THE TOLEDO MUSEUM OF ART

Energy Cost Reduction Plan

The Toledo Museum of Art

Prepared by

David R. Blair, P.E.

President & CEO

BHP Energy Solutions, Ltd.

January 18, 2005

Project

Project: CHP, Four (4) Capstone C60-JCHP MicroTurbines

Museum Director: Don Bacigalupi

Chief Operating Officer: Carol Bintz

Manager Physical Plant/Capital Projects: Paul Bernard

Turnkey Design/Build Contract

BHP Energy Solutions, Ltd.

Sub-Contractors

GEM Industrial, Inc. **Romanoff Electric, Inc.**

VM Systems, Inc. **Groskopf Engineering, Inc.**

Equipment

Capstone Turbine Corporation

Copeland Corporation

State Grant

Release of RFP		***May 16, 2003***
Submittal Deadline	***3:00 p.m.***	***June 27, 2003***
Award Announcement		***July 11, 2003***

Award: Min 1:1 Cost Share, Max Award $75,000

Eligible Technologies:

- *Clean burning reciprocating engines (must meet California Standard)*
- *Industrial turbines*
- *Microturbines*
- *Bio Mass*
- *Landfill Gas*
- *Innovative use of waste heat/CHP/Cogeneration*

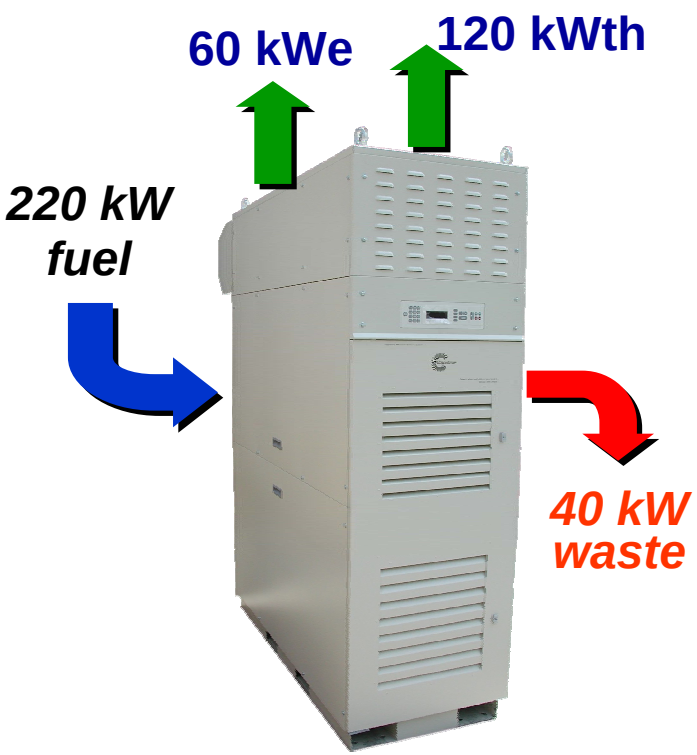
The Toledo Museum of Art

- Excellent fit for exhaust heat recovery
- Utility Interconnection
  - Ohio Net Metering Law favors microturbine
  - UL 1741 Compliance
- Environmentally friendly clean exhaust
- Economics favor reasonable investment payback
- Back-up power during grid failure

Less Fuel, Less Waste, Less Smog

Capstone C60-ICHP: 80% fuel efficiency

- 0.15 lb/MWh smog-forming NOx (97% less)
- 1,540 lb/MWh greenhouse gas CO_2 (47% less)



