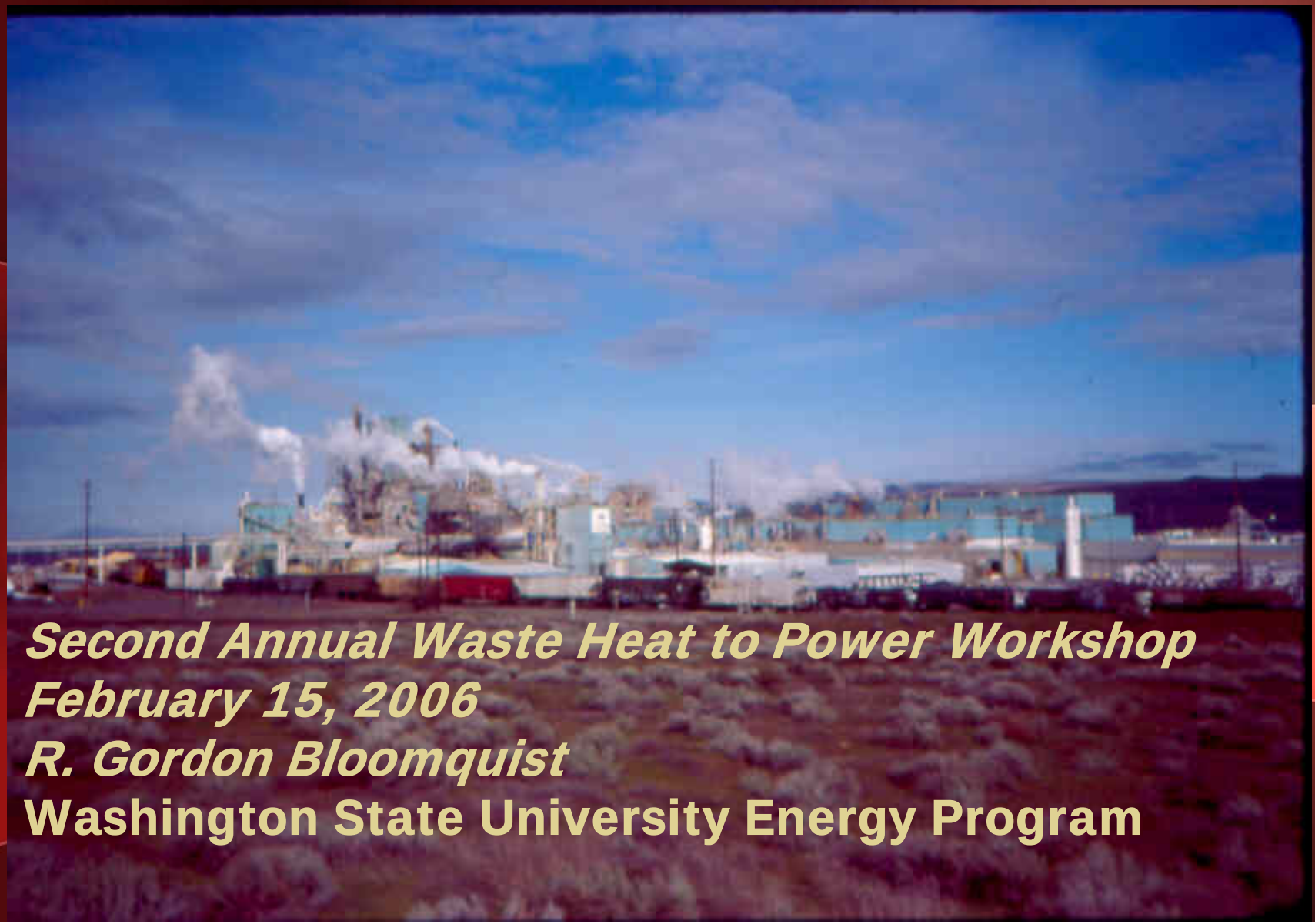
