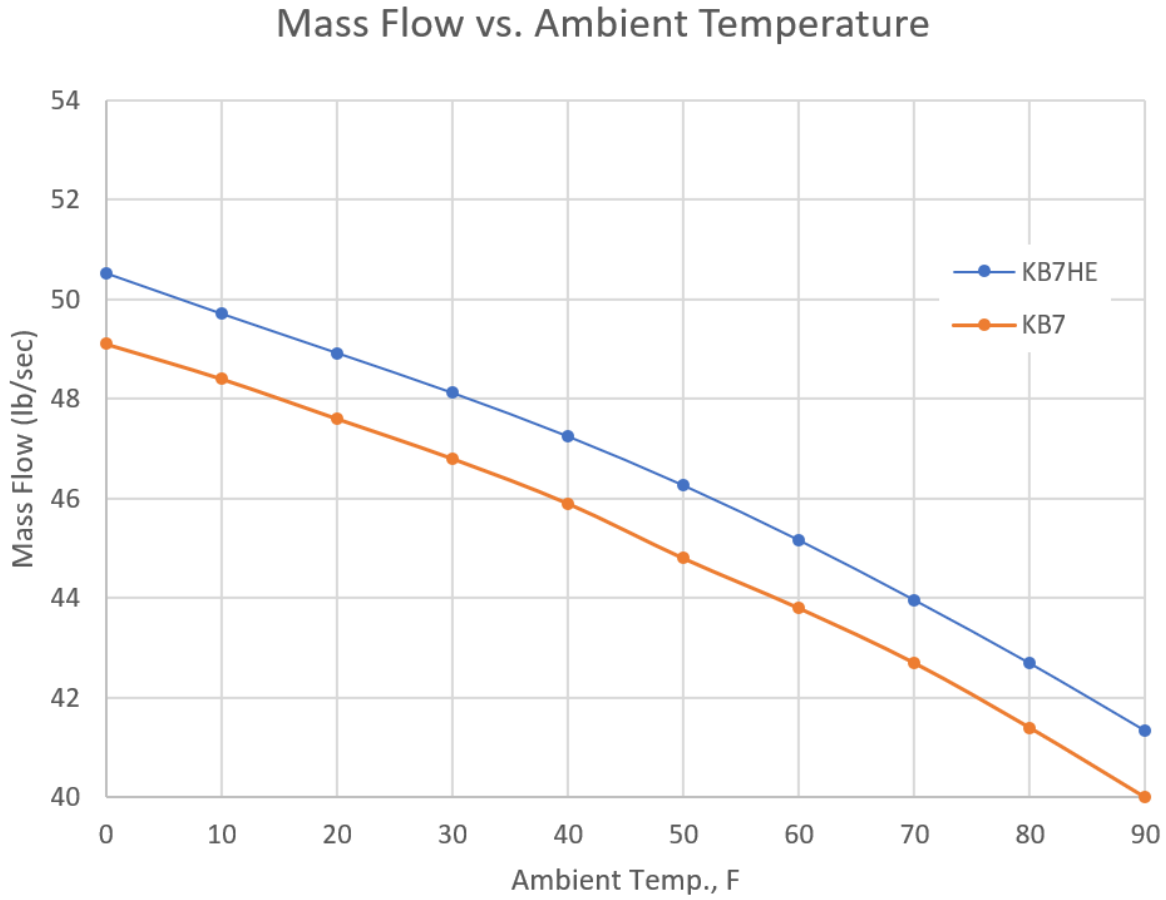
	Output	Efficiency
KB7	4.9 MW(e)	29.7%
KB7HE	5.8 MW(e)	33.2%

Cold-day benefit limited by existing AC generator hardware. Capped at 5.8MW.

