Squeezing More Energy from Biosolids at the Metropolitan Water Resource Reclamation Facility

Resource Recovery and Energy (R2E)

March 21, 2024

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Central States Water Environment Association

Resource Recovery and Energy (R2E) Committee

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Vice Chair Patrick Haney - HDR
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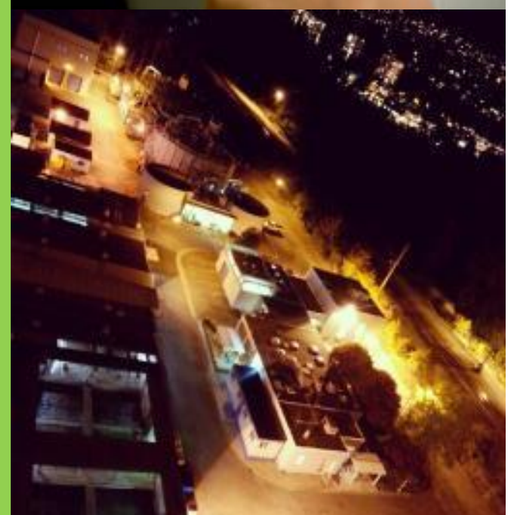
Member Emma Larson - St. Cloud
Member David Quast – SEH
Member Patrick Shea - - St. Cloud
Member Jacqueline Strait -HR Green
Member John Borghesi – Jacobs
Member Anndee Huff Chester – B&C
Member William Martin – Hazen & Sawyer
Member Anna Munson– Hazen & Sawyer
Member Heidi Hutter – MCES
Member Henry Croll– Stantec
Member Warren Olinger– Stanley Group

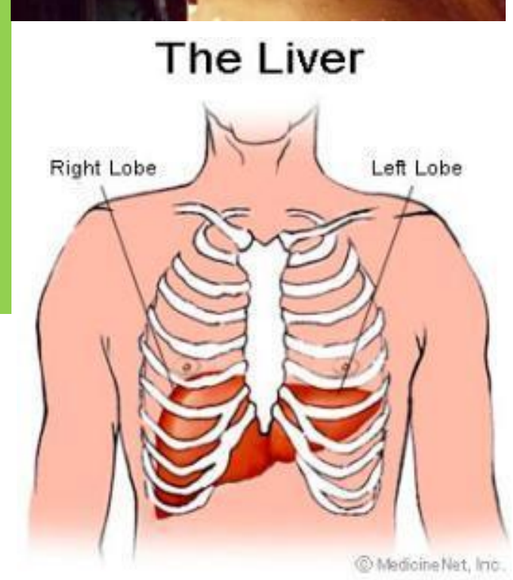
Others invited –

An Ode to Wastewater

By Dave Gardner

Whether simple stalls or cloistered halls,
A flush is all it takes -
To send to us from yesterday,
Your hamburgers and steaks.
The flow arrives around the clock,
Our lights are always on.
If you happen to work the night shift,
Feel free to use the john.
So think of us in your college days,
As you exercise your liver,
We're the unsung heroes of the sewer,
The guardians of the river.





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Metropolitan WRRF (Water Resource Recovery Facility) “Metro Plant”

The Metropolitan Council is committed to ENERGY and SUSTAINABILITY.

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ENERGY & SUSTAINABILITY

Our role to protect public health and the environment goes beyond cleaning wastewater. The Metropolitan Council works to minimize our environmental impact by operating the regional wastewater system in a sustainable way. Our practices demonstrate how other organizations can effectively build environmental stewardship into their operational approaches.

To advance sustainability in our operations, Metropolitan Council Environmental Services (MCES):

- Manages energy use
- Conserves and reuses water
- Reduces, reuses, and recycles solid waste and **recovers nutrients from biosolids**
- Advances sustainable landscapes and green stormwater practices
- Plans for climate change impacts and reduces our carbon emissions

Energy management and climate change

Energy use is a major expense for MCES – costing approximately $15 million per year. It is also our leading source of carbon emissions. Managing our energy use helps us keep costs to rate payers fair and reasonable and reduces our contribution to climate change.

Biosolids – A Commodity

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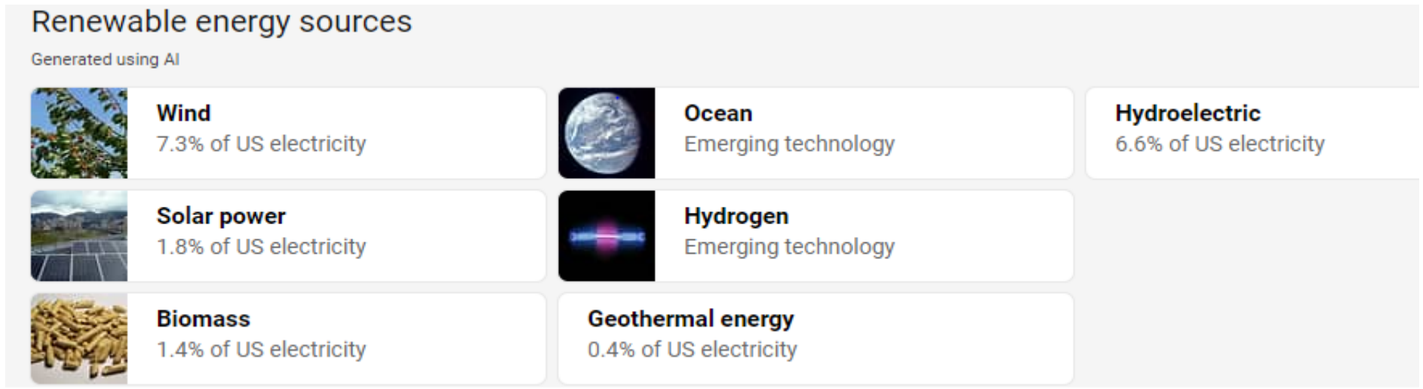
Coldest Winters

