COMBINED HEAT & POWER FOR COMMERCIAL & INDUSTRIAL CUSTOMERS

Hawaii, Kauai, & Maui County Energy Office Workshops

December 3, 4 & 6, 2002

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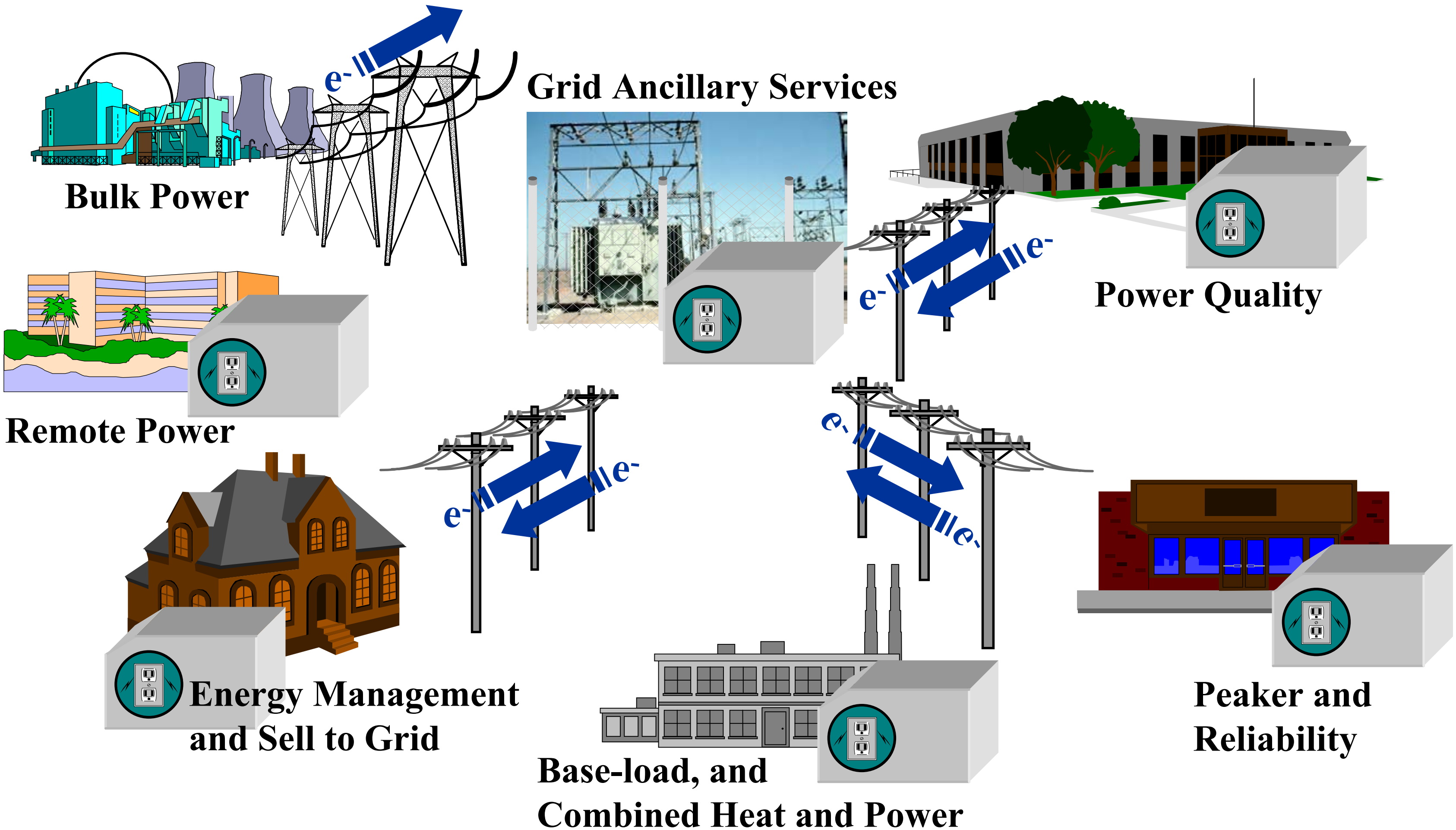
Distributed Energy Applications



Source: NREL

Distributed Energy Technologies

Storage Systems

.Reciprocating Engines

Photovoltaics

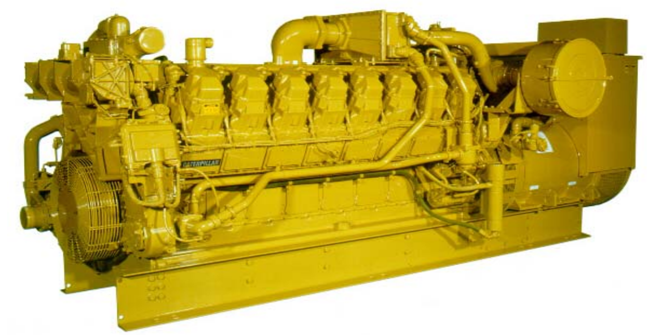
Fuel Cells

Wind

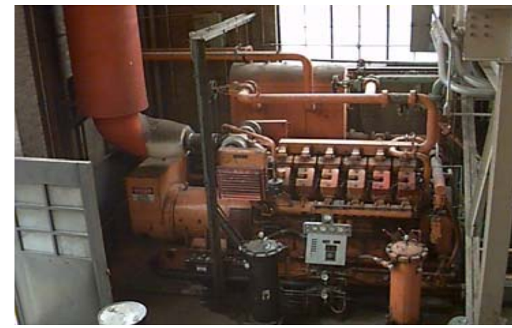
Microturbines

Commercial and Advanced Internal Combustion Engines

2 MW Spark Ignition Engines



1MW Compression Ignition Engines



- Engines dominate 1-5 MW electricity generation segment
- Up to 44% electric efficiency
- Advanced materials and manufacturing means lower
  - initial costs,
  - operating costs,
  - emissions and
  - size.

5 kW Gas Microengine

Powering the UCSF Medical Complex

Solar Taurus 60 and Caterpillar 3516B units perform flawlessly during electric power interruption

by Bruce Wadman

Besides the economic benefits of producing both electrical power and thermal energy from the same fuel source, an additional advantage of a cogeneration facility in a large hospital complex is the ability to provide critical power when there is a general interruption of service. A good example of this occurred December 8, 1998, in the San Francisco, California, U.S.A., area at the large University of California, San Francisco (UCSF) medical complex. The interruption of electric service to the facility gave UCSF the opportunity to test its preparedness for such an emergency.

