Hybrid Evolution and Deployment

Energy Efficiency and Renewable Energy Plan

Office of Distributed Energy and Electric Reliability

U.S. Department of Energy

What are Hybrid Systems?

- A hybrid system is an interconnected energy system that is any combination of at least two *distributed* energy technologies, or a single *distributed* technology operated from multiple fuels.

- Hybrid systems can be optimized to address value propositions such as reliability, efficiency and/or emissions -- at an acceptable cost.

What are *Distributed* Hybrid Systems?

Characteristics of *Distributed* Energy Resources:

- Located at or near Point of Use
- Locational Value
- Distribution Voltage

Microturbine/Storage

Microturbine/Chiller

Wind/Engine

Why is there interest in Hybrid Systems?

- Hybrids offer an opportunity to integrate a technology and its inherent attributes with other technologies to overcome weaknesses and emphasize strengths.
- Optimized hybrid systems can be designed to emphasize specific value propositions that can be important factors for customers – value propositions such as higher reliability, enhanced efficiency and/or lower emissions

Hybrid Systems Premise

- May incorporate technologies prior to meeting ultimate performance goals and cost targets
- Will create additional opportunities for technology-based performance testing, deployment, and partnerships
- Will expand markets for technologies that do not currently exist
- The "whole" is worth more than the "parts"
- "Value" is driver for DG -- not absolute "cost"

Potential Hybrid Technology Portfolio

- Fossil Fuel Engines
  - IC Engine
  - Stirling Engine
  - Rankine Engine Cycle
  - Brayton Turbine
  - Microturbine
- Renewables
  - PV, Concentrating PV
  - Solar Hot Water
  - Concentrating Solar Power
    - Trough
    - Dish
    - Tower
  - Wind
  - Hydro
- Fuel Cells
  - Solid Oxide
  - PEM
  - Phosphoric Acid
  - Molten Carbonate
- Storage
  - Lead acid batteries
  - Flow batteries
  - Reversible fuel cells
  - Supercapacitors
  - SMES
  - Flywheels
  - Thermal
  - CAES
- CHP

Promising Technology Combinations

- Zero Net Energy Buildings
  - Solar thermal roof/BIPV/daylighting/solar hot water/HVAC
  - Process heat derived from fuel cells
  - CHP with organic Rankine cycle bottoming
- Remote (Off-Grid) Power
  - Mini-grid residential: fuel cell or microturbine/storage/PV
- Village Power
  - Wind or PV/biogas fired engine, microturbine, or Stirling engine
  - CSP dish/propane, diesel, or biogas engine
  - Solar thermal trough/energy storage/organic Rankine cycle

The Value of Hybrid Systems

Renewables

Fossil Fuel Generators

Hybrid System

Value Propositions:

High Reliability

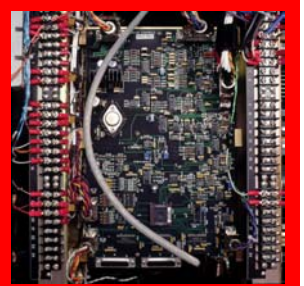
High Efficiency

Low Emissions

Acceptable Cost

Storage

Power Electronics



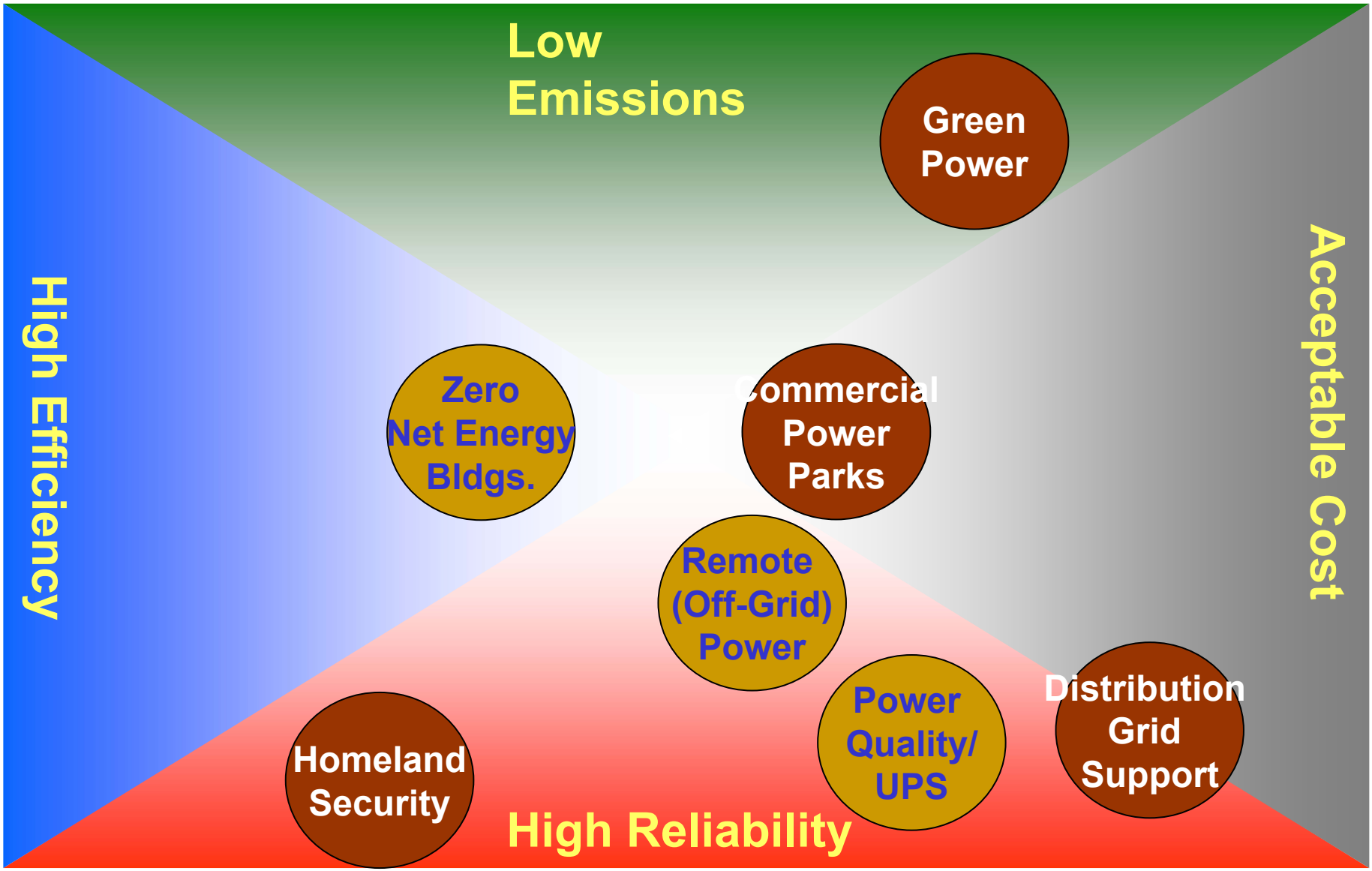
The whole is greater than the sum of its parts.

Emerging Market Opportunities for Hybrid Systems

- Homeland/Energy Security
- Industrial Power Quality
- Commercial Power Parks
- Distribution (Grid) Support
- Integrated Building Efficiency (CHP+)
- Zero Net Energy Buildings

- Remote (Off-Grid) Power
- Village Power
- Green Power
- Power Price Stabilization
- Water Resource Mgmt.
- Brownfields

Hybrids Can Be Customized to Meet Customer Needs



DOE/EE Hybrid Activities in 2003

- Hawaii DER / Hydrogen (Gateway) Project
- CHP Activities
- State Energy Programs – FY 2002 Special Projects

Hawaii DER (Gateway) Facility

- Signature project: Located at the entrance to the Hawaii Ocean Science & Technology (HOST) Park at the Natural Energy Laboratory of Hawaii (NELHA) – on the big island of Hawaii

- Initial construction funding of $3 million has been provided via grants from the U.S. Department of Energy – The first building (with a focus on DER) should be completed before the end of calendar 2003

- Three primary thrust areas
  - Distributed Energy Resources (Phase I)
  - Ocean Sciences and Marine Bioproducts
  - Education, Outreach and Tourism