World metropolitan areas (MSA) over 3,000,000 population (n = 159)

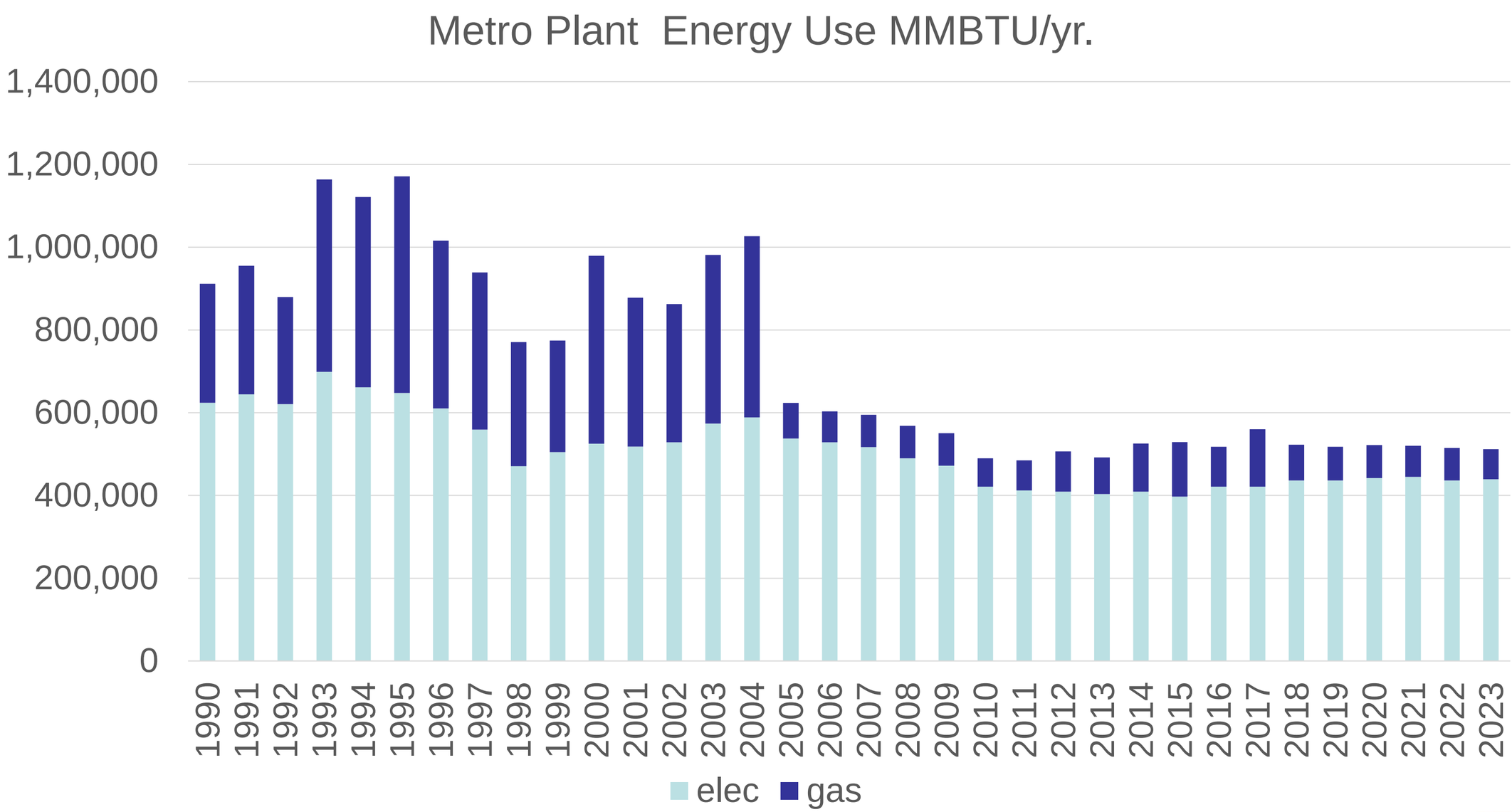
Metropolitan Area	Average Winter (Dec.-Feb.) Temperature °F
1. Harbin, China	5.5°F
2. Montreal, Canada	18.3°
3. Minneapolis – St. Paul, USA	18.7°
4. Moscow, Russia	20.9°
5. St. Petersburg, Russia	23.0°

MCES Energy Goals

- 2010: Reduce purchased energy by 15%
  - Actual reduction =17% by 2011
- 2015: Reduce purchased energy by 25%
- 2020: Reduce purchased energy by 50%
- 2040: 100% Carbon-free or renewable MN-2023



