An Education in Backpressure Heating & Cooling Load
CHP 101 at Middlebury College

Presented to EPA CHP Partners Meeting
Washington DC

May 13, 2004

TURBO STEAM

Creating Value from Steam Pressure

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Syllabus: Success Story / Obstacles to CHP

Success Story

Middlebury College Case Study

Energy Star CHP Award Consideration
Efficiency Driven / Environmentally Important / Technology Neutral Solution

Obstacles To Overcome

The Common Barriers To CHP?

Competing With The "Core Business"

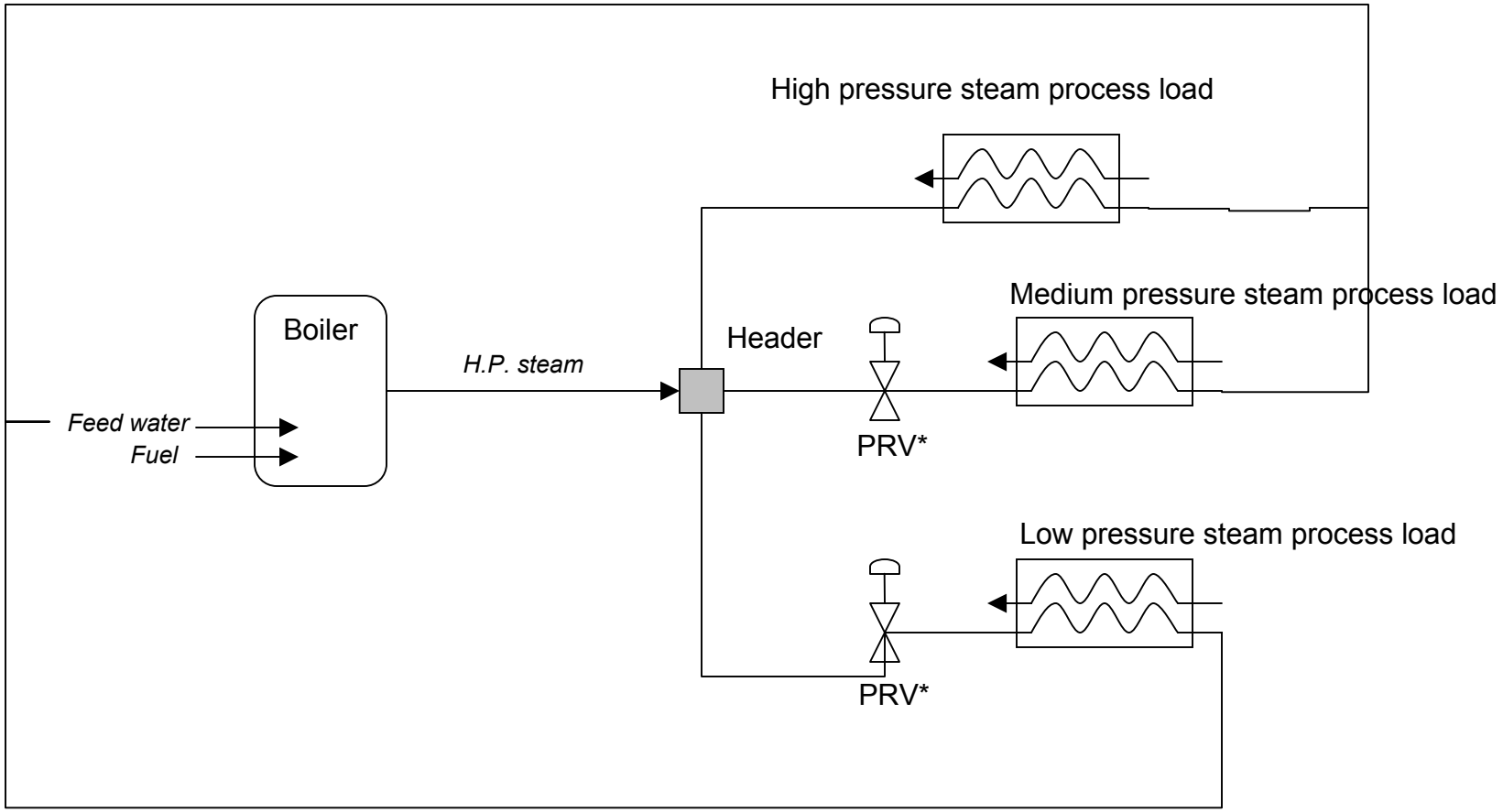
Removing The "Hassle Factor"

