2nd Annual: Waste Heat to Power Workshop
Irvine, California
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U. S. Department of Energy: Distributed Energy Perspective

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Outline of presentation

- Distributed Energy Mission & Cooling, Heating and Power (CHP)
- Regional Application Centers
- CHP Market Activities
- Integrated Energy Systems
- Distributed Energy Generation Technology Goals
- Advanced Reciprocating Engine Systems (ARES)
- Opportunity Fuels
- Recent Developments

Distributed Energy Mission
Cooling, Heat & Power (CHP)

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National Roadmap Priorities

Raising Awareness
National CHP Coordination and Outreach
Federal CHP Coordination and Outreach
Regional/State Coordination and Outreach

Eliminating Regulatory/Institutional Barriers
Output-based Emissions Standards
Streamlined Siting and Permitting
Fair Utility Practices
Equitable Tax Treatment

Developing CHP Markets & Technologies
Commercial Buildings
Industrial, Manufacturing and Process Plants
Federal and State Government Facilities
District Energy, Power Parks, Municipalities

CHP Challenge Goal: By 2010, increase the amount of CHP in the U.S. to 92GW

DOE Distributed Energy : Program Mission

The mission of the Distributed Energy (DE) Program is to strengthen America's energy infrastructure and provide utilities and consumers with a greater array of energy efficient technology choices for the onsite generation of electricity and use of thermal energy

Increasing Levels of Integration

Equipment into Package CHP System	Package CHP System Into Building	Building-Integrated CHP into Community

Past & Present Goals

Future Goals

Regional Application Centers (RAC)

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Regional CHP Application Centers

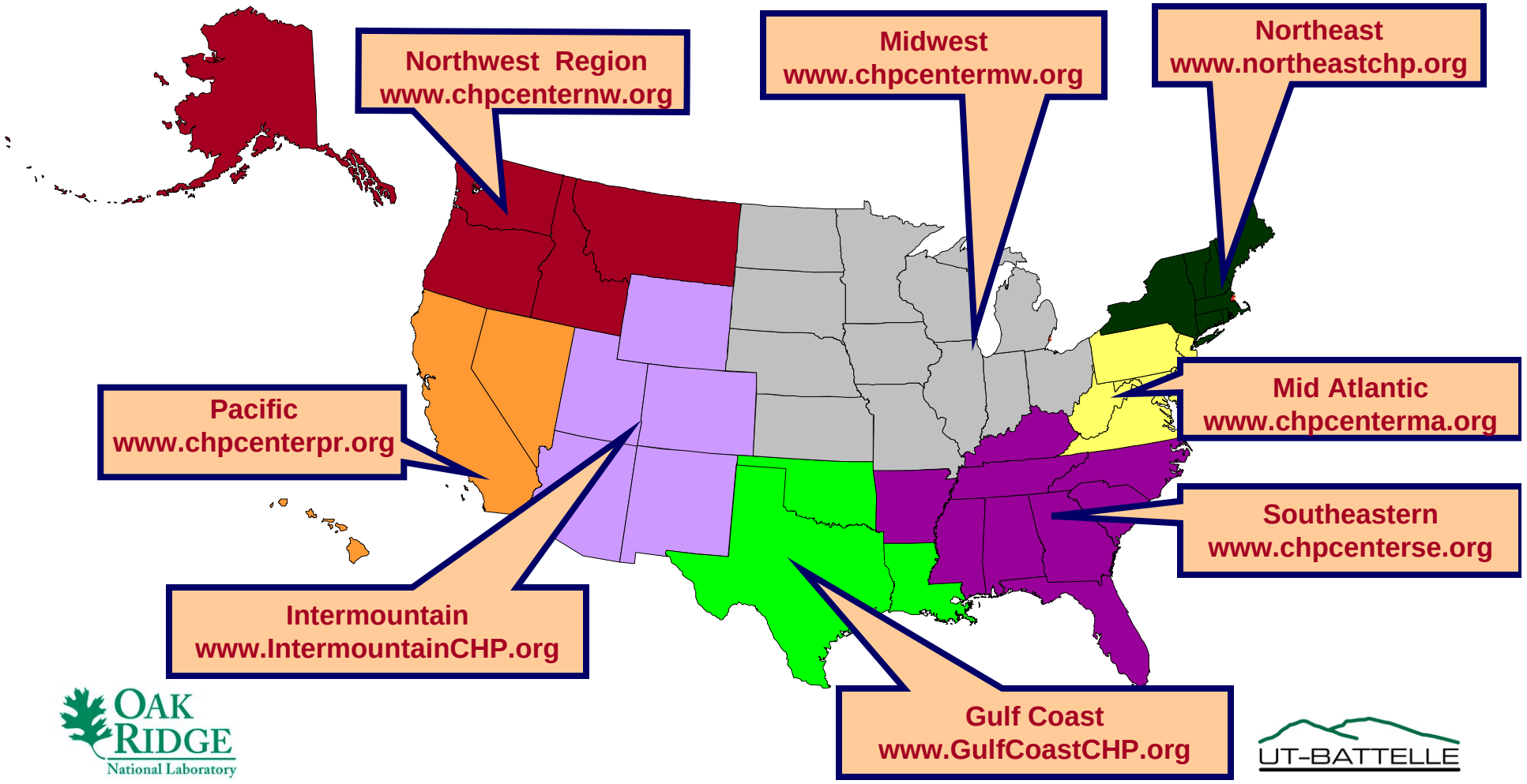
DOE Headquarters program of regional centers to lead deployment of CHP by