Hawaii DER (Gateway) Program

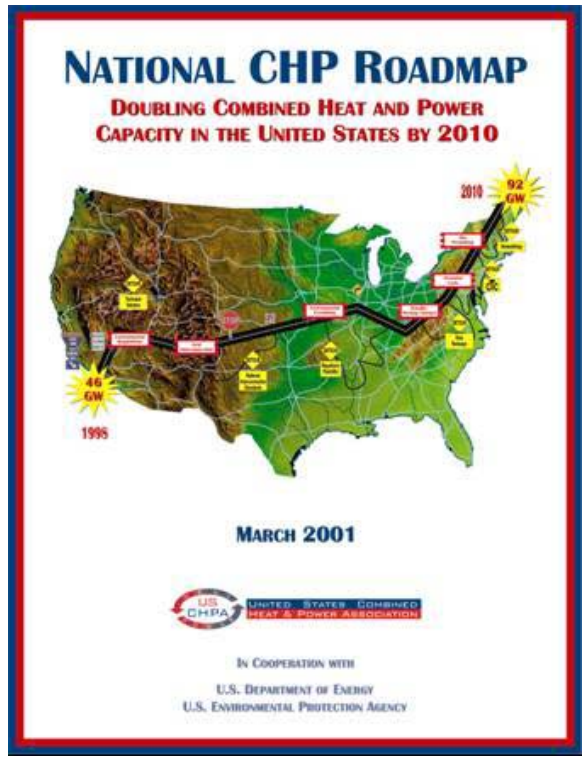
- **Construction grant to be used to design and build a state-of-the-art facility and infrastructure**
- **Center will serve as incubator for companies focused on both renewable and distributed energy generation**
- **Early technology focus on hybrids, including hydrogen fuel cells in combination with renewable energy**
- **Development of industry partnerships through co-sponsored RD&D is a key program element**
- **National partners will advance market penetration overseas (to bridge US technology with Asia-Pacific needs)**

CHP Vision and Technology Roadmap

By 2010, double the amount of CHP capacity in the United States

1998, 46GW → **2010, 92GW**

Our CHP activities are guided by the actions identified in the National CHP Roadmap as those items required of us to meet the CHP Goal