Metro Plant Energy Use 1990-2023



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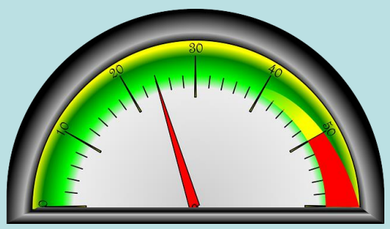
MCES Energy Savings 1998 - 2018



303 billion BTU per year

=

2475 Minnesota households (electric and heating for a year)

27% lower energy use since 1998

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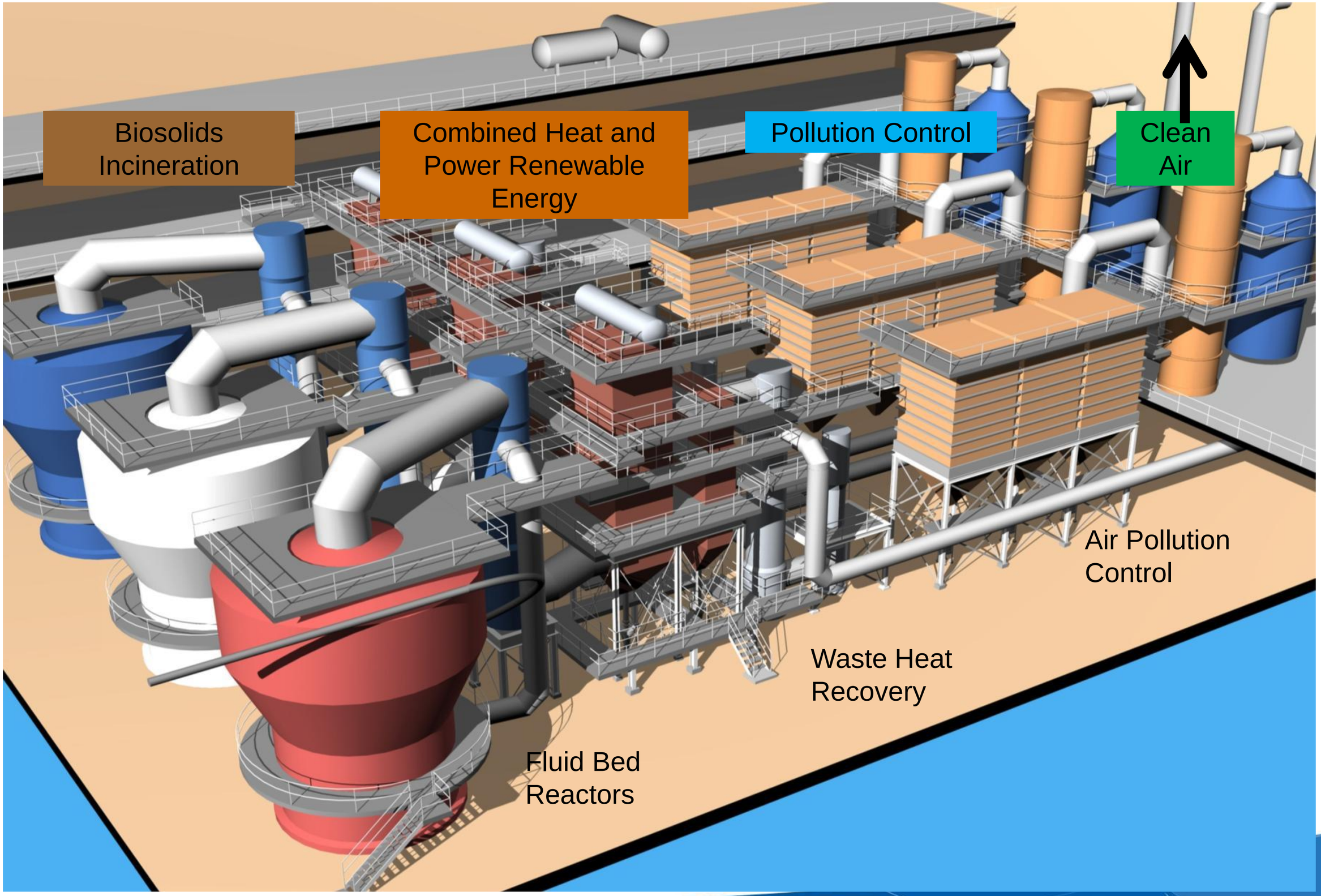