- Educating regional players on benefits to reduce perceived risk
- Providing project specific support
- Providing feedback to DOE and industry regarding future R&D program needs
- Providing regional coordination and implementation of DOE and other government projects

The overriding goal is to ensure achievement of the goal of doubling CHP use by 2010

Regional Application Centers

The regional application centers will promote combined heating and power (CHP) technology and practices, serve as a central repository and clearinghouse of CHP information, and identify and help implement regional CHP projects.



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RAC Strategy – Services

Services offered by all RACs:

- Education and Outreach
  - Websites
  - Focused Training and Education
  - Targeted End User Market Workshops
  - Regulatory / Regional Power Planning Group Education
  - Project Profiles / Case Studies
- Project Support
  - Site Evaluations / Screening
  - Application Analysis (Tech / Financial)
  - Technical Assistance

RAC Accomplishments

- Regional Roadmap Workshops
- Websites
- Technical Assistance > 200 sites assessed
  - 50 Project Profiles
- Education and Outreach: RAC is source of unbiased information and education
  - Target Market Workshops and Education
  - State and Regional Power Planning Efforts
  - Regulatory Forums and Interface

CHP Market Activities

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CHP Market Development Activities

- ORNL issued a solicitation in August 2002 for actions to address key findings of CHP Roadmap Process:
  - Raising CHP awareness
  - Eliminating regulatory and institutional barriers
  - Developing markets and technologies
- 14 subcontracts were awarded in February 2003
- 3-year plan
- Results are posted on DOE/public websites and disseminated via workshops, meetings, webcasts, and through the CHP Regional Application Centers.

Project Team

- American Council for an Energy Efficient Economy
- American Gas Foundation
- Cool Solutions
- Distributed Utility Associates
- Energetics
- Energy and Environmental Analysis
- Energy International
- Gas Technology Institute
- IC Thomasson
- International District Energy Association
- Northeast-Midwest Institute
- Resource Dynamics
- University of Illinois at Chicago
- United States Combined Heat and Power Association

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Task 1 Accomplishments: Raising CHP Awareness

- Updated the CHP Installation Database
- Capital Hill Technical Briefings:
  - Distributed Energy and the Energy Bill, October, 2005
  - Multi-Family Housing: An Underserved Market for Combined Heat and Power, September 2005
  - Combined Heat and Power - Realizing the Promise, February, 2005
  - CHP's Contribution to Alleviating Tight Natural Gas Markets, January, 2005
- State Opportunities for Action: Update of States' CHP Activities
- Combined Heat and Power Education and Outreach Guide to State and Federal Government
- DG Operational Reliability and Availability Database
- Case Studies
  - 525 kW Wind/Diesel Hybrid CHP Plant in Alaska
  - 130 MW Gas Turbine Combined Cycle Power Plant at SP Newsprint Company
  - Lewis and Clark College 30 kW Microturbine CHP in Portland, Oregon
  - Kimberly Clark 52 MW Wood-Chip Fired Steam-Turbine Generator in Washington
  - Columbia Boulevard Wastewater Treatment 320 kW Fuel Cell and Microturbine Plant
  - Kenai Fjords National Park 5 kW solid oxide fuel cell in Seward, Alaska

Task 2 Accomplishments: Eliminating Regulatory/Institutional Barriers

- Regulatory Requirements Database for Small Electric Generators
- CHP Emissions Calculator
- A Review of Distributed Generation Siting Procedures
- Natural Gas and Energy Price Volatility, Volumes 1 & 2
- Model for Sustainable Urban Design Blueprint for Urban Sustainability: Integrating Sustainable Energy Practices into Metropolitan Planning.
- Draft Reports:
  - DG Financing Options and Industry Feedback on Financing Issues
  - Impact of Electric Rate Structures on CHP Economics
  - DG/CHP Resource Planning and Procurement Guide for Utility Resource Planners and Power Procurement Specialists
  - Environmental Permitting Screening Tool