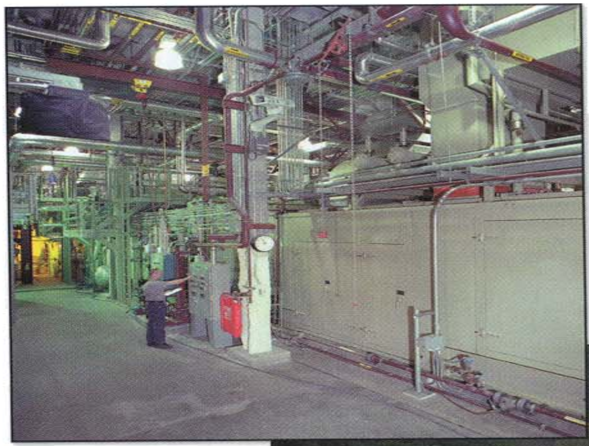
The cogeneration equipment includes two Solar Turbines Inc., Taurus 60 gas turbine generator sets, each with ERI exhaust heat recovery boilers installed downstream. Each Taurus 60 gen-set is ISO rated 4.8 MW and drives a 4160 V Ideal generator. Additionally, one 3.75 MW back-pressure steam turbine is installed for combined-cycle operation, yielding a total plant capacity of 12.1 MW.

Voltage is stepped up to 12 470 V where it interfaces with the electricity grid. The facility is capable of operating in either "utility" mode or separate "island" mode, as was the case during the 1998 outage.

Additional emergency standby equipment includes three Caterpillar 3516B diesel generator sets, each rated 2.0 MW and driving 12 470 V Kato generators, and featuring Caterpillar electronic modular control panels. Response time to a "start" command is within 10 seconds.

The Taurus 60 turbines are designed to operate on either natural gas or diesel liquid fuels. They utilize water injection with a selective catalytic reduction (SCR) system, achieving exhaust stack emissions of 5 ppmv NO_x on gas and 8 ppmv on liquid at 15% O_2 on a three-hour rolling average basis. The exhaust heat is captured by the heat recovery

continued on page 56



(Left) One of two Solar Taurus 60 gas turbine gen-sets at the UCSF medical complex in a cogeneration application. Each unit produces 4.8 MW output driving an Ideal generator. A steam turbine generator set is also included as a combined-cycle unit, giving a total plant capacity of 12.1 MW.

(Right) Aerial photo of the UCSF Central Utility Plant including the gas turbine cogeneration plant and emergency standby diesel generator sets.

Electric Generation wastes more energy than the total energy used in the transportation sector.

CHP is undisputedly the winner in lowest delivered cost and emissions impact

WHAT IS CHP?

- Integrated System
  - Power generation and heat recovery
- Located near or on customer's site
- Meets all of heating and cooling needs
- Provides all or part of power needs

COST OF CHP SYSTEMS

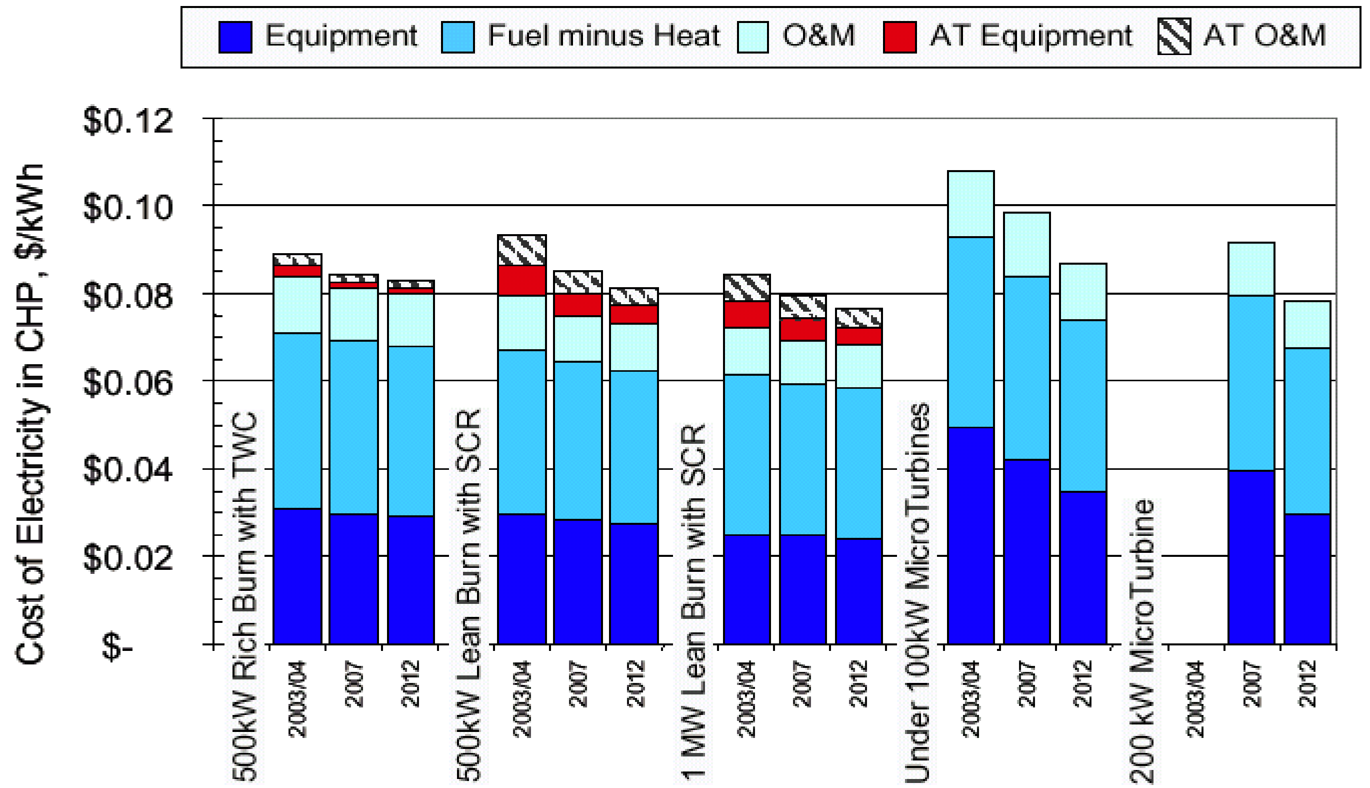


Exhibit 10 – COE for 1MW and Smaller CHP Systems (Base Case)