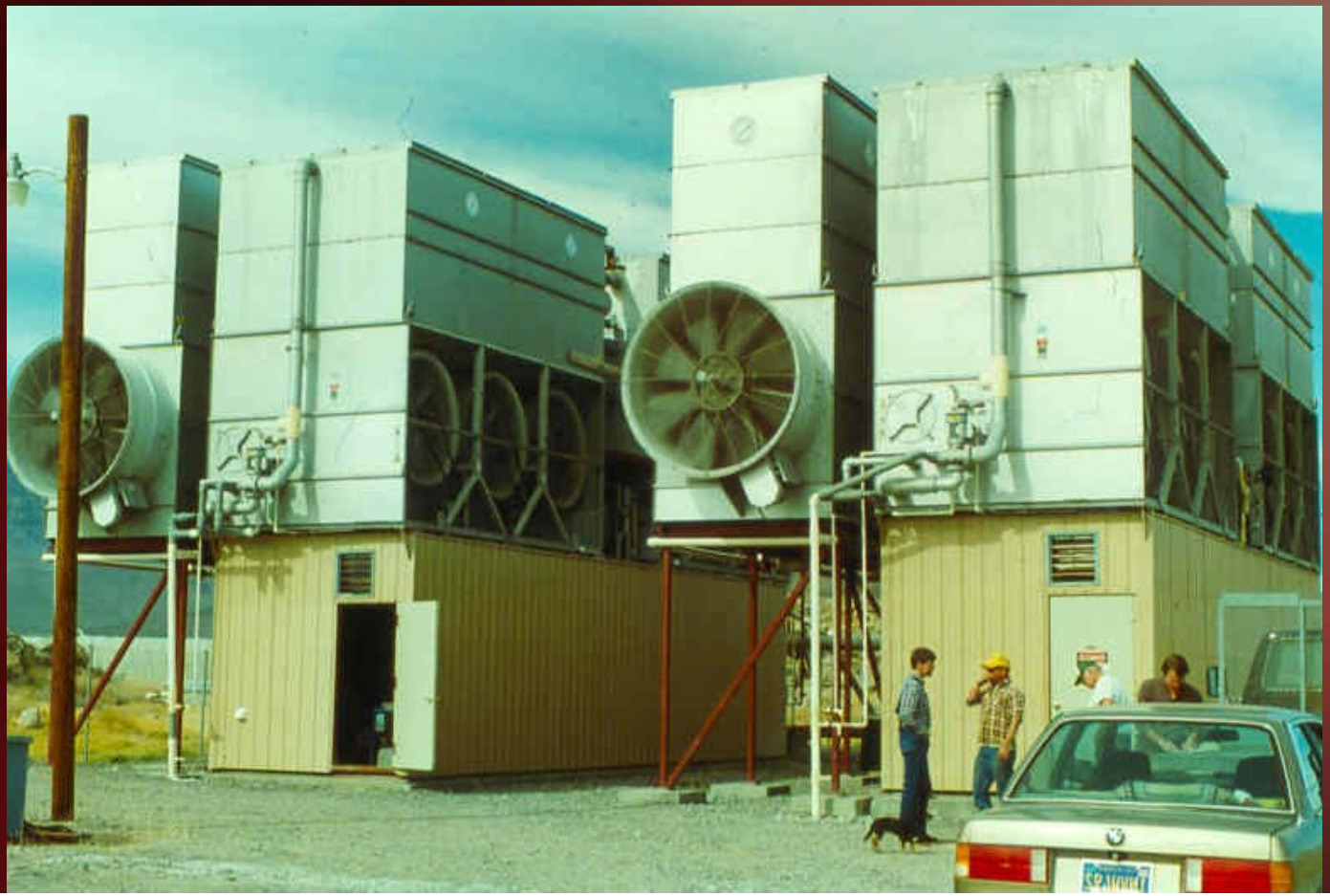
Waste Heat Utilization



