Recycled Energy Basics and Benefits

New Mexico Recycled Energy in Action

September 30, 2011

U.S. Department of Energy
Clean Energy Application Centers

U.S. DOE Clean Energy Application Centers (formerly CHP "RAC"s)

Develop regional strategies to support:

- Combined Heat and Power
- Waste Heat Recovery
- District Energy

1. Education and Outreach
   - Website, workshops, webinars
2. Project Specific Support
   - Audits, feasibility studies, assistance
3. Policy Development
   - Regulatory and policy outreach

Overview

1. Why Recycled Energy
2. Definitions and Technologies
3. Basics and Benefits - Examples
4. Barriers
5. Resources and Contacts

Why “Recycled” Energy

What do we mean, why do we care

We Aren't Really Interested in Energy
→ We are interested in Energy Services

Source

- Fossil
- Biomass
- Geothermal
- Wind
- Solar
- Nuclear
- Etc.

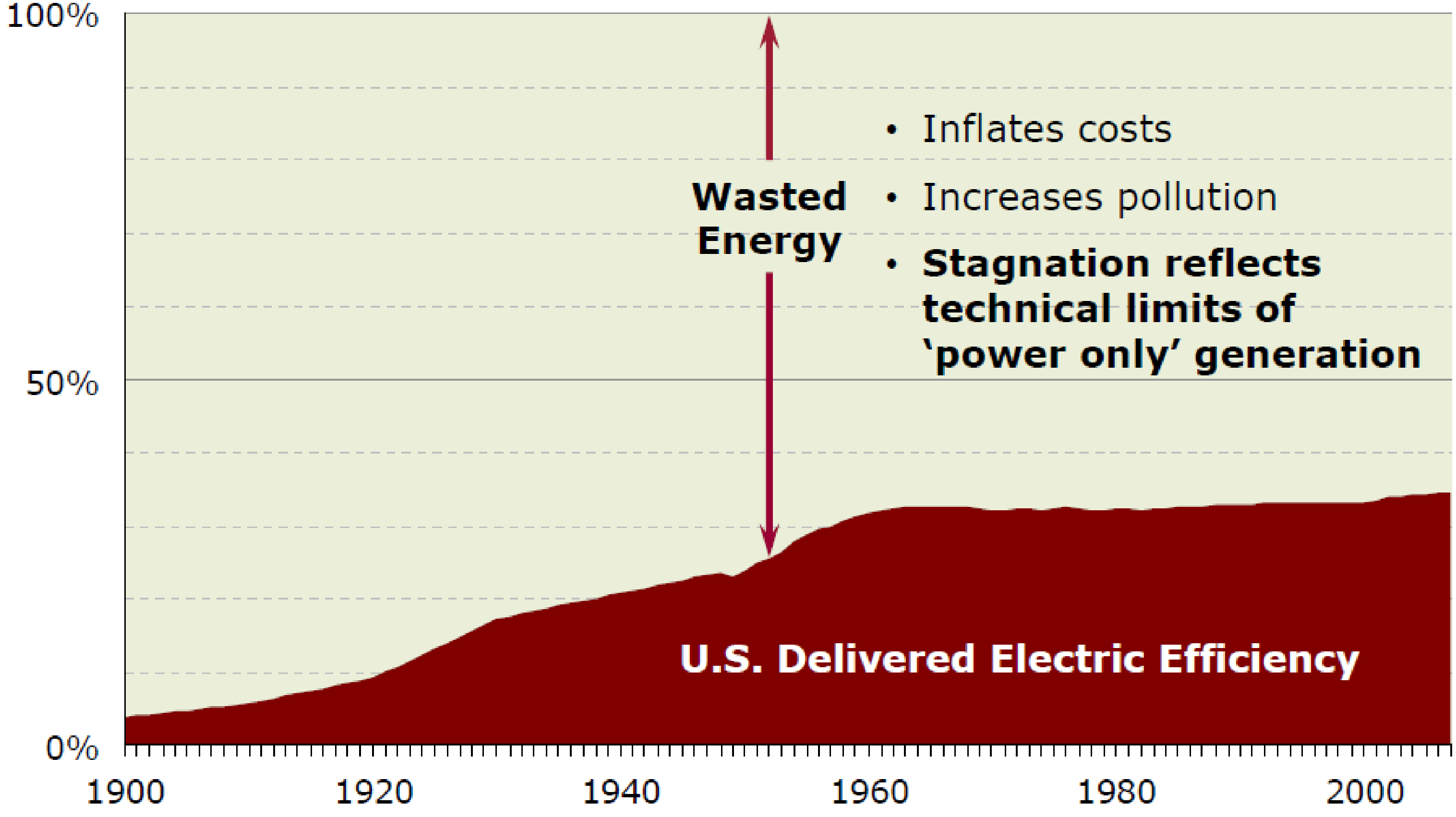
Service

- Heat
- Light
- Cooling
- Work

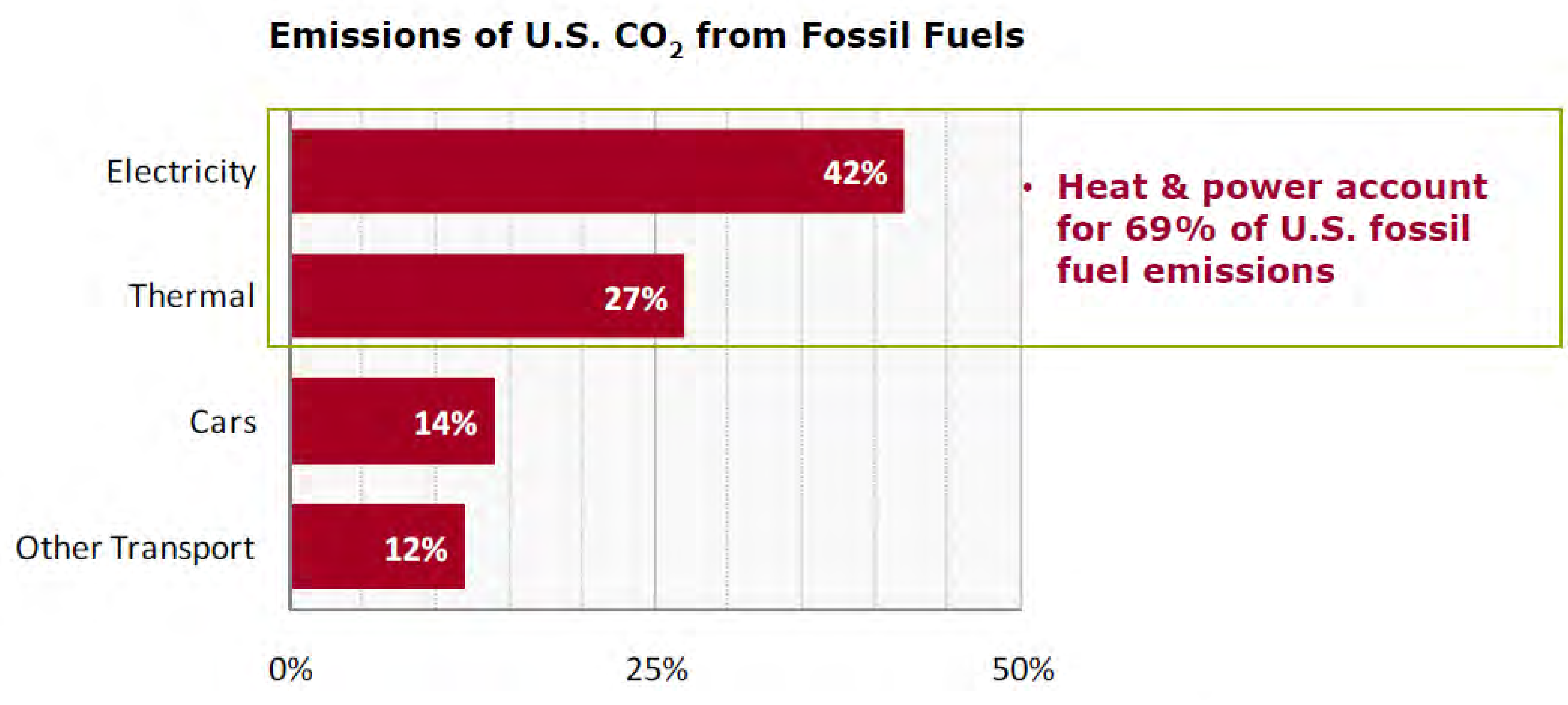
Our energy infrastructure is very inefficient

- Take the electrical grid for example

Not only is generation inefficient, it's stagnant



Heat and Power are Responsible for Two-thirds of U.S. CO_2



Source: RED calculations based on data from the U.S. Energy Information Agency and the U.S. Department of Transport