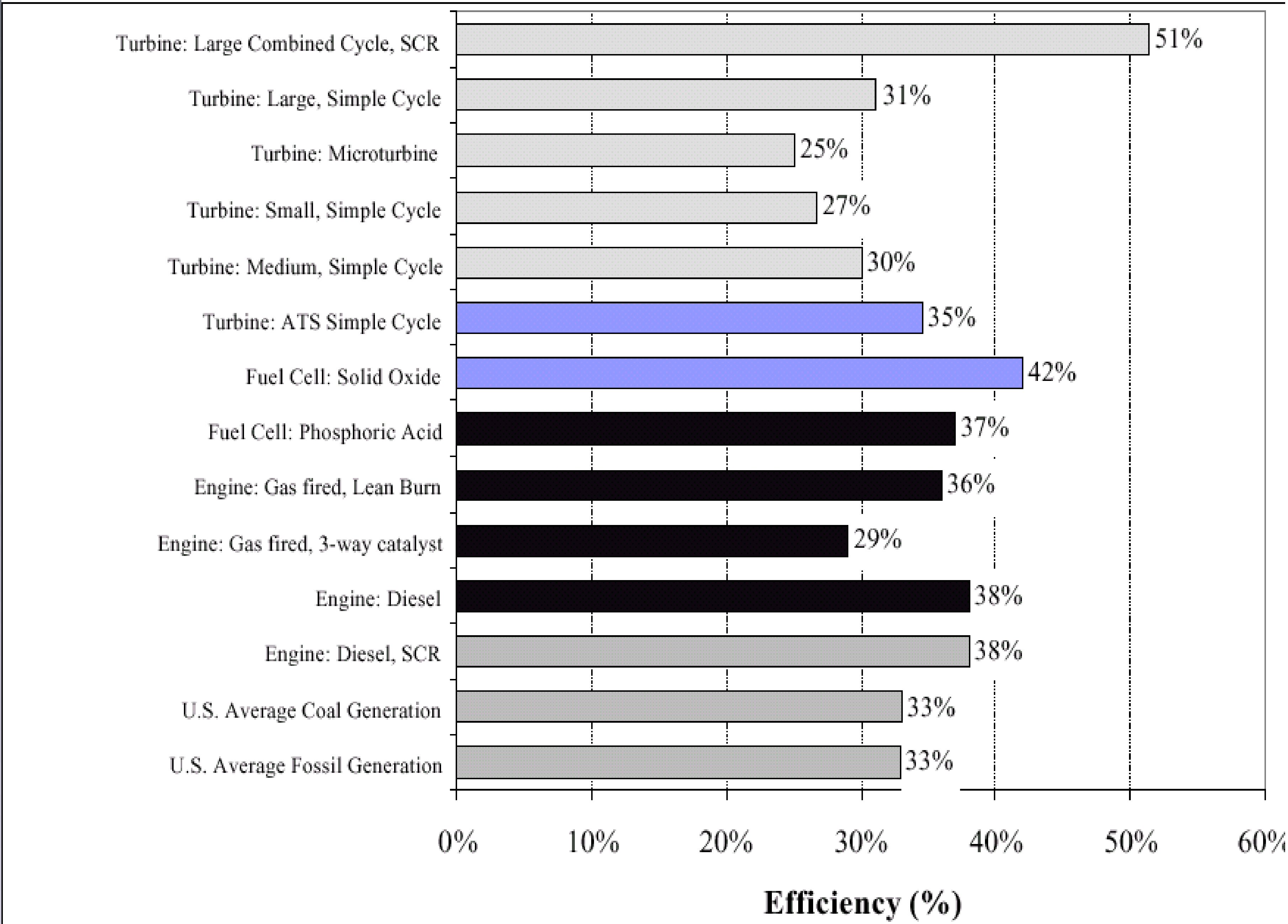
- AT=After-Treatment. Fuel minus heat = fuel to generate a kWh net displaced boiler fuel.
- Source: *Performance and Cost Trajectories of Clean Distributed Generation Technologies,* The Energy Foundation. May 29, 2002.

Power Technology DATA

Technology	Range (kW)	Year Commercial	Electric Efficiency (HHV) (%)	Installed Cost ($/kW)
Reciprocating Engine	50-6000	Available	29-44	200-800
Gas Turbine	500-20,000	Available	21-40	300-870
Microturbine	30-150	Available	25-28	1000-1500
Fuel Cell	10-3,000	?	32-48	3000-4000
Photovoltaic	10-10,000	Available	15-18	5000-10,000
Large CC, SCR	500,000	Available	51	
US Avg. Fossil	300,000	--	33	
CHP Recip	75-500kW	Available	55-85	1500
CHP CT	5000	Available	60-85	950