Second Annual Waste Heat to Power Workshop
February 15, 2006
R. Gordon Bloomquist
Washington State University Energy Program

Welcome To The Second Annual Workshop

Devoted Entirely to Utilization of Waste Heat for Power Production



Why a Workshop Devoted Entirely to Waste Heat to Power?

- Waste Heat is one of our most under-utilized energy resources
- 24.7 Quads of energy is used by industry – of this 20-50 percent is lost in the form of Waste Heat
- Energy losses within the following sectors equal 4.4 quadrillion BTUs (Quads) – 15 percent of the energy consumed in the U.S. per year

The Big Five

- Petroleum Refining
- Chemicals
- Forest Products
- Iron and Steel
- Food and Beverages

Waste Heat to Power Is

- Renewable – no additional fuel is consumed
- Environmentally Responsible – maximum input fuel use efficiency
- Affordable – essentially free

The Top Six Opportunities

1. Waste Heat recovery from gases and liquids in petroleum, chemicals and forest products
2. Heat recovery from drying processes
3. Waste Heat recovery from gases in metals/non-metallic minerals manufacturing, including hot gas clean-up
4. Energy Recovery/by-product gases
5. Waste Heat recovery/metal quenching/cooling processes
6. Waste Heat recovery from calcining

These Six Represent

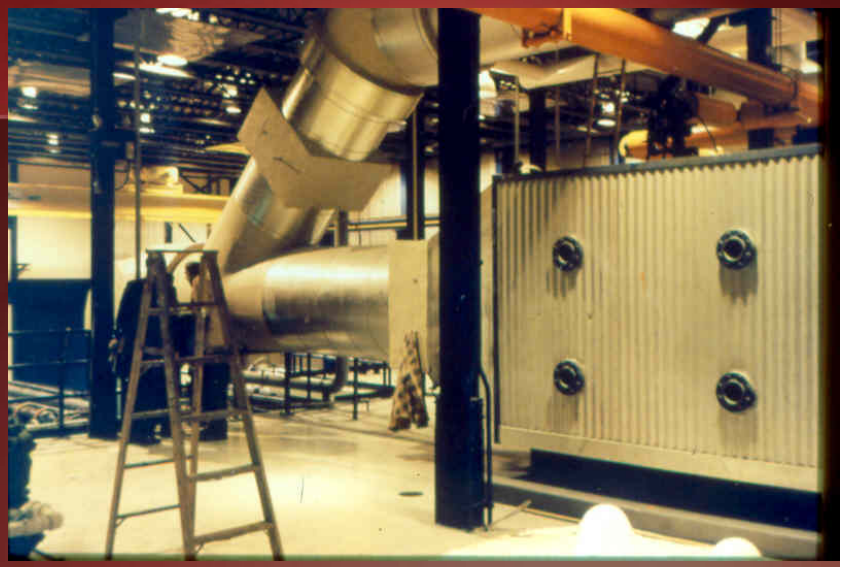
- 1.65 quads of Waste Heat
- $6.1 billion in cost saving
- ?? MWe in electrical generation
- ?? $ billion in electricity production

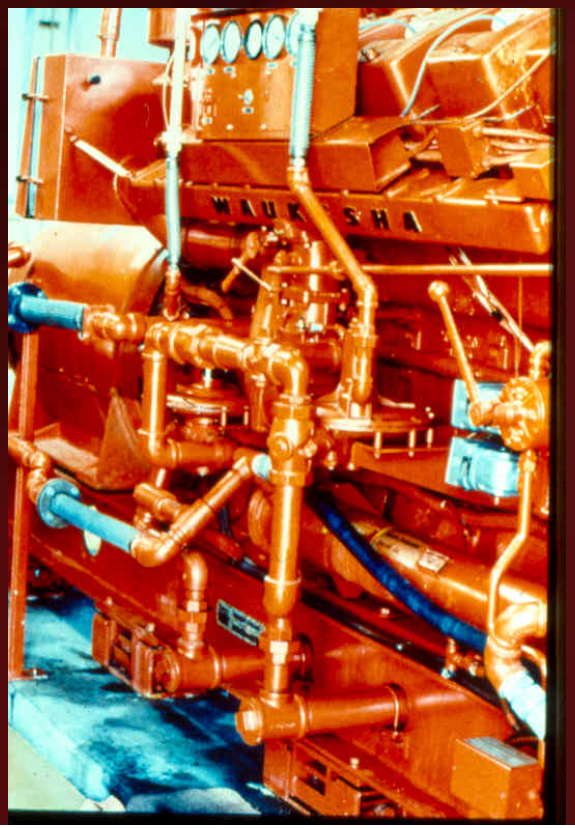
Additional Waste Heat Resources to Consider

