Quadrennial Technology Review

U.S. DEPARTMENT OF ENERGY

Industrial Technology Deployment and Market Activities

Isaac Chan
Industrial Technologies Program

U.S. Industrial Sector

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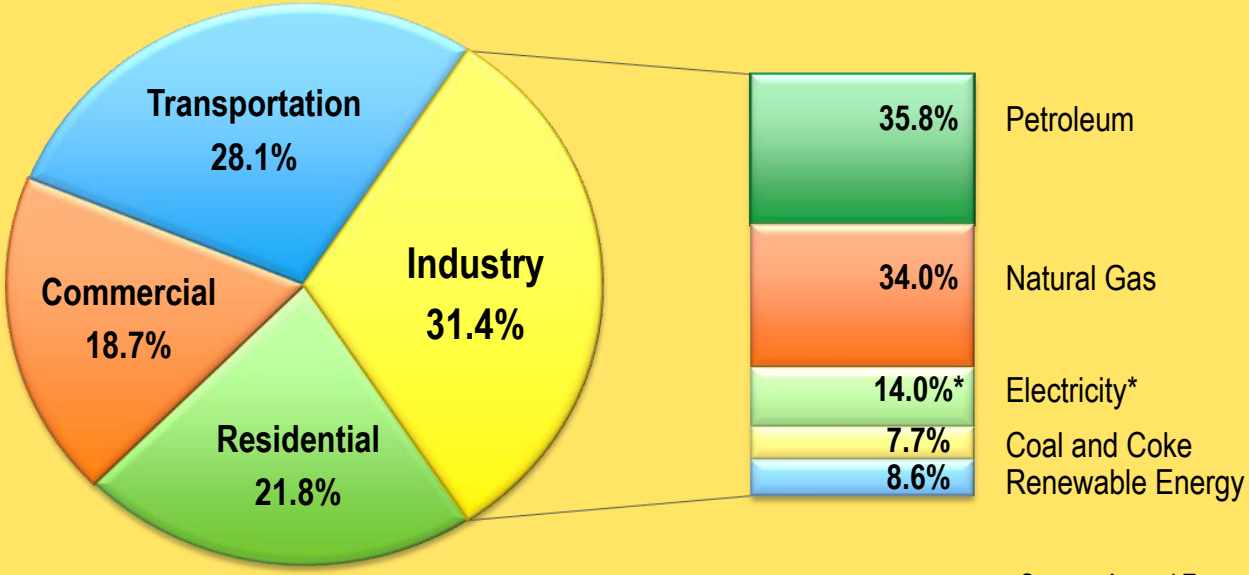
U.S. Industry (manufacturing, construction, agriculture) accounts for over 31% of total U.S. energy use



Energy Use by Sector

* Excludes losses

Source: Annual Energy Review 2008, EIA.

U.S. manufacturing is an essential economic engine

- Employs ~12 million people
- Generates ~11% of U.S. GDP
- Supplies ~57% of U.S. exports
- Accounts for ~20% of global manufacturing output