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Task 3 Accomplishments: Developing CHP Markets and Technologies

- Screening software for evaluating CHP potential in multi-family housing
- CHP in the Food and Beverage Manufacturing Industry Website
- CHP Installations with Turbine Inlet Cooling and/or Thermal Energy Storage Database
- Reports
  - CHP Opportunities at US Colleges and Universities
  - Market and Cross-cutting Technology Assessment for Industrial Sectors with High Potential for CHP Utilization
  - Targeted CHP Outreach in Selected Sectors of the Commercial Market
  - National Accounts Sector Energy Profiles
  - Market Potential of Opportunity Fuels in DE/CHP Applications
  - Characterization of the U.S. Industrial/Commercial Boiler Population
  - CHP Market Potential in the Western States
- Draft Reports:
  - The Value of Distributed Generation and Combined Heat and Power Resources in Wholesale Power Markets

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DOE Distributed Energy Technology Goals

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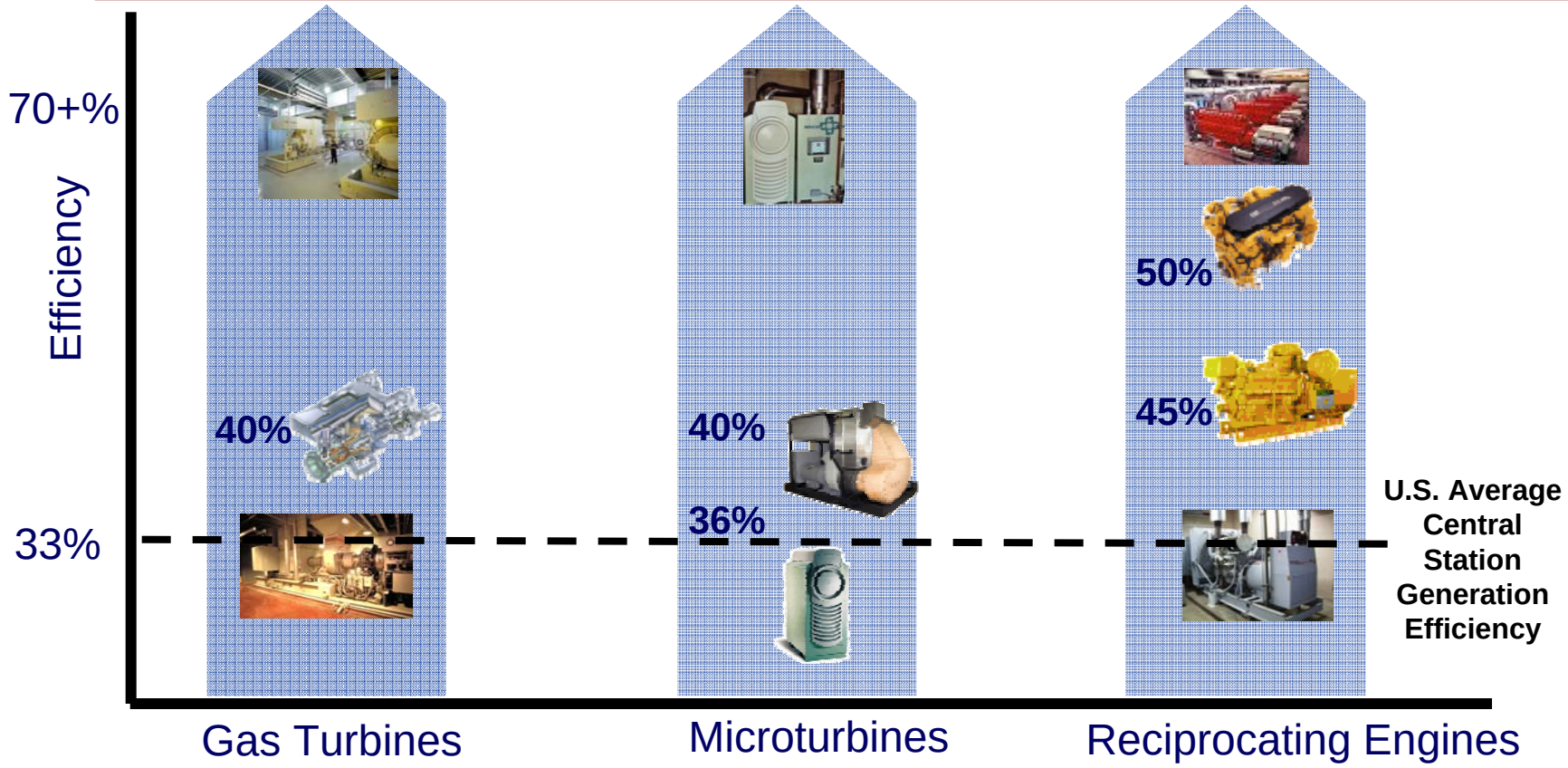
Improved Generation and Heat Utilization and Integrated CHP Systems

By 2008, complete development and testing of a portfolio of distributed generation technologies that will show an average of **25 percent increase in efficiency** (compared to 2000 baseline) with **NOx emissions of less than 0.15grams/KWh** at an **equivalent of 10% reduction in cost.**

By 2008, demonstrate the feasibility of **integrated energy systems**, which achieve **70% efficiency** and customer **payback in less than 4 years**, assuming commercial scale production.