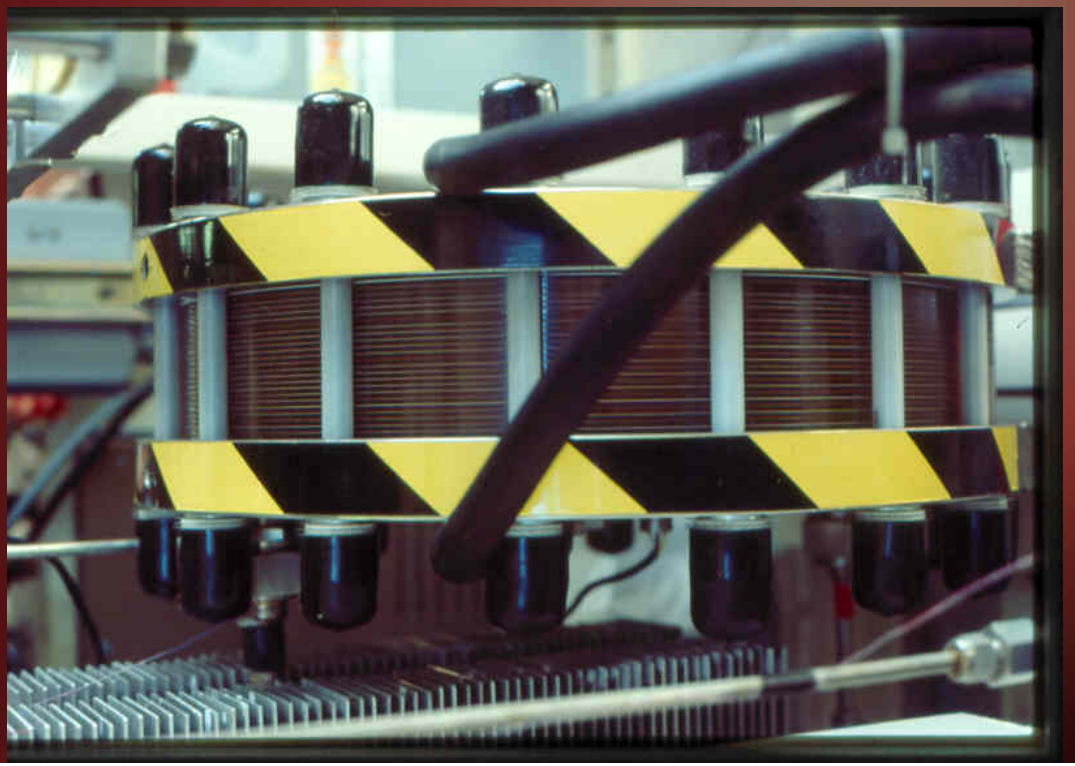
- Waste Steam
- Steam Pressure Reduction
- Natural Gas Pressure Reduction

