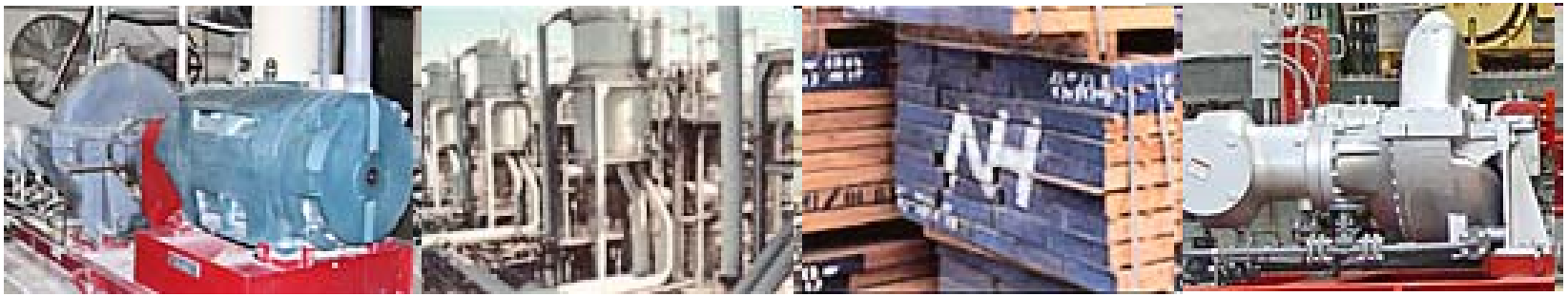
2010 Combined Heat and Power Partnership Meeting

Biomass CHP: Temple Inland Project

Bill Bullock

Turbosteam's Mission

- **To profitably help our customers reduce energy costs and lessen their environmental impact by converting wasted energy into useful energy.**



Business Model

- **Project Feasibility: identify customer value-drivers (IRR, NPV, reliability, unit cost) then customize a solution to their energy plant that maximizes this value.**
- **Equipment integration: deliver a modular unit for ease of construction with mechanical and electrical installation design services to deliver turnkey projects.**
- **Startup & Commissioning: provide all startup & commissioning services for all equipment, leaving the site when operators have achieved proficiency.**
- **Long-term service: extended service contracts to maximize annual power production, with in-field visits and web-based system monitoring.**

Biomass CHP

- Benefits of CHP
  - Unparalleled efficiency
  - Reduced grid congestion
  - Power factor improvement
- Benefits of Biomass
  - Carbon neutral
  - Lower cost fuel

This is a particularly powerful combination where biomass fuel is produced on site.

Long history with biomass in the wood products industry

1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010

Brattleboro Kiln Dry
- VT lumber mill
- 380 kW
- 18,000 lbs/hr
- Induction

Pompanoosuc Mills
- VT furniture mfr
- 50 kW
- 3,900 lbs/hr
- Induction

Fitzpatrick & Weller
- NY furniture mfr
- 450 kW
- 24,150 lbs/hr
- Synchronous

Buehler Lumber
- PA lumber mill
- 462 kW
- 20,700 lbs/hr
- Induction

Kendrick Forest Products
- WI lumber mill
- 50 kW
- 3,800 lbs/hr
- Induction

Middleton Building Supply
- NH lumber mill
- 578 kW
- 21,711 lbs/hr
- Synchronous

Craftmaster
- PA millworks
- 1060 kW B+C
- 106,670 lbs/hr
- Synchronous

Bell-Gates Lumber
- VT sawmill
- 75 kW
- 4,600 lbs/hr
- Induction

Aristokraft
- TN furniture mfr
- 825 kW BP+C
- 34,000 lbs/hr
- Induction

Marcel Lauzon
- Quebec sawmill
- 335 kW BP+C
- 17,000 lbs/hr
- Synchronous

Webster Industries
- WI lumber mill
- 550 kW, dual BP
- 27,600 lbs/hr
- Induction