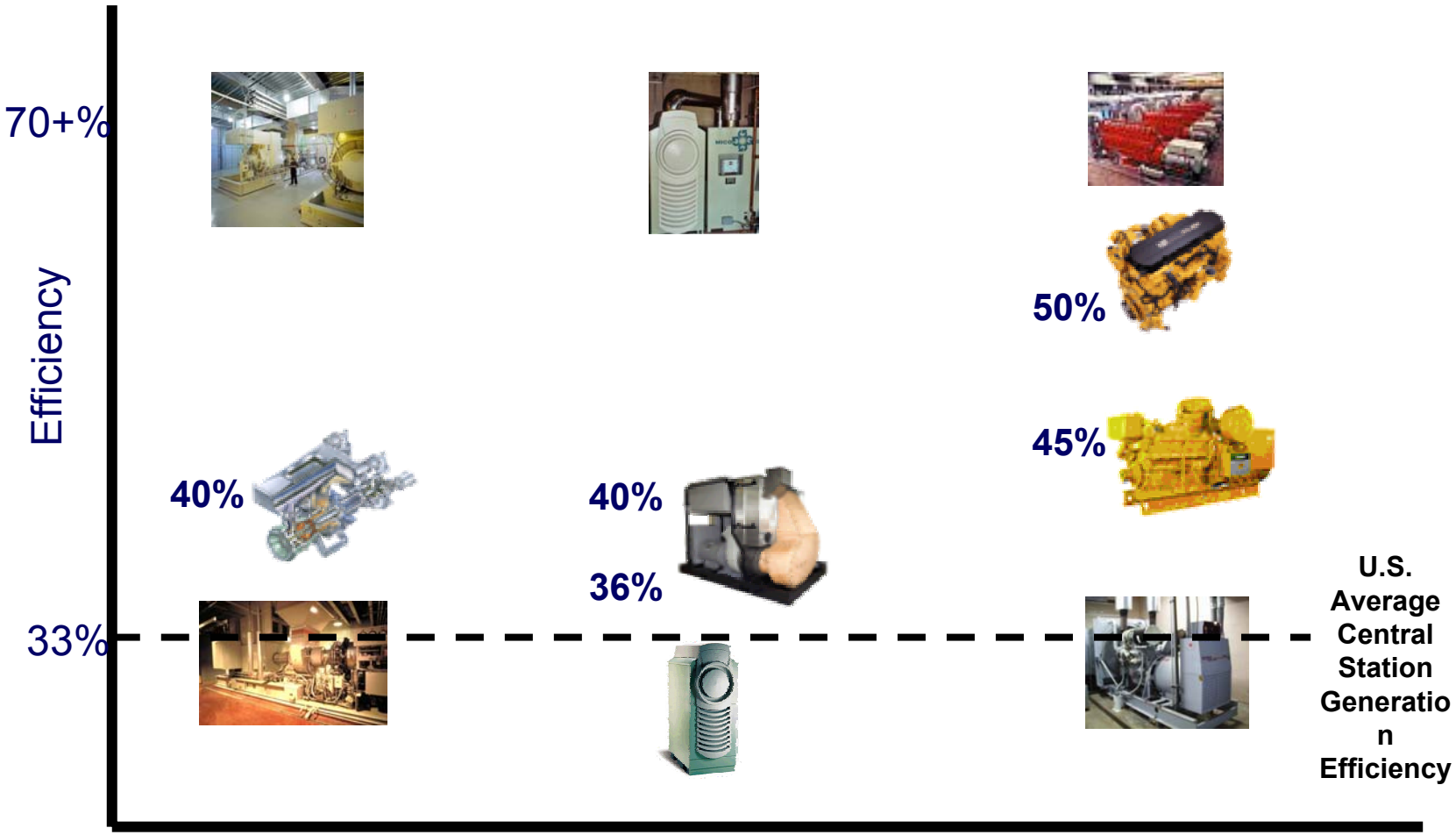


- **Raise CHP Awareness**
- **Eliminate Regulatory and Institutional Barriers**
- **Develop CHP Markets and Technologies**

DEER Activities Directly Supporting the Advancement of the CHP Goal

- Improved Generation and Heat Utilization
- Integrated Energy Systems
- CHP Outreach and Market Development
- End Use Applications
- Analysis and Evaluation Tools

CHP Systems


70+%
Efficiency
40%
40%
36%
50%
45%
33%
U.S. Average Central Station Generation Efficiency
Gas Turbines
Microturbines
Reciprocating Engines

CHP Solicitation Resulted in 18 Awards

- Raising CHP Awareness
  - Regional initiatives
  - Trade shows, meetings and educational activities for targeted audiences
- Eliminating Regulatory, Institutional and Technical Barriers
  - Reports with recommendations on utility interconnection and tariff practices, installation costs, financing options, lessons learned, electric rate structures, air permitting barriers, output-based regulations, and pricing scenarios
- Developing CHP Markets
  - Market segment and potential reports for targeted market segments
- Distributed Generation Analysis
  - Spreadsheet calculator on CHP emissions benefits
  - Preliminary environmental permitting screening tools

Regional Initiatives and Application Centers

University of Illinois-Chicago: Midwest Regional CHP Applications Center

- facilitate CHP projects, technical assistance
- region-specific information, application knowledge

www.chpcentermw.org/home.html

- State Energy Program -- Current CHP Topic is Regional Combined Cooling, Heating, and Power Application Centers