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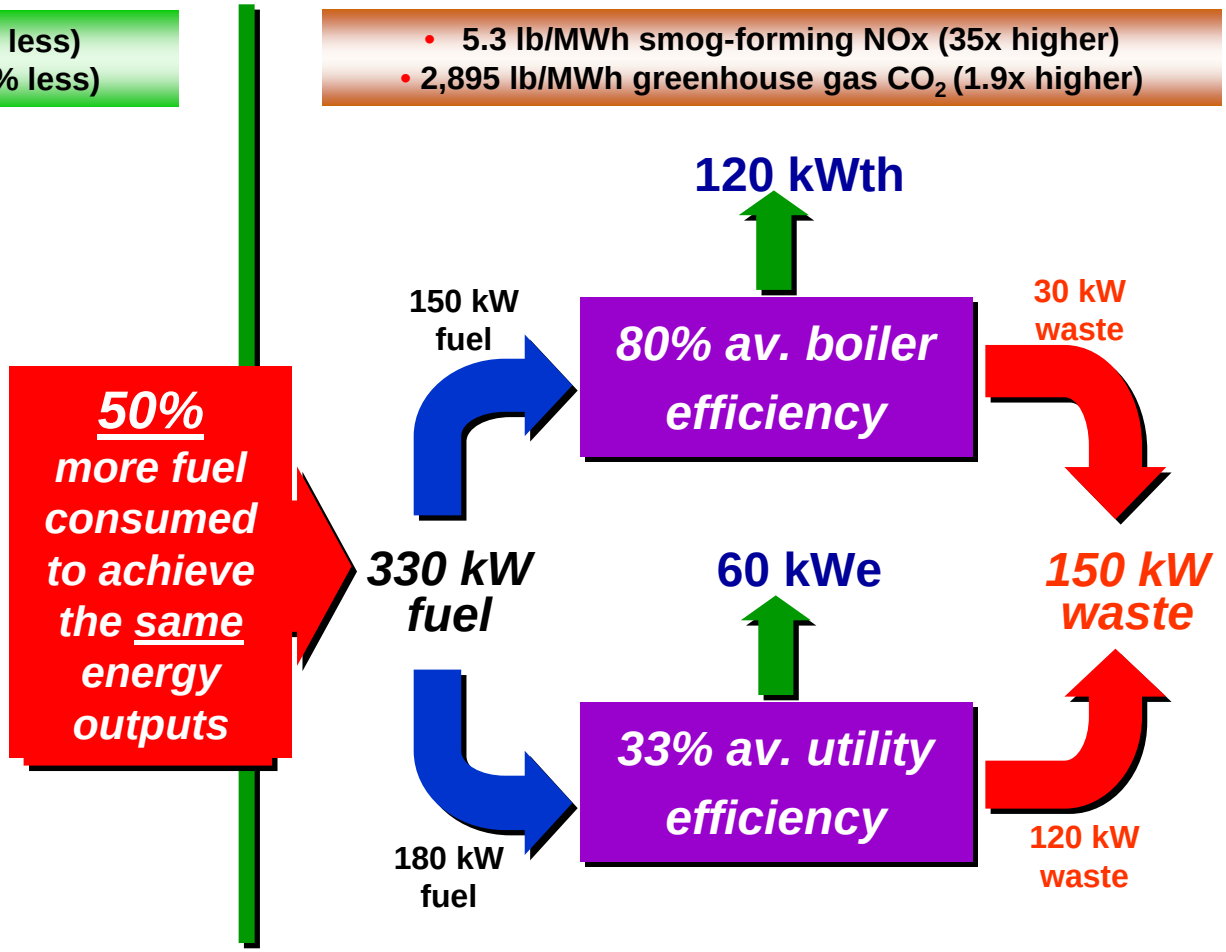
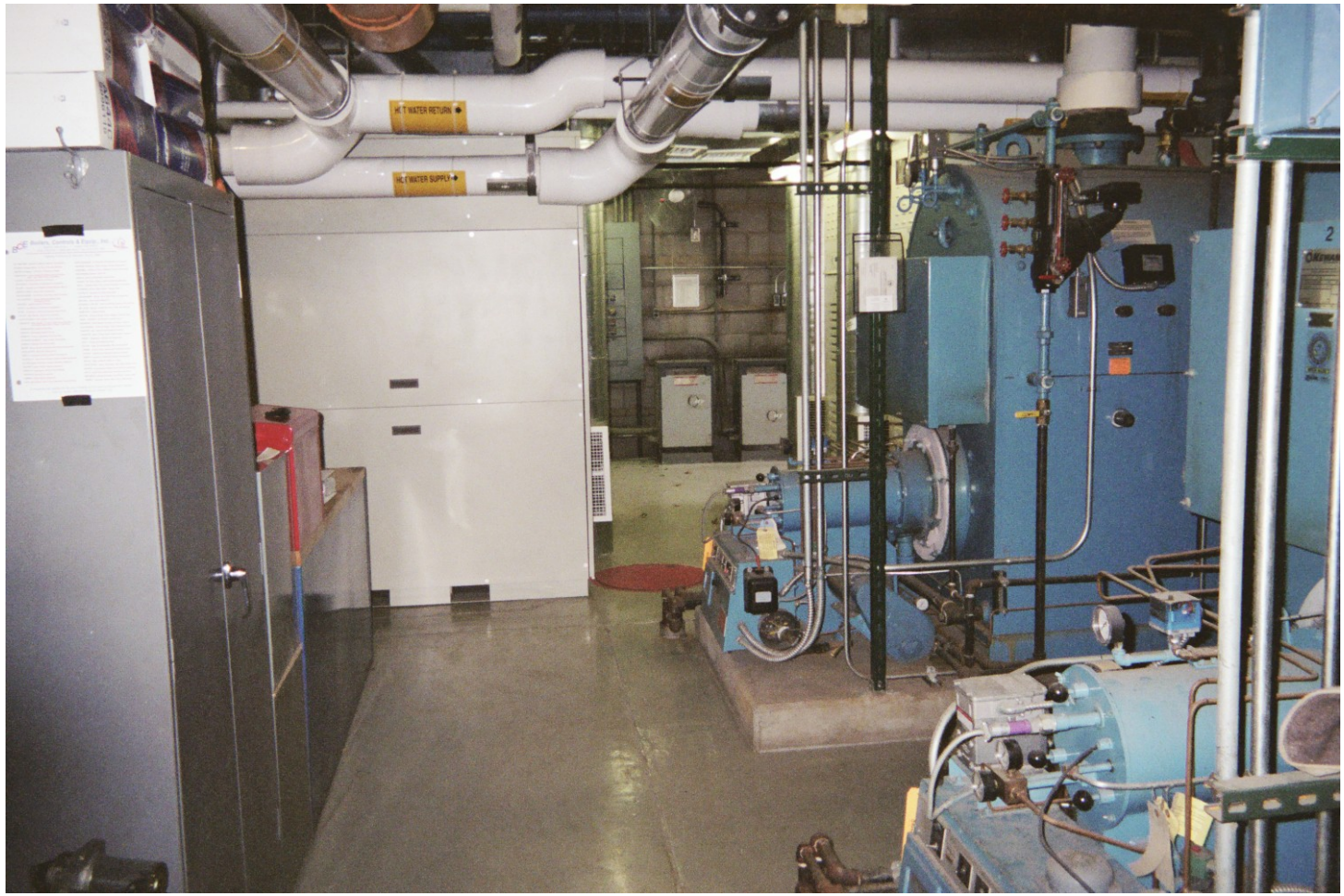