Much of the waste is caused by our silo approach to energy

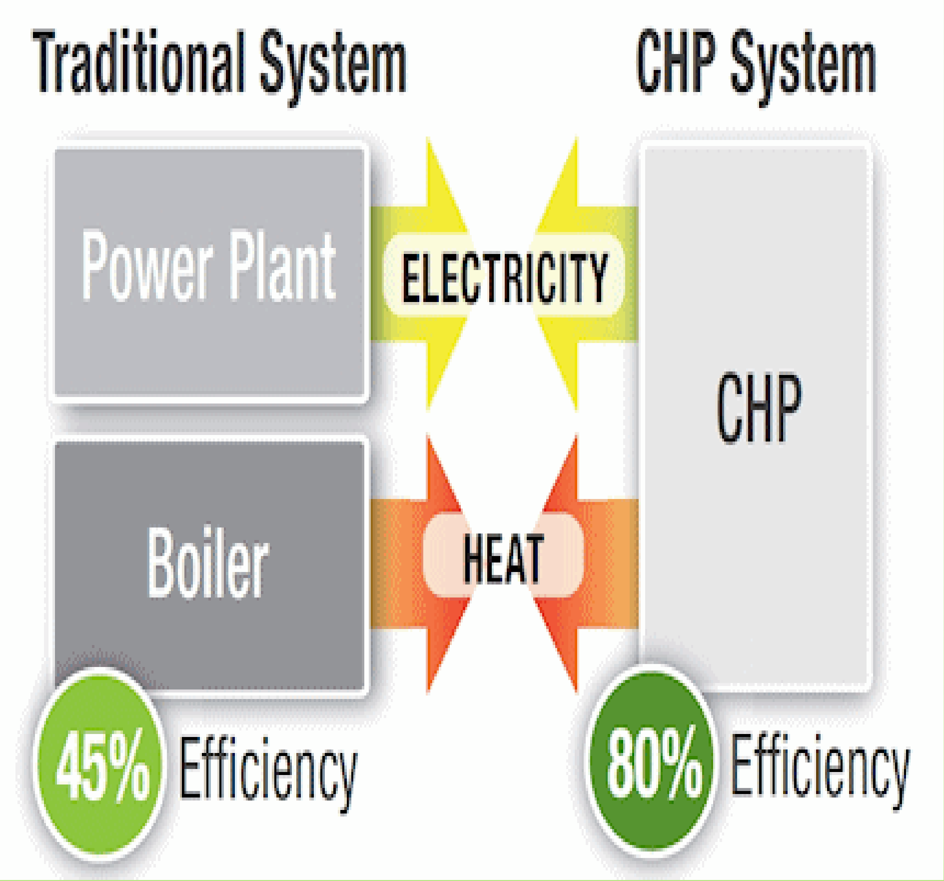
Recycling energy breaks the silos

- Bypass the power-only efficiency limits
- Integrate systems inside the plant (or campus, building, etc)
  - Electrical
  - Thermal (both heat and cooling)
  - Process

Definitions and Technologies

What do we do, and how do we do it?

Combined Heat and Power (Co-generation)



Concurrent production of electrical, mechanical, and/or thermal energy (heat and or cooling) from a single fuel source.

Waste Heat Recovery

- Capturing waste heat or pressure and turning it into;
  - Electricity (renewable)
  - Thermal
  - Mechanical
- No extra fuel
- No extra emissions

District Energy

- Central generation of some combo of:
  - Electricity
  - Heating
  - Cooling
- Distribution to:
  - Network of buildings, facilities, processes
- Enables integration/ energy recycling