Cox Lumber
- KY lumber mill
- 1,000 kW
- 45,000 lbs/hr
- Synchronous

Temple Inland
- TX lumber mill
- 1040 kW
- 100,000 lbs/hr
- Synchronous

Woodcraft
- TN millworks
- 239 kW
- 12,000 lbs/hr
- Synchronous

Young Mfg
- KY millworks
- 120 kW
- 13,000 lbs/hr
- Synchronous

Young Mfg
- KY millworks
- 200 kW
- 8,000 lbs/hr
- Synchronous

Bertch Cabinet
- IA cabinet mfr
- 279 kW BP+C
- 15,525 lbs/hr
- Induction

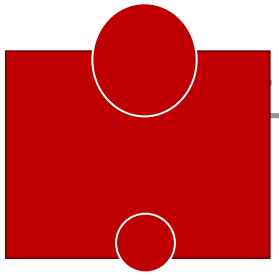
Bruce Hardwoods(2)
- TN flooring mfr
- 525 kW + 3250 kW
- 40,000 lbs/hr + 50,000 lbs/hr
- Synchronous

Wightman Lumber
- NY lumber mill
- 96 kW
- 5,000 lbs/hr
- Induction

Tostem Ayabe
- Japan lumber mill
- 248 kW
- 22,00 lbs/hr
- Induction

Moose River
- ME lumber mill
- 425 kW
- 22,674 lbs/hr
- Synchronous

Backpressure Application

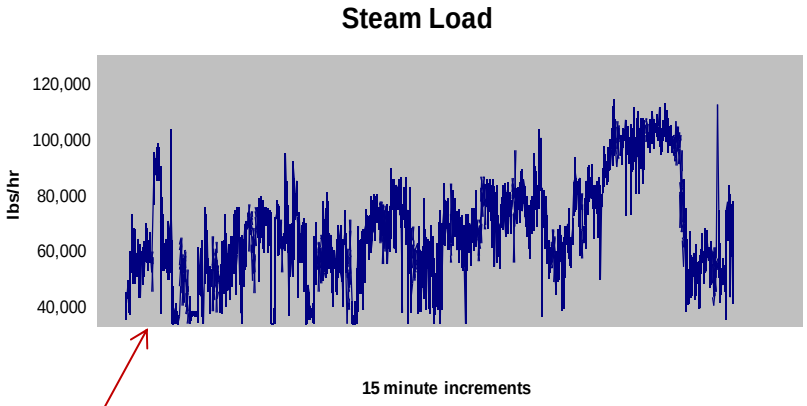


High Pressure Steam

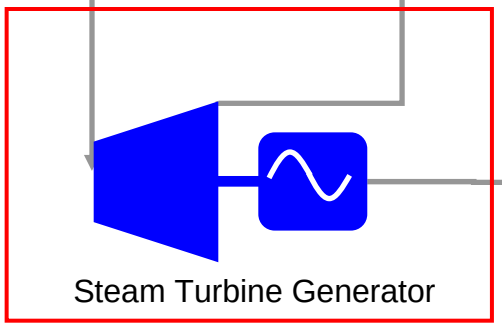
Pressure Reducing Valve

Low Pressure Steam

Process



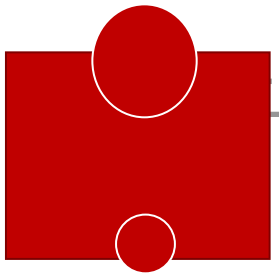
Turbine follows steam load



Steam Turbine Generator

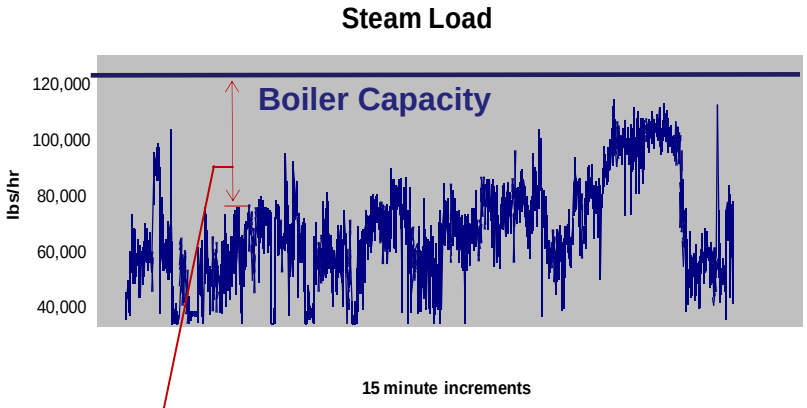
Electricity

Condensing Application



Steam

Process



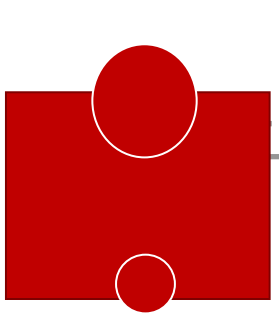
Steam Turbine Generator

Condenser

Electricity

Turbine operation is function of boiler capacity and steam flow.