Source: US EPA and US DOE, see notes page for specific references

Microturbine CHP Application



Microturbine CHP Application

Microturbine CHP Application

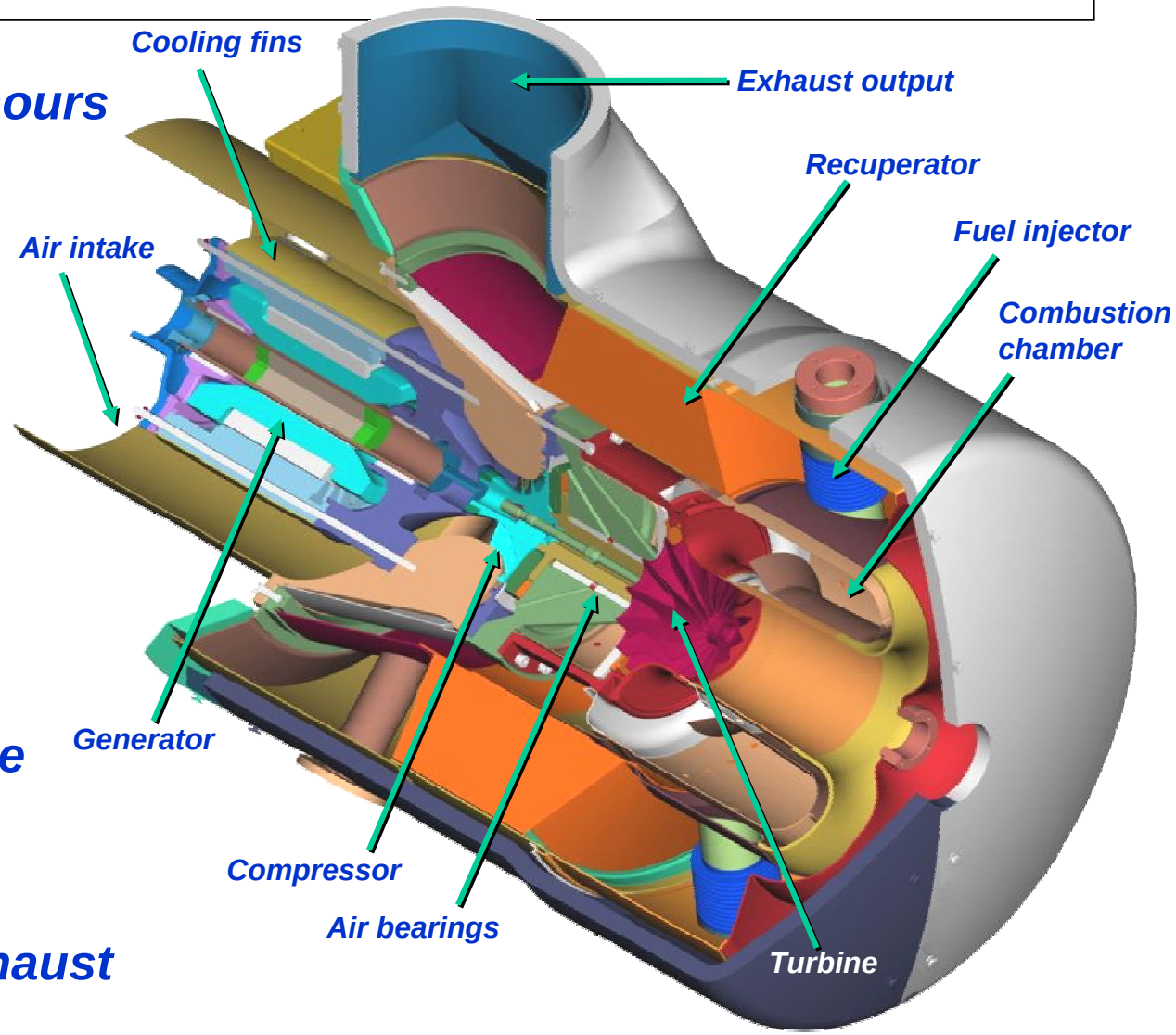
Timeline

• *Feasibility Study*	*June 12, 2003*
• *Grant Award*	*July 22, 2003*
• *TMA Review & Approval*	*8 months*
• *Contract Release*	*March 19, 2004*
• *Engineering*	*12 weeks*
• *Microturbine Delivery*	*10 weeks*
• *Drawing Release for Construction*	*June 17, 2004*
• *Interconnection & Air Permits*	*10 days to 8 weeks*
• *Start-up & Commissioning*	*Sept. 28, 2004*
• *Project Complete*	*Oct. 28, 2004*

Microturbine Engine

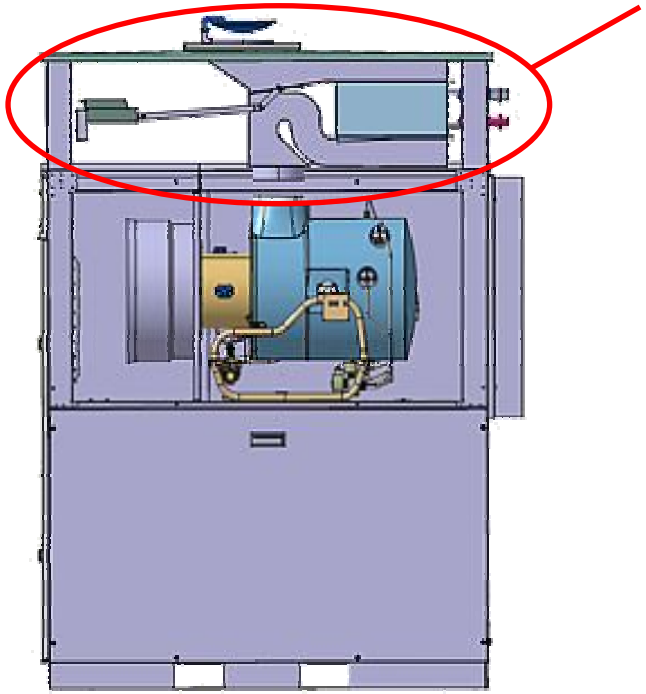
Deep Inside the Capstone MicroTurbine

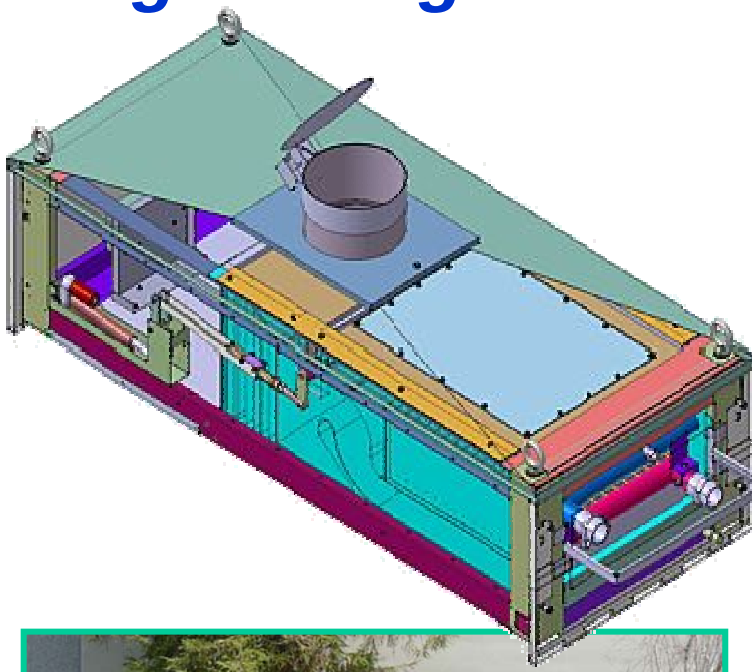
- Over 8.5 million operating hours
- One moving part
- No coolants or lubricants
- No gearbox or subsystems
- Super-low NO_X
  - 2003 CARB DG certified
  - Endorsed by the SCAQMD
- Compact and lightweight
- Comparably low cost
- Low scheduled maintenance
  - minor: once/yr (8,000 hrs)
  - major: once/5yrs (40,000 hrs)
- Clean, contaminate-free exhaust