Perceived Risk – Providing A Comfortable Option

Case Study: Middlebury College

- 2000 student liberal arts college located in Middlebury VT.
- District steam system heats 1.6 million square feet spread over 350 acre campus (36 buildings on system)
- Big winter heating load (60,000 lbs/hour at peak)
- Big summer cooling load for (~1,200 tons at peak)
- Campus steam load delivered by 4 #6 oil boilers, 2 @ 125 psig, 2 @ 250 psig
  - Boiler fuel prices range from 60 – 75 cents/gallon (#6 oil)
  - Equivalent to $5 - $6.25/Mlb steam
  - Delivery pressure = 22 psig
- College uses ~20 million kWh/year, at an average price of 8.5 cents/kWh
- **March 1, 2000: Started up a 912 kW Turbosteam backpressure steam turbine generator**
  - Supplemented 2 existing turbine-generators (850 kW) – have been generating power with backpressure turbine-generators since 1980.

Typical steam system design



*PRV = Pressure Reducing Valve

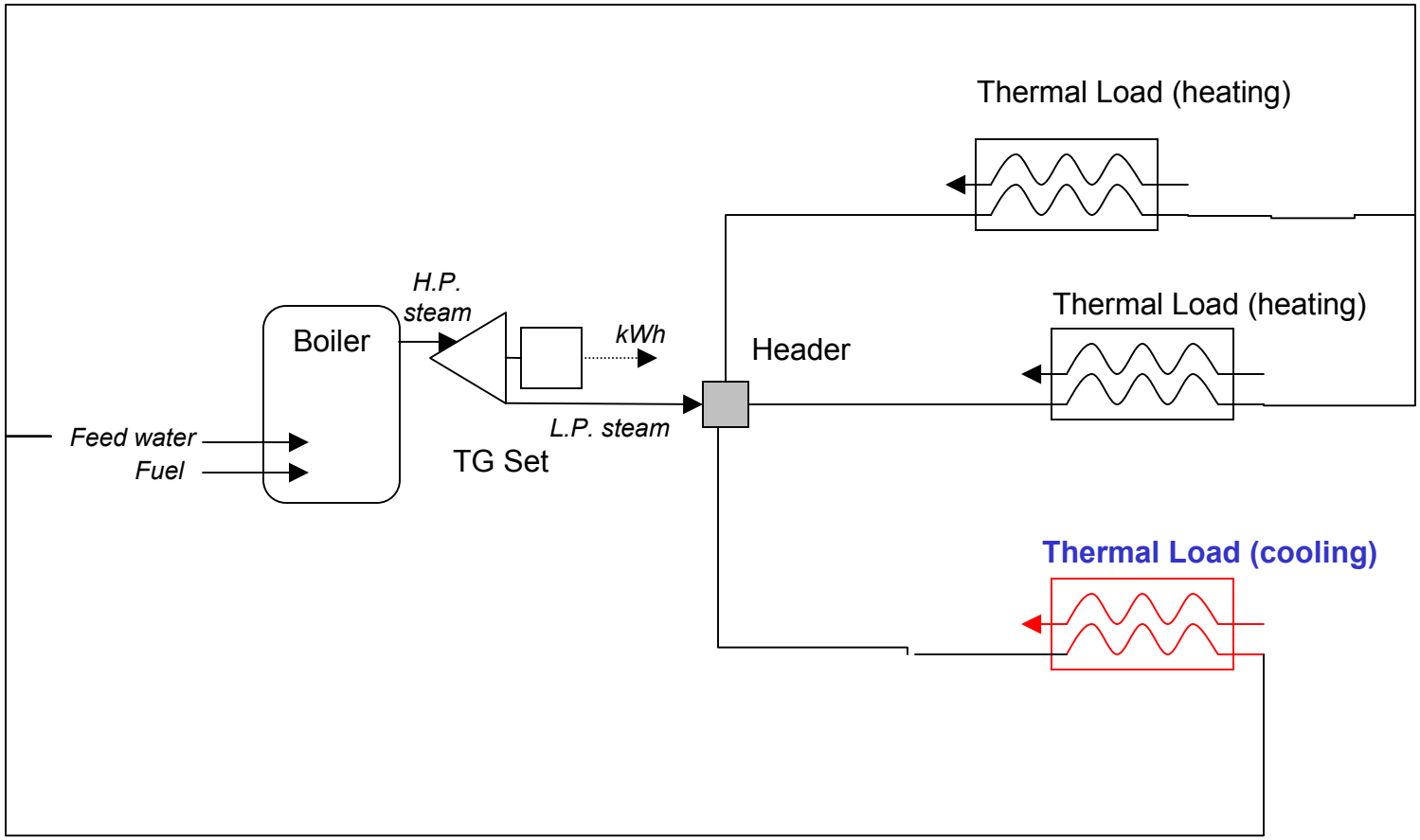
A backpressure turbine delivers the same pressure drop as a PRV – <u>and</u> produces useful electricity in the process.

