IDEA Conference – Seattle WA

The Steam Engine: An Emerging Power Production Technology

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Practical Steam

District Energy - Efficiency Improvement Opportunities

Opportunities:

- PRV Bypass
- Hydronic Heating
- Waste Steam/Heat Recovery

Solutions:

- Steam Turbine?
- Steam Engine?

Backpressure Steam System Equipment (District Heating Steam Applications)

High Pressure Steam From Boiler

Low Pressure Steam To District Energy

Feedwater Supply

Condensate Return (if available)

PRACTICAL STEAM

District Energy Application – PRV Bypass

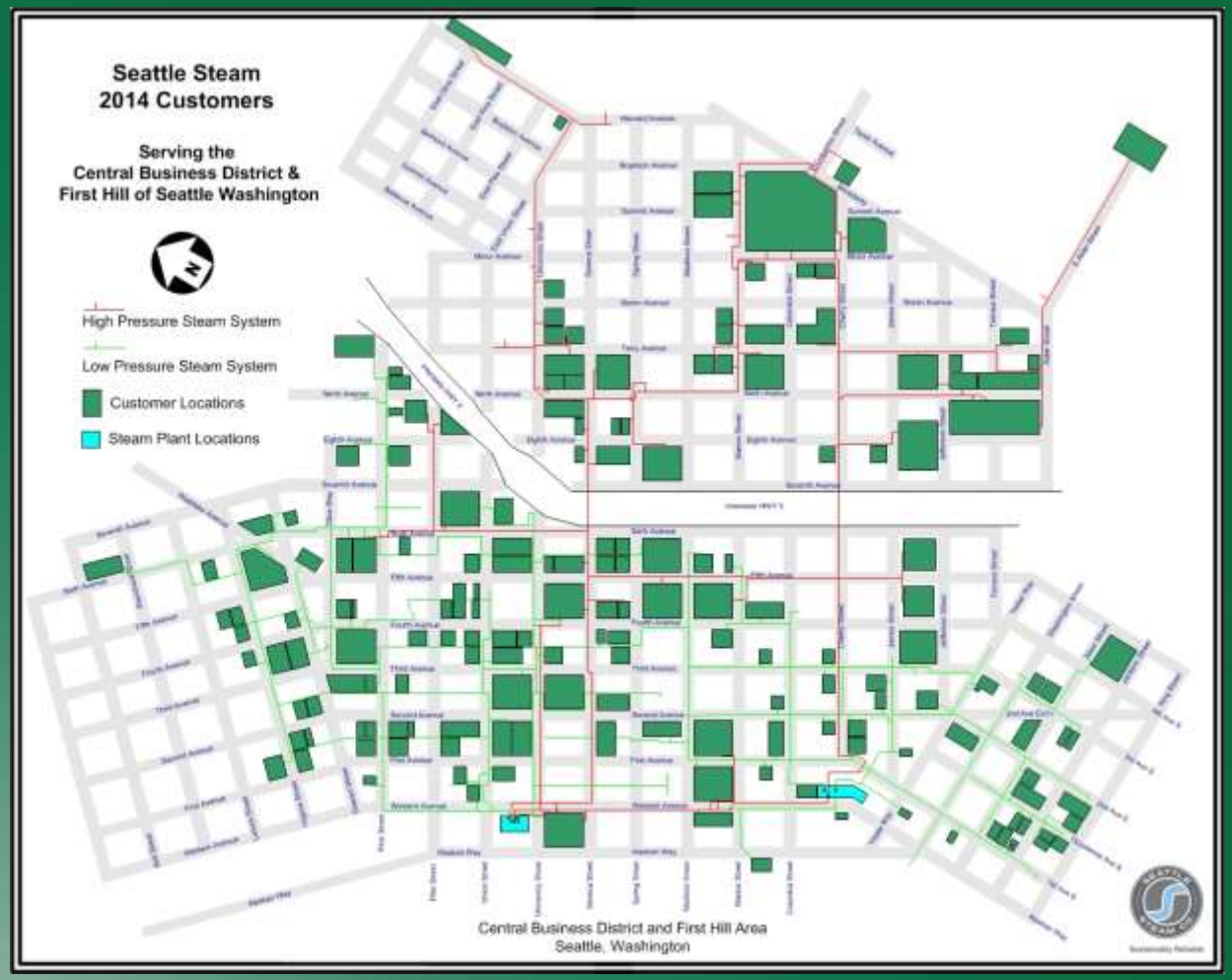
Use of PRV

- High pressure steam is reduced to low pressure steam
- Steam superheat is generated
- Steam superheat is lost through heat transfer

PRV Bypass with Backpressure Generator

- High pressure steam is reduced to low pressure steam
- Steam quality is reduced by some amount
- Electrical power is generated

District Heating Feasibility Study Commercial Buildings: Seattle, WA.