NM CHP installations

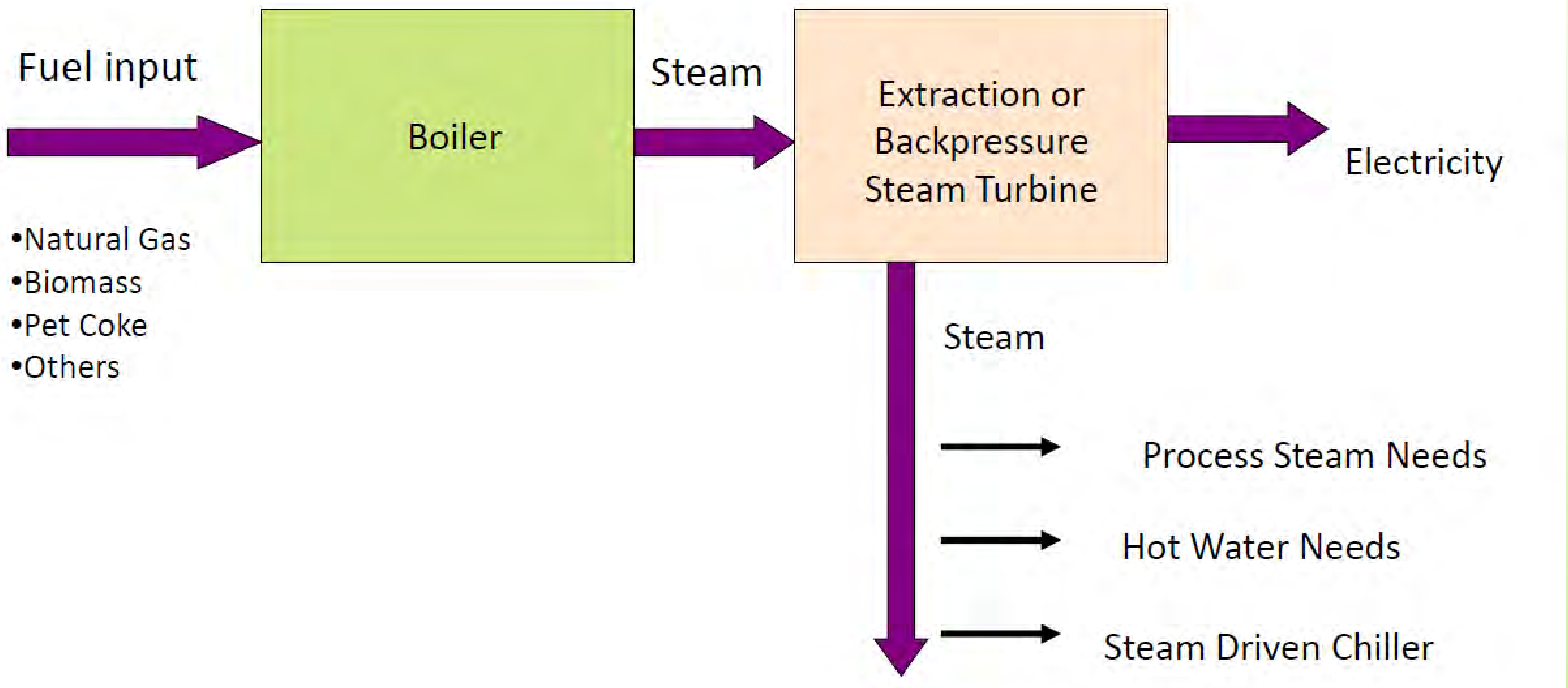
Facility Name	Prime Mover	Capacity (kw)	Fuel Type
Sangre De Cristo	Engine	100	NG
Ford Utilities Center	Gas turbine	7,000	NG
Southside Water Reclamation Plant	Engine	6,600	BIOMASS
Lovelace Medical Center	Engine	1,150	NG
Williams Field Services Kutz Plant	Gas Turbine	4,800	NG
Milagro Cogeneration Plant	Gas Turbine	60,800	NG
Ciniza Refinery	Gas Turbine	6,000	NG
Phelps Dodge Cobre Mining Co	Engine	1,600	OIL
Chino Mines Co	Boiler	84,000	NG
NMSU Central Heating Plant	Gas Turbine	4,700	NG
Hidalgo Smelter	Boiler	37,500	NG
Raton	Boiler	12,700	COAL
Santa Fe Hilton	Micro turbine	30	NG
St. Vincent Hospital	Micro turbine	60	NG
Coronado Center	Engine	23	NG