Industrial Sector Energy Profile

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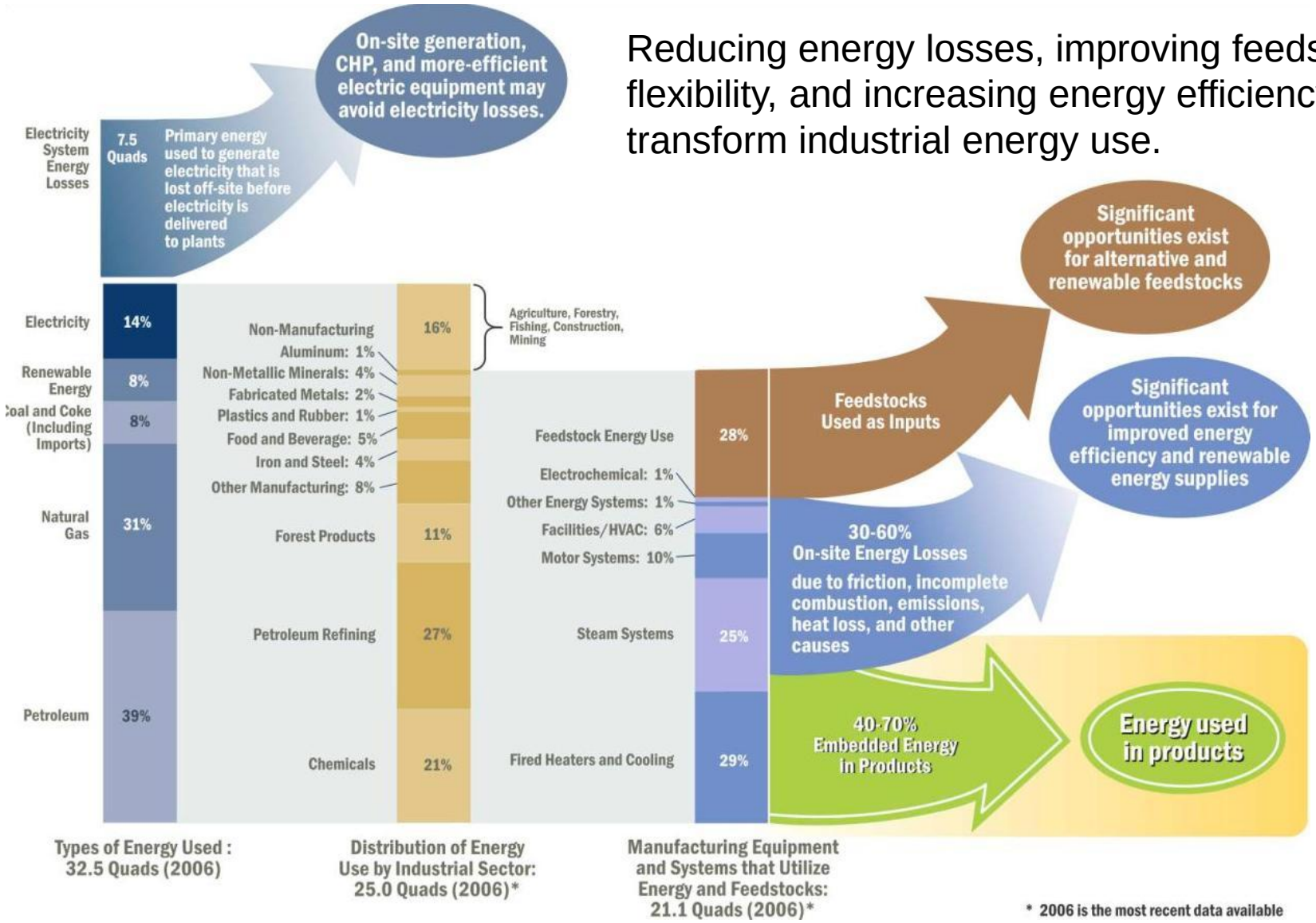
Reducing energy losses, improving feedstock flexibility, and increasing energy efficiency can transform industrial energy use.