Dual Turbine Application



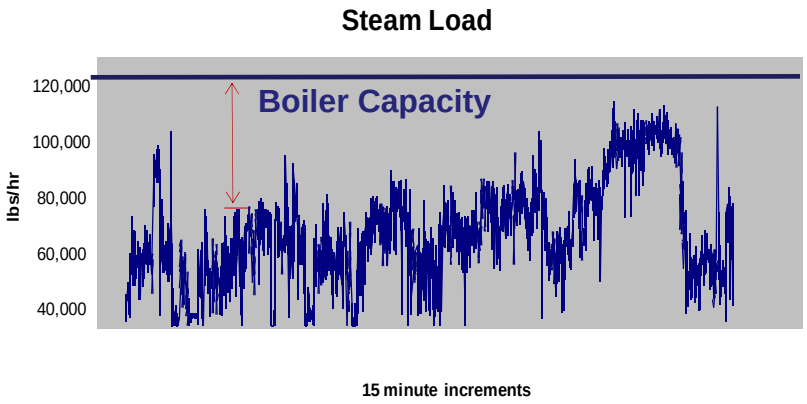
Pressure Reducing Valve

High Pressure Steam

Low Pressure Steam

Process

Steam Turbine Generator



Backpressure

Condensing

Condenser

Electricity

Backpressure turbine follows steam flow, condensing turbine matches boiler capacity.

Temple Inland

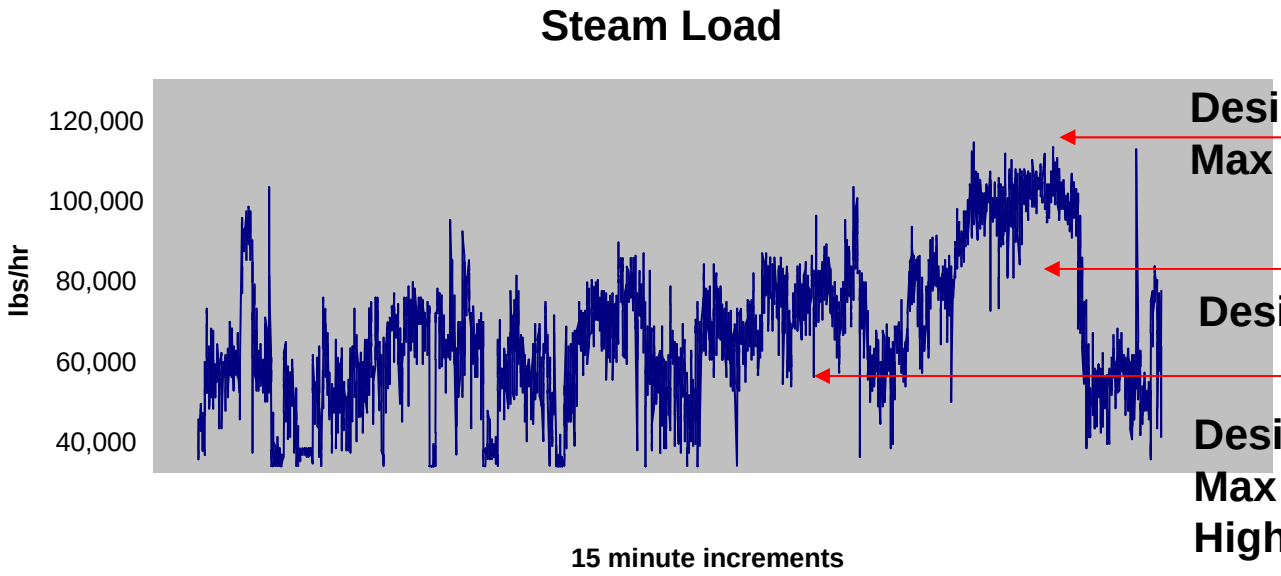
- Produces dimension lumber, timbers and decking
- Outlook for future electric rates, prompted examination of self generation
- Turbosteam engaged to assess feasibility