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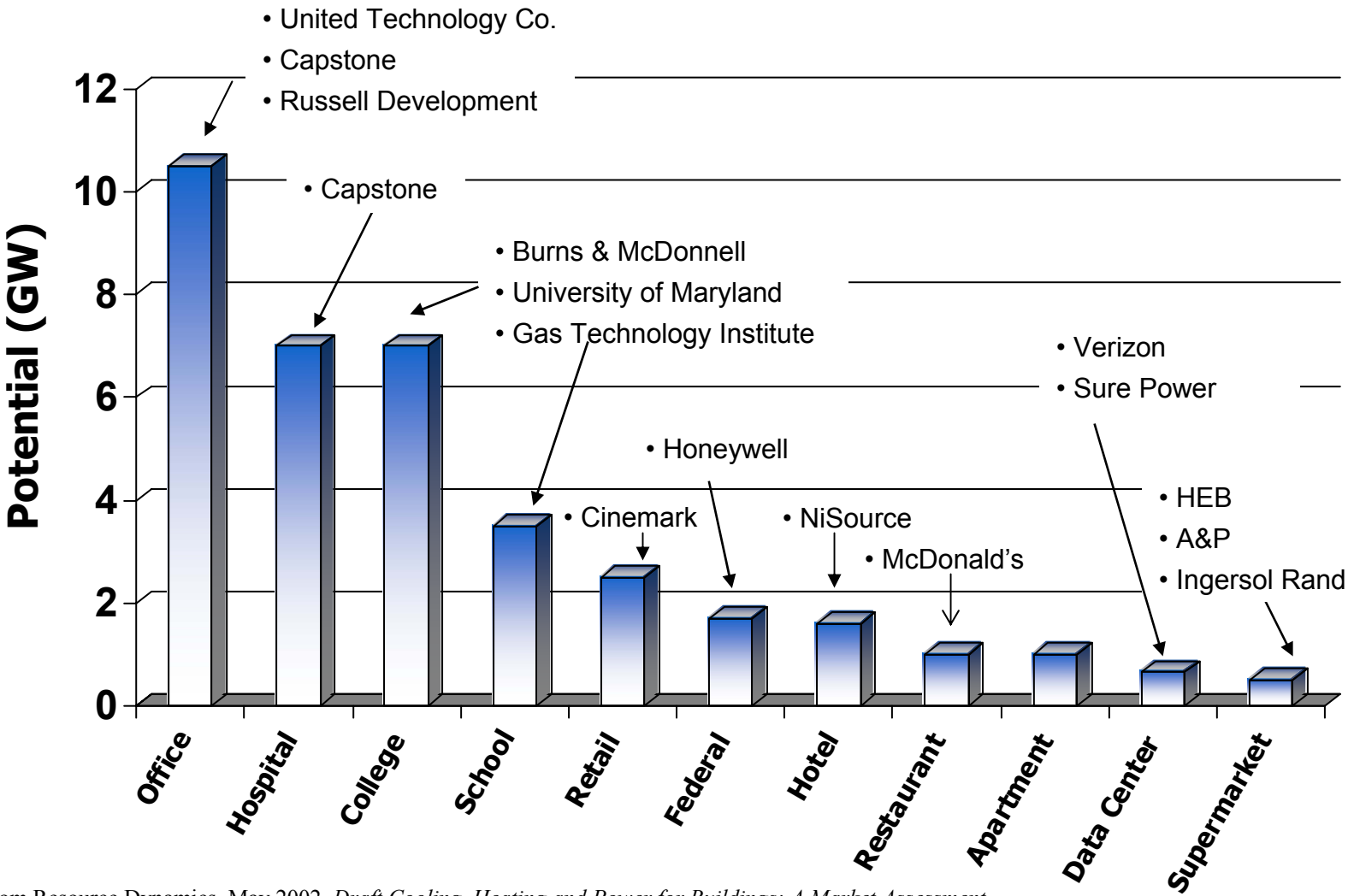
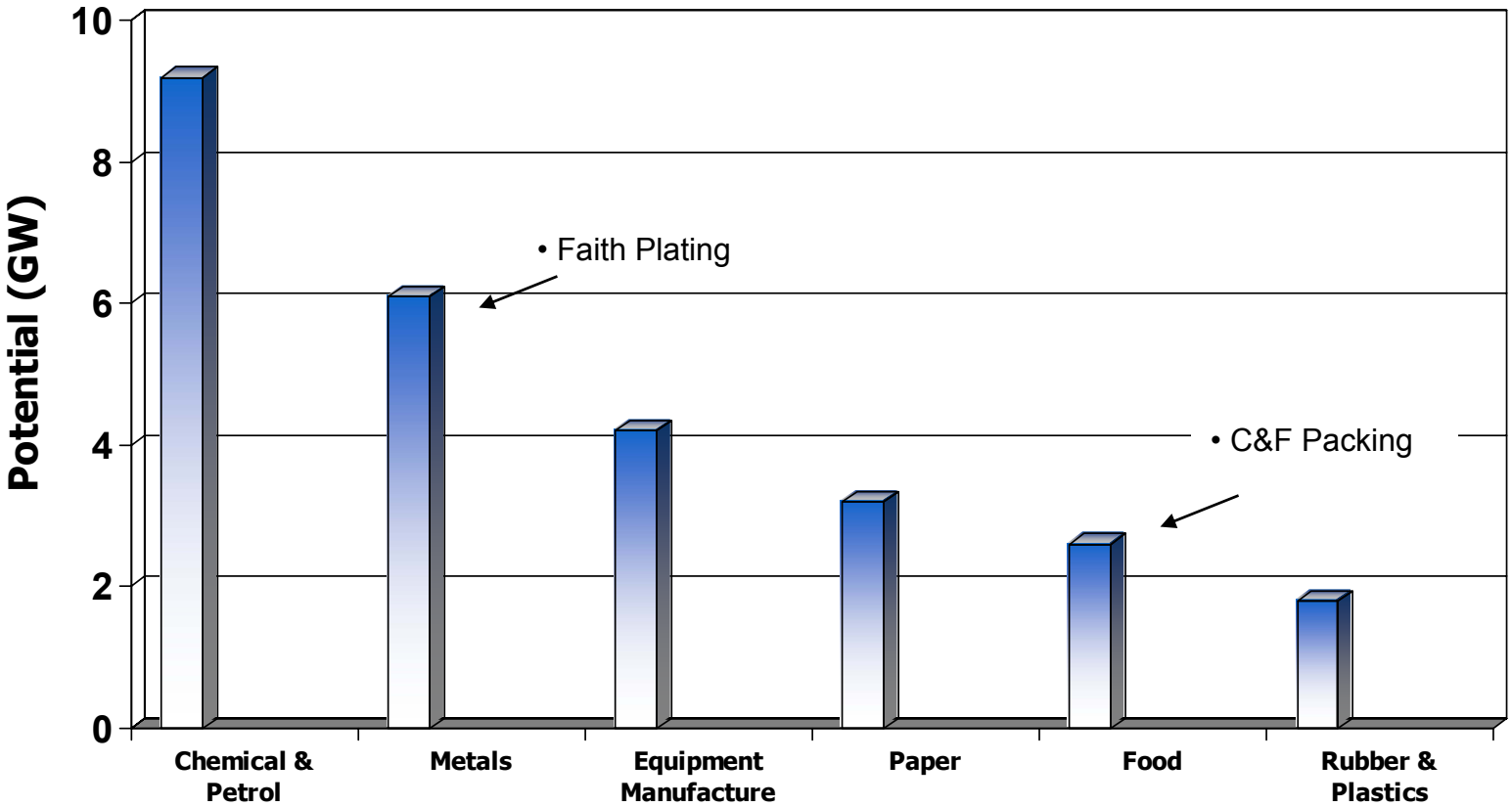
Web site: **http://e-center.doe.gov**