Industrial Energy Use and Intensity

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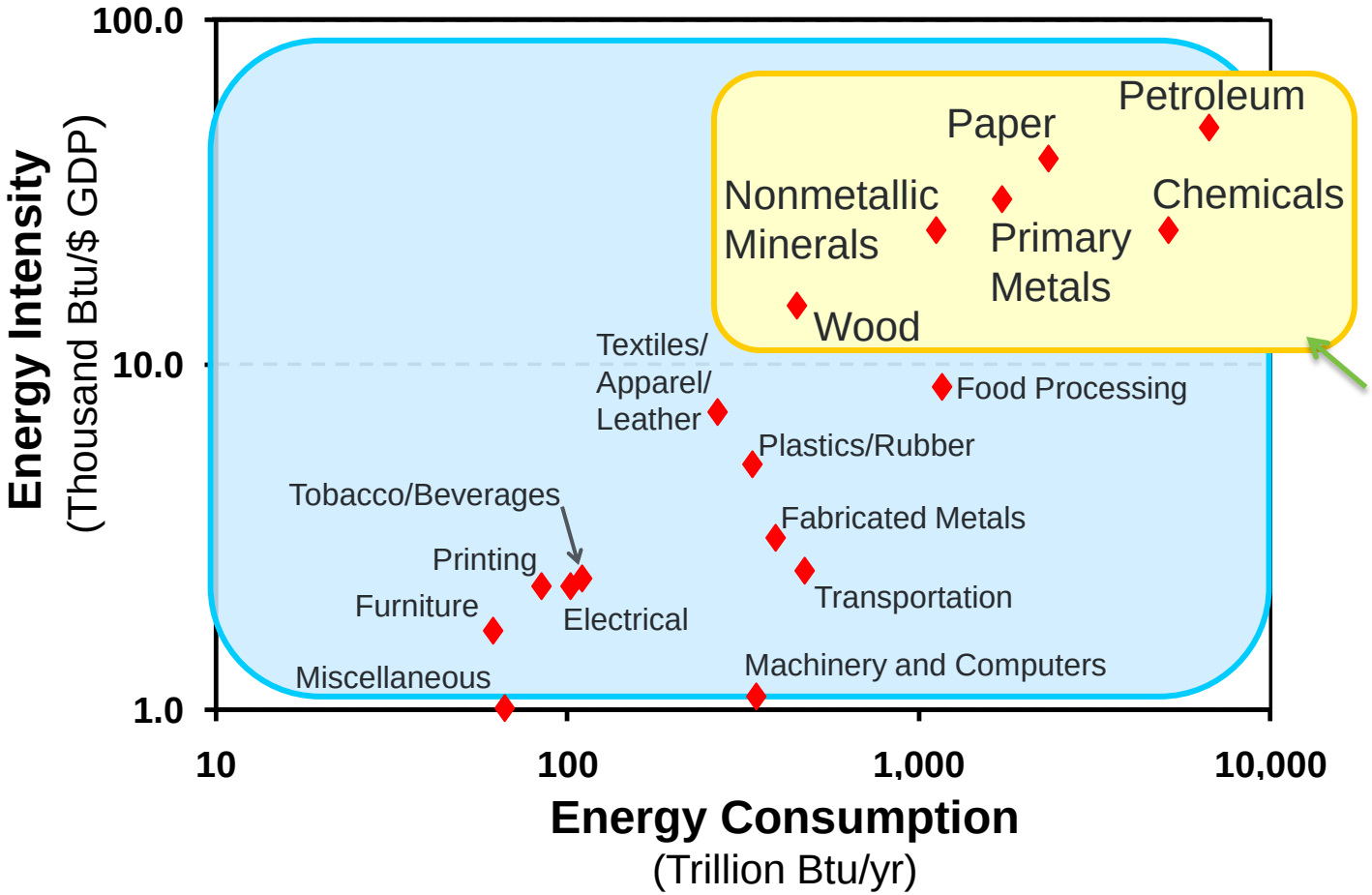
Opportunities exist across the industrial landscape



Savings here translate into reduced "embedded energy" and carbon in downstream products.

Sources: MECS (2006), BEA (2006)

A robust and profitable industrial sector is key to our national economic health

Wider use of state-of-the-art technologies and best energy management practices could drive energy and cost savings and help industry to meet national energy, carbon, and economic goals.

Significant near-term opportunities exist in

- Industrial energy systems
- Combined heat and power (CHP)
- Energy-intensive industrial processes