PRACTICAL STEAM

District Heating Feasibility Study Commercial Buildings: Seattle, WA.

Objectives

- Improve system efficiency
- Offset power purchased from local utility to reduce costs
- Earn renewable energy incentives
- Utilize low maintenance equipment

Challenges

- Small area available for installation
- Variable steam flow rate
- Insufficient flow rate for turbine
- Equipment cost must remain low for relatively small amount of power

District Heating Feasibility Study Commercial Buildings: Seattle, WA.

Before Installation

After Installation

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District Heating Feasibility Study Commercial Buildings: Seattle, WA.

Inlet Steam Conditions:
- 3,700 lbs/hr
- 144 psig
- Saturated Vapor

Outlet Steam Conditions:
- 3,700 lbs/hr
- 23 psig
- 93% quality

Steam Energy in:
- 4.439MMBtu/hr

Steam Energy out:
- 3.947MMBtu/hr

Electrical Energy out:
- 80kW=0.273MMBtu/hr

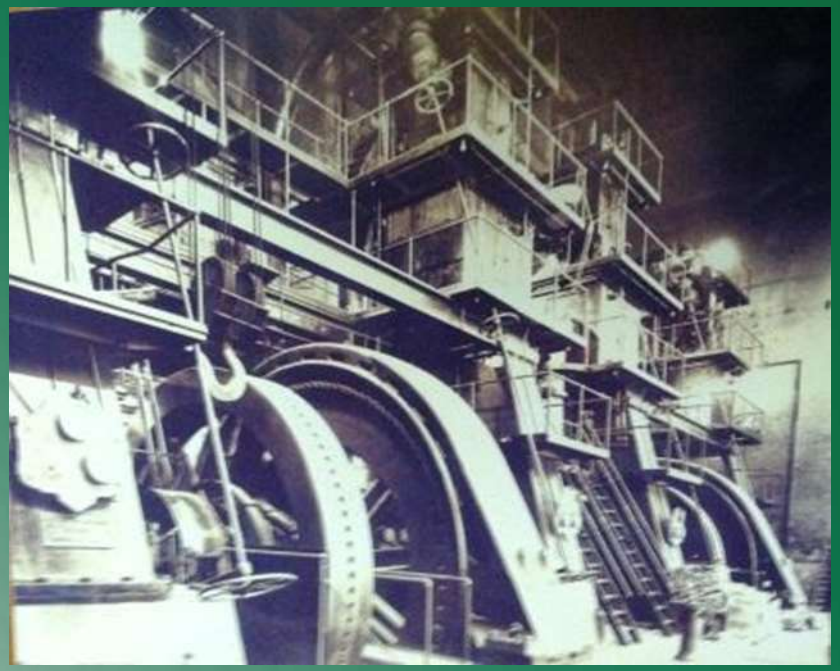
Thermodynamic Efficiency:
- 95.1% (System)

Losses:
- Generator Efficiency
- Heat Transfer
- Friction

District Heating Feasibility Study Commercial Buildings: Seattle, WA.

- 80 kW Backpressure engine installation
- Total Installed Cost: $150,000
- Power Cost: $.06/kWh
- Value of Power Gen: $38,400
- Likely Incentive from Seattle City Light: $.27/kWh or 70% of project cost
- Anticipated operating hours: 8,000
- 70% cap reached; customer cost is $45,000
- Payback is 14 months

Reinventing the Steam Engine:
How the engine solved technical issues



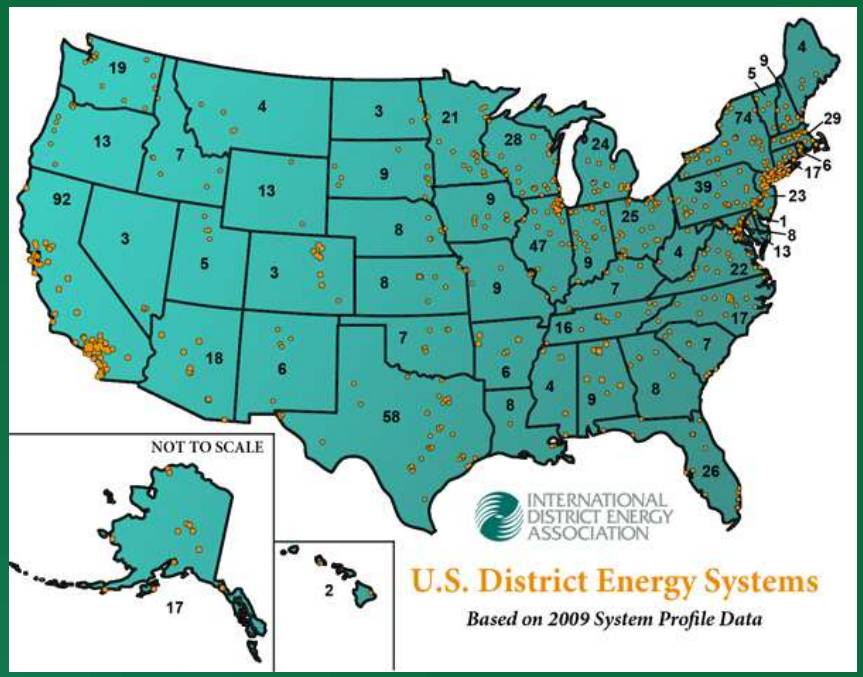
Steam engine that operated in Seattle Steam co-generation plant in Post Ave location.