High Pressure steam in

Electricity out

Low Pressure steam out

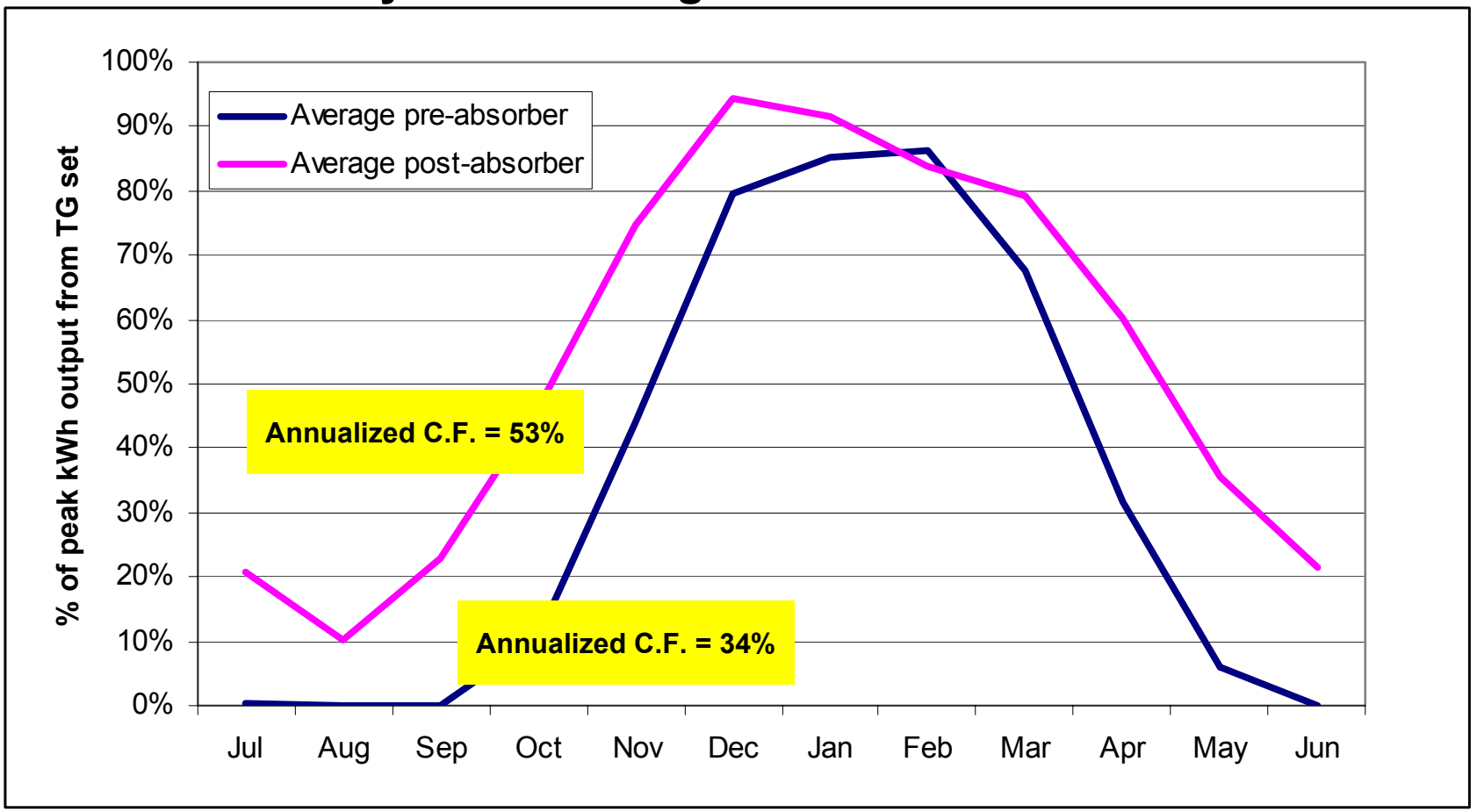
Middlebury design



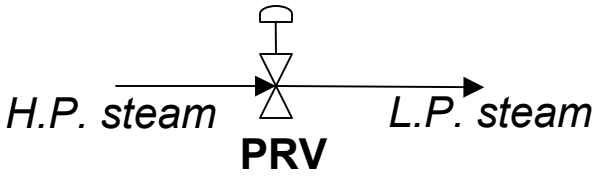
Absorption chillers and backpressure turbine-generator synergies

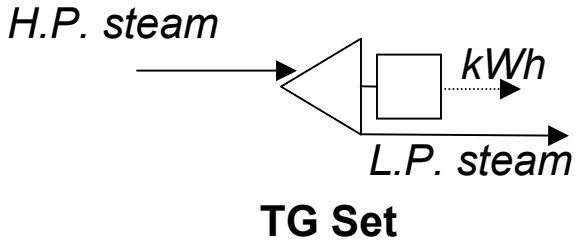
- In 1992, a Trane single stage absorption chiller was installed in arts center, using the low pressure exhaust steam from the turbine-generator to provide cooling
  - Rated at 465 tons, currently operating at 375 tons
  - Fully installed capex = $132,000
- **In 2001 two Trane single stage absorption chillers were added to provide cooling for the college's new Science Center, using the exhaust steam from the Turbosteam backpressure steam turbine-generator**
  - 2 X 520 tons
  - Fully installed capex = $357,000
- **Net result: Almost doubles TG set capacity factor**

The addition of the absorbers has almost doubled the annual value created by the turbine-generator.



So what's the efficiency of Middlebury's CHP plant?