Temple Inland

- Waste from mill burned in a stoker-fired boiler
- Steam generated at 380 psig
- Steam users are series of dry kilns utilizing 150 psig
- Peak steam load at ~100,000 lb/hr

Selecting Steam Turbine

Every process steam load profile warrants careful study



Design for peak?
Max kW, penalized on turndown

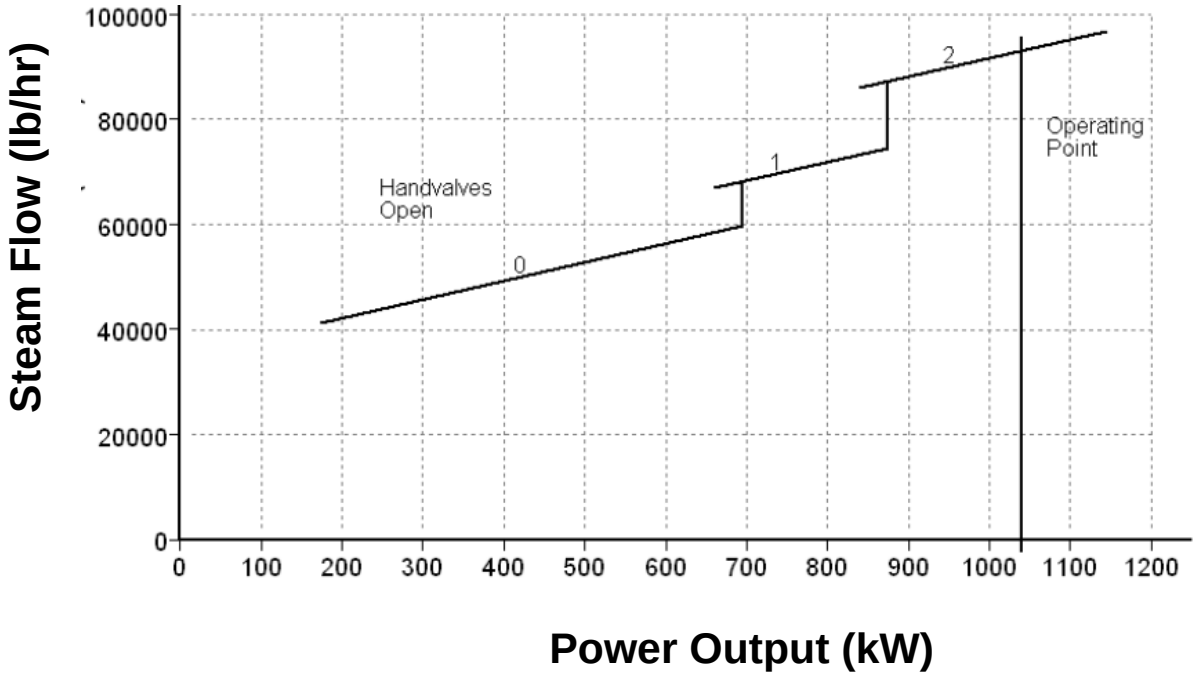
Design for max annual kWh?

Design for baseload?
Max capital utilization
High $/kW

There is no universal optimum: depends upon capital cost, system operating profiles, energy rates, estimates of future future growth and overall financial objectives.