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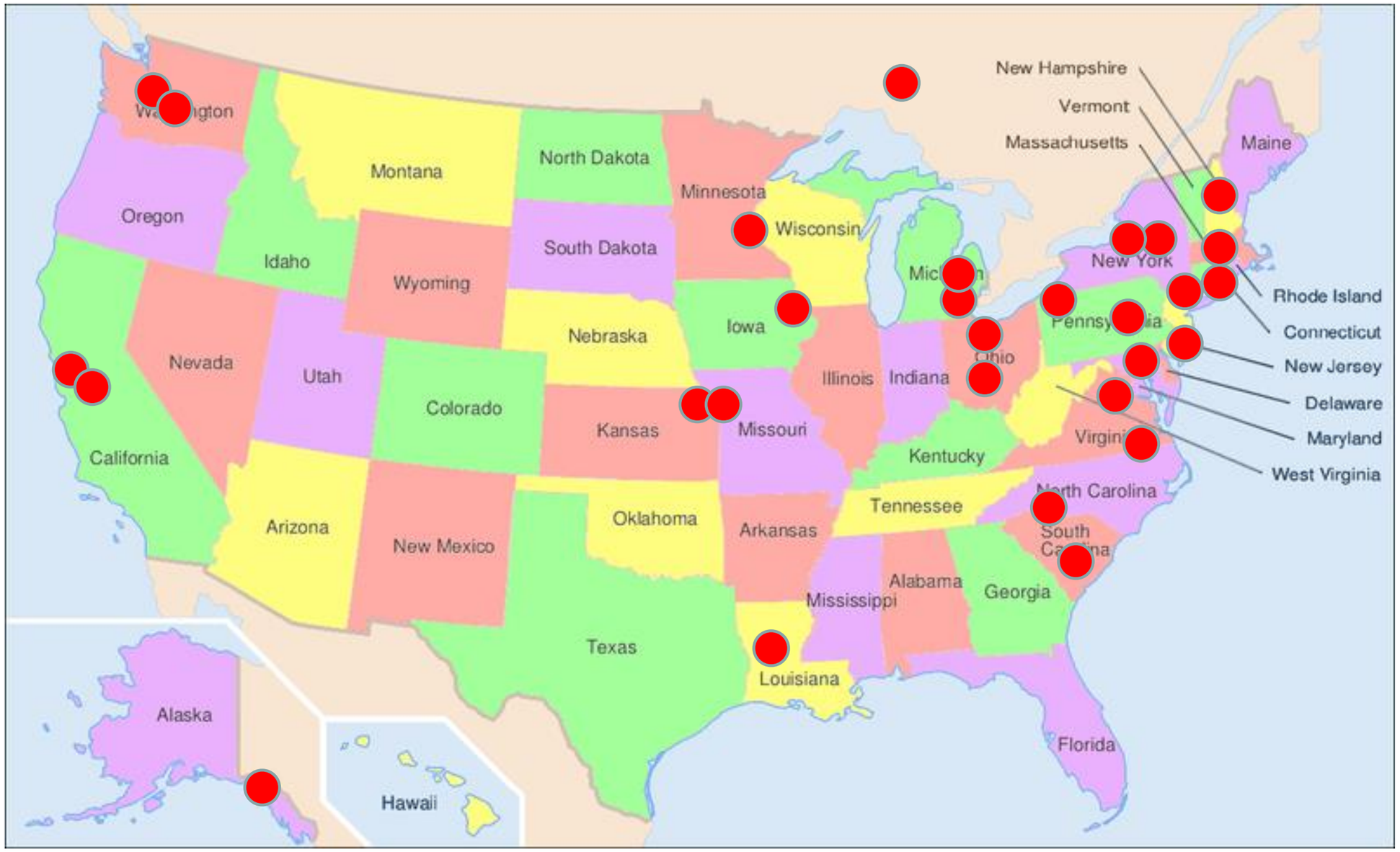
Location of Major Sewage Sludge Incineration Facilities



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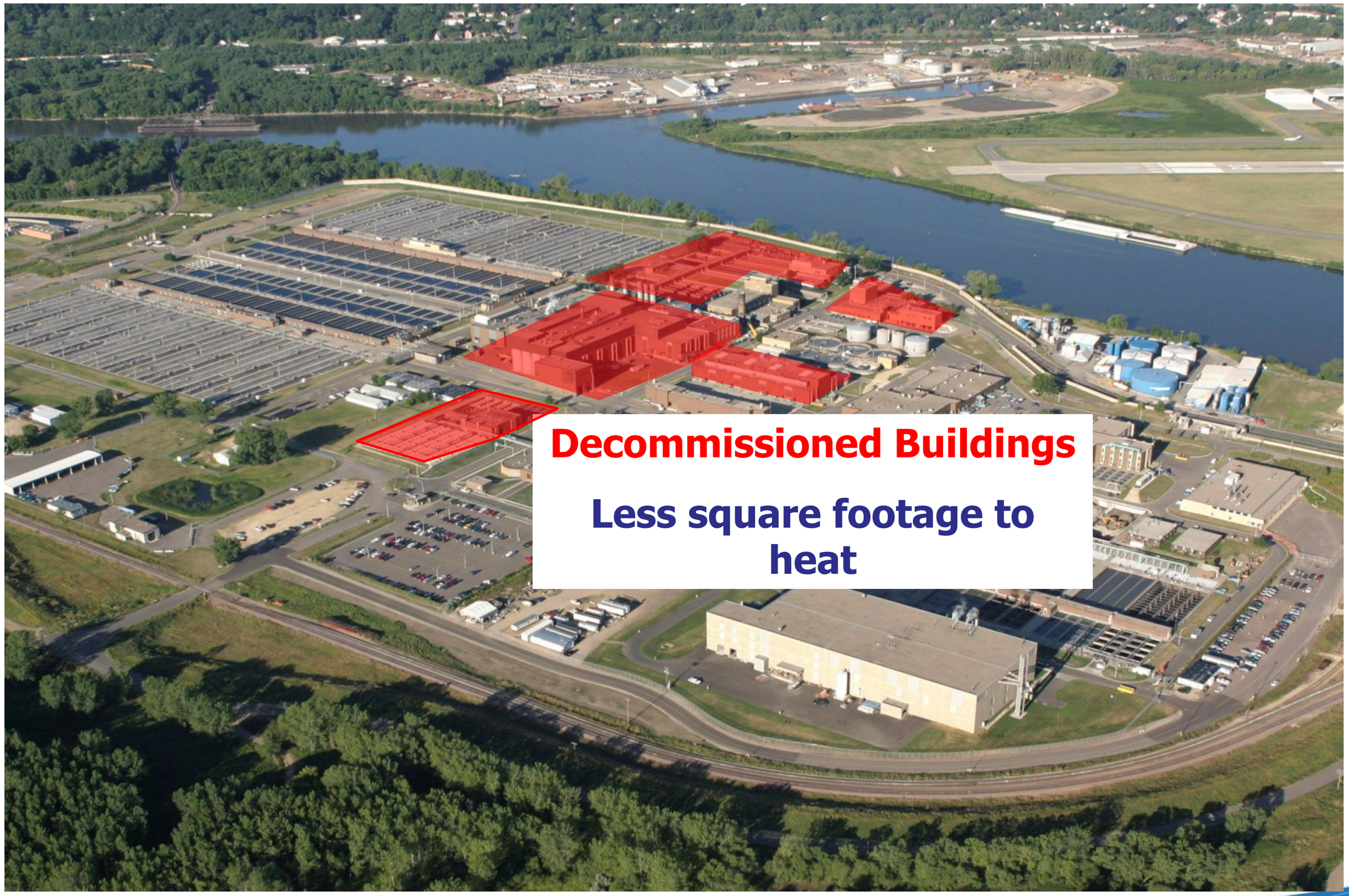