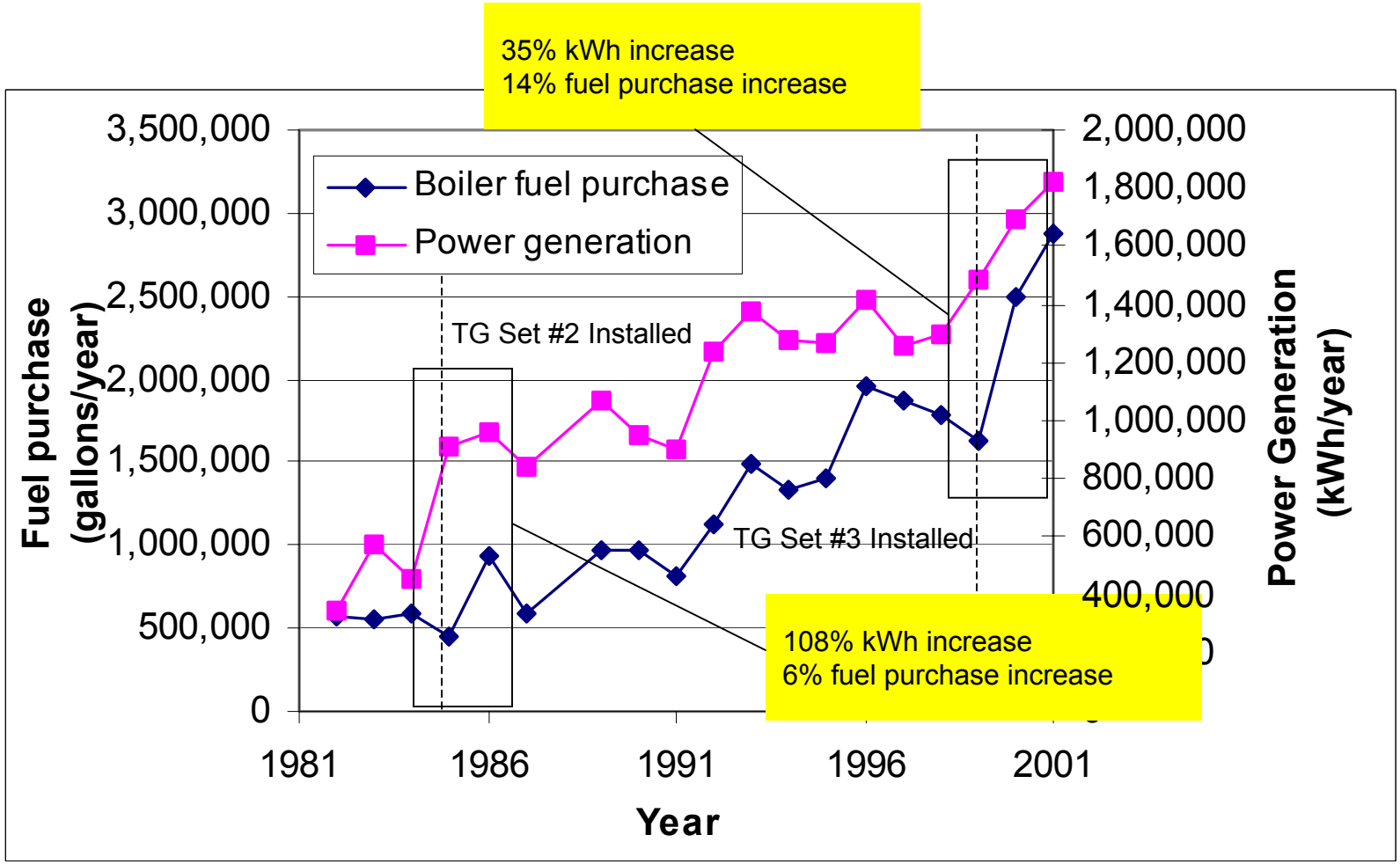




Thermodynamics	
1st Law Balance	PRV Efficiency
H.P. energy = L.P. energy	~100%
H.P. energy = L.P. energy + kWh	~Boiler efficiency = 80 – 85% PRV efficiency ~ power generation efficiency!

This efficiency implies a lower cost of operation and less emissions per kWh than <u>any other generation technology</u>.