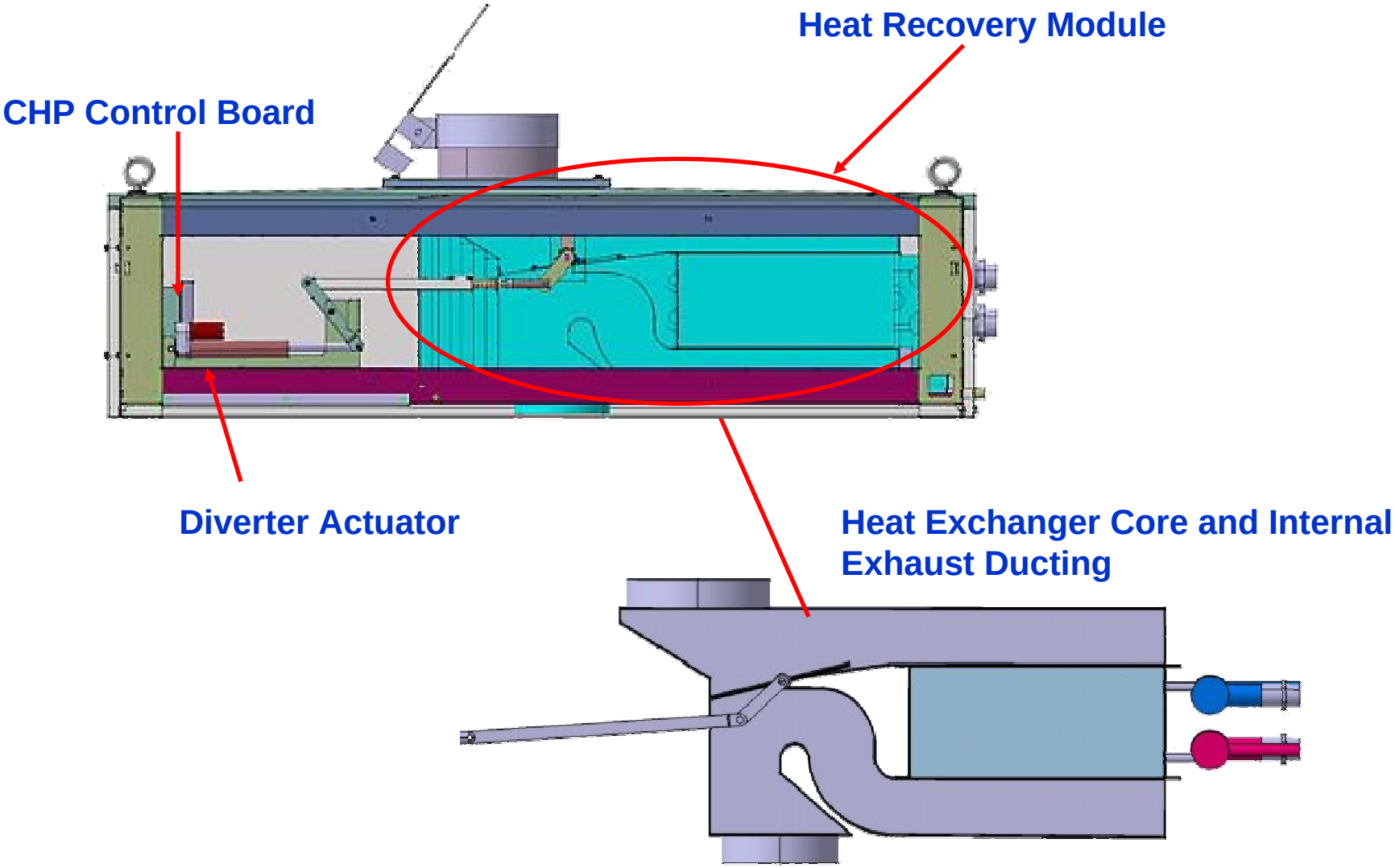
Hot Water CHP with the New C60-ICHP

Compact heat exchanger designed & manufactured by Capstone Turbine





Heat Recovery Module Elements



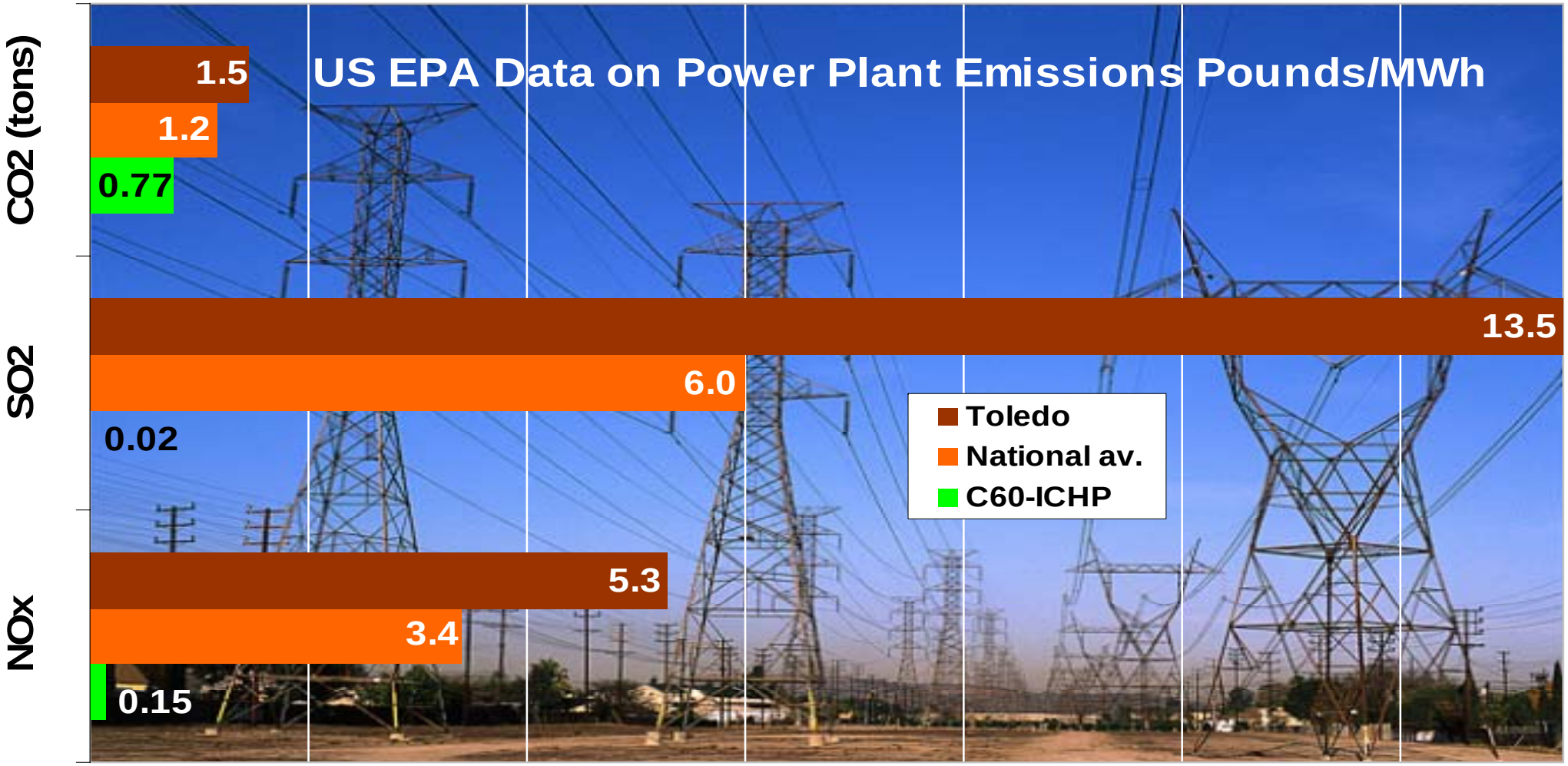
Utility Interconnection

- Ohio Net Metering Law favors microturbine
  - Use PUCO Short Form for 300kW or less
  - Up to 1% of Utility Generation Capacity
  - No stand-by charges
- UL 1741 Interconnect Standard
  - Capstone MicroTurbine in Compliance
  - Protective Relay Standard
- Utility Tariff, Medium General Service
  - Accepts Net Metering Rider
  - Customer generation up to 300kW
- Other Considerations

Environmentally Friendly

- Air Permit Considerations
  - Pre – Approval = California and New York
  - Ohio requires “minor source” PTI and PTO
- Applicable emissions = PE, SO2, NOX, CO, and VOC
- Ohio Rule 3745-15-05 “De Minimis” Source Exemption applicable if less than 10 pounds per day
- EPA Test Report for Capstone C60 MicroTurbine
  - All emissions below “De Minimis” except CO
  - At 100% load, CO measured at 0.15 lb/day
  - At 50% load, CO data is 16.27 lbs/day
- Other Considerations

