

Recycled Energy Basics and Benefits

Utah Recycled Energy in Action

July 13, 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 want what it does

Source

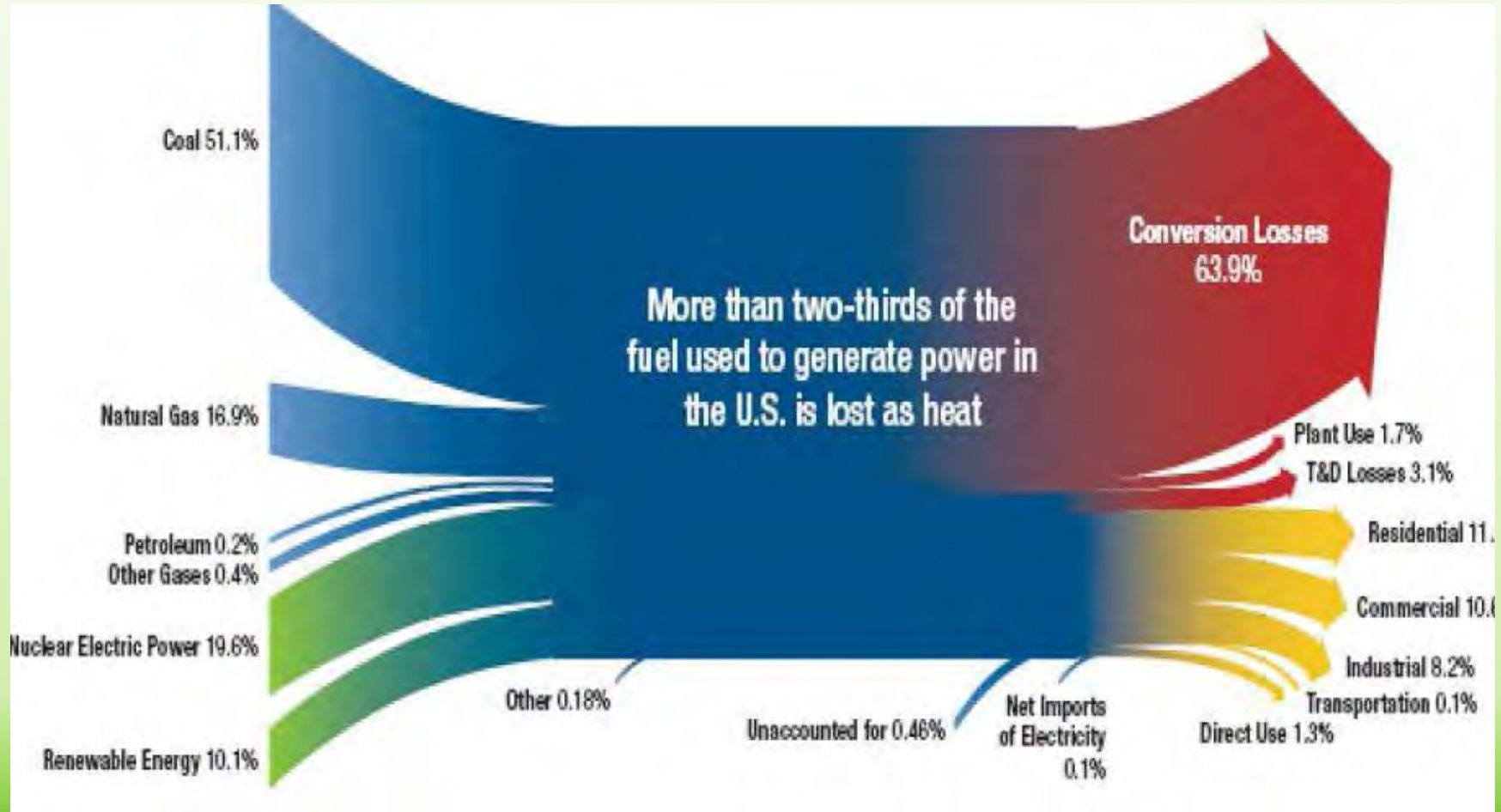
- Fossil
- Biomass
- Geothermal
- Wind
- Solar
- Nuclear
- Etc.