Current end-use projects target CHP market sectors



Data from Resource Dynamics, May 2002, *Draft Cooling, Heating and Power for Buildings: A Market Assessment*

Industrial Sector Projects Develop CHP Potential



Data from Resource Dynamics, May 2002, *Draft Cooling, Heating and Power for Industry: A Market Assessment*

Information Clearinghouse and Networking

www.eere.energy.gov/der

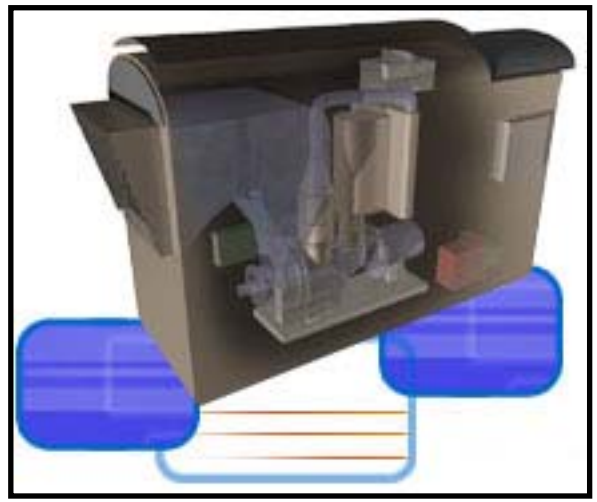
- Technical publications
- Workshops and conferences
- Technology planning
- Cost-shared RD&D
- Solicitation announcements

Integrated Energy Systems

(Packaged Cooling, Heating & Power Systems - CHP)