Improved Generation and Heat Utilization

Microturbines

2000
- $900-$1,200/kW
- 17-30% Efficiency
- 0.35 lbs/MWh NOx

2007
- Cost competitive with the market
- 40% Efficiency
- 0.15 lbs/MWh NOx

Gas Turbines

1992
- 29% efficiency
- +2 lbs/MWh NO_x
- $600/kW

2001
- 38% Efficiency
- 0.15 lbs/MWh NO_x
- $400/kW

2010
- Cost competitive with the market
- <<.15 lbs/ MWh NO_x

Reciprocating Engines

2000
- $300-$400/kW
- 25-40% Efficiency
- 2-3 lbs/MWh NO_x

2010
- Cost competitive with the market
- 50% Efficiency
- 0.15 lbs/MWh NO_x

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Integrated Energy Systems

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Integrated Energy Systems

By 2008, demonstrate the feasibility of **integrated systems in three new customer classes**, which could achieve **70+% overall efficiency** and customer **payback in less than 4 years**, assuming commercial scale production. One in 2005; 3 developed by 2008

2000

- **Individual power generation and heat recovery/thermally activated products**
- **Average efficiency 54%**
- **7+ years payback**

Integrated Energy Systems

2007

- **70% + Efficient Packaged Systems**
- **4 year or less payback**

All efficiency values are Lower Heating Value (LHV)

Seven Packaged Systems (IES) Projects - Three Up and Running

- **Burns and McDonnell – Austin Energy**
  - **5.2 MW turbine generator integrated with 2,500 RT waste heat fired absorption cooling**
- **Honeywell Laboratories – Fort Bragg, NC**
  - **5 MW turbine generator integrated with 1,000 RT waste-heat driven absorption chiller**
- **UTRC– A&P Supermarket, New York**
  - **4, 5, or 6 Capstone 60 Microturbines coupled with 110 to 155 RT Carrier absorption chillers. Also considering refrigeration, desiccants, and thermal storage systems. PureComfort™ now commercially available**
- **Gas Technology Institute - New Lenox school**
  - **Engine generator (~600 kW) integrated with absorption chiller. Installation is on-going.**

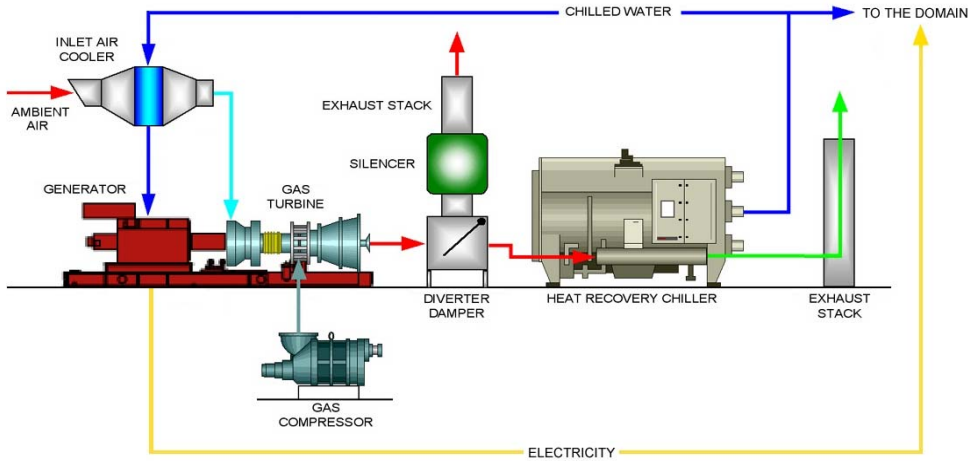
Integrated Energy Systems- Austin Energy

Absorption Chiller Module

Exhaust Recovery Module

Gas Turbine Module

Control / Pump Module



Modularization is the key to success through:

- **Installed cost reduction**
- **System reliability improvement**
- **Operating cost savings**

Burns and McDonnell – Austin Energy

- **5.2 MWe turbine generator integrated with 2,500 RT waste heat fired Broad absorption cooling, 30% reduction in cost of materials and installation, estimated 7 yr payback, 82% efficiency**