Results

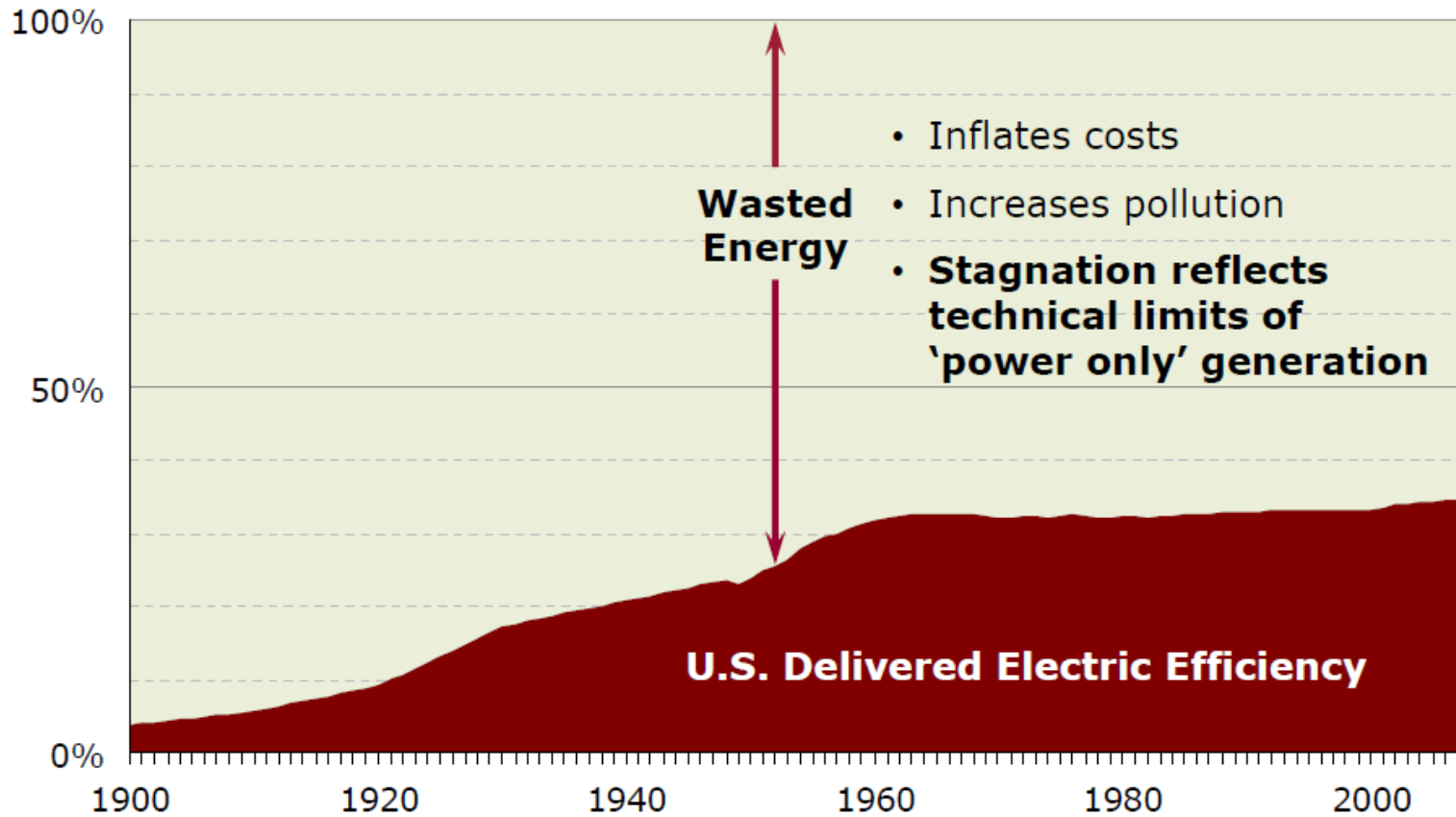
- Heat
- Light
- Cooling
- Work

Our energy infrastructure is very inefficient

- Take the electrical grid for example

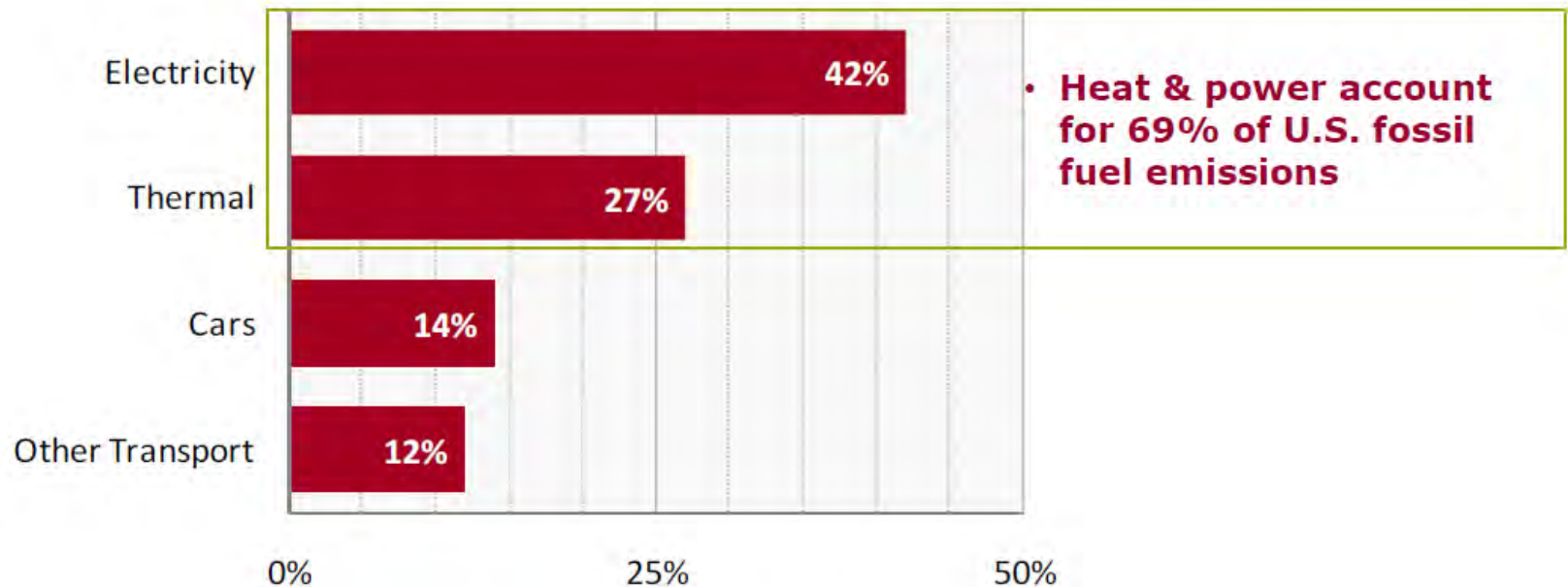


Not only is generation inefficient, it's stagnant



Heat and Power are Responsible for Two-thirds of U.S. CO₂

Emissions of U.S. CO₂ from Fossil Fuels



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

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)
 - Thermal (both heat and cooling)
 - Electrical
 - Process