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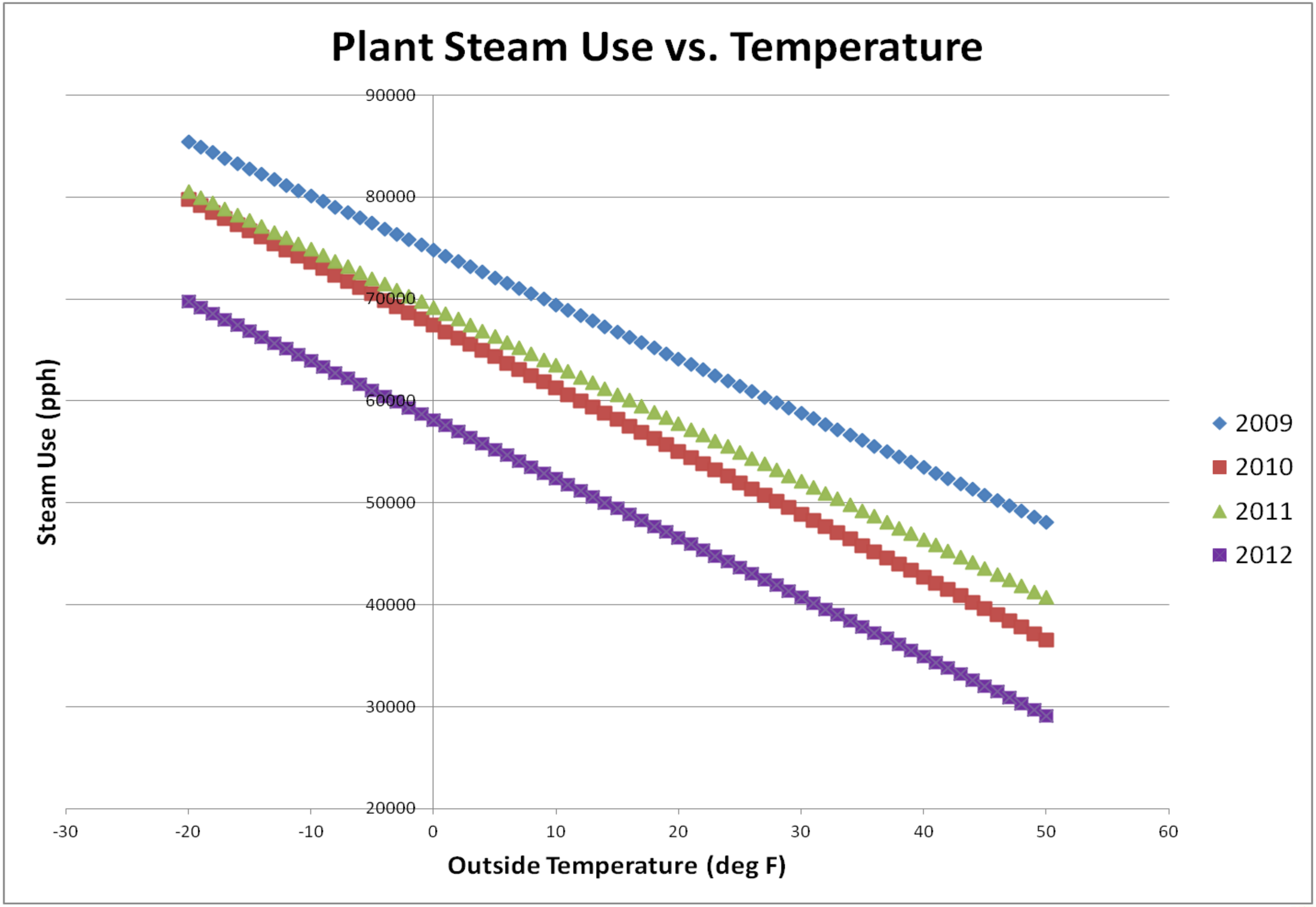
Steam System