4. Commercial

Heat Generation: KB7 versus KB7HE





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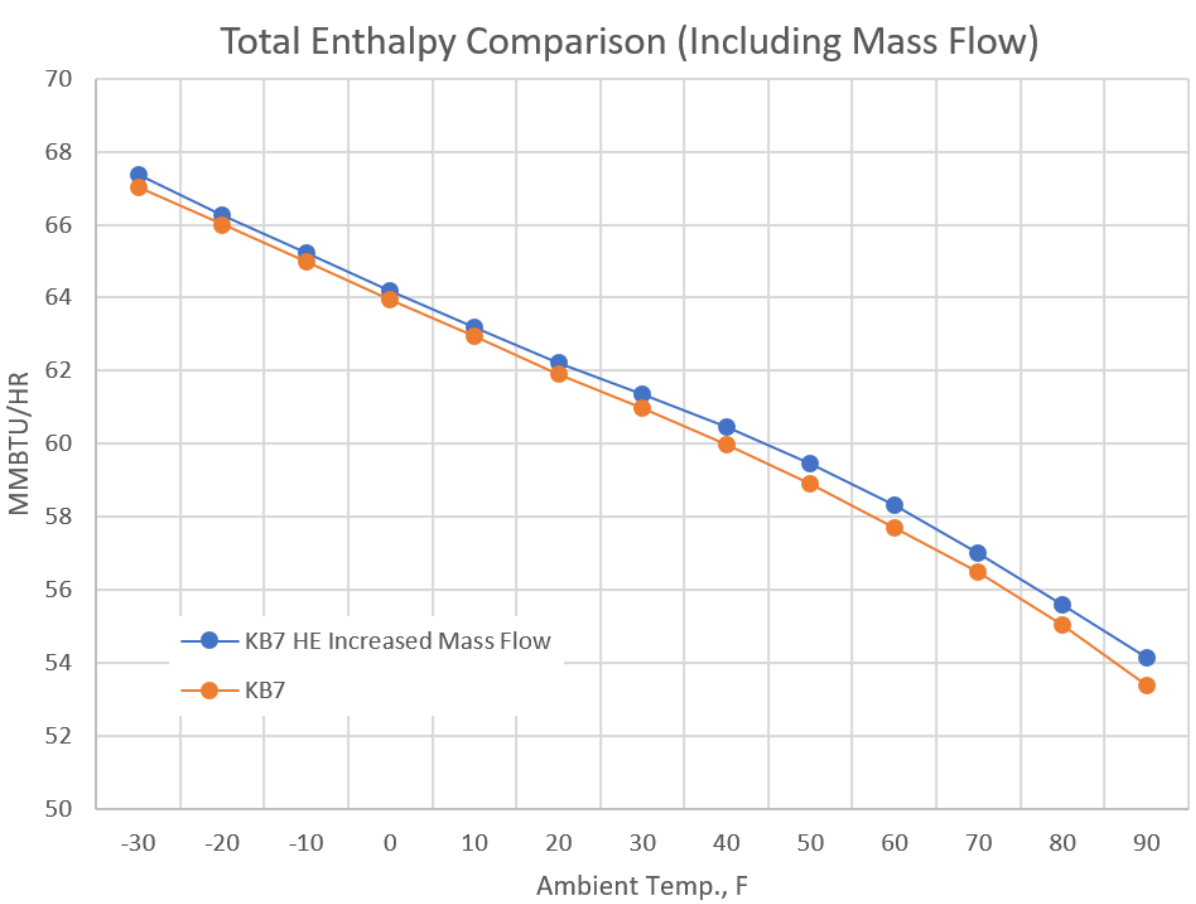
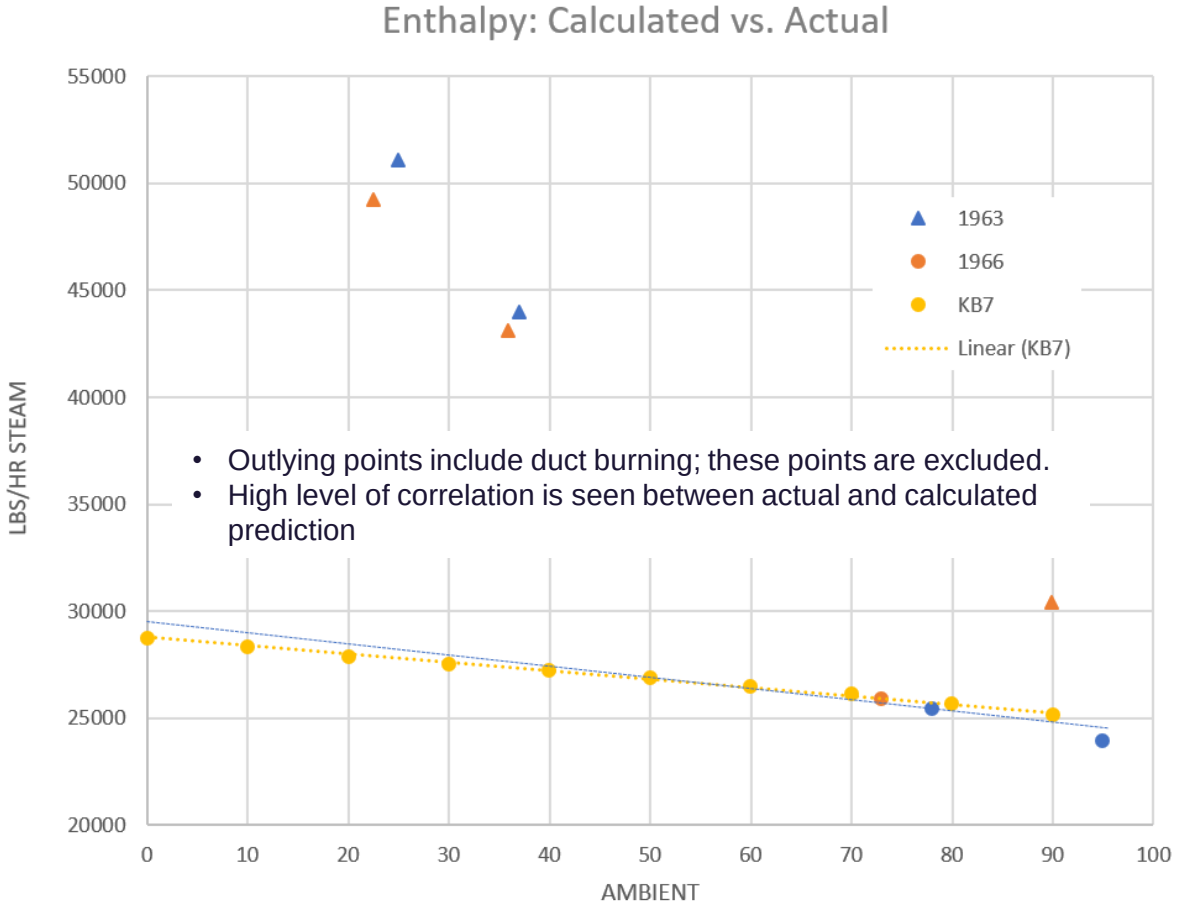