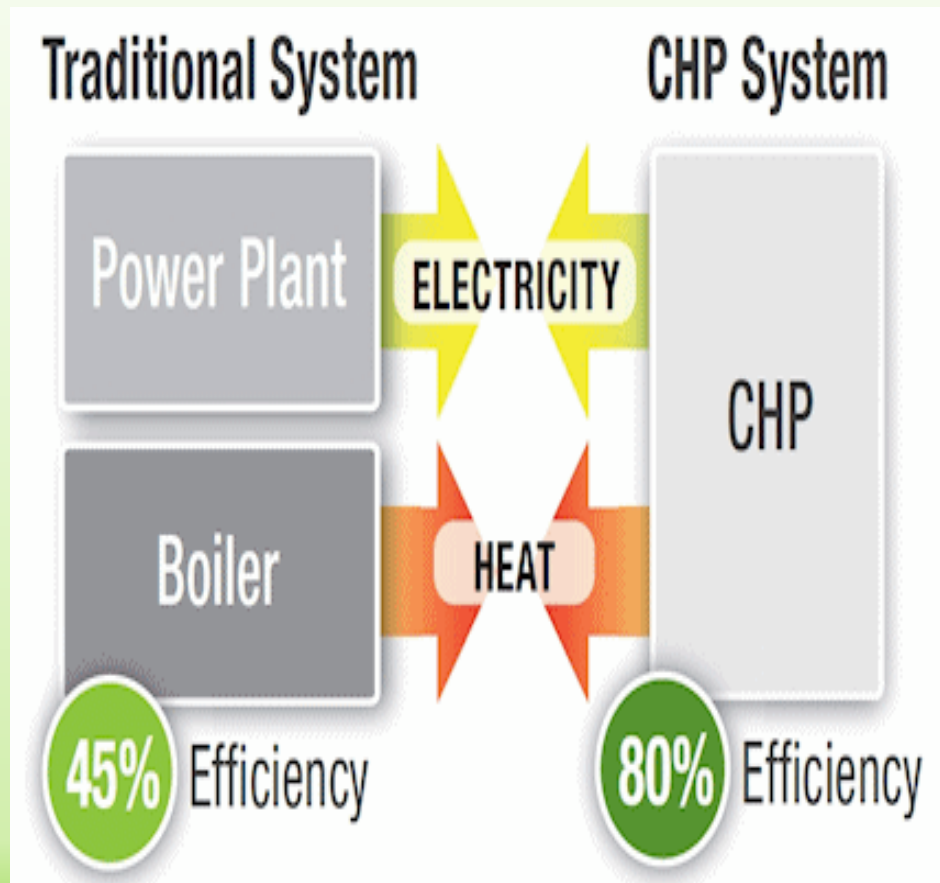


Definitions and Technologies

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



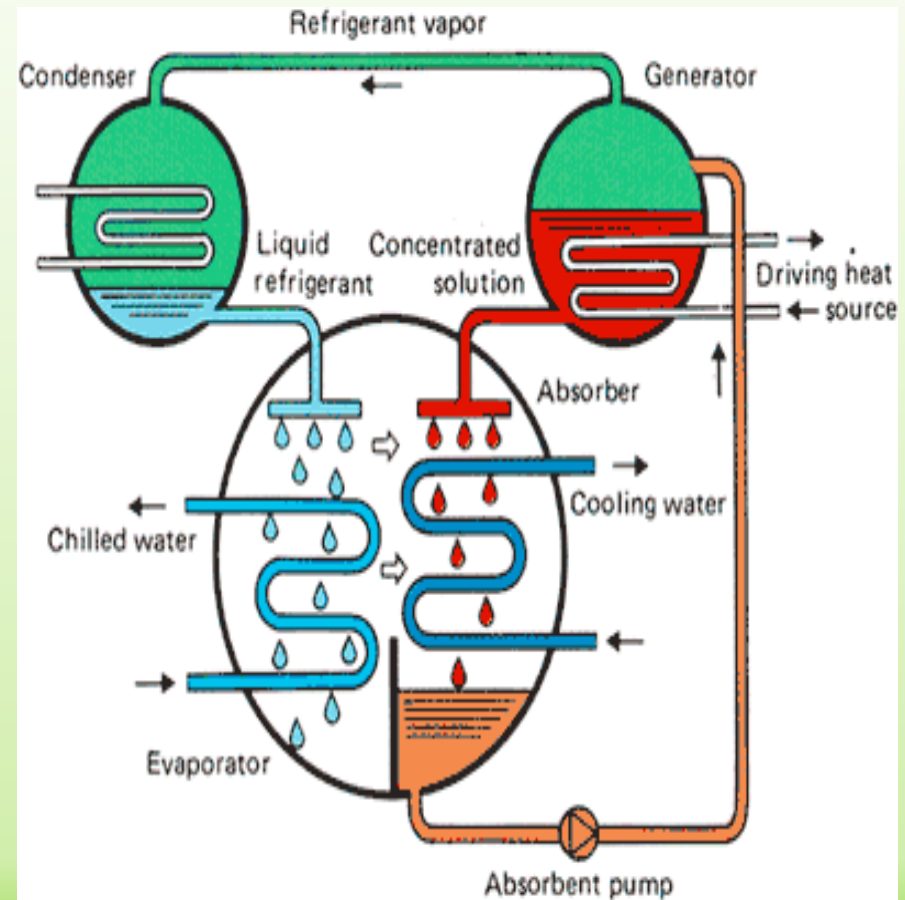
CHP Technologies -Electrical

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