- Each incinerator train can produce 27,000 lb/hr. of 450 psi superheated steam
  - 4.5 DTPH @ 6 MMBTU/DT
- Provides winter heating for entire plant
- Building decommissioning and steam trap improvements have decreased plant steam demand

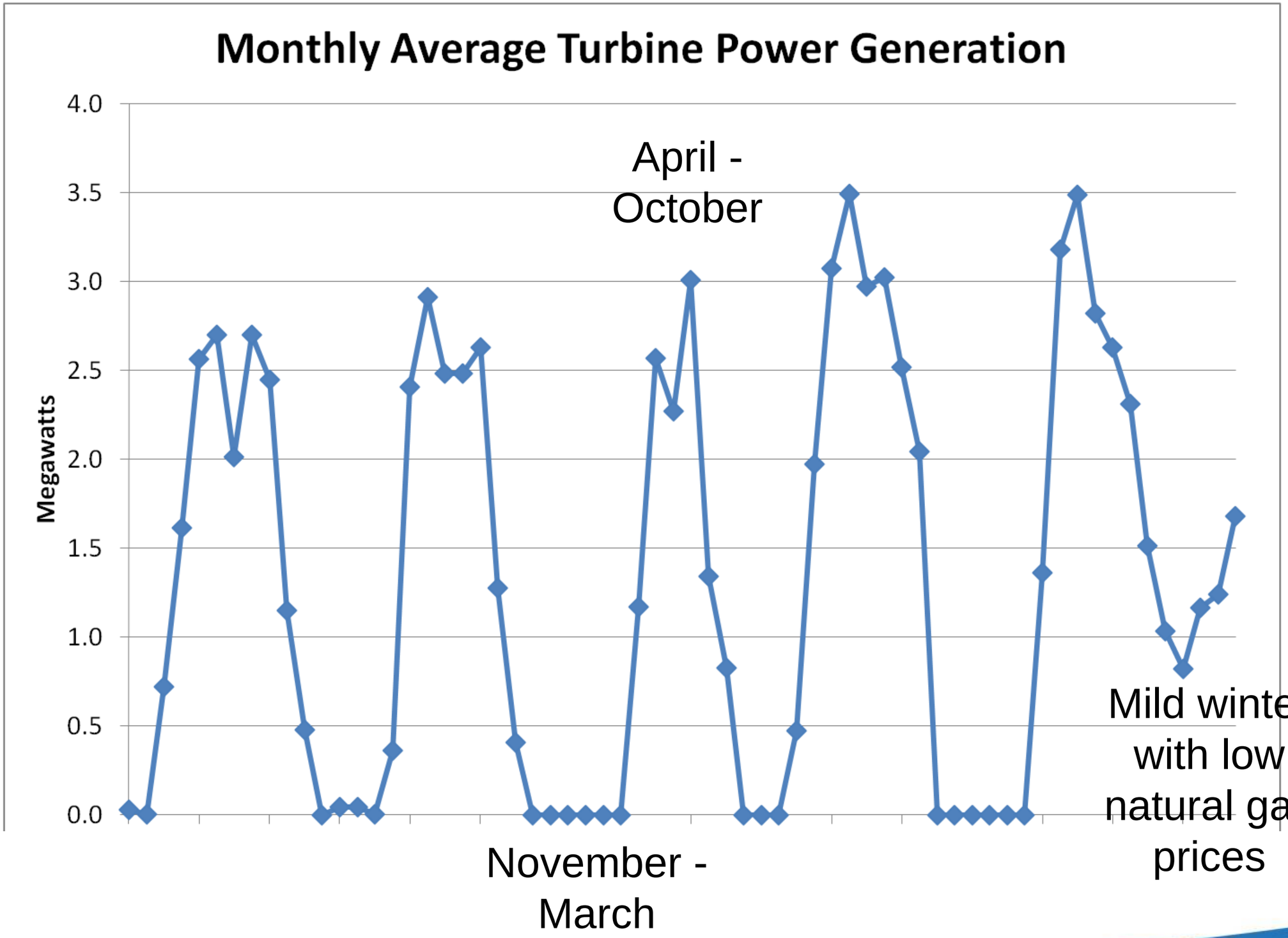

Plant Steam Use vs. Temperature
Steam Use (pph)
90000
80000
70000
60000
50000
40000
30000
20000
-30
-20
-10
0
10
20
30
40
50
60
Outside Temperature (deg F)
2009
2010
2011
2012

Non-Condensing Turbine

- Installation finished: Nov 2012
- Replaces pressure reducing valve (PRV)
  - Reduces steam from 450 to 150 psi
  - No energy recovered by PRV
- Generates up to 830 kW
- Estimated Yearly Savings: $150,000
- Turbine runs year round