Emissions: Capstone C60-ICHP vs. utility power & boiler



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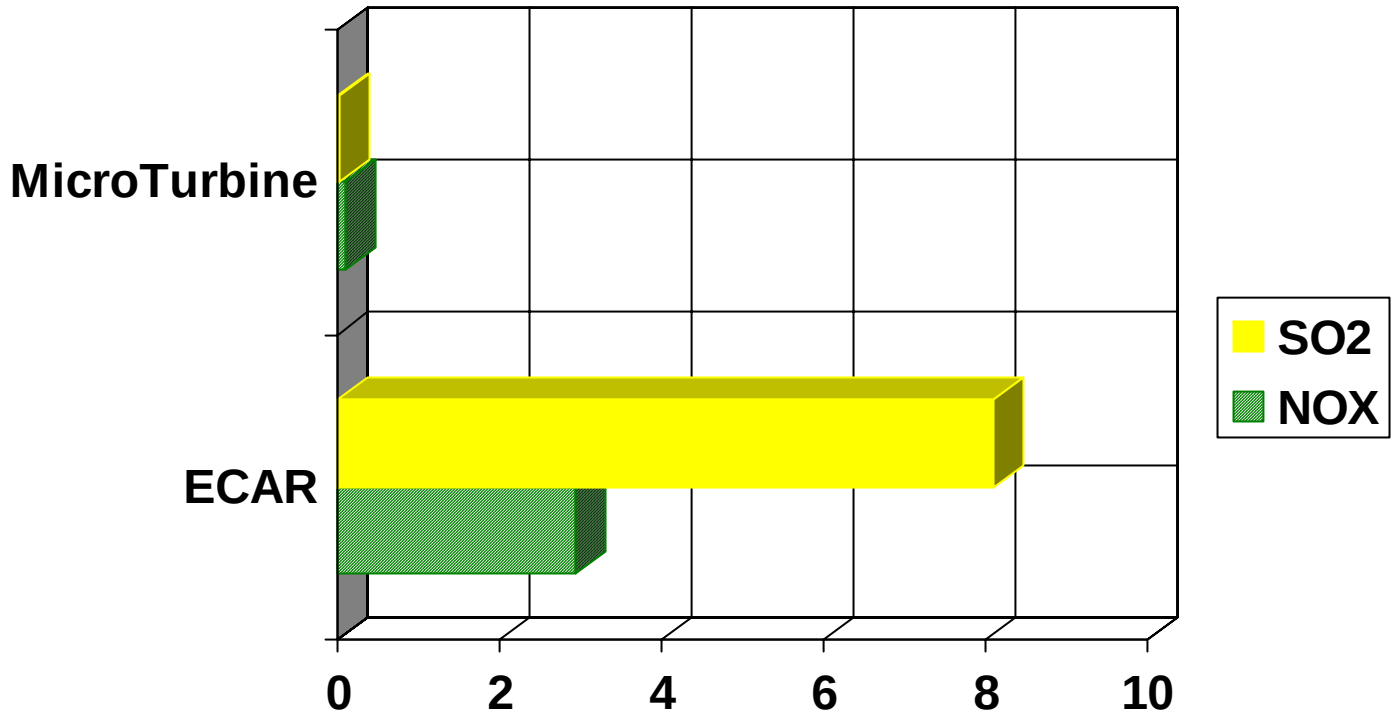
Environmentally Friendly

MicroTurbine compared with Utility Power Plants

TONS PER YEAR

- Toledo Museum
- 240kW Generation
- 5,000 Hrs per year



REDUCED EMISSIONS: (4)60kW MicroTurbines compared with ECAR Power Plants

* Reference EPA Test Data for Capstone C60 and EPA published data for ECAR emissions

Environmentally Friendly

MicroTurbine compared with Utility Power Plants

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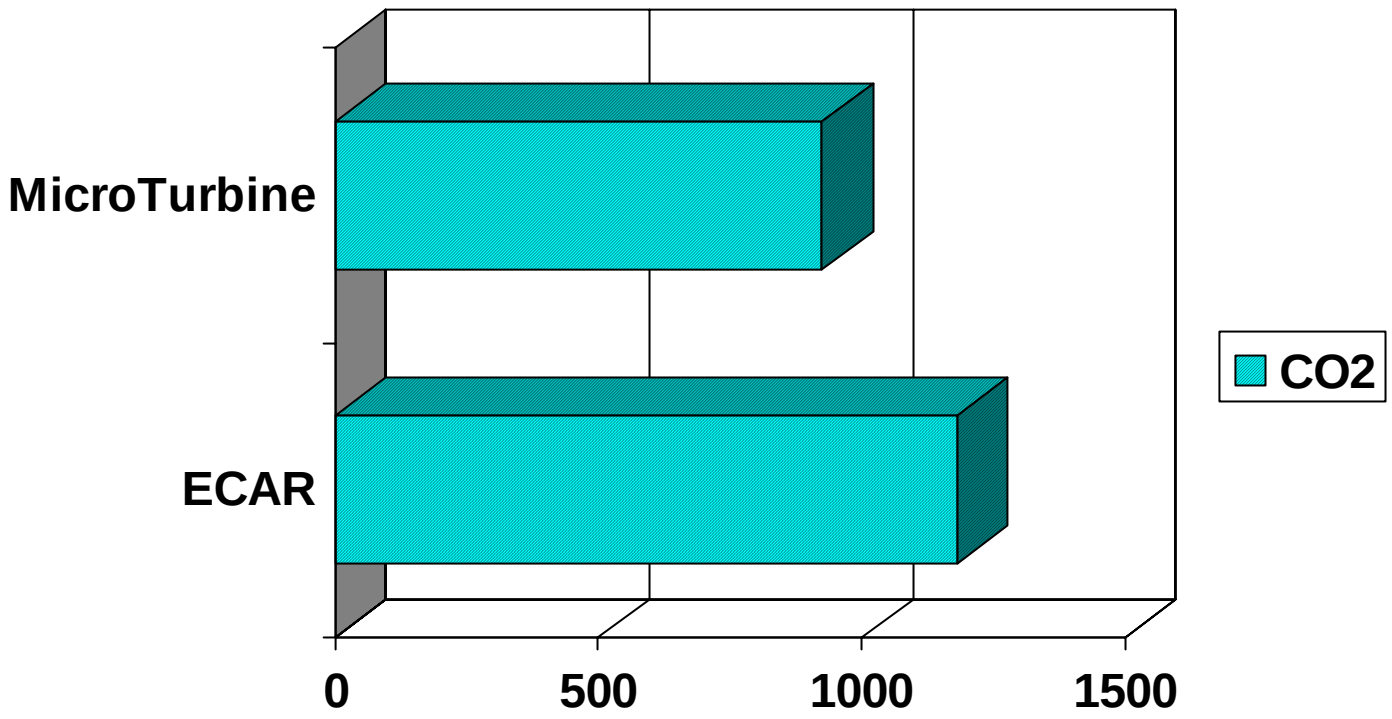