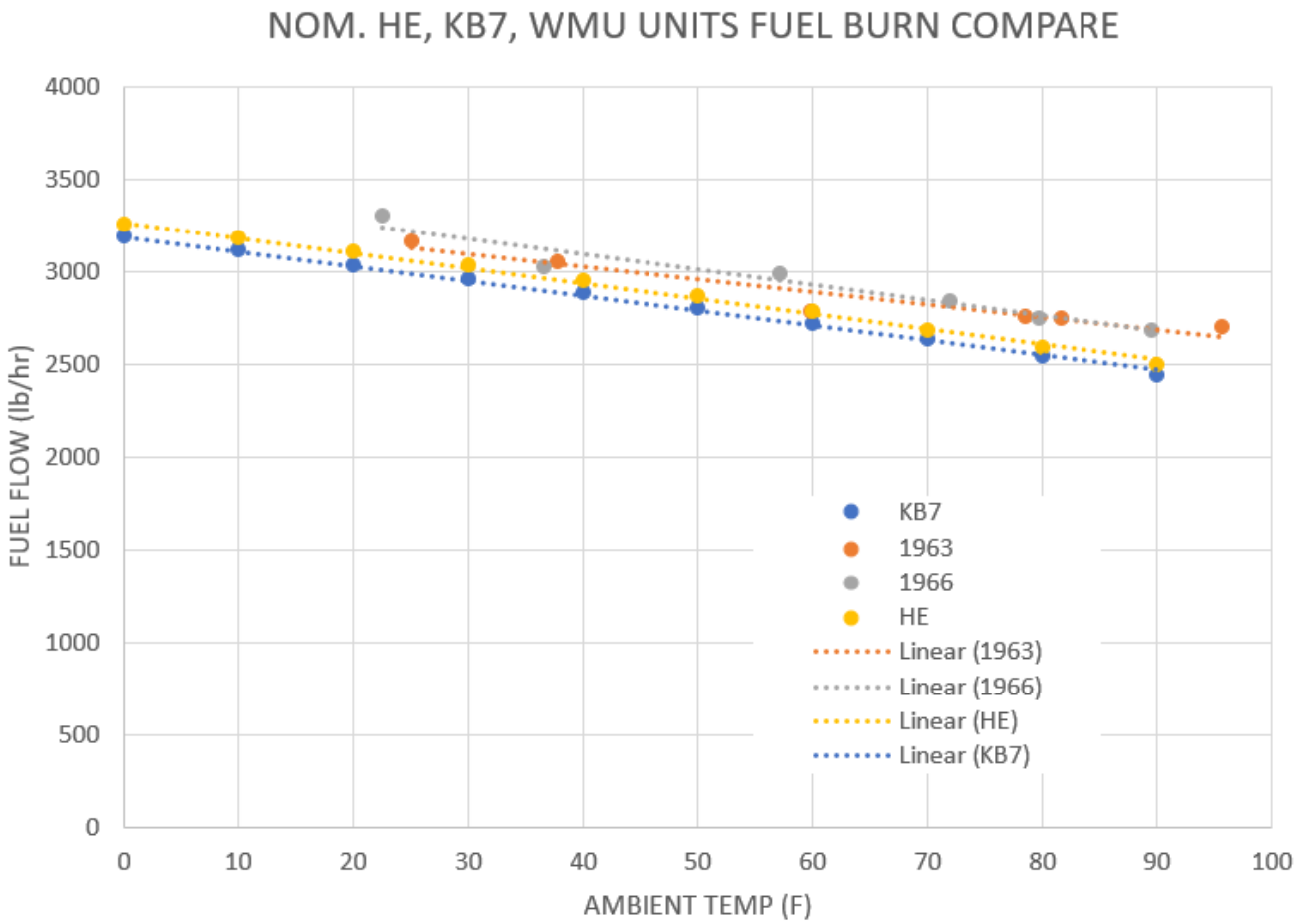
Heat Generation: KB7 versus KB7HE