- Synchronous speed:1800rpm
  - Direct connection to generator
  - Low cost
  - Small Footprint
  - Affordability
- Retrofitting of existing parts
  - Low and easy maintenance
  - Affordability
- Automated engine adjustability
  - Efficient operation with variable flow
- Efficient operation
  - Offset significant utility power consumption
  - Earn renewable energy incentives

PRACTICAL STEAM

Volume of Markets – District Heating

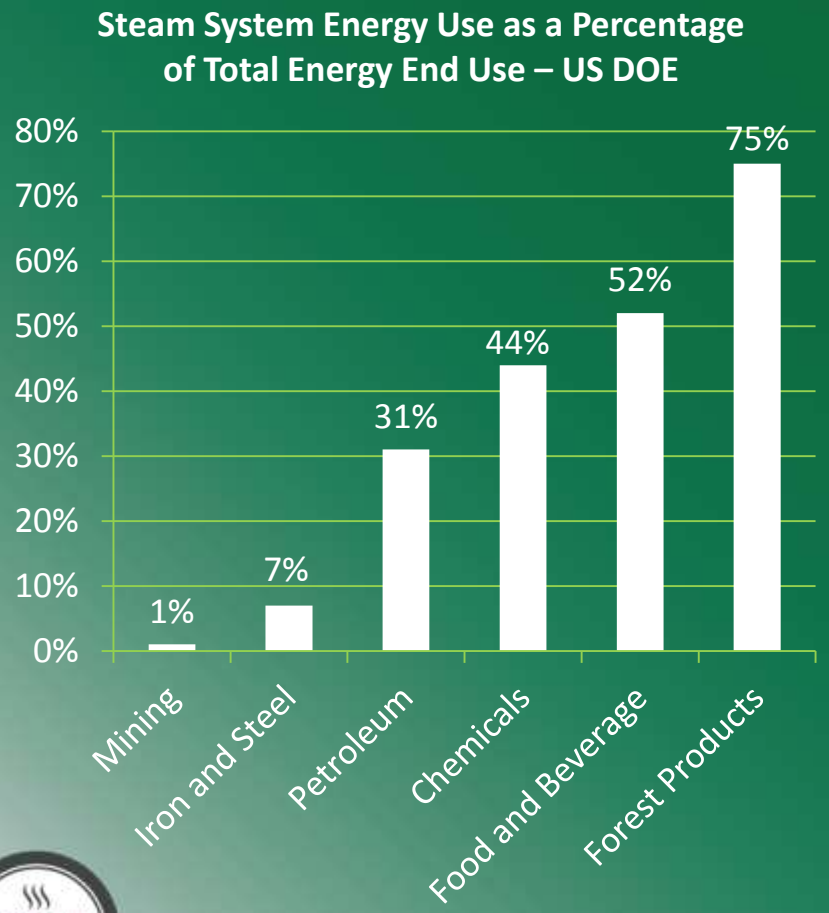
- 800+ District heating systems including more than:
  - 400 Colleges & Universities
  - 115 Community Utilities
  - 250 Healthcare Installations
  - 40 Military/Gov Installations
  - 580,000 commercial buildings in the U.S. are served by boilers
- Potentially incentive eligible:
  - Federal
  - State
  - Utility



Potential Energy Saving Markets

- District Energy Systems
  - Replacement of PRV with energy generation product. Hydronic heating.
- Commercial Cogeneration
  - System to produce steam and provide heating.
- Waste Steam
  - Use of waste steam for power production.
- Industrial Waste Heat
  - Use of waste heat to produce steam for power production.
- Biogas
  - Use of landfill gases to produce steam for power production.
- Biomass
  - Use of waste materials to produce steam for power production.