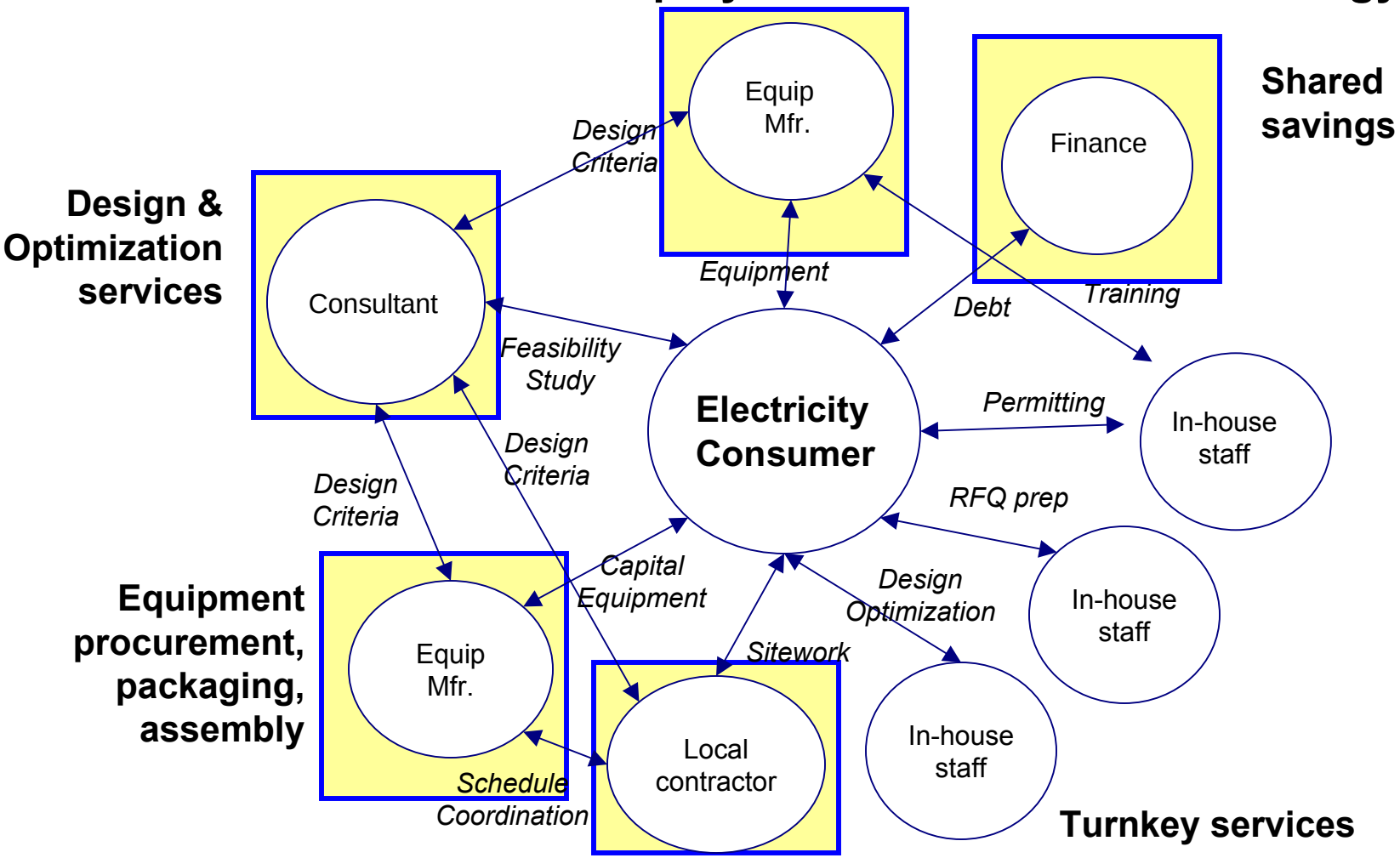
Actual efficiency may be even higher; Middlebury does not include a line item for fuel purchase in their operating budget.