Integrated Energy System – A&P

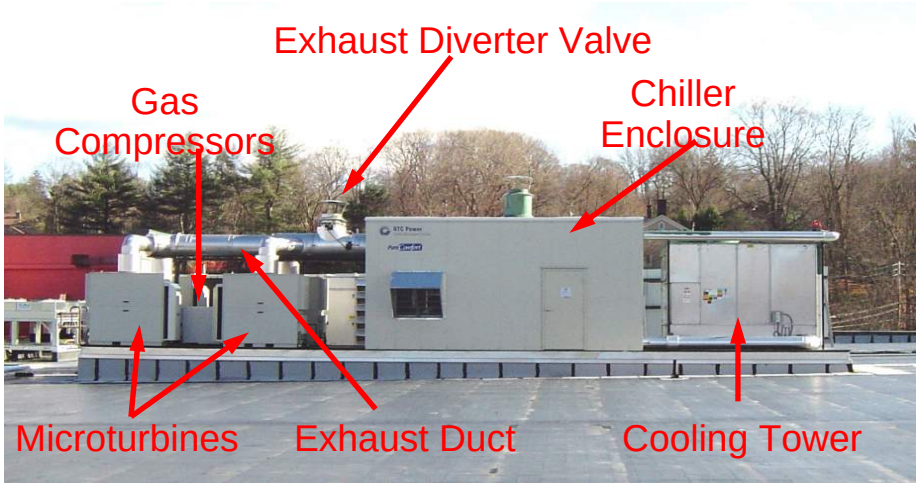
"Pre-Assembled" Integrated System:

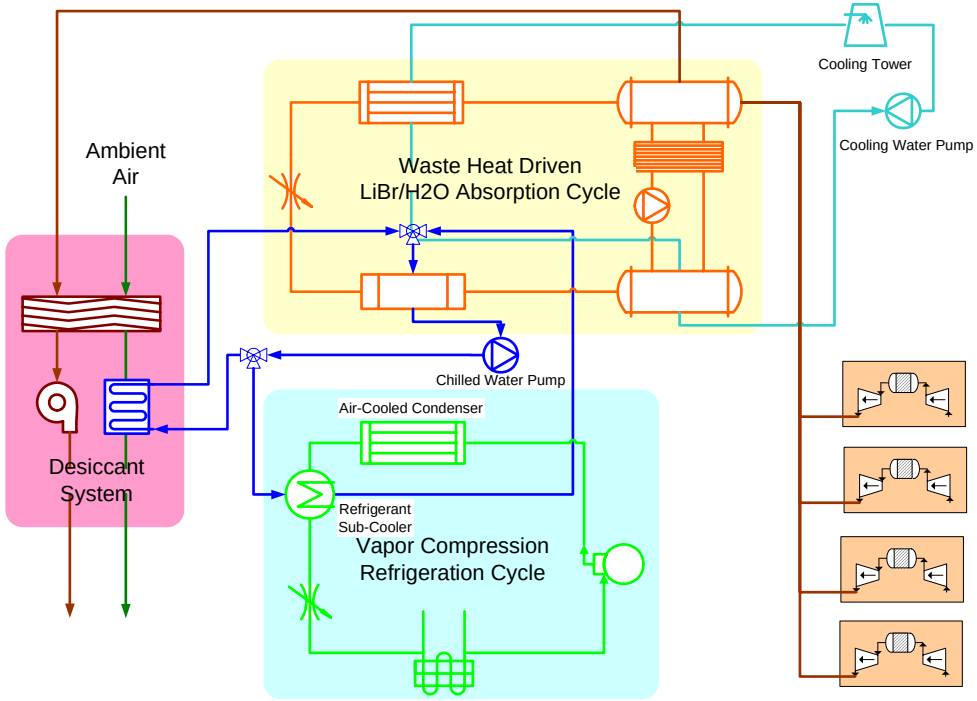
- Skid Mounted
- 4 @ 60 kWe microturbines
- Carrier Double Effect Absorption Chiller
- Provides 240 kWe of Electricity and 110 tons of Chilled water (95F day) or 956 MBTU Hot water (32F day)
- Munter Desiccant

UTRC– A&P Supermarket, New York

Future- considering refrigeration, and thermal storage systems.