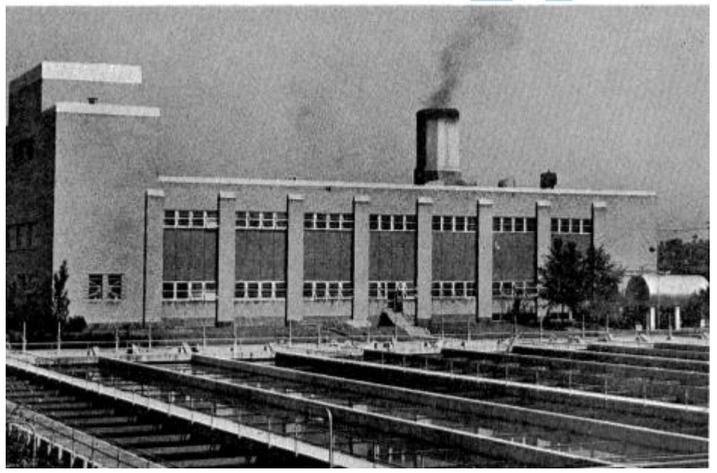
Condensing Turbine – Operation

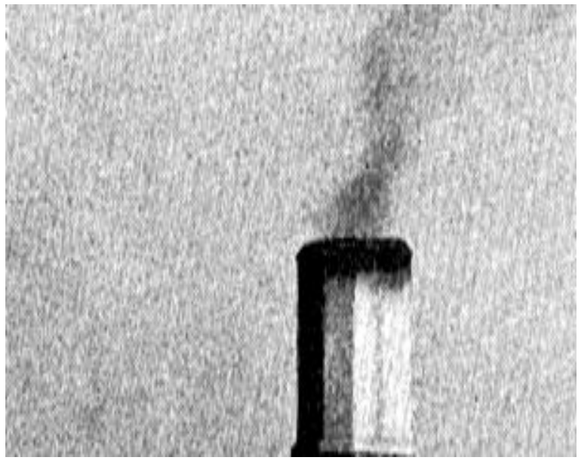
- Due to reductions in plant steam demand, winter turbine operation was proposed
  - Normal shutdown dates: November - March
- Engineering and Operations agreed to run turbine until it was no longer financially beneficial


Monthly Average Turbine Power Generation
Megawatts
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
April - October
November - March
Mild winter with low natural gas prices

Clean Energy

1940s
No air pollution control
No energy recovery





1980s
Some air pollution control
Some eenergy recovery

2000s
Better air pollution control
Better energy recovery

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EPA Administrators and Priorities – 1970 - 2024

Clean Water Act
Clean Air Act

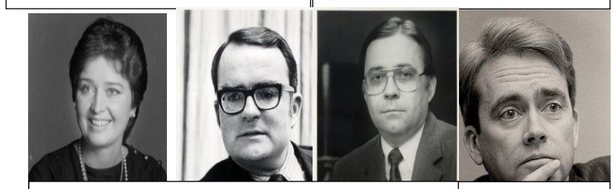
William D. Ruckelshaus, 1970 - 1973
Russell E. Train, 1973 - 1977

Nixon - Ford

Nuclear waste, dioxin, asbestos, Chesapeake Bay, pesticides, Montreal Protocol – CFC phaseout, lead phaseout, Right To Know, Rio Earth Summit, CAAA

Anne M. Gorsuch [Burford], 1981 - 1983
William D. Ruckelshaus, 1983 - 1985

Lee M. Thomas, 1985 - 1989
William K. Reilly, 1989 - 1993



Reagan | Bush

Clear Skies Initiative (SO2, NOX, Hg), watershed-based approach, brownfield, ozone, Great Lakes, WaterSense, vehicles

Christine Todd Whitman, 2001-03
Michael O. Leavitt, 2003 - 2005
Stephen L. Johnson, 2005 - 2009

Bush

PFAS research, Superfund effective partnerships, sound environmental policies

Scott Pruitt, 2017 - 2018
Andrew Wheeler, 2019 - 2021

Trump

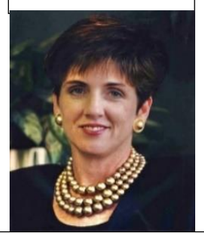
1970 | 1980 | 1990 | 2000 | 2010 | 2020

Carter

Douglas M. Costle, 1977 – 1981

Superfund – Love Canal, Three Mile Island, clean air

Clinton



Carol M. Browner, 1993 - 2001

Brownfield programs refinery, lead paint, and new air quality regulations

Obama

Lisa P. Jackson, 2009 - 2013
Gina McCarthy, 2013 - 2017

Biden

Michael Regan, 2021 - present

Climate change, air quality, chemical safety, environmental justice, community cleanup, sustainability, tribal partnerships, upgrading aging water infrastructure

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The only engineer Administrator

Lisa Jackson –
EPA Administrator
2009 - 2013

2024 PFAS Destruction

WRF Paper March 2024Sewage Sludge Incinerator
PFOA, PFAS destruction efficiencies

WRF study emission factors (Published March 2024)		
	Removal efficiency	lb/DT
PFHxA	94.2%	6.65E-07
PFOA	97.3%	2.31E-06
PFOS	99.9%	1.08E-06

Very little PFAS in air; very little fluorinated GHG compounds; no PFAS detected in ash. Most PFAS in water stream.

Another look at incineration

The PFAS issue is probably the most promising area for additional investment in incineration/thermal treatment.

There's definitely more (positive) chatter about the role of incineration than I have heard in 20+ years.

Whether EPA makes an official determination or not, I don't think that changes.

Chris Hornback, Deputy Director of NACWA

Incineration vs Digestion: Energy Recovery Accounting

- Which solids processing method recovers energy and resources from solids more efficiently?