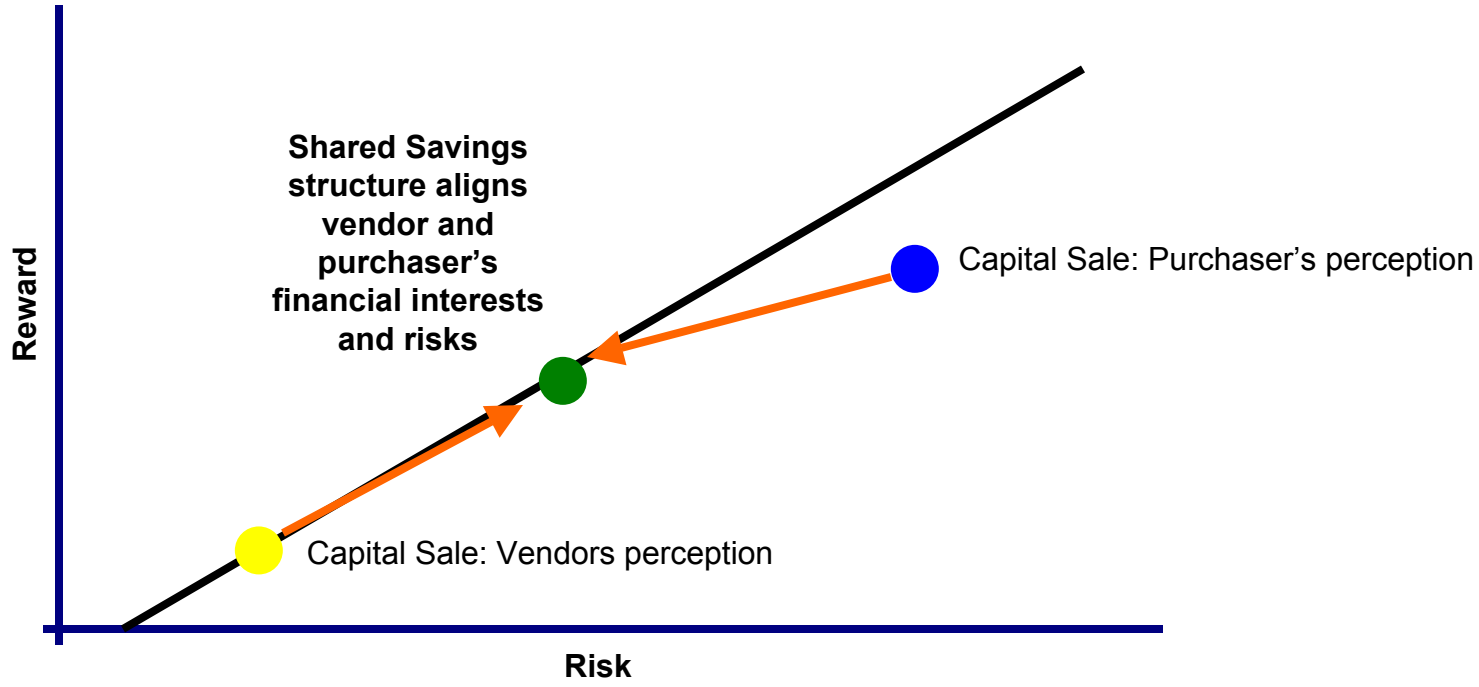
Duplicating Middlebury's success requires first addressing the barriers common to all CHP projects.

- Your core business is not electricity generation
  - Often easier to take energy costs for granted rather than invest in capital to reduce
- You may not be familiar with power generation technologies, and thus perceive a high level of risk
- "Stick to your knitting" in an uncertain economy
- Hassle factor