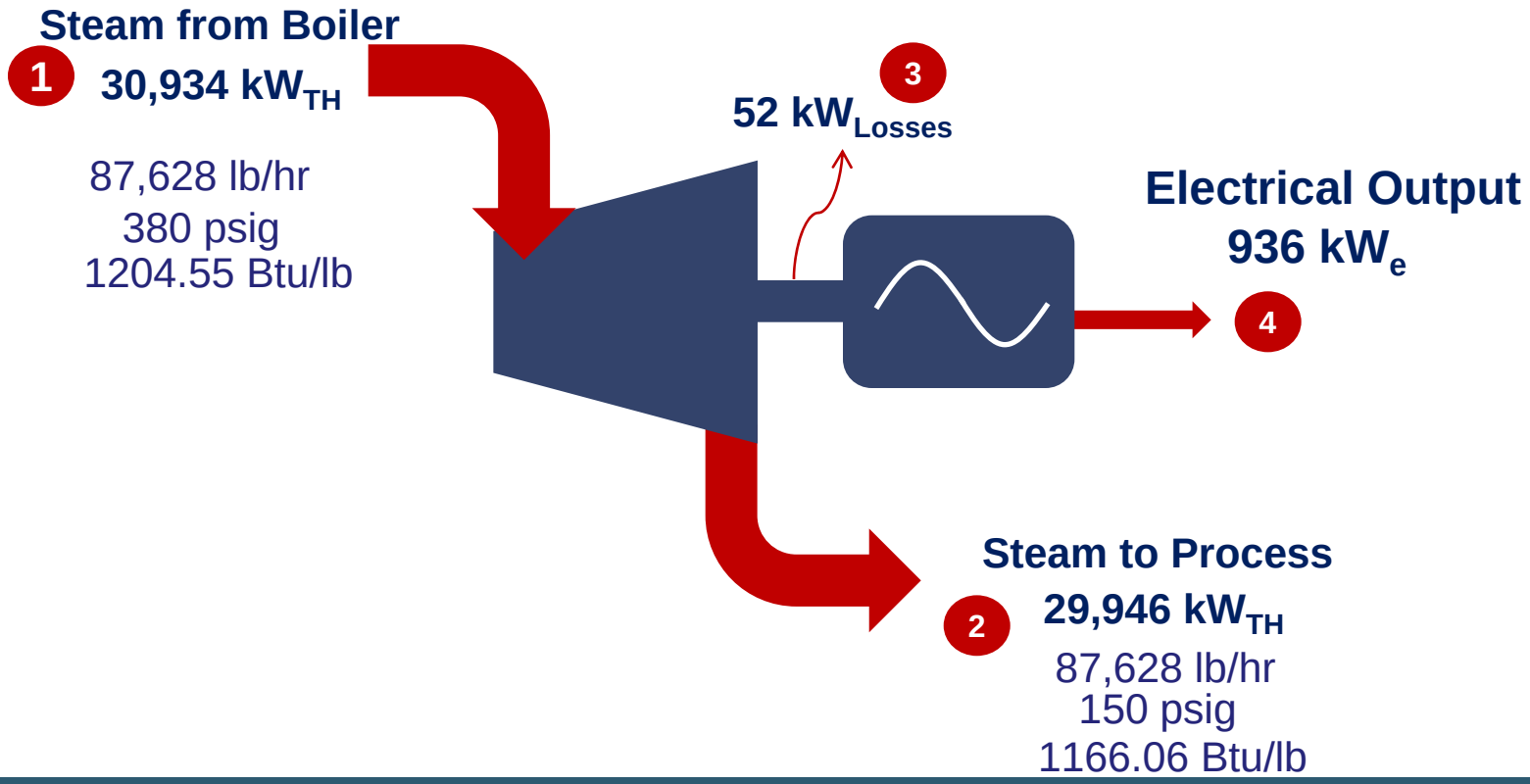
Example: Temple Inland Turbine Design & Performance

- **Project designed for upper range of steam flow and ~1 MW, but expected to operate in the range of 70,000 lb/hr ~800kW**
- **Automatic nozzle valves help to increase efficiency at part loads**



Unparalleled Efficiency

$$\text{Efficiency} = \frac{\text{Electric Output}}{\text{Energy from Steam}} = \frac{\text{936 kWe}}{\text{30,934 kWth} - \text{29,946 kWth}} = 94.7\%$$