Significant Energy Reduction Potential Exists in Energy-Intensive Industries

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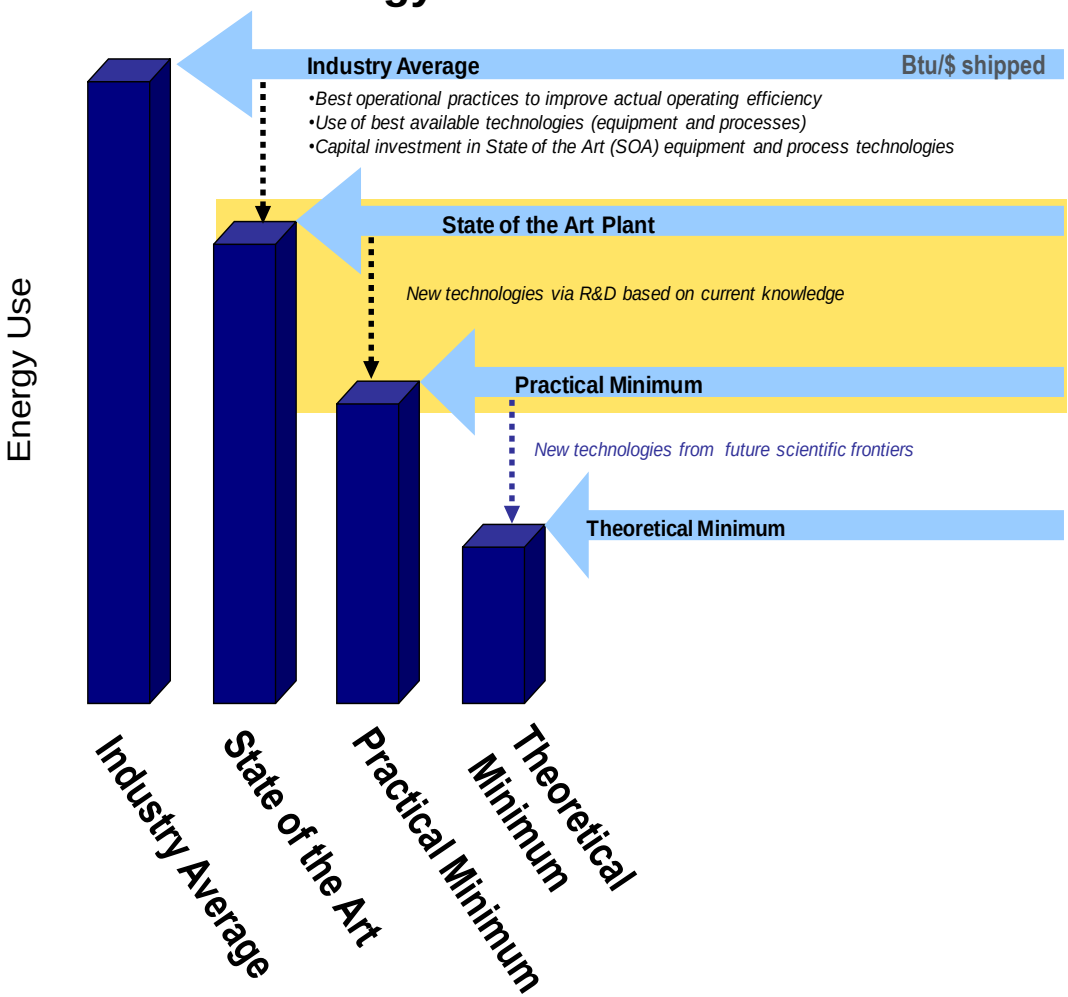
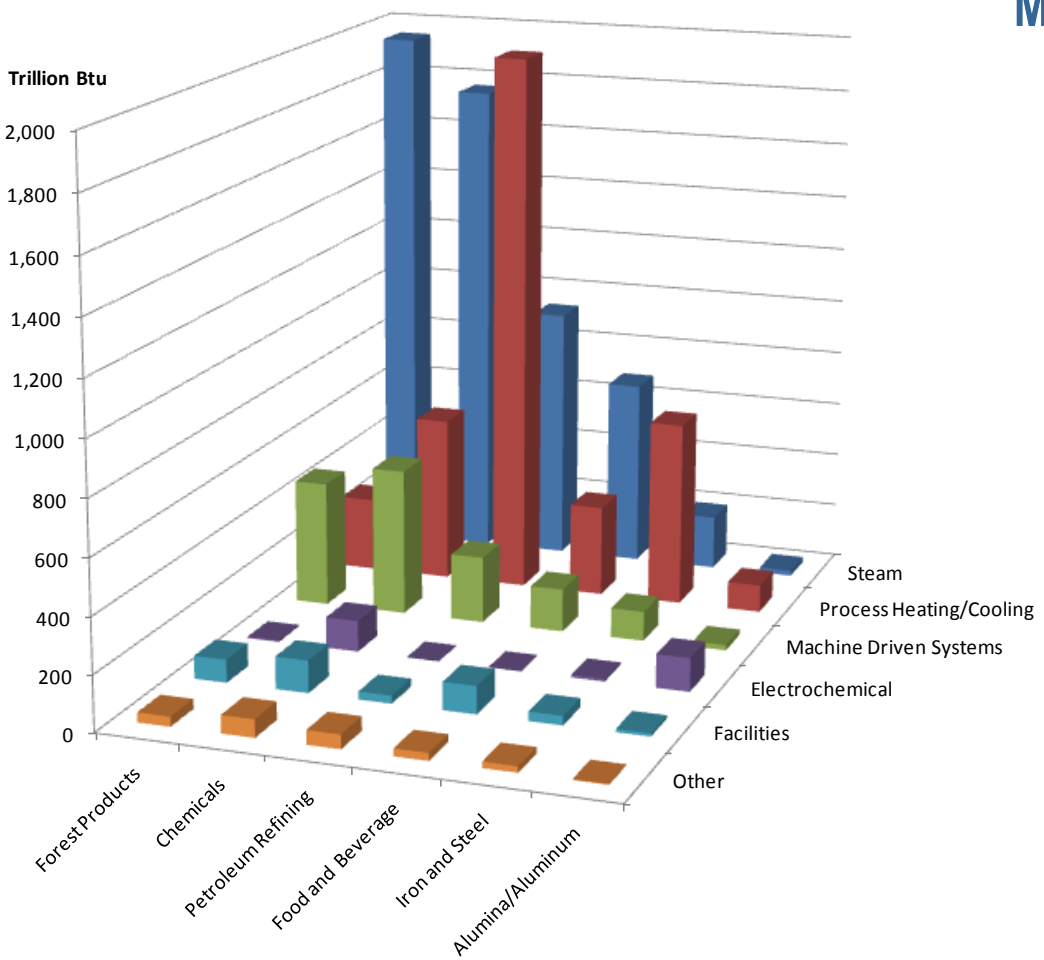