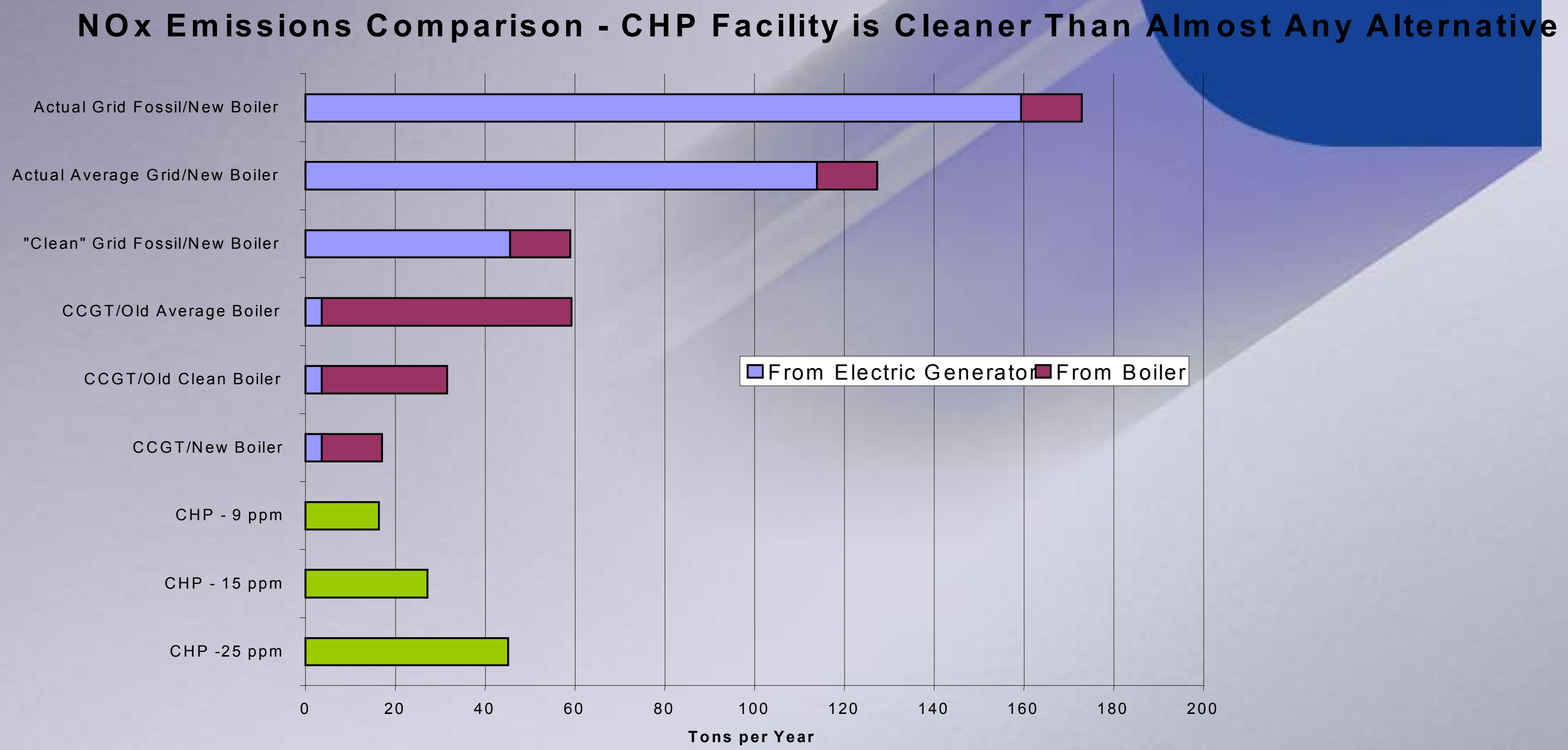
CHP GRID and Economic Benefits

- Versus Central Station Power Plants
  - Less capital outlay; flexes decision-making
  - Eliminate new or upgraded T&D AND no T&D losses
  - Minimal need for onsite personnel
  - Heat Recovery = $ savings & increased efficiency
  - Lower emissions per kWh produced
  - Lowers overall system costs
- Economic--Goods, services, rates
  - Direct energy bill savings lowers bottom line cost
  - Lower systems costs = lower ratepayer costs

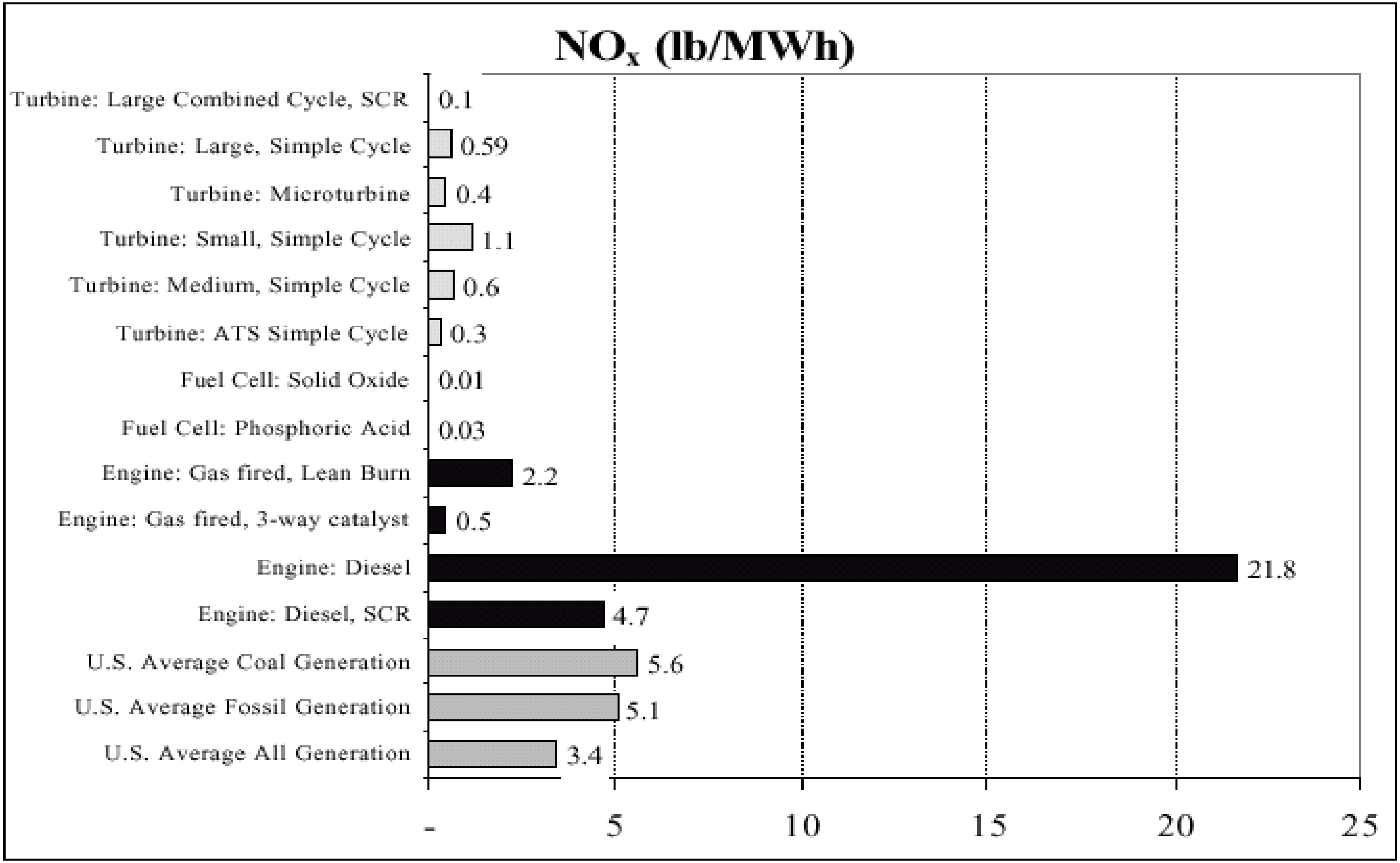


Turbine: Large Combined Cycle, SCR
51%
Turbine: Large, Simple Cycle
31%
Turbine: Microturbine
25%
Turbine: Small, Simple Cycle
27%
Turbine: Medium, Simple Cycle
30%
Turbine: ATS Simple Cycle
35%
Fuel Cell: Solid Oxide
42%
Fuel Cell: Phosphoric Acid
37%
Engine: Gas fired, Lean Burn
36%
Engine: Gas fired, 3-way catalyst
29%
Engine: Diesel
38%
Engine: Diesel, SCR
38%
U.S. Average Coal Generation
33%
U.S. Average Fossil Generation
33%
0%
10%
20%
30%
40%
50%
Efficiency (%)