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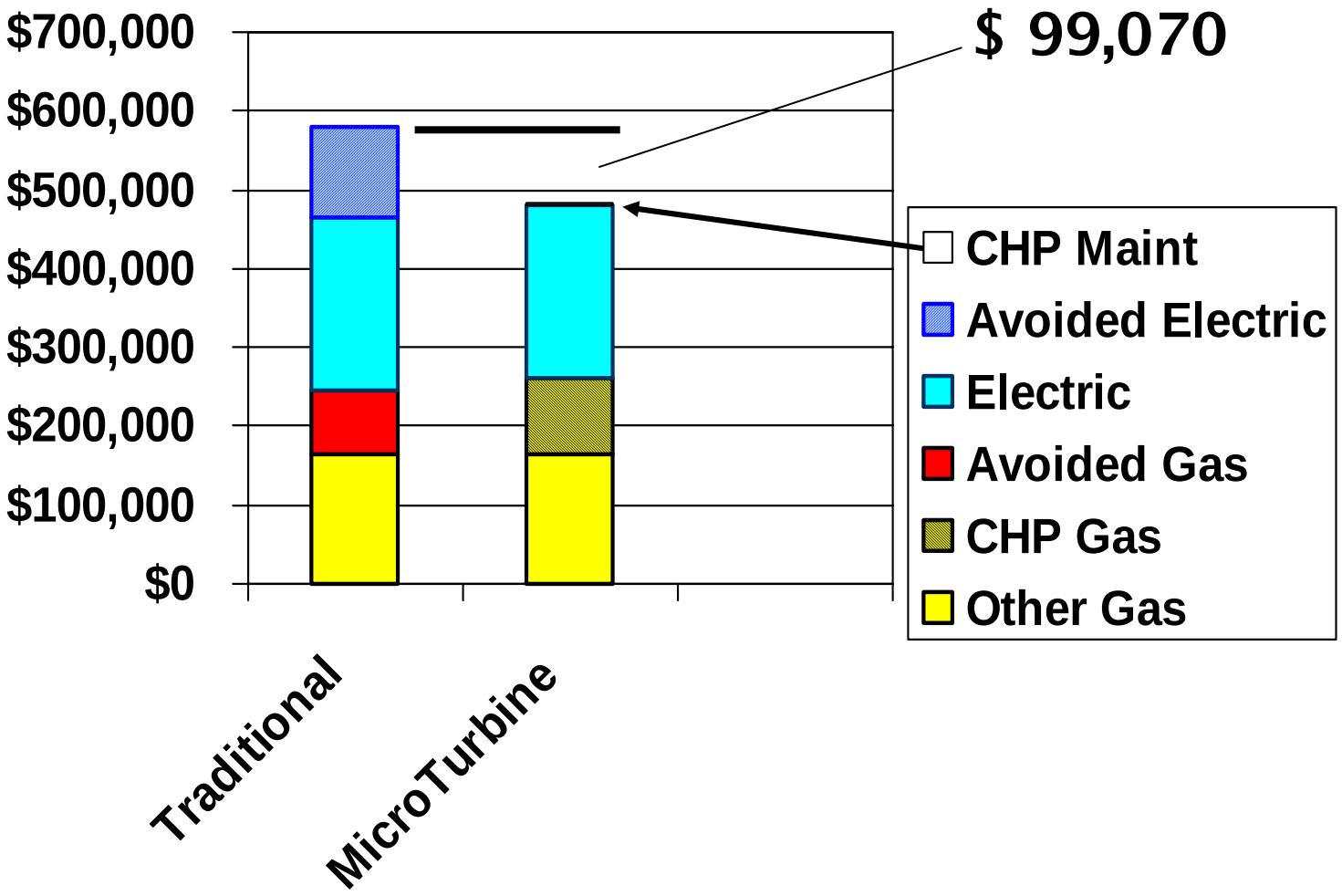
Energy Cost Savings per Year



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Conservative Analysis: Ten Year Plan

- Electric increase likely, but not considered
- Natural Gas = $6.50 / MCF
- Energy Savings (85% efficiency)
- Installation Cost = $472,000
  - less grant $75,000 = $396,728
- Analysis includes annual maintenance cost
- ROI = 4.0 years, straight line

Performance

	1st QTR	2nd QTR	3rd QTR	4th QTR
Hours	8196	8129	7901	7923
KWH	450,780	406,450	395050	435165
Natural Gas**	5496	4959	4820	5316
Hot Water *	3078	2678	2603	2871

**MCF

*Mmbtu or MCF Equivalent

Reliability, Uptime

Operating Hours=	***32,149***
Hours Available=	***35,040***
Uptime =	***92%***

Most likely cause of downtime

- ✓ ***Utility Grid***
- ✓ ***Fuel***
- ✓ ***Heating Plant***

Toledo's SeaGate Convention Centre

Toledo's SeaGate Convention Centre

Scheduled Energy Need

- High Energy Need During Event
- Low Energy Need Waiting for Next Event

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Project I

- Install MicroTurbines and Controls
- Hot Water Heat Recovery

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Project I

- Install MicroTurbines and Controls
- Hot Water Heat Recovery

Project II

- Chilled Water System

Toledo's SeaGate Convention Centre

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Combined Heat and Power

- ***Apply existing technology***
- ***Turn waste heat into useful heat***
- ***Deliver electric power at point of use***