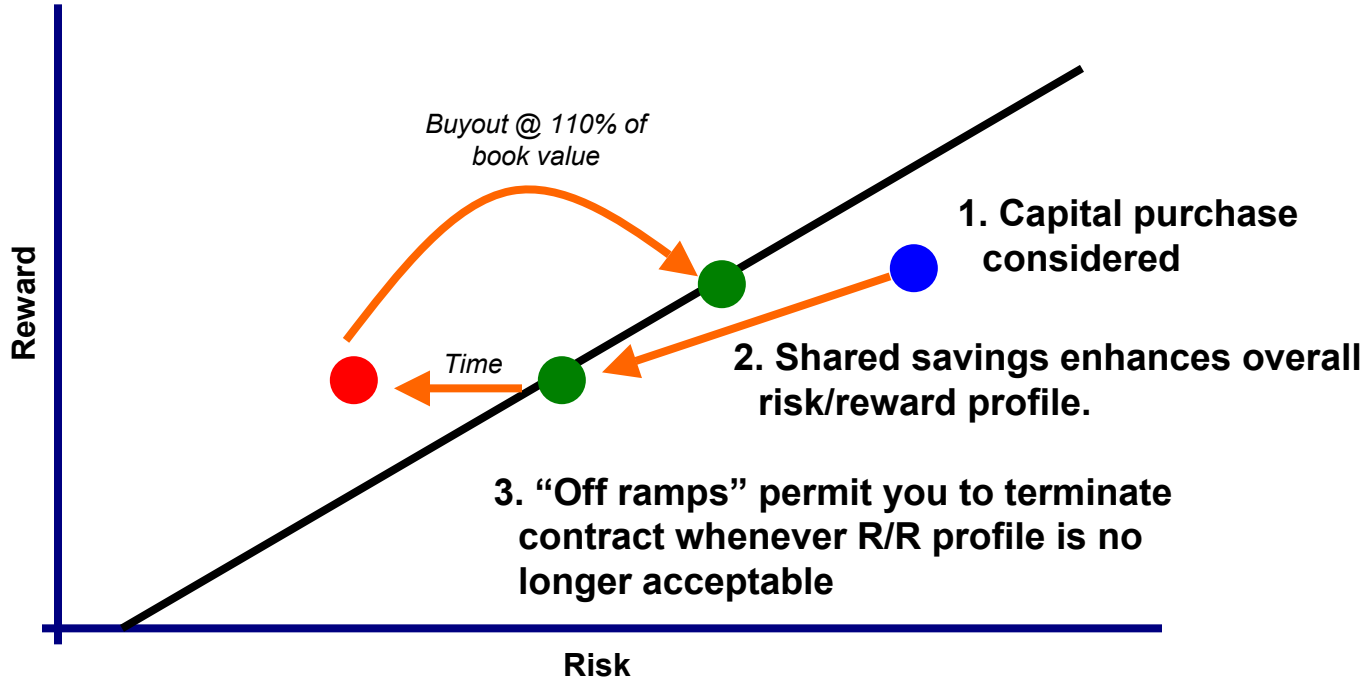
Turbosteam's business is structured to reduce this "hassle factor" to facilitate the deployment of clean CHP technology.



Our shared savings program is based on minimizing risk.



Buyout provisions maintain the focus on risk/reward throughout the contract term.



So where else can you find opportunities?

	Probably not attractive	Probably attractive	Drop-dead gorgeous
Steam flow rate	<3,000 lbs/hr	>3,000 lbs/hr	>10,000 lbs/hr
Inlet pressure	<125 psig	>125 psig	>150 psig
Pressure drop	<100 psi	>100 psi	>150 psi
Price of electricity	<1.5 ¢/kWh	>2 ¢/kWh	>6 ¢/kWh
Capacity factor	<25%	>25%	>50%

In short, almost anywhere steam is produced!

Does Implementing CHP Make Sense?

The Oldest and Smartest and Wealthiest of our 180+ Clients, Middlebury College has Additional CHP as a Key Part of its Long Range Expansion Plans.

The Obstacles to

Cleaner Energy

More Efficient Energy

Cheaper Energy

Potential Reliable Back-Up Energy

Are Easily Managed and Overcome.

Focus on Your Core Business

Find a Partner You Trust