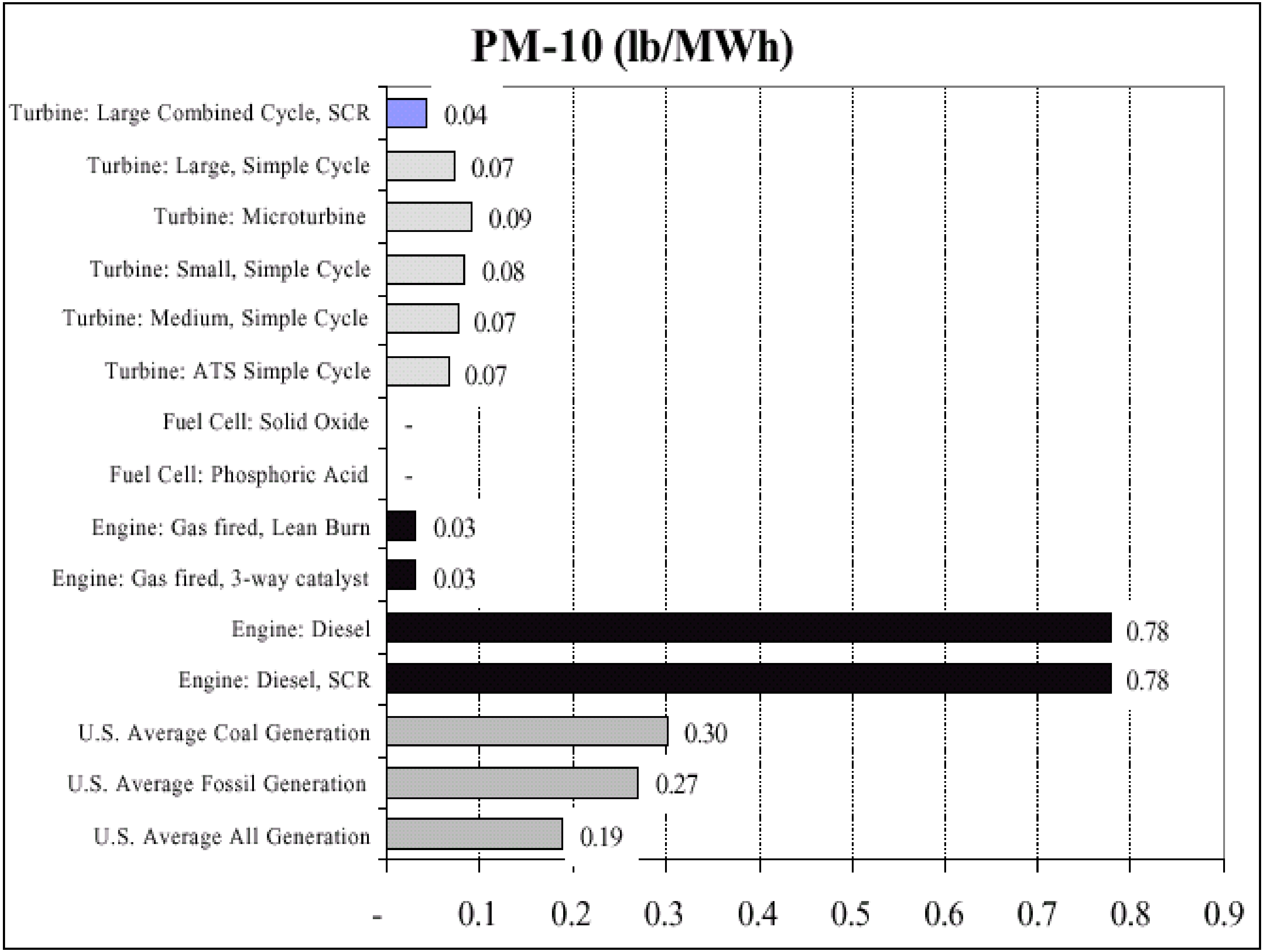
CHP EMISSIONS

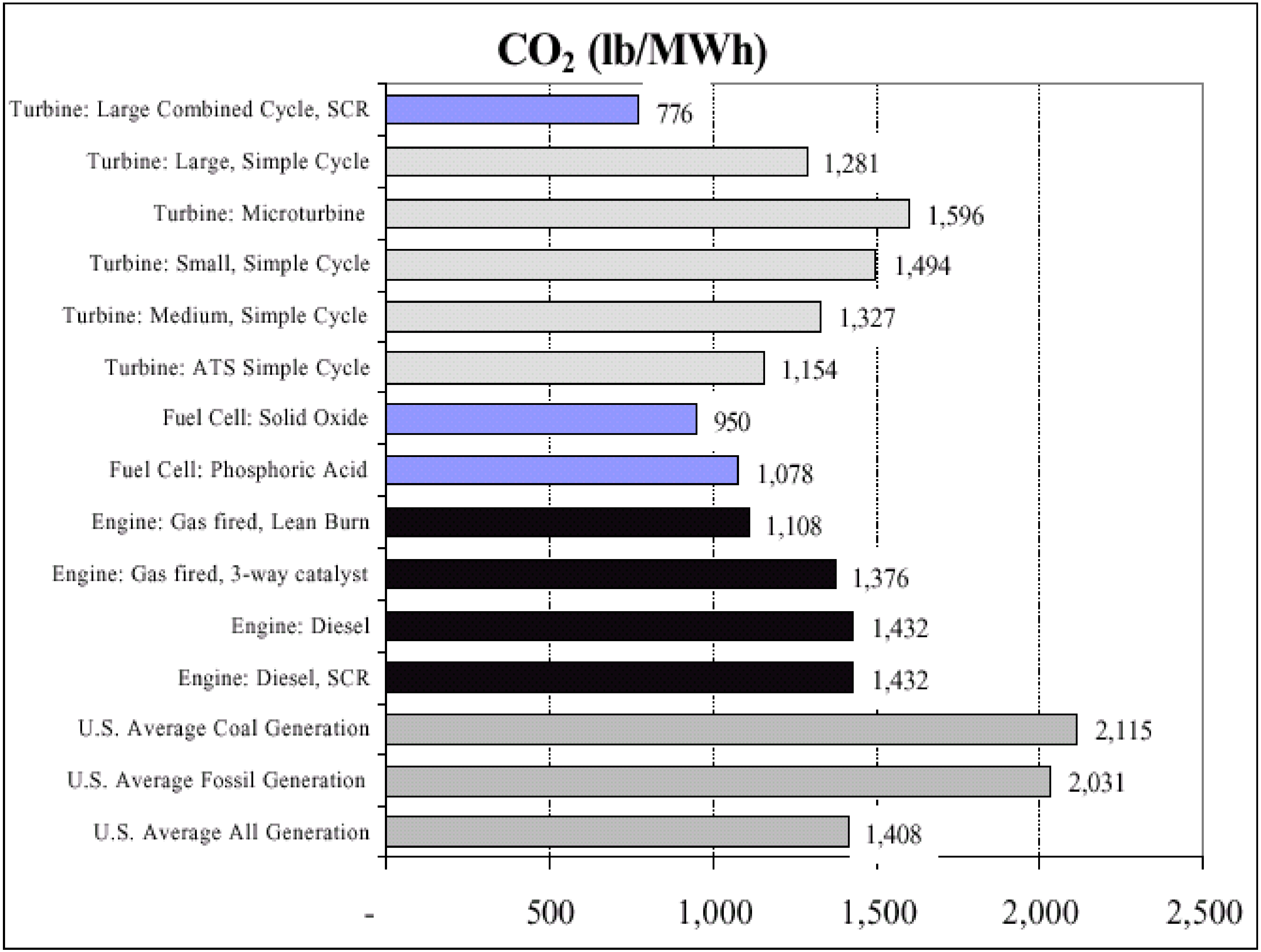


CHP system using small gas turbine <10 MW



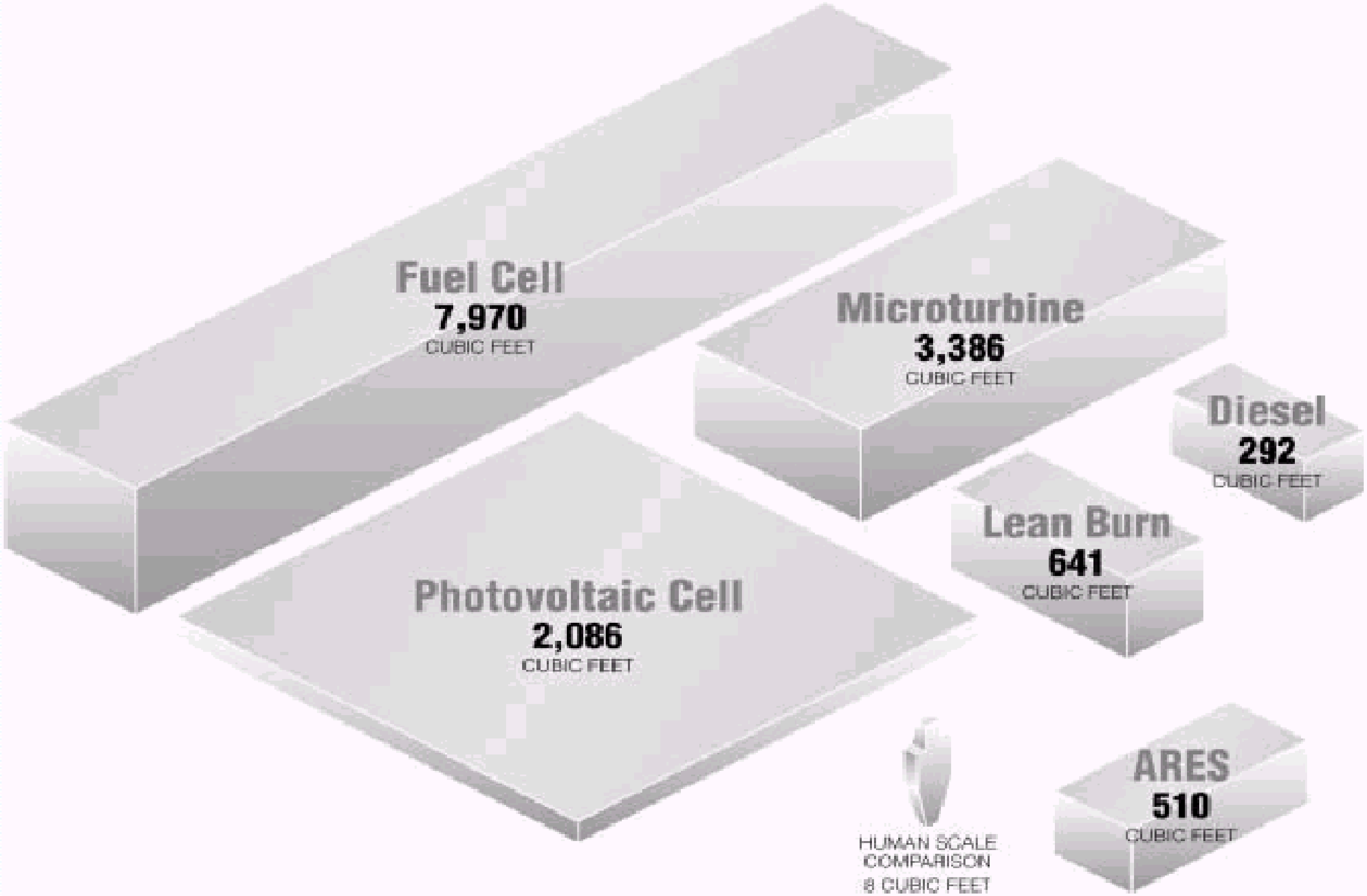
These are typical values for new units of the specified technologies. They do not apply to older, existing units. The values were calculated on the basis of assumptions about typical operating conditions; however, because actual operating conditions are rarely typical, the actual emissions performance of a unit may differ from these values.


PM-10 (lb/MWh)
Turbine: Large Combined Cycle, SCR
0.04
Turbine: Large, Simple Cycle
0.07
Turbine: Microturbine
0.09
Turbine: Small, Simple Cycle
0.08
Turbine: Medium, Simple Cycle
0.07
Turbine: ATS Simple Cycle
0.07
Fuel Cell: Solid Oxide
-
Fuel Cell: Phosphoric Acid
-
Engine: Gas fired, Lean Burn
0.03
Engine: Gas fired, 3-way catalyst
0.03
Engine: Diesel
0.78
Engine: Diesel, SCR
0.78
U.S. Average Coal Generation
0.30
U.S. Average Fossil Generation
0.27
U.S. Average All Generation
0.19
-
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9



CO2 (lb/MWh)
Turbine: Large Combined Cycle, SCR
776
Turbine: Large, Simple Cycle
1,281
Turbine: Microturbine
1,596
Turbine: Small, Simple Cycle
1,494
Turbine: Medium, Simple Cycle
1,327
Turbine: ATS Simple Cycle
1,154
Fuel Cell: Solid Oxide
950
Fuel Cell: Phosphoric Acid
1,078
Engine: Gas fired, Lean Burn
1,108
Engine: Gas fired, 3-way catalyst
1,376
Engine: Diesel
1,432
Engine: Diesel, SCR
1,432
U.S. Average Coal Generation
2,115
U.S. Average Fossil Generation
2,031
U.S. Average All Generation
1,408
-
500
1,000
1,500
2,000
2,500

Physical Size -- 500kW Generator



Energy and Environmental Analysis, Inc.