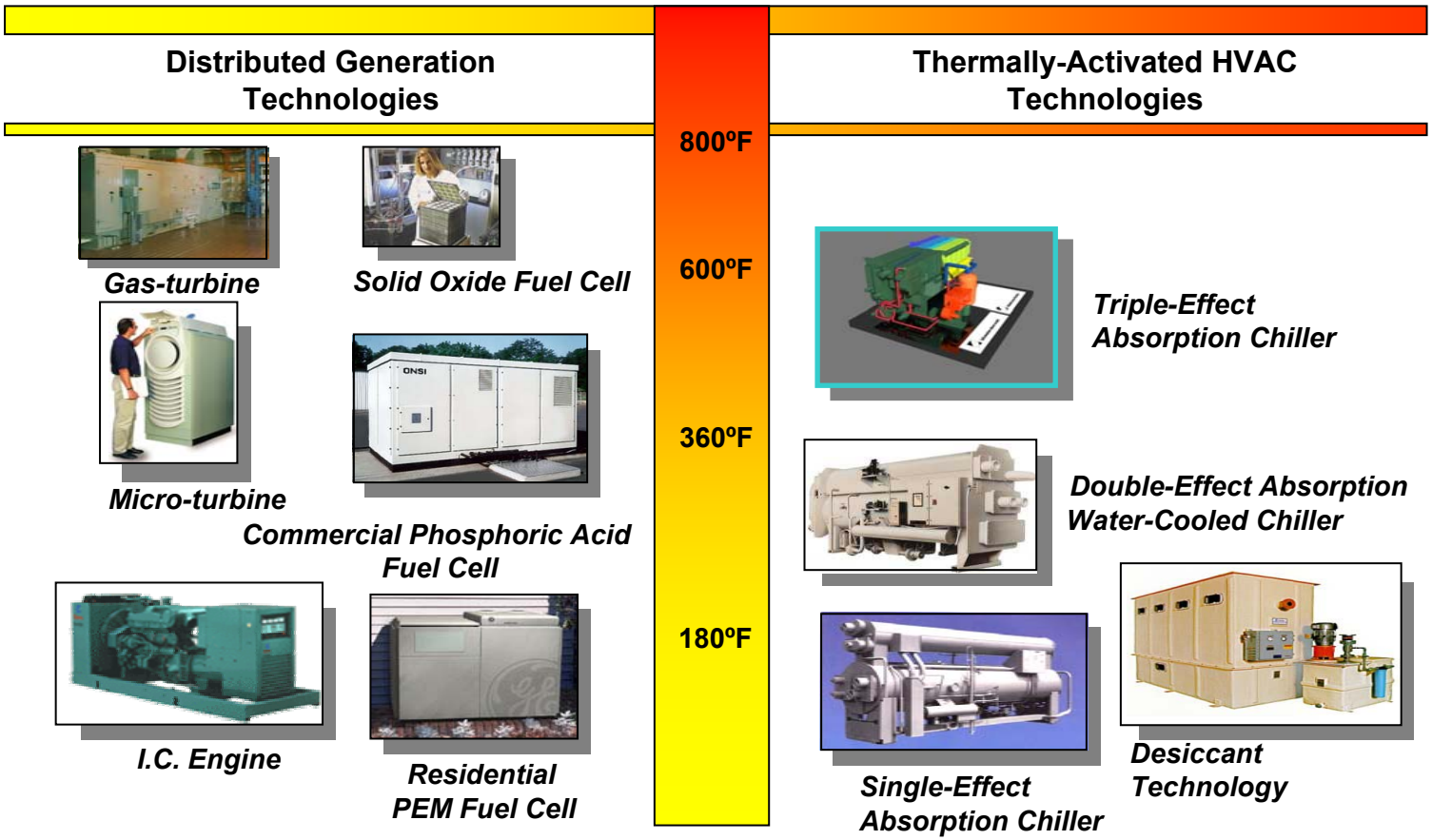
IES Vision: Packaged System Integration

2002: Individually optimized products combined on-site



2010: IES - single optimized package from manufacturer

Thermally-Activated HVAC Technologies are Key to Improving Overall Efficiency of DG



Recoverable Energy Quality (Temperature) and HVAC Technology Match

Benefits of Integrated Energy Systems

- Compared to today's custom engineered Cooling Heating and Power systems, packaged systems should:
  - Improve performance (efficiency)
  - Increase reliability
  - Reduce first (capital plus installation) cost
  - Reduce maintenance cost
- "One-Stop Shopping"
  - Packaged Systems will simplify the evaluation, specification, bidding and purchasing of IES.
- This will enable many more architects, engineers, developers, and building owners to easily consider and use these systems.

$19 Million Awarded For Integrated Energy Systems

- Seven industry teams have been selected for awards for research, development and testing of “First Generation” Integrated Energy Systems .

- These Distributed Energy Resource (DER) systems are highly efficient with low emissions.
  - Allow small-scale (< 10 MW) power generation close to the point of use.
  - Combined with thermal recovery to heat or cool nearby buildings.
  - Improve energy security – electric reliability.

- More than 43% Industry cost-sharing (over $31 million total project costs).