4. Commercial

Fuel Burn: KB7 versus KB7HE



4. Commercial

CHP Summary: KB7 versus KB7HE

- Power increases with HE over existing KB7 equipment but is limited by existing gearbox and AC generator.
- Total enthalpy (as measure of steam heating energy) of KB7HE is equal to or exceeds heat output of existing KB7.
- The fuel consumption of new, higher efficiency, KB7 HE is the same or lower fuel consumption than current ASP-1963 and ASP-1966.

4. Commercial

Operational Benefit: KB7HE

Simple average of high and low temperatures for each month.

Maximum power is limited by external gearbox and AC generator.

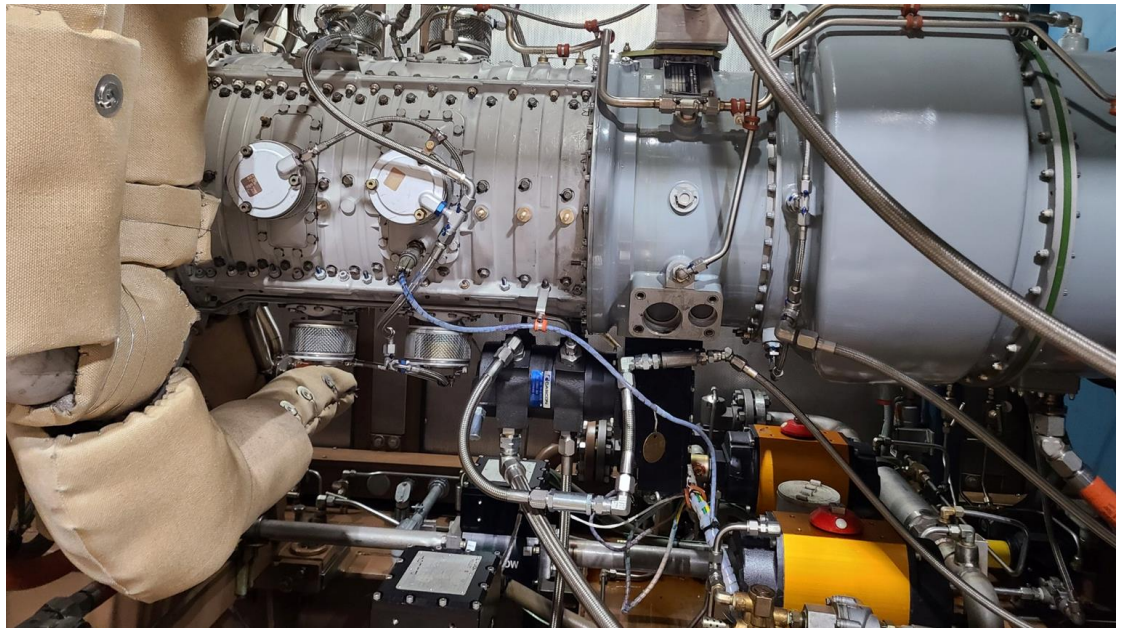
=min(HE, Max) - WMU

Month	Ambient, F	Ambient, C	WMU, kW	HE, kW	Max.	Benefit, kWh	Days	Hours/Mo	kWh/Mo	$/kWh	$/Mo
January	24.3	-4.3	5,415	6,185	5,800	385	31	744	286,696	$0.10	$28,670
February	26.9	-2.9	5,380	6,127	5,800	420	28	672	282,528	$0.10	$28,253
March	36.7	2.6	5,244	5,905	5,800	556	31	744	413,631	$0.10	$41,363
April	49.3	9.6	5,071	5,623	5,800	552	30	720	397,094	$0.10	$39,709
May	59.8	15.4	4,927	5,386	5,800	460	31	744	341,905	$0.10	$34,191
June	68.9	20.5	4,802	5,182	5,800	380	30	720	273,487	$0.10	$27,349
July	72.6	22.6	4,750	5,097	5,800	347	31	744	258,165	$0.10	$25,817
August	70.9	21.6	4,774	5,136	5,800	362	31	744	269,570	$0.10	$26,957
September	63.4	17.4	4,877	5,305	5,800	428	30	720	308,172	$0.10	$30,817
October	51.5	10.8	5,041	5,573	5,800	532	31	744	395,994	$0.10	$39,599
November	41.2	5.1	5,182	5,804	5,800	618	30	720	444,867	$0.10	$44,487
December	29.3	-1.5	5,346	6,072	5,800	454	31	744	337,879	$0.10	$33,788
							365	8,760			**$400,999**