- Source EEA database of all known CHP installations

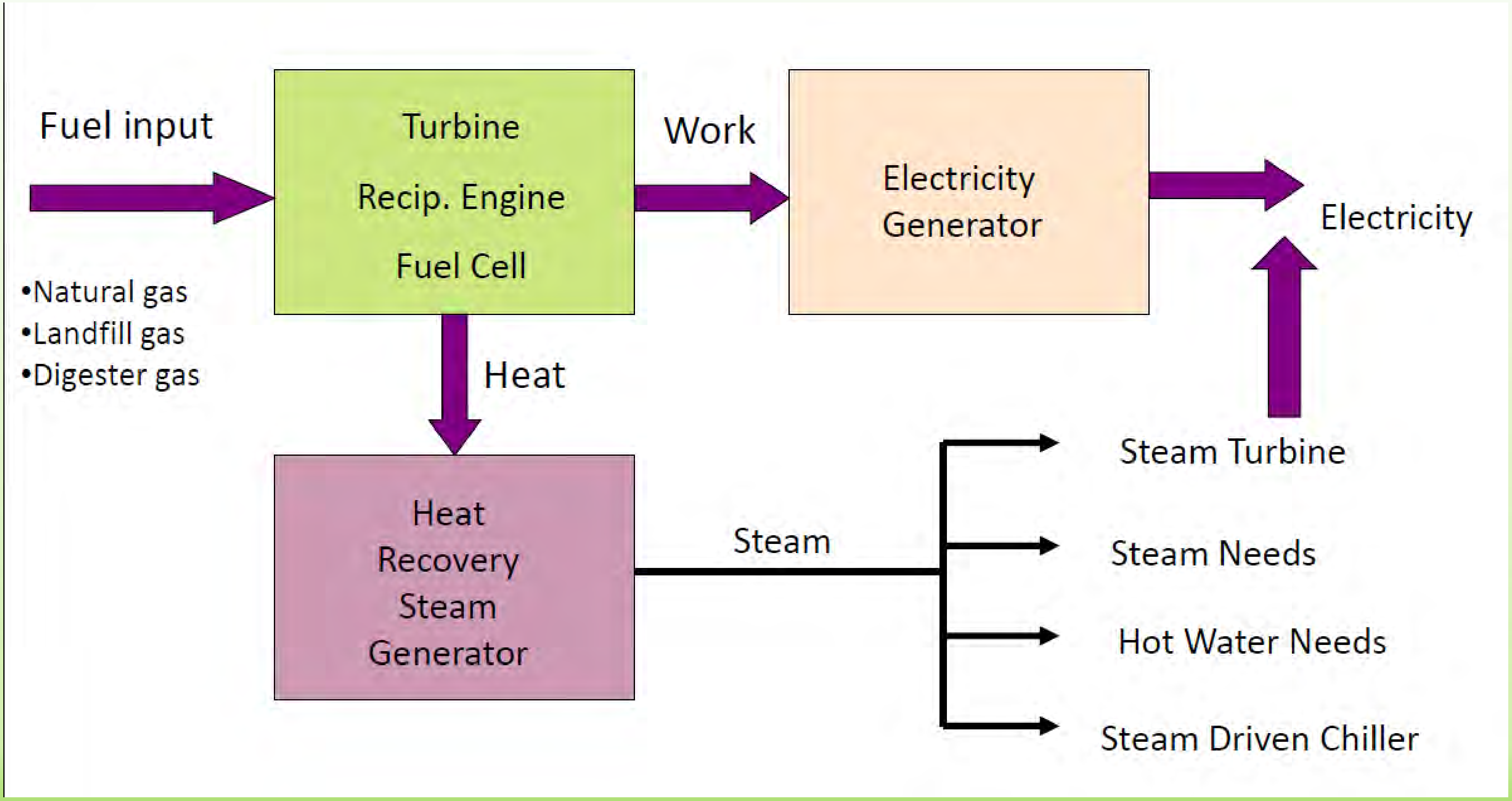
CHP (co-gen)Terminology

- Topping cycle - Electricity/work then use heat. Classic installation is steam turbine with heat recovery condenser
- Bottoming cycle – Heat first then power typically high temperature operations/stacks, newer low-temp systems
- Combined cycle (not really CHP) Electricity, heat-recovery=>steam, more electricity (utility gas turbine systems)

CHP: Boiler/Steam Turbine



CHP: Fueled Prime Mover

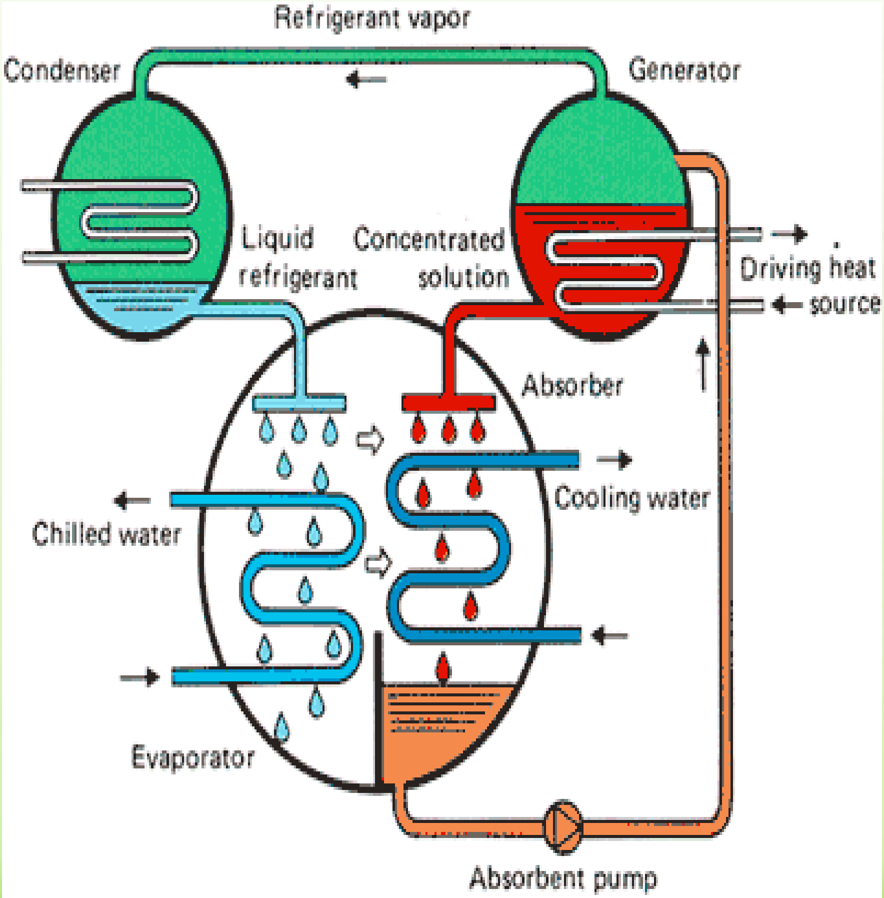


CHP Technologies -Electrical

- Reciprocating Engines
- Steam Turbines
- Gas Turbines
- Microturbines
- Fuel Cells

CHP Technologies – Thermal

- Heat Exchanger / Heat Recovery
- Heat Recovery Steam Generators (HRSG)
- Absorption Chillers