	Chemicals	Petroleum Refining	Pulp & Paper	Steel	Aluminum
Industry Average (Btu/$ shipped)	4,860	6,310	13,930	12,480	6,450
State of the Art Plant	17%	28%	26%	22%	12%
Practical Minimum	42%	38%	39%	39%	38%
Theoretical Minimum	84%	71%	43%	53%	62%

Source: ITP Energy Bandwidth Studies

Energy Uses in Energy-Intensive Industries



Major Energy Uses

- **Steam Systems:** Boilers and steam distribution networks for industrial processes and machine-driven systems, chemical reaction and separation vessels (>4,750 TBtu in steam use)
- **Process Heating:** Furnaces, ovens, digesters, evaporators, kilns, and melters that are used in many types of manufacturing processes (~5,000 TBtu in fuel use)
- **Motor Systems:** Motor-driven equipment (e.g. pumps, compressed air, material handling) accounts for >1,700 TBtu of electric energy use

Source: Based on Energetics analysis of Energy Information Administration , 2006 Manufacturing Energy Consumption Survey, (Published 2009/2010)

Combined Heat and Power (CHP)

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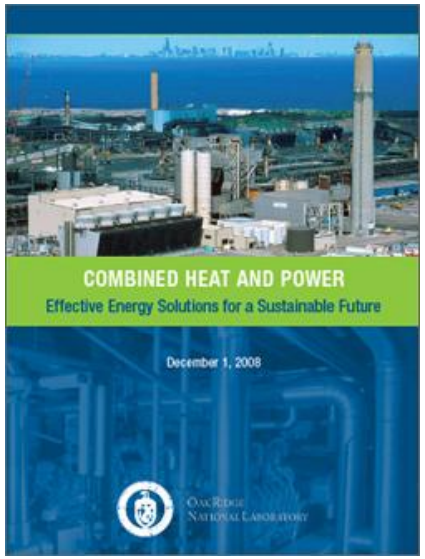
CHP can simultaneously