Projected incremental income per year per unit

5. Installation Complete

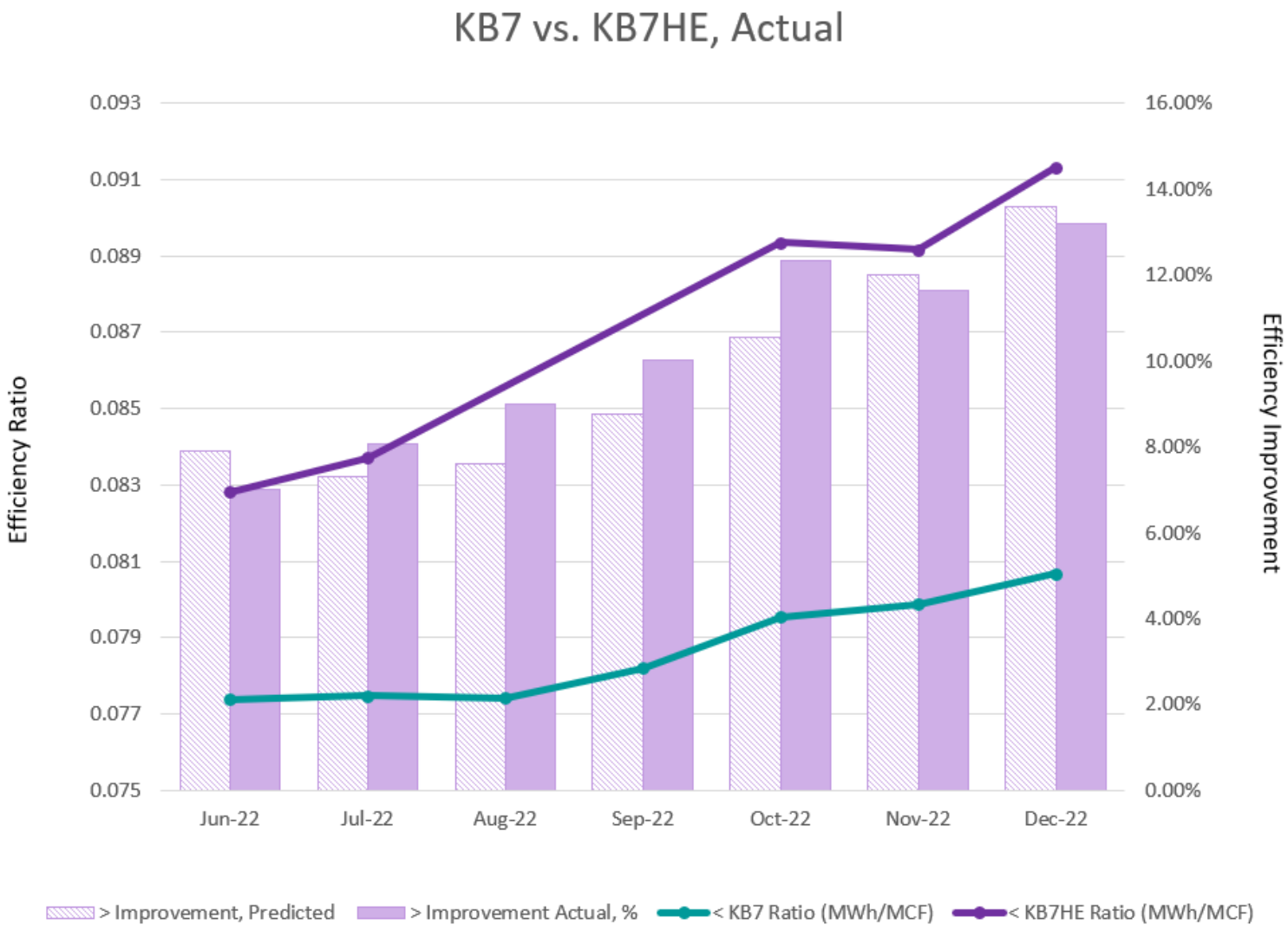
SGT-A05 KB7HE gas turbine installed in existing berth.



New compressor bleed air silencer and exhaust for CO turndown.