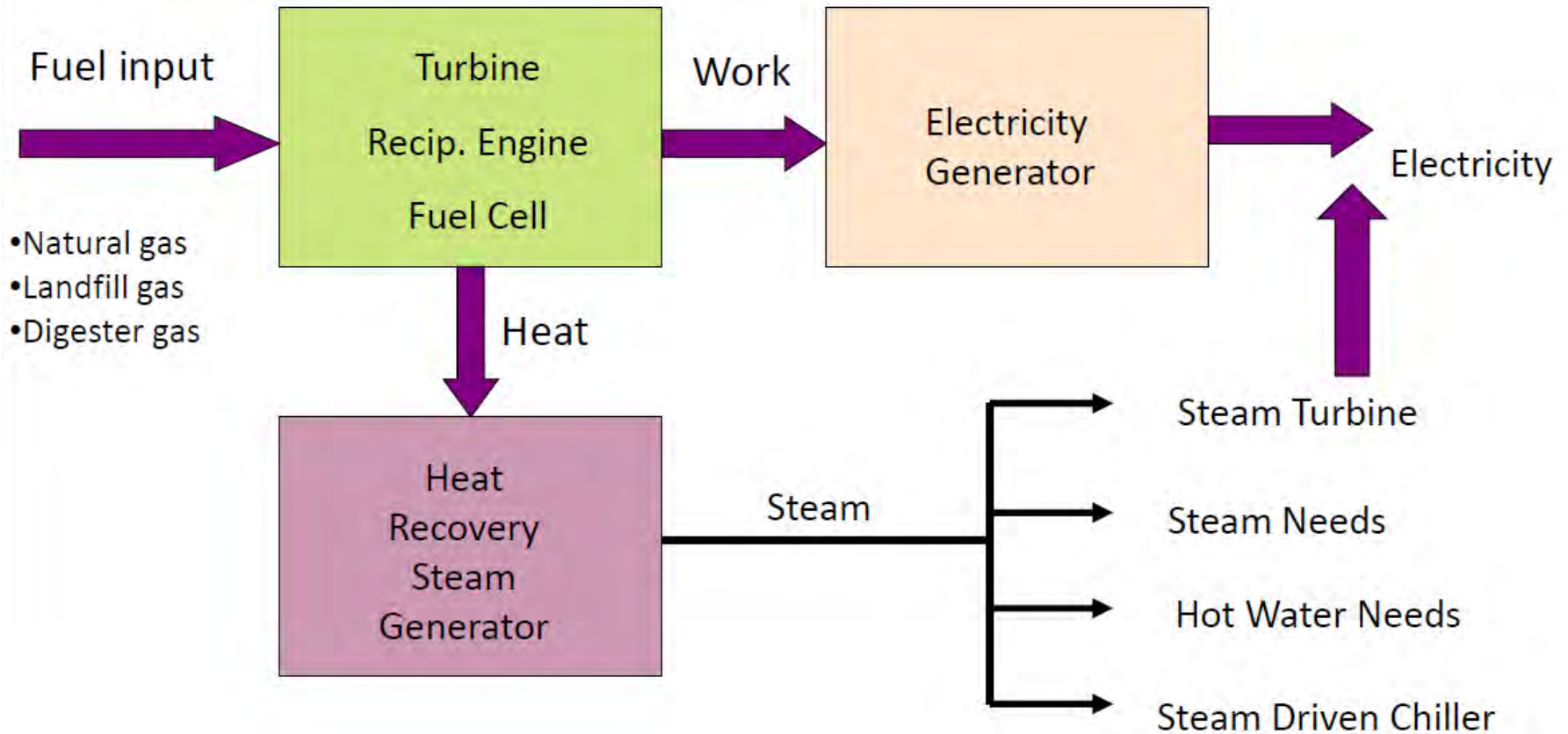


CHP Technologies – Thermal

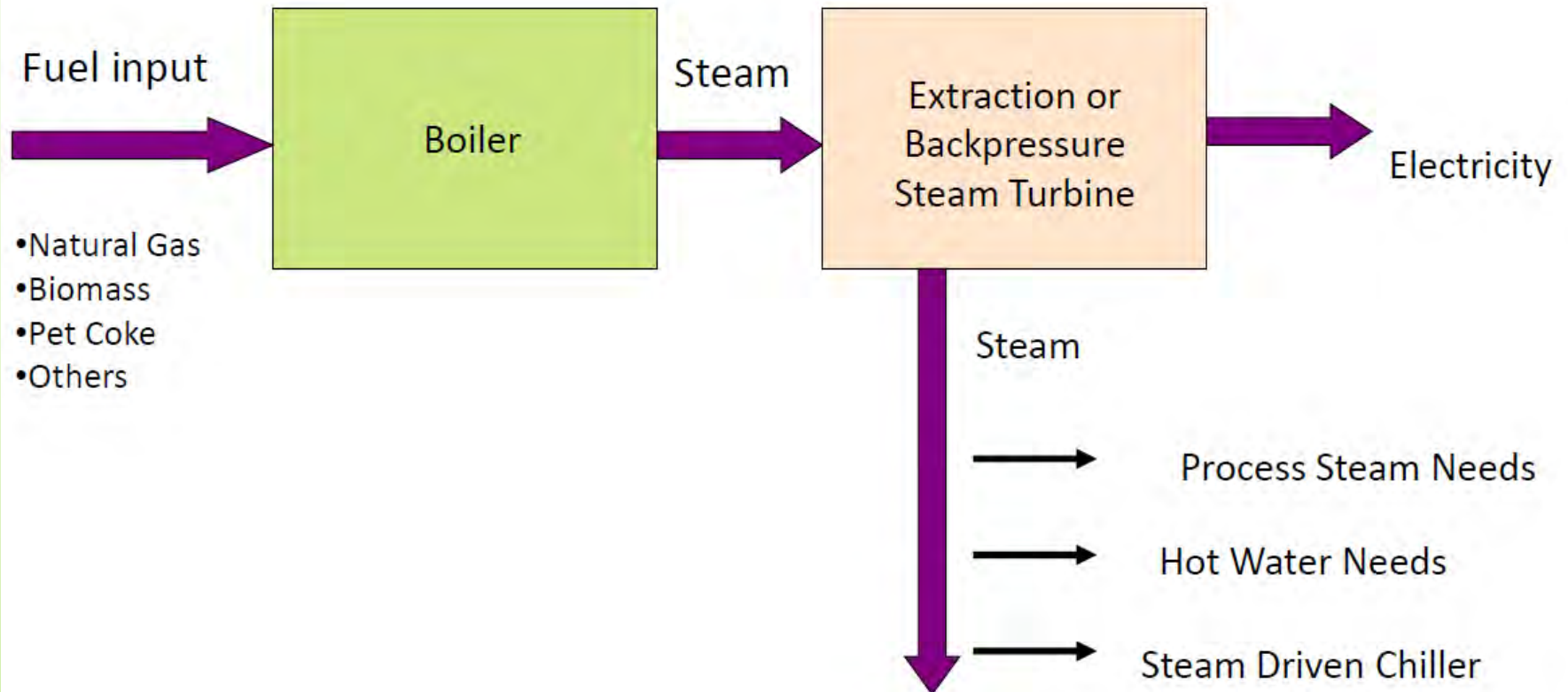
- Heat Exchanger / Heat Recovery
- Heat Recovery Steam Generators (HRSG)
- Absorption Chillers