PureComfortTM now commercially available, estimated 7 yr payback, 78% efficiency





Advanced Reciprocating Engine Systems (ARES)

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ARES Program Is Built Around Stretch Goals With 3 Phases

A commercial natural gas engine by 2010 with:

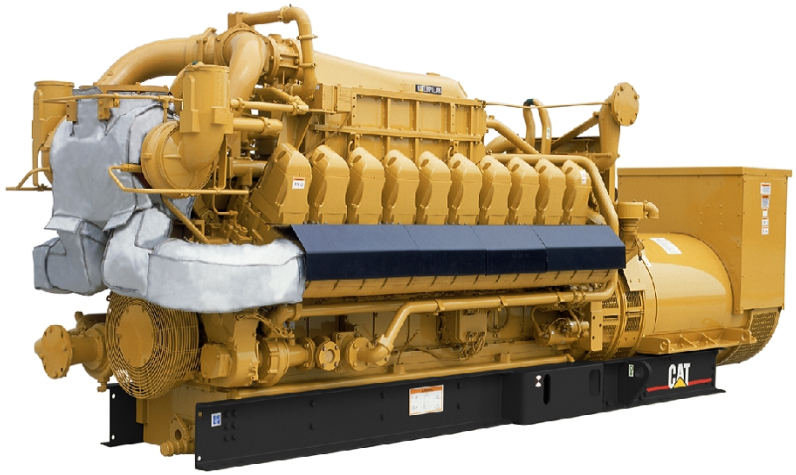
- High Efficiency – Thermal efficiency of at least 50%
- Environmental Superiority – NOx < 0.1 g/bhp-hr (no increase in other criteria pollutants or HAPs)
- Reduced Cost of Power – Energy costs, including O&M, at least 10% less than current state-of-the-art engines
- Reliability, Maintainability & Availability – Equivalent to current state-of-the-art engines
- Fuel Flexibility – Adaptable to future firing with dual fuel capabilities

Cummins CAT® DRESSER Waukesha

Phase	Year	BTE (%)	NOx (g/bhp-hr)
Phase I	2004-2005	44%	0.5
Phase II	2007	47%	0.1
Phase III	2010	50%	0.1

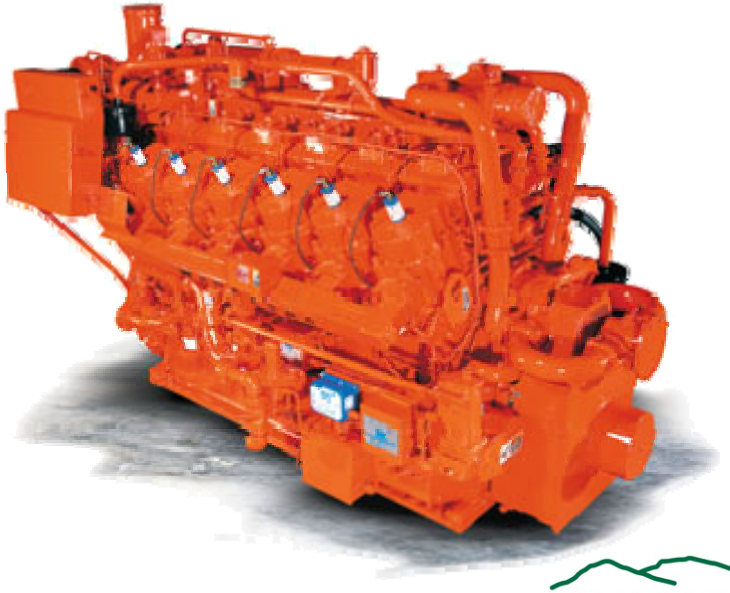
ARES Phase I engines are commercially available & accepted

- ✓ **Caterpillar 3520C & E models**
  - **Multiple models available**
  - **Significant world-wide sales**



- ✓ **Waukesha APG model**
  - **Recently released at PowerGen**

- ✓ **Cummins model to be released soon**



- ✓ **All ARES Phase I engines**
  - **less engine-out NO_x**
  - **42-44% efficient**
  - **1 - 2 MW size**
  - **higher power density**