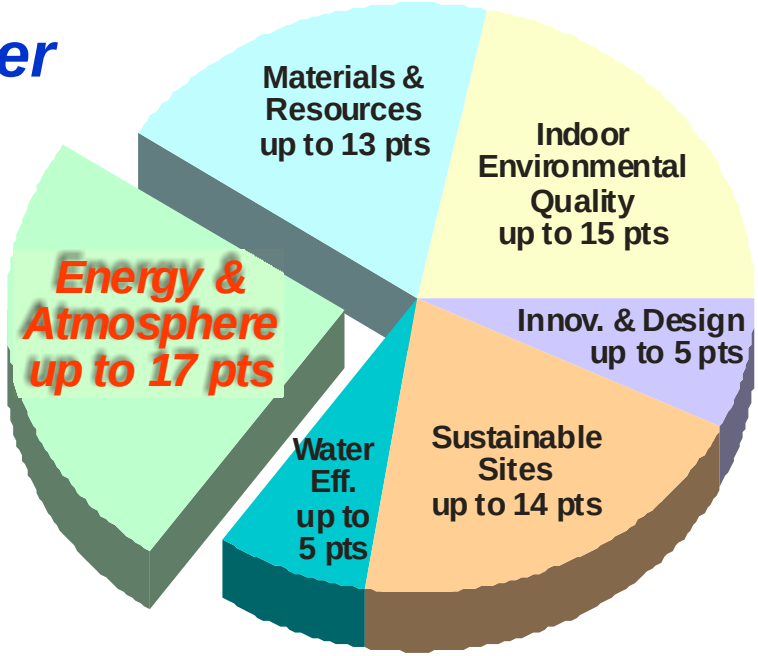
Image courtesy The Economist

Additional Thoughts

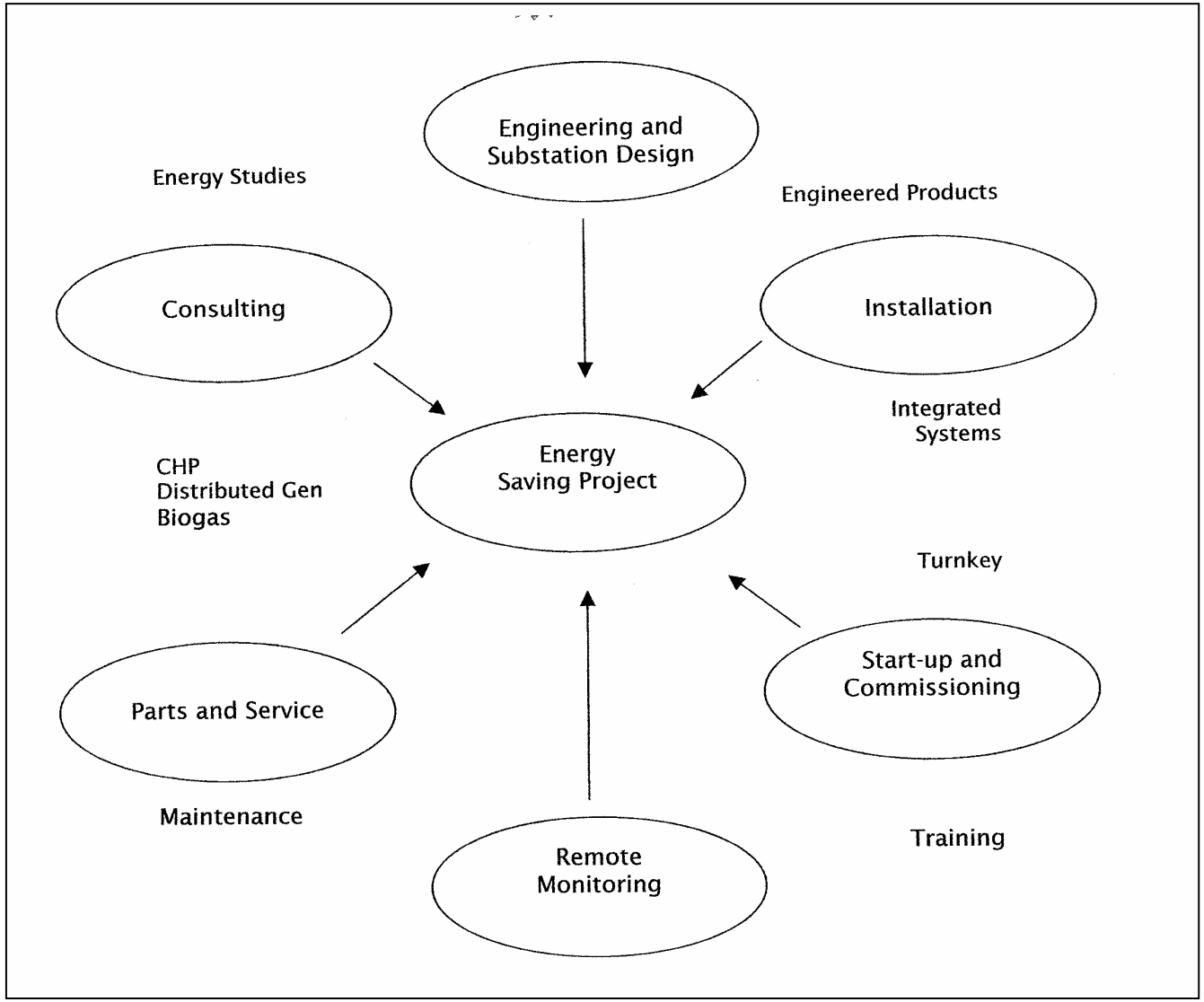
- LEED Points and Microturbines
- Chilled Water
- Direct Exhaust
  - Industrial Process
  - Greenhouse Agriculture
- Biogas Fuel Source
  - Landfill gas
  - Waste water treatment
  - Agriculture
- Hybrid fuel cell / Microturbine

LEED Points & Microturbines

- *Capstone MicroTurbine solutions can help buildings earn more than a dozen LEED points*
  - *Up to 10 points for Energy & Atmosphere Credit 1*
  - *Up to 2 points if within 500 miles of Los Angeles*
  - *1 point for exhaust-driven absorber*
  - *Up to 4 points if biogas-fueled*
    - *Antioch High School in Illinois uses 12 Capstone C30s to generate heat and power using waste flare gas from a nearby landfill that is piped to the Capstone array on the campus*



BHP Energy Solutions…A new kind of company for a new kind of need



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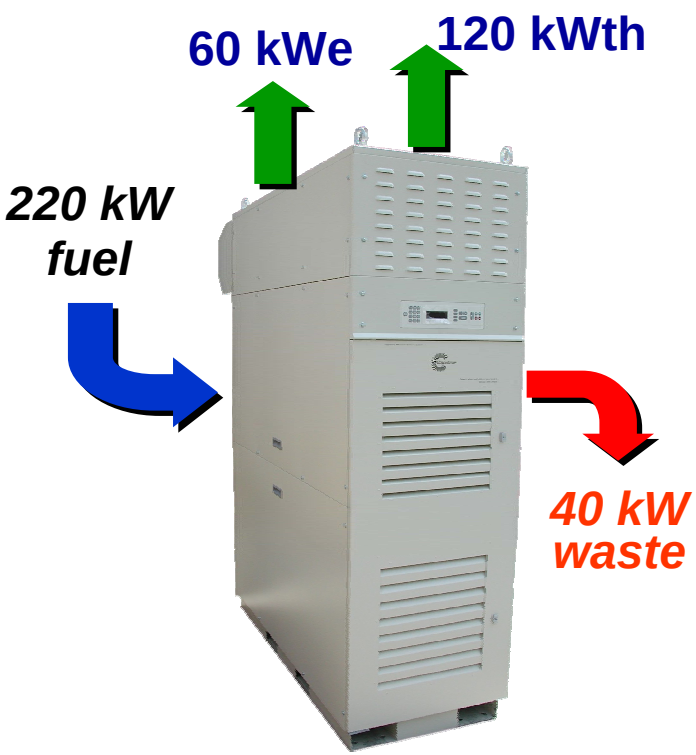