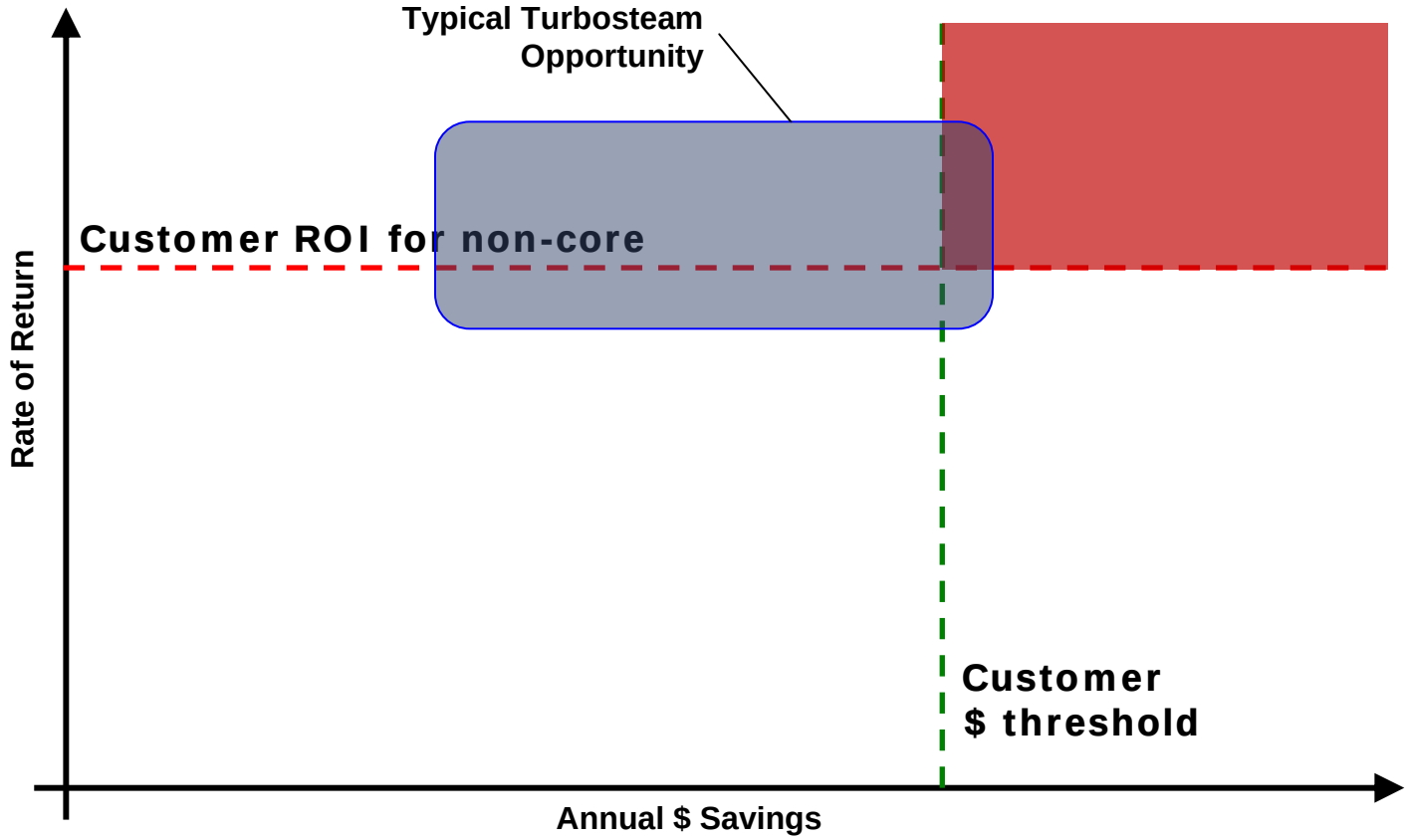
Turbine Generator

- Steam Turbine
  - Single Stage Dresser Rand Model RLHB24
  - 1040 KW @ 3638 RPM
- Steam condition inlet:
  - Inlet 380 psig
  - Exhaust 150 psig
- Synchronous Generator
  - 1800 RPM
  - 4160 Volt

Project Metrics

- ~1 MW of ~95% efficient, clean power
- Project payback less than 2 years
- Based on expected operating loads, the project reduces CO_2 emissions from less efficient grid electricity by over 4,000 ton/yr

These projects are attractive-just not always to hosts focused on their core manufacturing processes



What can help?

- Investment tax credits
- Production tax credits
- Loan programs
- Standard offer programs
- New Source Review consideration

For more information:
www.turbosteam.com

TURBO STEAM
A Division of Recycled Energy Development

161 Industrial Boulevard
Turners Falls, MA 01376

413-676-3016

BILL BULLOCK
General Manager

bbullock@turbosteam.com