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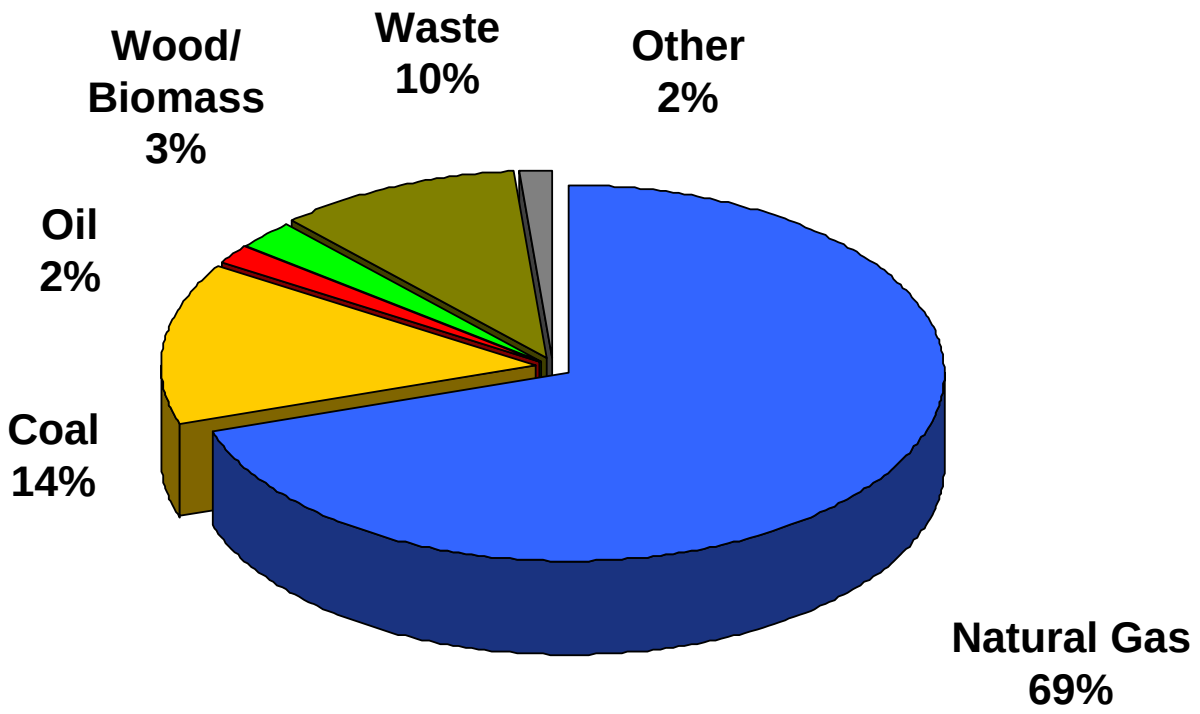
Opportunity Fuels

CHP Uses a Wide Range of Fuels

- *Natural Gas is the preferred fuel*



Source: Energy and Environmental Analysis

CHP Systems Need Alternative Fuel Choices

- High natural gas prices have decreased spark spreads and reduced CHP market potential
- Natural gas prices will likely remain high for some time
- Renewable portfolio standards, public benefit funding, and other renewable incentives are spurring investment in biomass and other available fueled projects
- Vast amounts of these “opportunity fuels” available - often waste products that have an environmental impact
- Introduce these low quality fuels into energy infrastructure
- Transportation costs prohibit use in large scale power plants
- Tremendous need for energy security and a hedge against NG volatility

Alternative: Develop Other, Cost-Effective Fuels

- Opportunity Fuel: any fuel that has the potential to be used for economically-viable power generation, but is not traditionally used for this purpose
- Opportunity fuels include:
  - ✓ Anaerobic Digester Gas
  - ✓ Biomass Gas
  - Black Liquor
  - Blast Furnace Gas
  - Coalbed Methane
  - Coke Oven Gas
  - Crop Residues
  - Food Processing Waste
  - Industrial VOC's
  - ✓ Landfill Gas
  - Municipal Solid Waste
  - Orimulsion
  - Petroleum Coke
  - Sludge Waste
  - Textile Waste
  - ✓ Tire-Derived Fuel
  - Wellhead Gas
  - ✓ Wood
  - ✓ Wood Waste

Source: Resource Dynamics

Why are Opportunity Fuels Not Used More Often?

- Availability of fuel source often inconsistent in volume and in quality, resulting in variations in fuel volume, BTU content, and contaminants
- Often requires changes (adding $) to generating equipment or purchasing processing equipment (digester, filtration, gasifier)
- Site where fuel is located has little thermal and/or electric demand
- Costs to transport fuel to ideal site can kill projects
- Producing/processing fuel can be labor intensive
- Technology not yet commercialized for small-scale use in U.S.