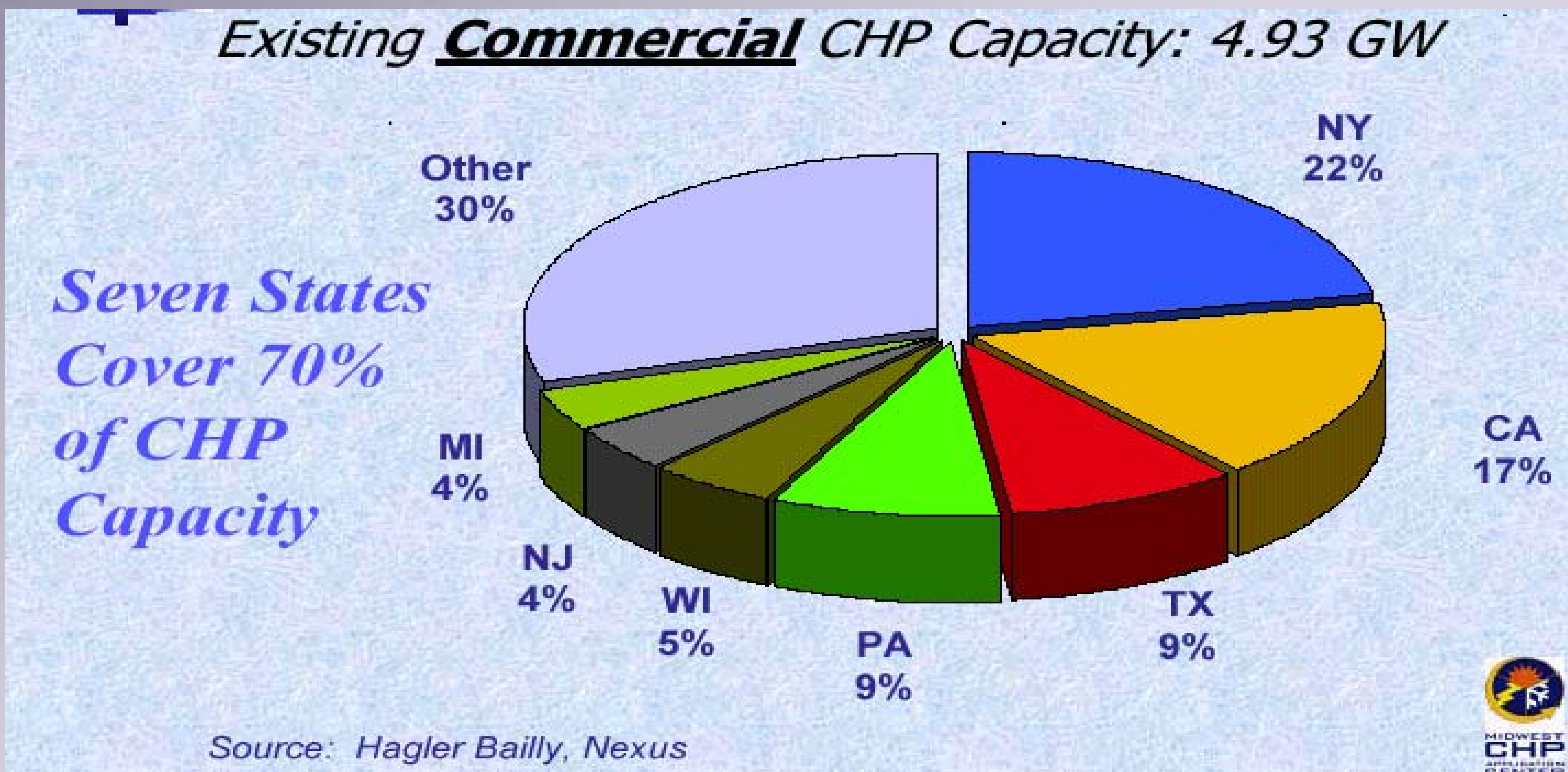
US CHPA ROADMAP

- BY 2010
  - Industrial
  - Buildings
  - District Energy
  - Federal Facilities
  - Existing:46 GW in US

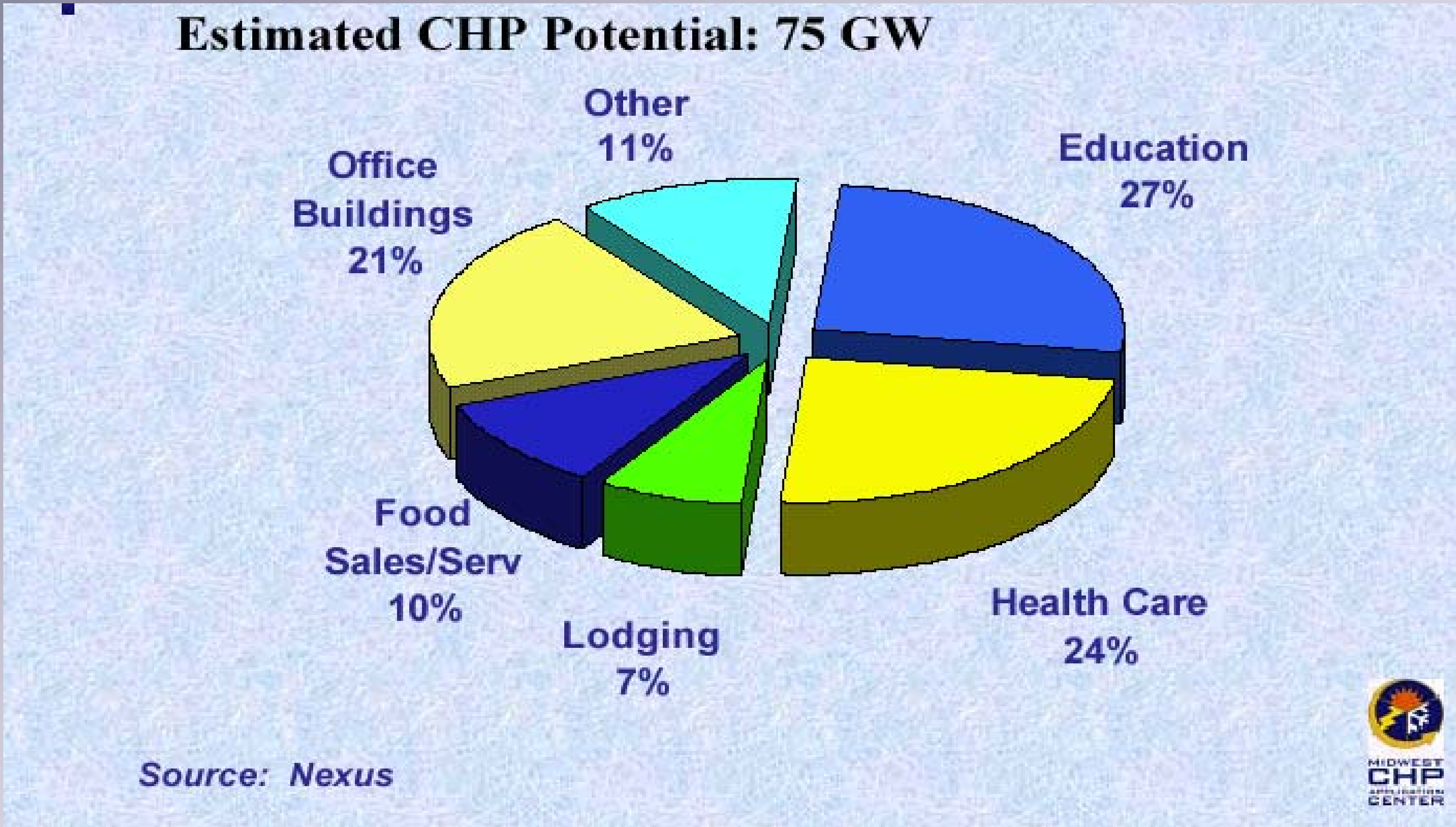
- MWs
  - 27,000
  - 8,000
  - 8,000
  - 5,000
  - 48,000 Total

US & HAWAII CHP MARKET

- All Islands 1600 MWs total installed
  - Recent Tom Casten paper quotes cogen and small power at 32%
  - Based on data received from developers, 17 MW total or about 1 %



CHP POTENTIAL -- COMMERCIAL SECTOR



CHP--WHEN DOES IT MAKE SENSE?