CHP: Fueled Prime Mover



CHP: Boiler/Steam Turbine



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



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
SO ₂	124,200 kg/yr
Renewable energy credits used to meet RPS requirement (Colorado)	

Recycled Energy Benefits

○ For owners

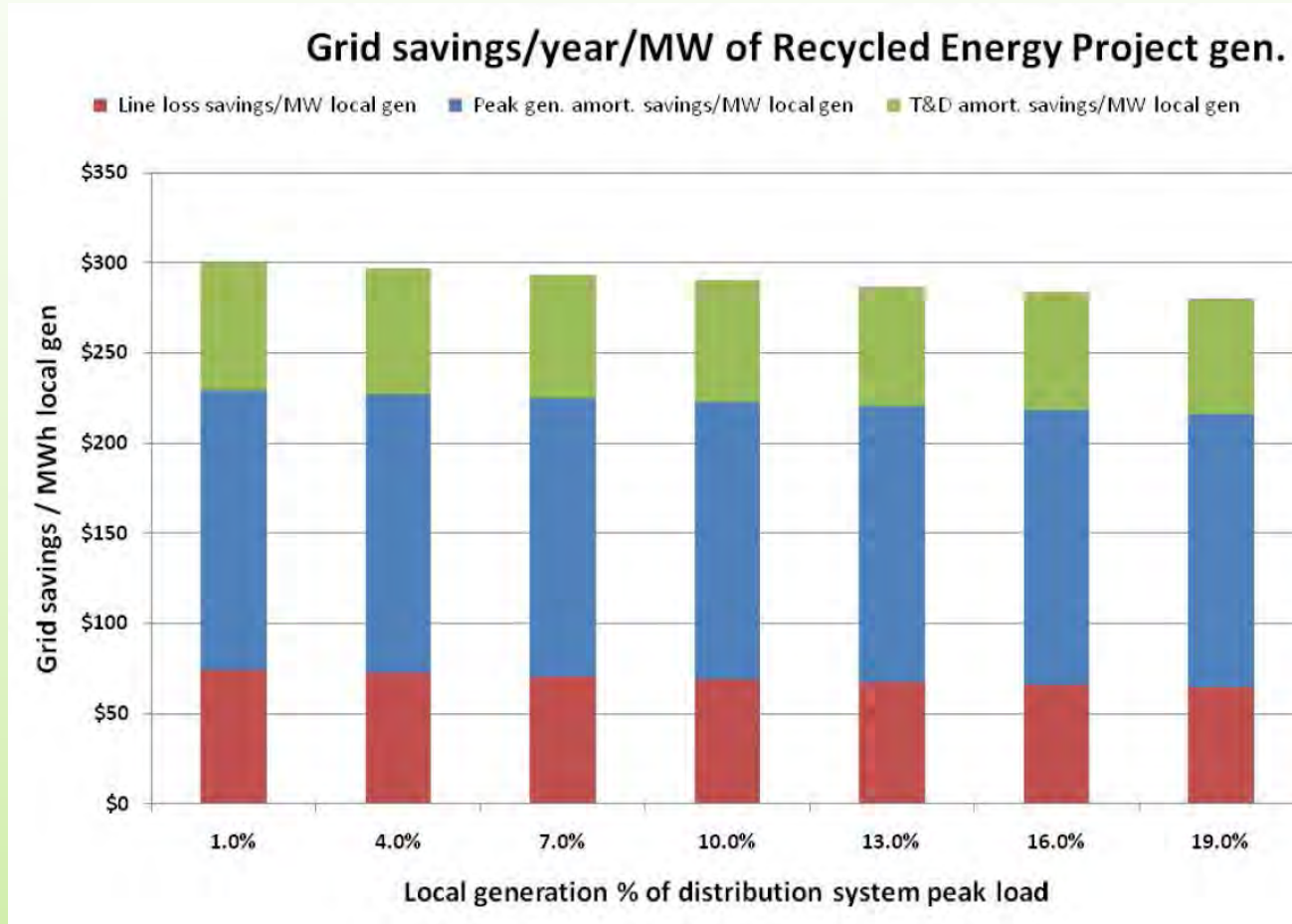
- Improved fuel efficiency
- Reduced cost
- Enhanced energy security
- Improved power quality & reliability
- Improved energy cost predictability