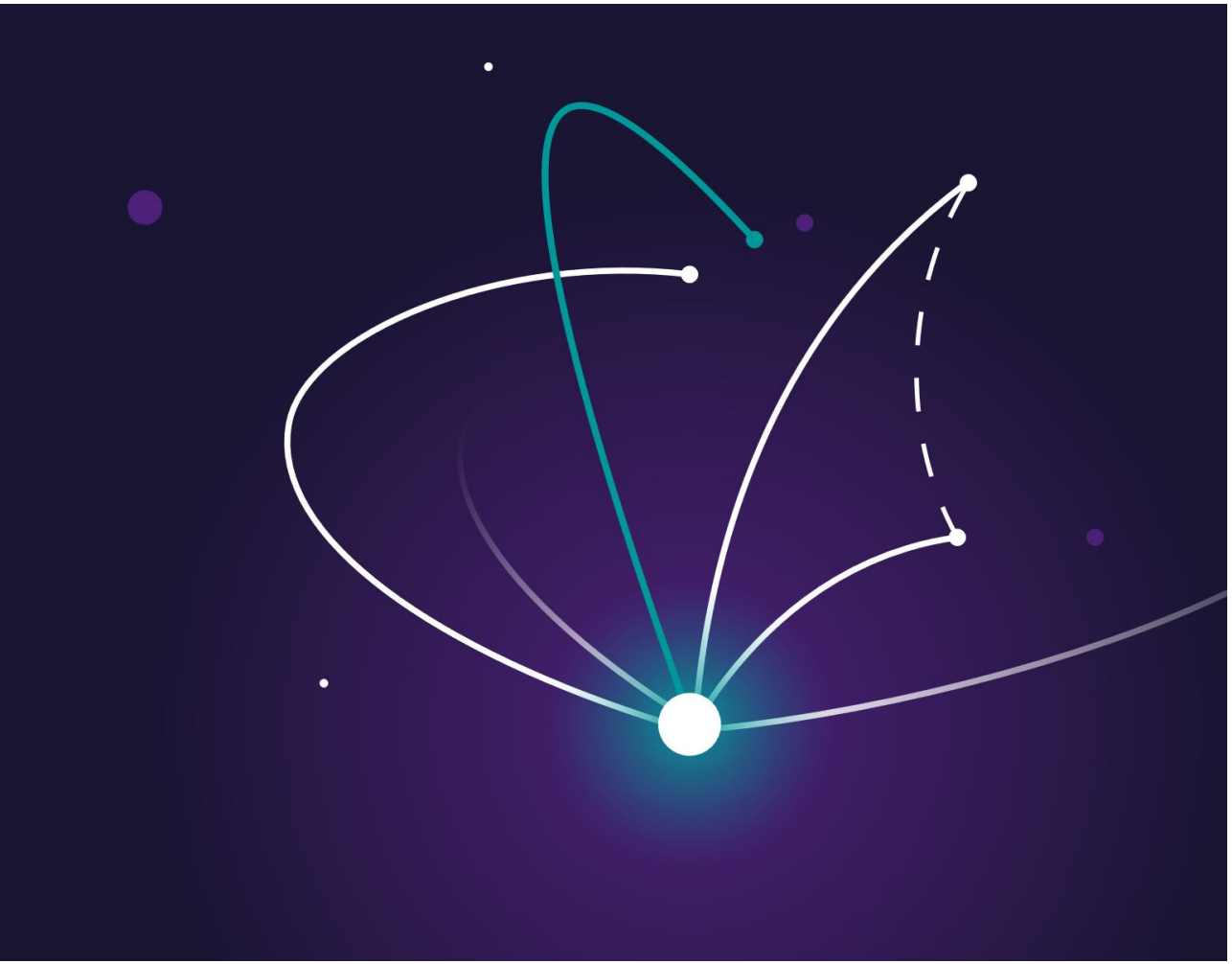
5. Installation Complete

Confirmation of Performance Projections



- Actual performance correlates very well with predicted performance.
- Small variations seen associated with “warmer than expected” or “cooler than expected” months.
- WMU now selling electricity back to grid at prevailing rates and seeing significant electricity credits.
- WMU’s CHP electricity is generated at higher efficiency and lower carbon footprint than state of Michigan.

Contact



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