CHP Equipment Types:
Engines

- 200 kW to 2000 kW
- Electrical efficiency: 24-38%
- Heat produced: 4-5000 BtuH/kW
- Load-follows well
- Good match for under 200F heating loads

CHP Equipment Types:
Gas Turbines

- 1,000 kW- 50,000 kW
- Electrical efficiency: 24-36%
- Heat produced: 5-6000 BtuH/kW
- A little more heat, a little less electricity
- Better match for steady base loads
- Good match for steam heating loads
- Lower capital and operating cost than engines

CHP Equipment Types:
Steam Turbines

- 200 kW to 10,000 kW
- Electrical efficiency: 15-40%
  - Condensing higher, backpressure lower
- Heat produced: Varies widely
- Load-follows well
- Good match for existing steam system or when fuels are combusted in boiler (Need high pressure steam.)

CHP Equipment Types:
Microturbines

- 30 kW to 200 kW
- Electrical efficiency 25-30%
- Heat produced 6-7000 BtuH/kW
- A little more heat, a little less electricity than turbines or engines
- Good match for hot water heating loads
- Higher capital cost per kW, similar operating cost to engines

Waste Heat "Technologies"
- Simplest to most complex

- Recycle back into same process
- Recycle into other process
- Transport to other process/location – heat pump, absorption
- Waste heat to power
- Back pressure turbine

CHP Equipment Types:
Fuel Cells

- 5 kW to over 1000 kW
- Electrical efficiency: 33-60%
- Heat produced: Varies
- No combustion, very low emissions
- Very expensive: 3 times capital cost of engines/turbines

CHP Applications

- Two major characteristics of favorable applications for CHP
  1. High electric costs compared to CHP fuel cost (Large “Spark Spread”)
  2. CHP waste heat is usable through nearly all the year

Basics and Benefits

Two simplified examples from a very complex “universe”

CHP - IC (recip.) engine

- Hospital site
- Hot water thermal load
- Sized to meet base thermal load
- Load following
- Operated to maximize overall system efficiency
- Natural gas-fired engine
- 700 kW delivered
- Heat rate 11,000 Btu/kWh
- 85% availability (7,446 hr/yr)
- 70% overall system efficiency

CHP: Simple Economics

Prime Mover	I C Engine	Baseline
Size	850 kW (altitude de-rate)	
Capital cost ($1,500/kW)	$1,275,000	
Purchased electricity cost		$373,000
Fuel consumed (dth/yr)	57,334	27,900
kWh/yr generated	5,212,200	0
O&M cost/yr (.018/kWh)	$94,000	0
Fuel cost/yr	$411,000	$222,000
Total/yr	$505,000	$595,000
Savings	$90,000	
Simple Payback	14 yr	

CHP: Emissions Reduction

	CHP	Grid Power	Base Thermal	Emission reduction	% reduction
NOx (tons/yr)	1.40	14.99	2.21	15.8	92%
SO2 (tons/yr)	0.02	9.89	0.01	9.88	100%
CO2 (tons/yr)	4,463	6,256	2,582	4,475	50%
Carbon (mton/yr)	1,103	1,547	638	1,082	28%
Number of cars removed				723	
EPA CHP Partnership CHP emissions calculator http://www.epa.gov/chp/basic/calculator.html					

Waste heat example
- Trailblazer Pipeline Heat to Power

- Natural gas pipeline compressor station
- Two 14,500 hp gas turbines
- 900 F exhaust gas

- Organic rankine cycle heat to power
- 4.5 MW turbine
- 70% capacity factor
- Export power to 12,47 kV line
- Energy Output 27,600 MWh/yr

Waste Heat Economics

- Yearly savings $600,000
- Pipeline owner paid for heat
- Estimated 20-yr savings of $10 million
- Joint project by:
  - Co-op (Highline Electric Association)
  - G&T (Tristate Generation and Transmission)
  - Pipeline owner (Kinder Morgan)
  - Project developer/equipment supplier (Ormat)