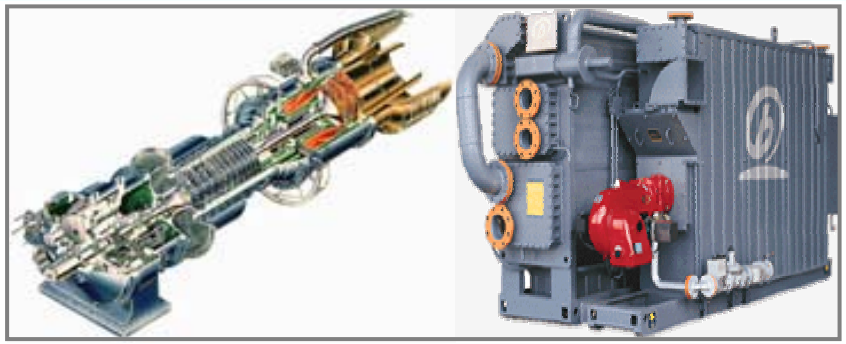
Seven Industry Teams Selected for Award

- Honeywell Laboratories (Fort Bragg)
- Burns and McDonnell
- Gas Technology Institute
- United Technologies Research Center
- Ingersoll-Rand
- NiSource Energy Technologies
- Capstone Turbine Corporation

Honeywell Laboratories

- Honeywell Laboratories (Minneapolis, Minnesota)
- Honeywell Team to develop and field test a 5 MW IES.
- A 5 MW turbine generator will be combined with a turbine exhaust fired 1,000 RT absorptio
- The prototype will be set up and tested at Fort Bragg, N.C.
  - Coordinated with FEMP Fort Bragg Project.
- Supervisory controls system
  - Automated energy and cost management
- Develop reference designs
  - 1.2 to 5 MW designs for more customers

Burns and McDonnell



- Burns and McDonnell (Kansas City) teamed with:
  - Solar Turbines Inc (San Diego – turbine generator)
  - Broad USA (New York – absorption chiller)
- The Burns and McDonnell Team to design and construct a 5.2 MW packaged IES with 2,500 tons of cooling
- Greater than 70% Efficiency (Btu Out/Btu In)
- Evaluated 14 different sites, selected Austin Energy (Austin, Texas)
  - Plan to provide power, heating and cooling to two customers
    - Domain (high-tech industrial park)
    - University of Texas at Austin

Gas Technology Institute

- Gas Technology Institute (Des Plaines - Chicago) teamed with:
  - Waukesha (Waukesha, WI - engine generators)
  - Trane (LaCrosse, WI - absorption chillers)
  - Ballard Engineering (Rockford, IL - energy and power management)
- The GTI Team is combining Waukesha engine generators with Trane absorption chillers.
  - Engine generator sizes range from 280 kW to 810 kW.
  - Matched to several absorption chillers.
  - Developing a modular range of sizes to match a variety of building types/markets.

United Technologies Research Center

- United Technologies Research Center
- UTC/Capstone Team for an accelerated IES system.
  - Based on multiple Capstone 60 micro-turbines.
    - Coupled to Carrier absorption chillers.
  - Initial packaged system is being developed.
- Also evaluating use of waste heat to drive:
  - Ammonia water refrigeration systems.
  - Desiccant systems.
  - Thermal storage.

Ingersoll-Rand

- Ingersoll-Rand (Portsmouth, NH)
- IR Team to combine a new 70 kW microturbine with an ammonia-water absorption refrigeration system.
  - The absorption system will be used for:
    - Cooling the turbine's inlet air.
    - Producing refrigeration for building space conditioning.
    - And producing refrigeration for refrigerator-freezer applications.

- NiSource Energy Technologies
- Teamed with new Hilton Hotel
  - modular Integrated Energy System
  - Hilton Garden Inn IES System in Operation
- Goal of becoming the hotel/motel customers' standardized model.
- Complete system will consist of:
  - Three microturbines.
  - Heat recovery heat exchangers.
  - Absorption chiller.
  - A desiccant unit.
  - Integrated control system.

Capstone Turbine Corporation

- Capstone Turbine Corporation (Woodland Hills, CA).
- Capstone Team to design and test initial IES.
  - Based on using waste heat from Capstone's 30 kW & 60 kW microturbines.
    - Both recuperated and un-recuperated microturbines will be evaluated.
  - Coupled with absorption chillers for air-conditioning.
- Formed Strategic Alliance with United Technologies (2002)

Conclusions

- Hybrids energy systems have potential to accelerate acceptance and development of DER
- Hybrids can meet a variety of customer needs
- Industry is interested in potential of hybrids
- Current hybrid projects incorporate a variety of DER technologies
- Funding exists to support new hybrid projects and partnerships