- Paying more than 10 cents/kWh for electricity
  - propane at $2/gallon makes economics work
- Thermal load (Hot water, steam, cooling)
  - Swimming pool
  - Laundry facilities
  - Air conditioning, chillers, desiccant dehumidification
- Space available
- Sound attenuation -- containers are expensive

CHP Barriers

- Regulatory Compact & Deregulation
  - Monopoly franchise in paradigm shift to competition--the antithesis of regulated rate of return
  - Requires clear and unequivocal vision of stable rates and greater power system efficiency through competition
    - Economic and environmental benefits are real
    - But, utility suffers reduced ROR. PUC needs to compensate behavior and functions that honestly incorporate DG/CHP
- Rates
  - Average rather than Real-time rates
  - Standby rates which assume failure during peak hours. Remedy: buy what you need; provide own back-up
  - Ban against anyone but local monopoly providing back-up

CHP BARRIERS

- Prohibition on sales between customers
- Air Agencies that do not regulate emissions on output-based basis (lb/MWH)
- Lack of Appropriate Interconnection Standards and *Streamlined* Interconnection Procedures
- Lack of equitable tax treatment
  - Accelerate depreciation schedule to match 7-10 engineering life

CHP FUTURE

- "While significant progress has been made or is in the works for environmental and legislative barriers to CHP, the utility company barriers have not yet been effectively approached. Even within the restructuring markets of states, some utilities have successfully ended CHP projects in their infancy. With the removal of environmental and legislative barriers, this is becoming the overriding cause of CHP not having a fair market share. To fully integrate CHP into the energy economy, a strategy altering detrimental utility practices must be designed and carried out."
  - **CHP FIVE YEARS LATER:POLICIES AND PROGRAMS UPDATE, R. Neal Elliott, Ph.D., P.E., Anna Monis Shipley, and Elizabeth Brown. October 2002; American Council for an Energy-Efficient Economy, Washington, DC**

STANDARD MARKET DESIGN

NOTICE OF PROPOSED RULEMAKING (NOPR)

Federal Energy Regulatory Commission

WHY IS THIS NEEDED?

- Increasingly Regional Nature of Electricity Trade
- Residual Discrimination – Independence Issue
- Minimize "Seams"
- Avoid Market Manipulation
- Promote Investment in Necessary Infrastructure
  - gx vs. tx vs. demand response
  - encourage development of new technology
- Lower Costs to Customers
- Framework for Effective State & Federal Regulation

PRESERVING STATE PREROGATIVES

States continue to:

- Set retail rates
- Site transmission and generation
- Deal with local distribution issues

In addition, we are proposing:

- Regional State Advisory Committees for policy issues and RTO management and budget review
- Multi-State Entities for planning, certification, and siting at a regional level
  - Complements recommendation of Task Force to National Governors Association

MAJOR ELEMENTS

- Independent Transmission Provider
- New Transmission Tariff
- Transmission Pricing Reform
- Organized Day-ahead & Real Time Spot Markets
- Mitigation of Market Power/Market Monitoring
- Resource Adequacy
- Regional Planning Process

Federal Energy Regulatory Commission

POST-NOPR PROCESS

- Comments Due November 15, January 10
- Reply Comments Due February 17
- More Technical Conferences
- Final Rule Implementation
  - Sept. 30, 2003 ---- Bundled Retail Under Tariff
  - Dec. 1, 2003 ---- SMD Compliance Filings
  - 1 Yr. after Rule ---- Regional Planning
  - Jan. 31, 2004 ---- Security Standards
  - Sept. 30, 2004 ---- SMD in effect

DEMAND RESPONSE

- Avert or minimize shortages, delay need and capital outlay for new or upgraded T&D, increase grid resiliency for reliability and security
- Includes
  - Demand response bids from DG
  - Ancillary services –regulation and frequency response
  - Energy efficiency improvements
  - Interruptible loads
  - Other dependable load management

DEMAND RESPONSE

- Successful Demand Response
  - Requires Planning Horizon that enables time to develop new renewable and non-renewable resources
  - Is a key component of Long Term Resource Adequacy
  - Encourages technology innovation
  - Provides customer options

WHAT FERC CAN-CANNOT DO

- Wholesale not distribution level sales
  - Demand Response and bilateral sales for resource adequacy are wholesale
    - Hawaii PUC needs to address DG bilateral sales between customers or between customer and utility
- Cannot leverage environmental
  - EPA and Air Agencies
- Interconnect Agreement and Procedures
  - HPUC can adopt FERC standard

DG/CHP COLLABORATIVES

- *Vision: to implement CHP in Hawaii and to reap its reward in terms of lower system/grid costs and energy efficiency; direct business and employment benefits; and lower environmental impact per kWh and BTU produced.*
  – What is it going to be???

DG/CHP COLLABORATIVES

- Decision Points
  - Membership: rules of nature -- “all friends or foes alike?” Voluntary organization or formal?
  - By-laws
  - Dues
  - Voting structure-- “no stacking the deck”
    - 1 company, 1 vote
  - Decision-making
    - Consensus Vs unanimous
    - Majority
    - All points of view given equal weight

CALIFORNIA ALLIANCE FOR DISTRIBUTED ENERGY RESOURCES (CADER)

- Voluntary Public-Private Partnership
  - No by-laws, members participated at own expense
- Distributed Generation Roundtable
  - Recommended formation of Collaborative (4/96)
  - Collaborative formed (10/96)
- Representation
  - Regulators, rate-payer, utilities, national labs, environmental, OEMs, Research, end-users, USDOE, consultants

CADER's CONSENSUS PROCESS

- Committees -- Self assignment
  - Legislative, Regulatory & Market Incentives
  - Siting & Environmental
  - Technology Characterization
  - Modeling & Planning
  - Steering Committee
- Decision-making
  - Administrative matters: simple majority vote
  - Issues: all points of view given equal weight
  - Chair attended most committee mtgs. *"Glue"*

CADER's BARRIER IDENTIFICATION

- Barriers
  - Limited Government Policy Support
  - Omission of DG from utility resource plans
  - Inconsistent regulatory treatment and lack of pre-certification procedures
  - No models exist to compare DG benefits with other options
    - Existing models oriented to Discos than to customers
  - Regulatory compact unclear as to utility role and ownership of DG
  - Mechanism to convey accurate locational (congestion) marginal prices does not exist

CADERS BARRIER IDENTIFICATION (con't)

- Independent Bid Entity to hold, evaluate and score bids to meet utility needs may resolve controversy of utility doing same
- Consumers and regulators confused about technology claims--performance, commercial availability, and cost
- Lack of appropriate Interconnect Stds.and streamlined procedures.
- Cost & benefits need to be quantified, valued and allocated among stakeholders

CADER's
BLUEPRINT FOR ACTION

- Action Plan led to 3 rulemakings
  - CEC: Interconnection Standards and Streamlined Procedures. R&D&D for clean DG.
  - CARB: Air Quality Implications of DG
  - CPUC: Tariff and rate design (work in progress)
- DG Community active in getting laws passed re: standby charges, cogeneration, buy-down incentive programs, rate design