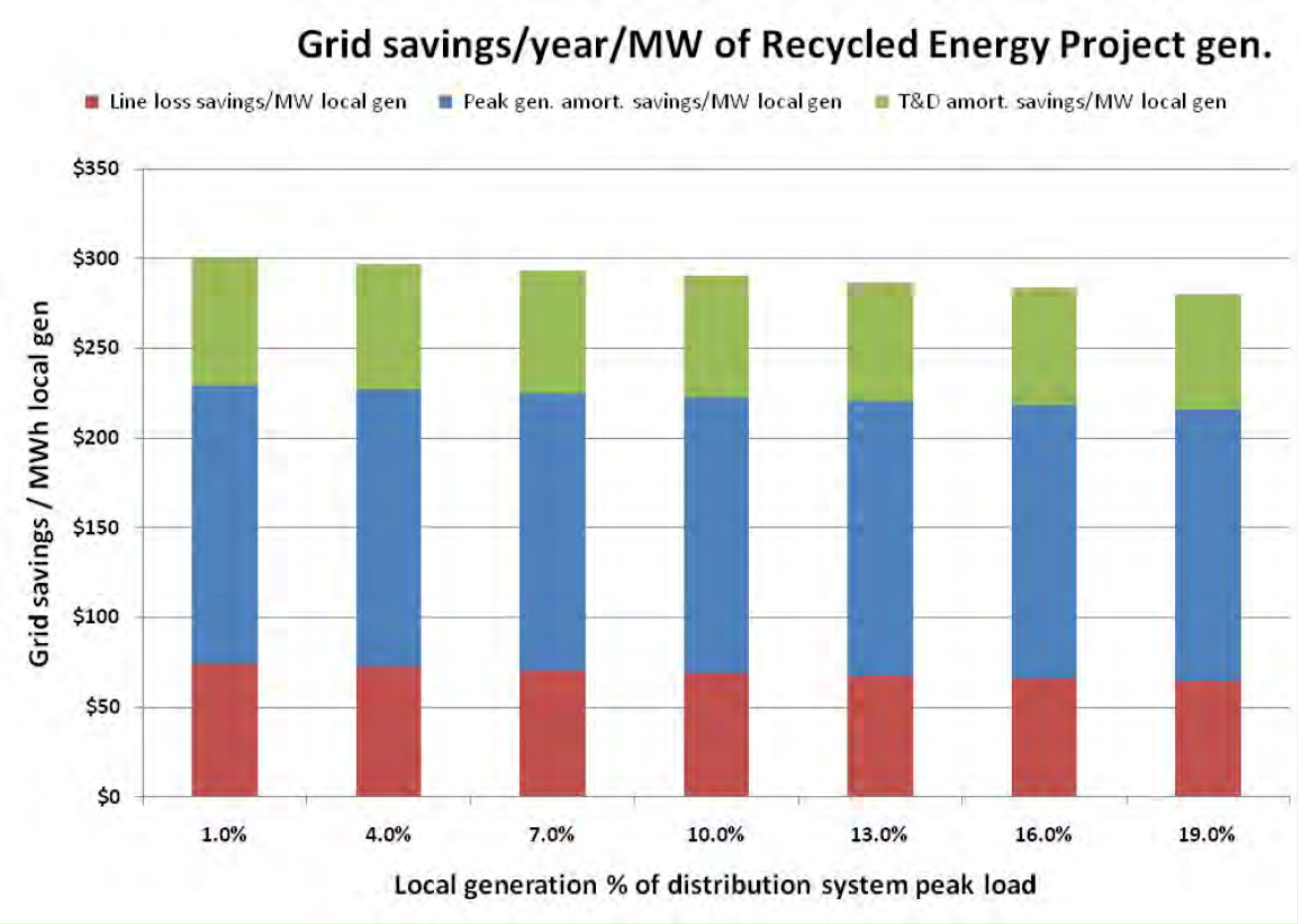
Waste Heat: Emissions Reductions

	Savings
CO_2	27,600 tons/yr
NO_x	34,500 kg/yr
SO2	124,200 kg/yr
Renewable energy credits used to meet RPS requirement (Colorado)	

Recycled Energy Benefits

- For owners
  - Improved fuel efficiency
  - Reduced cost
  - Enhanced energy security
  - Improved power quality & reliability
  - Improved energy cost predictability
- Global
  - Reduced emissions per unit of useful output
  - Reduced water use
  - Reduced land use impacts
  - Creation of new-high tech jobs
  - Improved grid economics

Grid Savings from Recycled Energy



From Casten http://www.midwestcleanenergycenter.org/Archive/wasteheat2010/presentations.html

Barriers

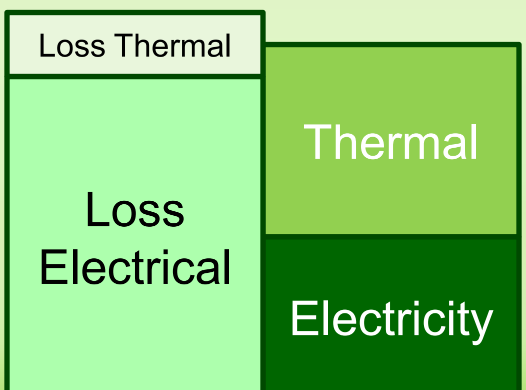
Well, if recycling energy is so great, why don't we do more?