Other Sources Include

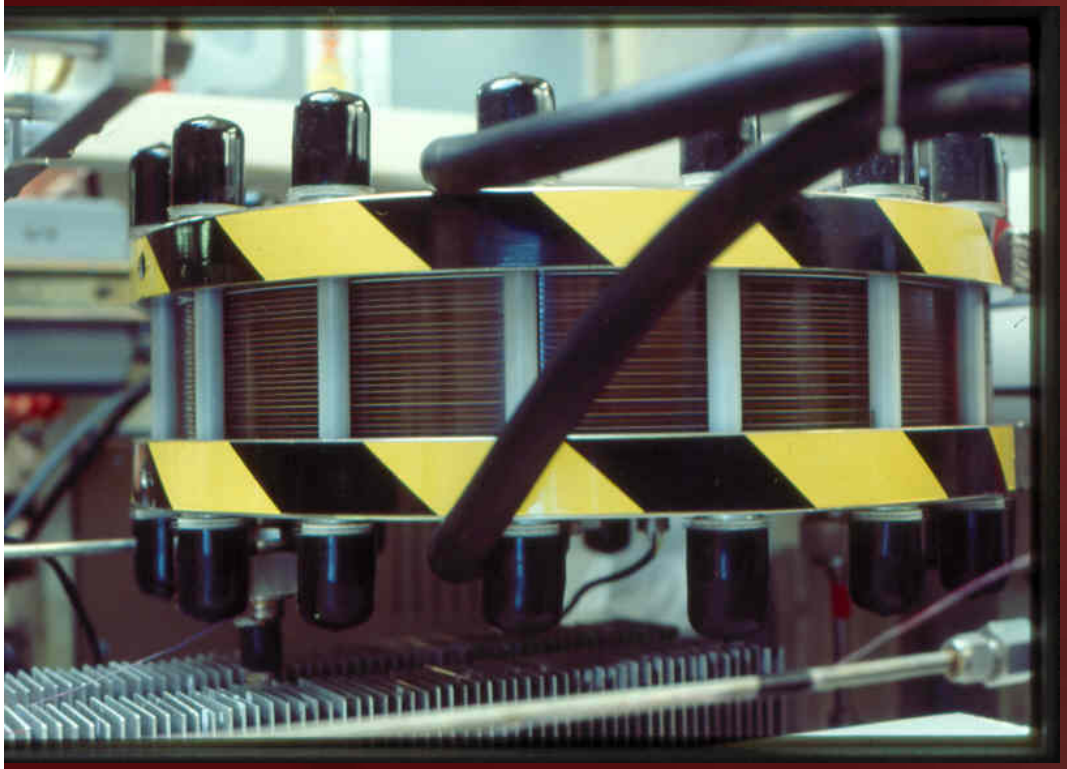
- Conventional generation
  - Turbines
  - Reciprocating Engine
  - Fuel Cells