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Solids Energy Recovery

- Feed Sludge
  - Both ~80% VSS
  - Calorific Value = 8,350 Btu/lb dry basis = 16.7 MMBtu/DT
- Incineration
  - Converts ALL VS to energy
  - Must then recover that energy from the flue gas
- Digestion
  - Converts VS to energy based on VS destruction
  - Usually ~40-60%

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Metro vs Blue Lake: Case Study

- Metro
  - 9.8 DTPH
  - Waste Heat Boilers recover 6.8 MMBtu/DT
  - Scrubbers recover 10.6 MMBtu/DT
  - 25 MMBtu = 7.3 MW avg used to heat plant (38% of generated)
  - The rest is *ideally* used by turbine generator
- Blue Lake
  - 1.7 DTPH
  - Digester Gas recovers 8.8 MMBtu/DT
  - DG used to heat dryer & boilers (used to heat digesters)
  - 30% avg flared

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A self-defeating process?

- How much of the energy generated by solids processing is used by solids processing?
- Metro Incineration
  - Power to run SMB
  - Primary & Secondary heat exchangers
- Blue Lake Digestion
  - 2.5 MMBtu/DT to heat digesters
  - Most of the biogas is used to dry solids into pellets

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Heat is Cheap
Electricity is Expensive

- Typical heat pump COP
  - 3 to 5
  - For every 1 kW of electrical energy, you get 4 kW of heat
  - 400% efficiency (if you assume waste heat has no worth)
- Metro Turbine Generator
  - WHB requires 1,150 Btu of heat to generate 1 lb of steam
  - 1 lb of steam contains ~1,000 Btu of useful heat
  - G7 generates 250 Btu of electricity per lb of steam
    - 25% efficiency (13,000 pph 420 psi steam per MW)
  - New turbine generator would generate 320 Btu/lb steam
    - 32% efficiency (9,000 pph steam per MW)
  - *this is why CHP is a thing

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Electricity Generation at Metro

- G7
  - When operating properly, 4.2 MW capacity
  - Utilizing all excess steam = 2 MW avg annual generation
- New Turbine Generator
  - 7 MW capacity
  - Utilizing all excess steam = 3.5 MW avg annual generation
  - Utilizing ALL steam = 5.6 MW avg annual generation

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Scrubber Effluent Water

- 3000 GPM of effluent re-use water that takes flue gas from 350F to 60F
- Scrubber Eff Temp
  - ~135 F
  - 110 MMBtu/hr of heat absorbed
- Total Effluent Water temperature is about 2 deg F warmer due to heat from the scrubber water
- The scrubbers recover almost twice as much heat from the flue gas as the WHBs (64 vs 110 MMBtu/hr)

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More Energy to Count

- Gas for trucks taking cake/pellets/ash from plant
- Energy costs of digestion & incineration equipment
- Energy cost to heat digesters
- Chemical costs & energy to create
- Capital, maintenance, & replacement costs of equipment

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More Difficult to Count

- Value of the pelletized fertilizer product
- Value of ash as a fertilizer
- Carbon & air quality effects
- Possibility of converting biogas to higher value products

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Rebates

MCES Rebate Examples

Equipment Rebates (external link)

Cost Saving Programs

Renewable Energy Options

See all business programs (external link)

Common Utility Rebate Opportunities

Motors & Drives
- NEMA Premium or Premium+ motors
- New or replacement VFDs

LED Lighting
- New or retrofit lamps & fixtures
- Lighting controls

HVAC
- Unit heaters
- Chillers / DX units
- Heat pumps
- PTACs
- Energy recovery ventilators

Clean Water Pumps
- New or replacement Pump Energy Index rated pumps

Boilers & Steam Traps
- Condensing boilers
- Burner controls
- Tune-ups
- Steam traps

Fans & Blowers
- Fan Energy Index rated fans & blowers
- Axial / Centrifugal / Mixed flow

Custom Efficiency
- Controls
- Compressed air
- Process optimization

Use WAM to Track Rebate Opportunities

Add Benchmark B008700 to Work Orders with potential rebate-eligible equipment

Please contact David Ponder with any questions.
david.ponder@metc.state.mn.us | 651-602-8369

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Rebates

More Rebates to Explore

Clean Water Pumps

See how our rebates can help cover the cost for pump upgrades or new installations.

EXPLORE WATER PUMP REBATES →

Commercial Refrigeration

Reduce both energy and costs for your refrigeration replacements or upgrades with these helpful rebates.

GET REFRIGERATION REBATES →

Compressed Air

Discover long-term savings when you implement fixes from our comprehensive system study.

FIND COMPRESSED AIR SAVINGS →

- Condensing boilers
- Burner controls
- Tune-ups
- Steam traps

Boilers & Steam Traps

- Fan Energy Index rated fans & blowers
- Axial / Centrifugal / Mixed flow

Fans & Blowers

Use WAM to Track Rebate Opportunities

Add Benchmark B008700 to Work Orders with potential rebate-eligible equipment

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Biosolids to Energy

By Dave Quast

To keep our rivers safe and clean,
Contaminants we do remove
From the water reclamation plant
In a way that communities approve.
Left with residuals of great value.
No need to throw it away.
Burn it to make steam to heat the plant
Even on the coldest winter day.
In the summer, turbine steam
Creates electricity
Remove PFAS, get a rebate
Biosolids to Energy.

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