Eligible Renewables Sources

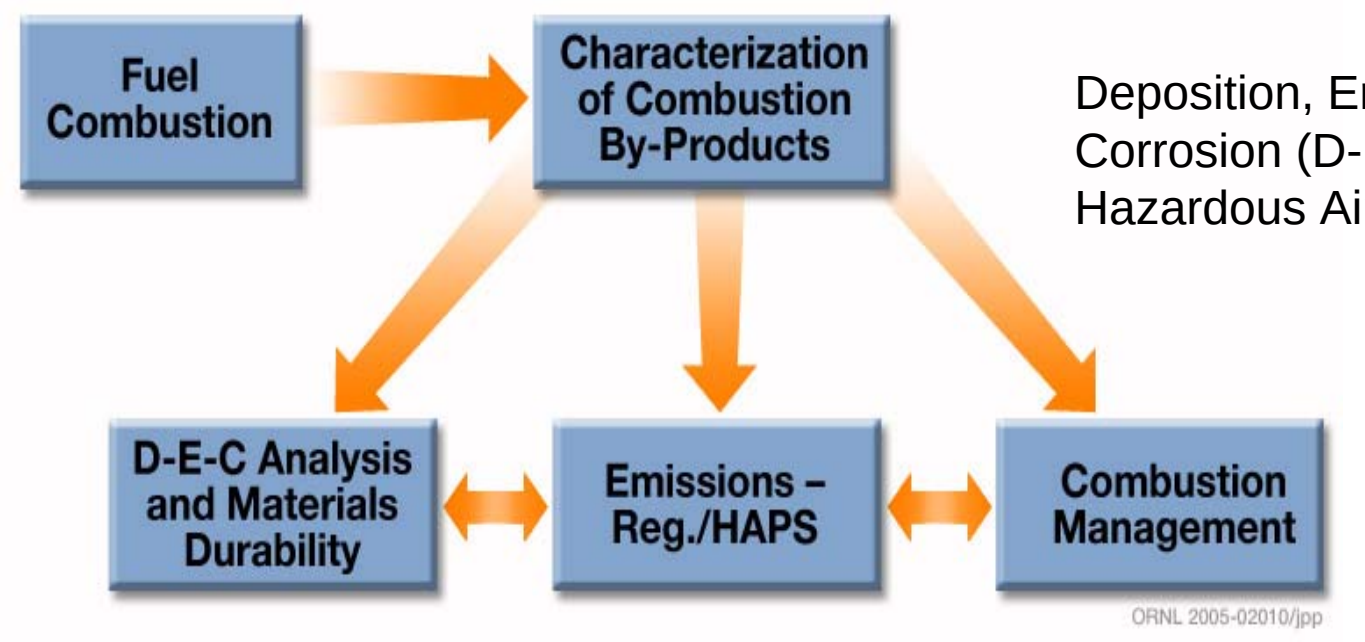
Eligible Renewables / State	CHP	Solar	Wind	Hydro	Geo	Tidal/ Wave	Bio-mass	PV	Landfill Gas	Muni. Solid Waste
Arizona		✓	✓				✓	✓	✓	✓
California		✓	✓	✓	✓	✓	✓	✓	✓	✓
Connecticut		✓	✓				✓		✓	
D.C.		✓	✓	✓	✓	✓	✓	✓	✓	✓
Hawaii	✓		✓	✓	✓		✓	✓	✓	✓
Iowa			✓	✓			✓	✓		
Illinois			✓				✓	✓		
Maine		✓	✓	✓	✓	✓	✓			✓
Maryland		✓	✓	✓	✓	✓	✓		✓	
Massachusetts		✓	✓		✓	✓	✓		✓	
Minnesota		✓	✓	✓			✓	✓		✓
Nevada	✓	✓	✓	✓	✓		✓	✓	✓	✓
New Jersey		✓	✓	✓	✓	✓	✓		✓	
New Mexico		✓	✓	✓	✓		✓			
New York			✓	✓		✓	✓	✓	✓	
Pennsylvania	✓	✓	✓	✓	✓		✓			✓
Rhode Island			✓			✓	✓	✓	✓	
Texas		✓	✓	✓	✓	✓	✓			
Wisconsin		✓	✓	✓	✓	✓	✓			

Source: DSIRE Website (http://www.dsireusa.org/)

DE Lab Call Included Fuel Combustion Thrust

- Analysis of combustion for multi-fuel systems (turbines, reciprocating engines)
- Insight into combustion, combustor design, & effects of contaminants on materials
- Consider multiple fuels (liquid & gas) while meeting emissions requirements
- Explore dual-fuel systems, varying fuel quality, and alternative fuel blends (low quality)
- Investigate innovative combustion cycles
- Excluded fuel processing technologies
- Projects awarded to Sandia, Brookhaven, LBNL, and ORNL
- Heavy emphasis on micro-turbines from other labs

Outline of ORNL Fuels Combustion Approach



Deposition, Erosion, and Corrosion (D-E-C)
Hazardous Air Pollutants (HAPS)

- Consider turbines and recips using Opportunity Fuels
- Fuel contaminants cause emissions and materials corrosion issues
- Need for improved understanding of combustion and impact of contaminants

Recent Developments

Recent Developments

- Office of Distributed Energy (DE) was recently merged into Office of Electricity Reliability and Distributed Energy (OE)
- OE has more emphasis on grid restructuring
- FY 2006 budget contained significant earmarks
- Discretionary funds limited - strong impact on DE portion of Office
- Overall reductions in DE
- Opportunity Fuel work was not funded in FY 2006

Where do we go from here?

- Some areas (projects) have matured to natural conclusion
- Others still need government involvement
- Look for new home for key areas
  - Opportunity fuels similar to Bio-energy and others
  - Examine state and other interests
- RACs in FY 2007 budget request

Thank you for your time and attention

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