- Industry
- Municipal waste incineration
- Compressor stations
- And more

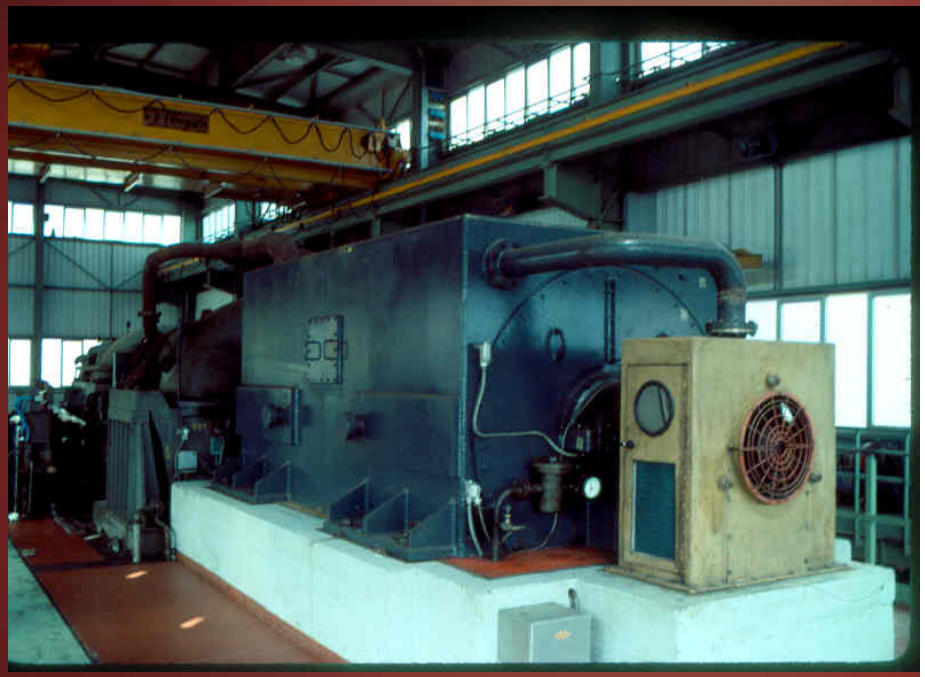


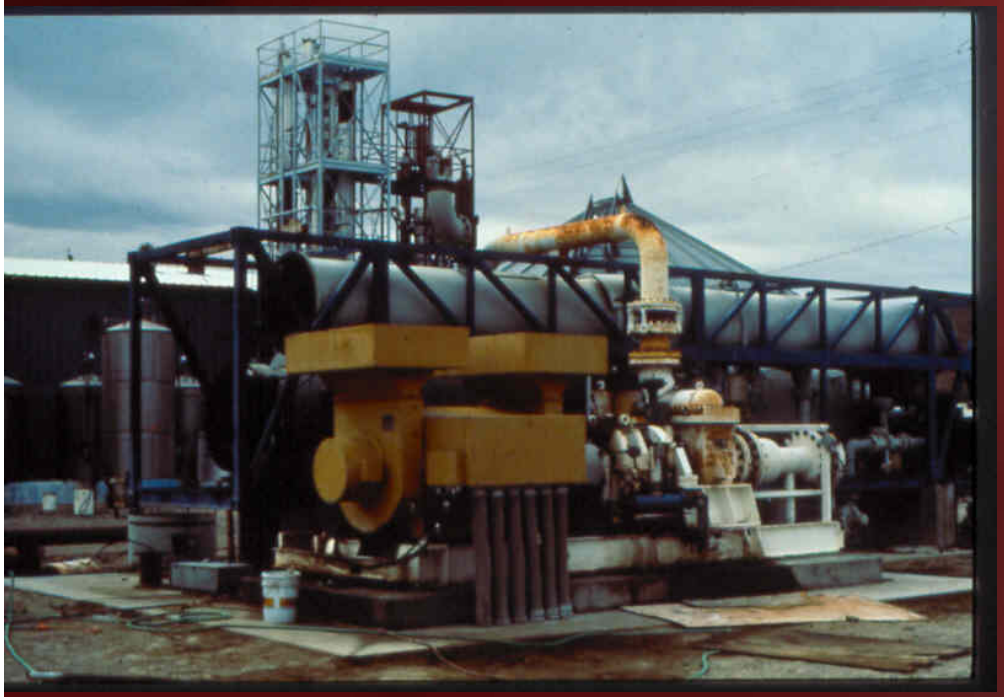
Potential Uses of Waste Heat

- Industrial process
- Power generation
- Dehydration
- Refrigeration
- Space cooling / district cooling systems
- Space heating / district energy systems

Power Generation

- Steam cycle
- Organic Rankine cycle
- Kalina cycle





To Achieve Wide-Spread Application of Waste Heat to Power

- Education
- Research, Development, Demonstration
- Industrial Facility Assessments that identify power production opportunities
- Understanding of available conversion technologies
  - Steam Cycle
  - Organic Rankine Cycle
  - Kalina Cycle
- Recognition as Renewable
- Inclusion in Renewable Portfolio Standards
- Consistent tax treatment for all Renewables

Development of a Technology Roadmap – How can we Achieve our Objectives?

- Technology requirements
- Overcome legal, regulatory and institutional barriers
- Obtain utility contracts
- Financing
- More?

Workshop Agenda

- State and Federal views and initiatives
- Utility relations
- Financing Options
- Legal and institutional issues
- Contracting
- Power Conversion Technologies
- Case Studies
- Developing a Roadmap for the future
- Field trips

Keynote Address: Recycling Energy – Affordable Clean Energy / Tom Casten, Chairman and CEO of Primary Power