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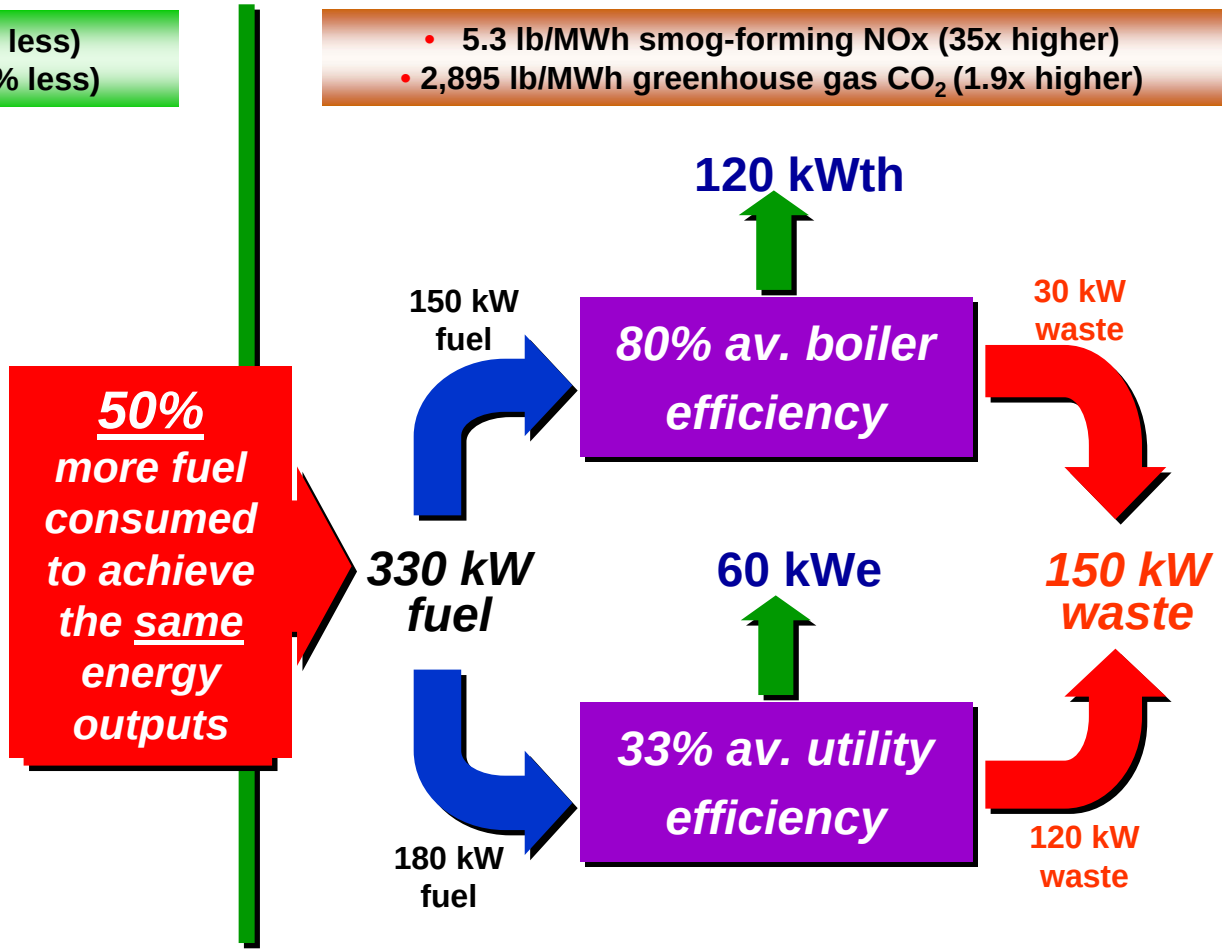

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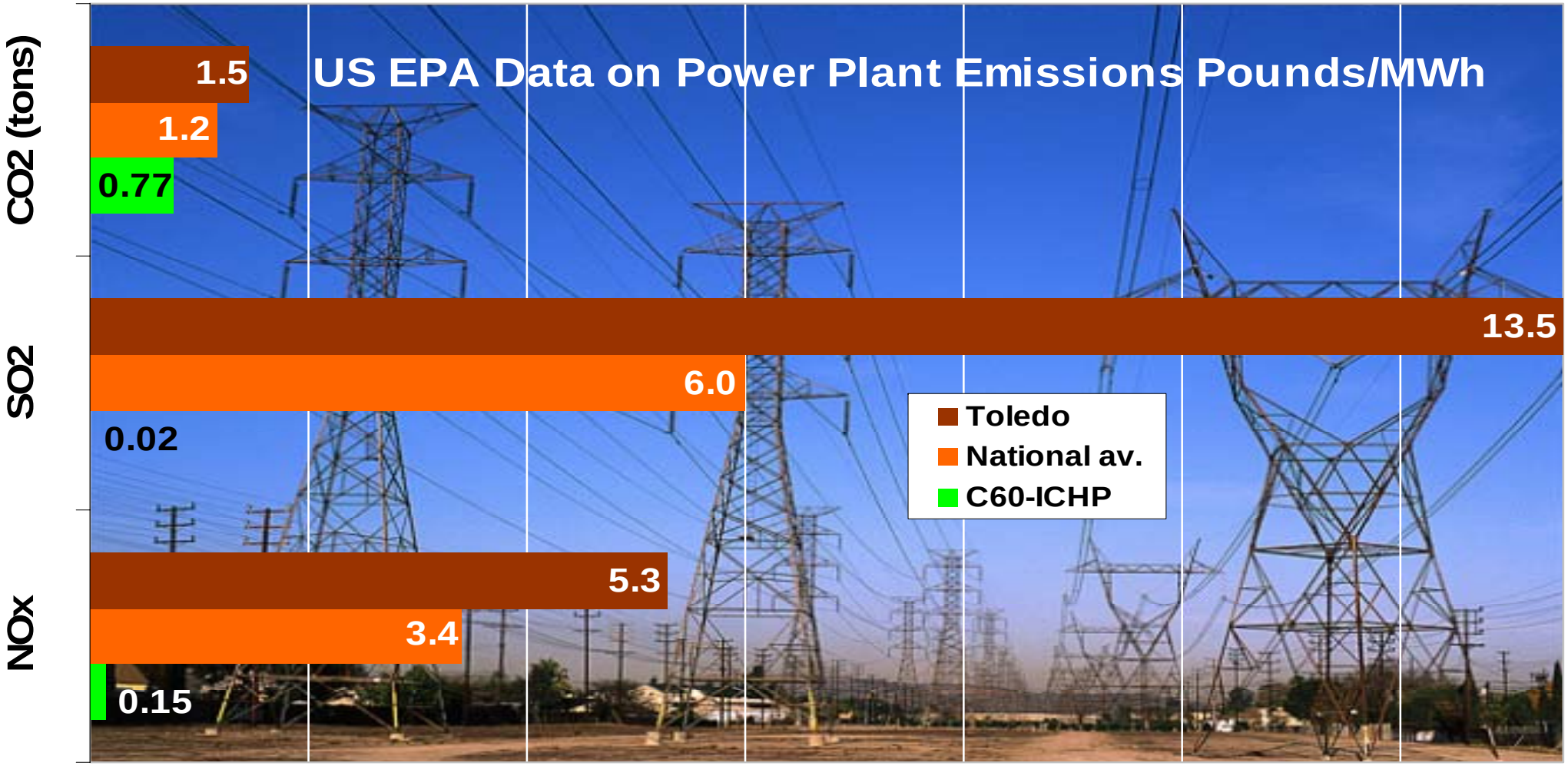

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