Volume of Markets Waste Steam



- Boilers consume about 40% of all energy in the commercial and industrial sectors.
- 163,000 commercial and industrial boilers in the U.S.
- 21,000 industrial facilities in the U.S. have boilers.
- Potentially incentive eligible:
  - Federal
  - State
  - Utility

Waste Steam Feasibility Study
Steel Mill in Ontario Canada

Problem Statement

- Steam venting from 150# steam header, primarily during the summer months
- Steam plumes appear to be ‘Pollution’ from the public’s perspective.
- Steam venting is very noisy, causing complaints
- Steam system consumes chemicals, steam venting releases chemicals that need to be made up.
- Energy is simply being lost to the atmosphere

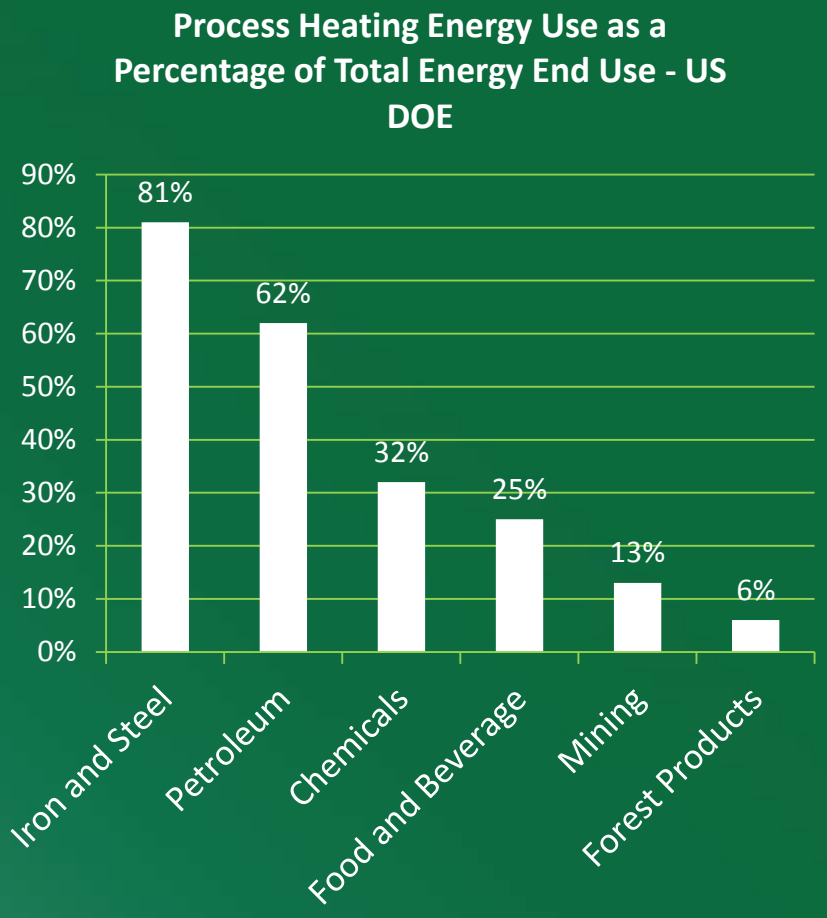
Practical Steam Solution

- Waste steam: 8,300 lbs/hr at 150 psi.
- Expected power production: 270 kW
- Annual electricity generation: $140K
- Purchase Price: $260K
- *Simple payback period: < 2 Years

*Without incentives

Volume of Markets Industrial Waste Heat

- DOE estimates up to 20% of process heat energy could be saved if waste heat was used to generate steam.
- The DOE estimates approximately 330 million MWh annually (23.6 Million households) could be recovered from industrial waste heat.
- Potentially incentive eligible:
  - Federal
  - State
  - Utility



R&D Condensing Testing Performance

Practical Steam R&D Test Engine

- Performed at Seattle Steam Post Ave Plant
- Inlet Pressure: 135 psig
- Vacuum: 15 in-Hg
- Specific steam consumption: 32.1 lbs/kWh
- Integral condenser and condensate pump.

Incentives in the Markets

- The market for energy efficiency applications will continue to be driven by:
  - Increases in energy prices
  - Government policy with incentives for production and use of “green energy”
- Two significant federal tax credits:
  - 1603 tax credit
  - Renewable Energy Production Tax Credit
- States have begun to mandate energy efficiency, further improving opportunities. Here are a few examples:
  - WA: 15% by 2020
  - OR: 25% by 2025
  - CA: 33% by 2020
  - NY: 29% by 2015
  - HI: 40% by 2030

The Practical Steam Engine

- Breakthrough technology to allow efficient electrical generation using steam.
- Proprietary, high-efficiency, high speed reciprocating design provides an economical solution for sub-megawatt applications.
- Optimized for 10,000 lb/hr or less steam flow.
- Completely pre-engineered package, including condenser, all on a skid.

The Practical Steam Engine

Steam Engine Opportunities

- The steam power generation market is currently dominated by steam turbine generators.
- Current steam turbines are designed for more than 10,000 lbs/hr of steam.
- 387,000 boilers in the U.S. produce less than 10,000 lbs/hr of steam.
- This leaves tremendous energy saving opportunities.

Questions?

Thank you for your interest.

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