○ 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?








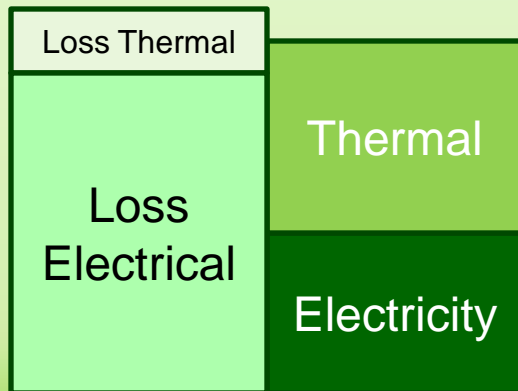
Barriers to Recycled Energy

- 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

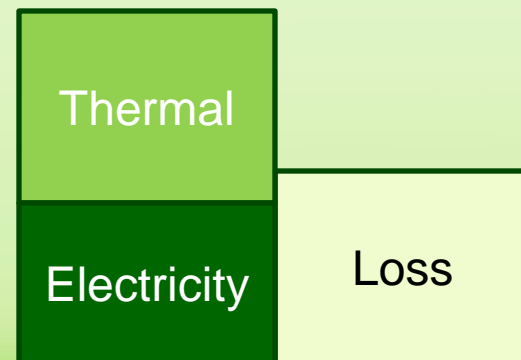


Example of Economic Disconnect

	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

The image displays two project profile cards from the U.S. DOE Clean Energy Application Center. The top card is for the Trailblazer Pipeline, a 4-MW Waste Heat Recovery System. The bottom card is for the Kennecott Utah Copper Smelter, a 32-MW Waste Heat Recovery System. Both cards include a 'Quick Facts' section and a 'Site Description' section. The Trailblazer card also includes a 'Reasons for Waste Heat Recovery' section. The Kennecott card includes a 'Reasons for Waste Heat Recovery' section and a 'Site Description' section. The Trailblazer card also includes a 'Quick Facts' section. The Kennecott card also includes a 'Quick Facts' section. The Trailblazer card also includes a 'Reasons for Waste Heat Recovery' section. The Kennecott card also includes a 'Reasons for Waste Heat Recovery' section.

Trailblazer Pipeline
4-MW Waste Heat Recovery System

Quick Facts

- LOCATION: West, Colorado
- MARKET SECTOR: Pipelines
- FUEL: None (uses heat only)
- INSTALLATION: None
- WASTE CAPACITY: 4.5 MM
- AVERAGE CAPACITY FACTOR: ~70%
- ENERGY OUTPUT: 27,000 MWh per year
- % OF FACILITY LOAD: 100%
- EQUIPMENT: Organic Rankine cycle
- USE OF ELECTRICAL ENERGY: Renewable energy for Highline Electric Association members
- ESTIMATED 20-YEAR SAVINGS: Over \$1.0 million
- ESTIMATED ANNUAL SAVINGS: Over \$600,000
- JOINT PROJECT BY: Highline Electric Association, Tri-State Generation & Transmission, Kinder Morgan, and Conoco
- ENVIRONMENTAL BENEFITS: 27,000 tons of CO₂, 24,000 kg of NO_x, and 124,300 kg of SO_x