Barriers to Recycled Energy

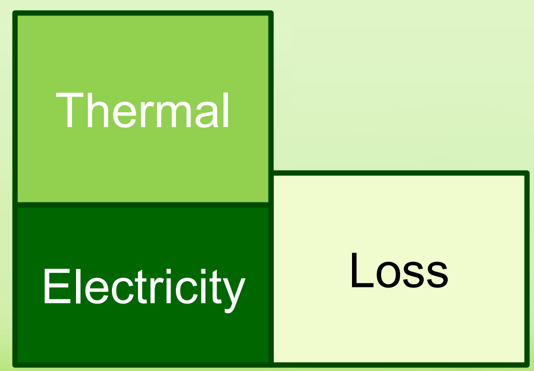
- Economic “playing field” is different for consumers and utilities
- Misaligned costs and benefits
- High transaction costs for projects
- Policy and regulatory structures don’t recognize benefits

Example of Economic Disconnect

	Electric Utility Sells	Owner Buys	Gas Utility Sells
Baseline	$373,000	$373,000 and $222,000	$222,000
CHP		$411,000	$411,000



Baseline (45 %)



CHP (70 %)

Barriers – Gory Details

- **Interconnection** delays, costs, inconsistencies
- **Standby charges** from the utility
- **Air regulations** that don't recognize benefits
- **Environmental permitting** (non-standardized, time-consuming)
- **Complex local ordinances** (siting, zoning, fire code, etc...)
- **Volatile natural gas prices** and "spark spread"
- **Facility managers unaware** of the benefits
- **Lack of a tax depreciation category** (multiple categories depending on config, period ranging from 5-39 years)
- **Utilities' lack of experience** (lack of data/models/analysis tools for evaluating DG, lack of practices for incorporating DG into electric system planning and operation

Resources and Contacts

Our goal is to promote energy efficiency.

We provide information and technical assistance to end users, regulators and policy makers

What We Actually Do

- Inform prospective end users on the benefits, business models, & resources available for their specific application
  - Workshops, trainings, webinars, guides, websites, advice
- Help potential projects “take the next step”
  - Free project feasibility screenings
  - Help on permitting issues, tariffs/rate assessments, equipment questions, convincing upper management, 3rd party review of proposals…
- Promote CHP as an effective clean energy **policy** solution:
  - Educate state policymakers and regulators, remove barriers

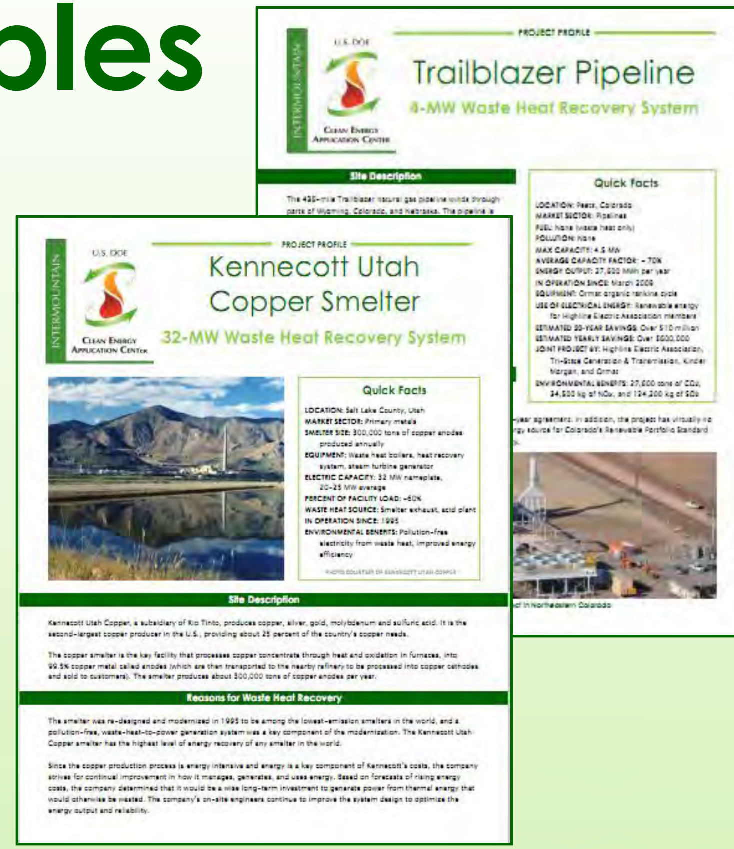
Technical Assistance for Potential Projects

1. PRE-SCREEN / SITE QUALIFICATION
2. LEVEL 1 SCREENING ANALYSIS
3. LEVEL 2 CONCEPTUAL & FINANCIAL
4. LEVEL 3 INVESTMENT GRADE ANALYSIS
5. PROCUREMENT, OPERATION, & MAINTENANCE

- We provide free Pre-Screening, Level 1 Analyses, and Level 2 Analyses
- We advise businesses on all other steps

Information Examples

- Basic info
- Market-specific applications
- Policies & regulations
- Installations and contacts
- Project profiles
- Technical reports/studies
- Evaluation tools
- News & events
- Presentations



Over 100 Project Profiles

www.intermountaincleanenergy.org

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Thank you!

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