Site Description

The 430-mile Trailblazer natural gas pipeline winds through parts of Wyoming, Colorado, and Nebraska. The pipeline is

Kennecott Utah Copper Smelter
32-MW Waste Heat Recovery System

Quick Facts

- LOCATION: Salt Lake County, Utah
- MARKET SECTOR: Primary metals
- SMELTER SIZE: 300,000 tons of copper anodes produced annually
- EQUIPMENT: Waste heat boiler, heat recovery system, steam turbine generator
- ELECTRIC CAPACITY: 32 MW nameplate, 25-28 MW average
- PERCENT OF FACILITY LOAD: ~60%
- WASTE HEAT SOURCE: Smelter exhaust, acid plant in operation since 1995
- ENVIRONMENTAL BENEFITS: Pollution-free electricity from waste heat, improved energy efficiency

Site Description

Kennecott Utah Copper, a subsidiary of Rio Tinto, produces copper, silver, gold, molybdenum and sulfuric acid. It is the second-largest copper producer in the U.S., providing about 25 percent of the country's copper needs.

The copper smelter is the key facility that processes copper concentrate through heat and oxidation in furnaces, into 99.9% copper metal (anode) which are then transported to the nearby refinery to be processed into copper cathodes and sold to customers. The smelter produces about 300,000 tons of copper anodes per year.

Reasons for Waste Heat Recovery

The smelter was re-designed and modernized in 1995 to be among the lowest-emission smelters in the world, and a pollution-free, waste-heat-to-recovery generation system was a key component of the modernization. The Kennecott Utah Copper smelter has the highest level of energy recovery of any smelter in the world.

Since the copper production process is energy intensive and energy is a key component of Kennecott's costs, the company strives for continual improvement in how it manages, generates, and uses energy. Based on forecasts of rising energy costs, the company determined that it would be a wise long-term investment to generate power from thermal energy that would otherwise be wasted. The company's on-site engineers continue to improve the system design to optimize the energy output and reliability.

Over 100 Project Profiles



www.intermountaincleanenergy.org



U.S. DEPARTMENT OF ENERGY

Intermountain Clean Energy Application Center

Promoting CHP, District Energy, and Waste Heat Recovery

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Policy Success

In Utah, recycled energy is eligible for the Renewable Portfolio Goal.

In Arizona, recycled energy is eligible for the Energy Efficiency Resource Standard.



In Colorado, recycled energy is eligible for the Renewable Portfolio Standard.

In New Mexico, recycled energy is eligible for tax incentives.

[LEARN MORE >](#)



[UP NEXT: MILLERCOORS](#)

Combined Heat and Power (CHP) is... generating electricity right near where it will be used, and then recycling the thermal energy for heating or cooling. It's very efficient, it already supplies 10% of our nation's energy, and it can and should supply more.

District Energy is... CHP, heating, and/or cooling for an entire university, office park, medical campus, mixed use sustainable development, or downtown. Over 400 building networks in the U.S. already use district energy, and the number is on the rise.

News

JULY 13 - UTAH RECYCLED ENERGY IN ACTION

Free Webinar: Biomass CHP, June 30, 12pm MDT

New National Project Profile Search Tool

Don't Miss Out: \$700-800 per kW Incentives for CHP in Arizona

More REAP Grants for CHP and Waste Heat

White House Energy Plan Recognizes CHP (and us)

Utah's 10-Yr Energy Plan Includes Waste Heat Recovery

Recycled Energy Adds Jobs and Strengthens Manufacturing in New Mexico

Utah Gov: EE and Tech Initiatives Can Power Utah's Future

[E-NEWSLETTER >](#)

[ARCHIVE >](#)

Contacts

- **Christine Brinker – Policy**
Southwest Energy Efficiency Project, 720-939-8333 cbrinker@swenergy.org
- **Tom Broderick – Technical Assistance**
928-527-8036 tbroderick@swenergy.org
- **Lin Alder – Education and Outreach**
ETC Group 801-278-1927 x 121 lalder@etcgrp.com
- **Patti Case “any of the above, but I delegate”**
ETC Group 801-278-1092 x 102 plcase@etgrp.com



Thank you!

Patti Case
Christine Brinker
Lin Alder
Tom Broderick



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