- Reduce GHG emissions
- Promote use of secure domestic and renewable energy sources
- Reduce exposure to energy price hikes and volatility
- Stimulate economy and create jobs

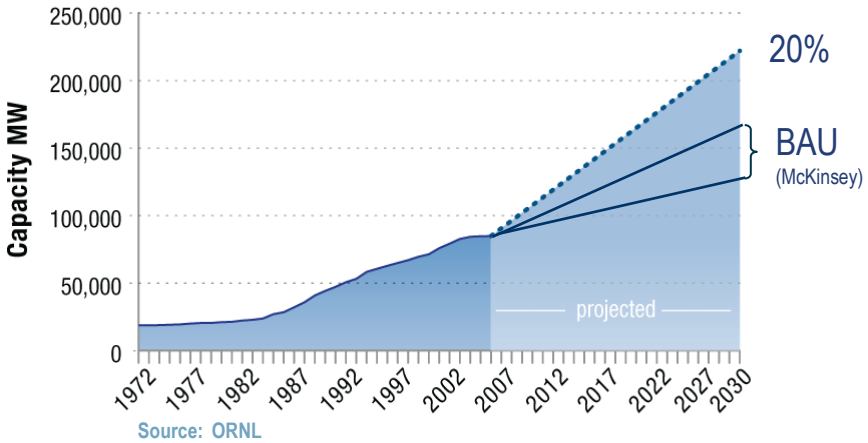
Oak Ridge National Lab (Dec. 2008):

"What would it mean if CHP were to supply 20% of U.S. generating capacity by 2030?"



2030 CHP – 20% of U.S. Capacity	**240.9** GW
Reduced Annual Energy Consumption With CHP	**5,272** trillion Btu/yr
Total Annual CO_2 Reduction	**848** MMT
Carbon Saved	**231** MMT
Cars Taken Off Road	**154** million

Source: Based on *Annual Energy Outlook 2008* (AEO 2008), U.S. Energy Information Administration and eGRID, EPA.



CHP Opportunities

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Regulatory and Market Barriers to CHP:

- Unfavorable utility tariff structures and interconnection practices
- Lack of recognition of CHP benefits in regulations
- Uncertainty in GHG requirements, energy markets, and fuel prices

Texas Medical Center, along with Rice University, looking towards downtown Houston

Technical Needs:

- Remove technology limitations potentially affecting life-cycle costs: reliability, availability, maintainability, cost, and durability
- Prevent complications to grid operations arising from improper installation or improper coordination by developers and utilities
- Improve energy and environmental performance of CHP and thermal energy recovery technologies
- Lower capital, installation, and implementation costs
- Increasing fuel flexibility of combustion systems with no degradation of emissions profile, performance, or reliability, availability, maintainability and durability will reduce operating costs and fuel risk.

Energy-Intensive Process Opportunities

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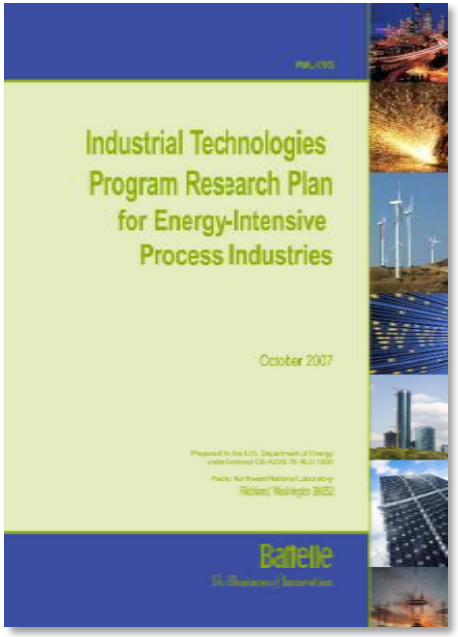
Advanced process technologies can reduce energy use and carbon emissions in industry. Further R&D and deployment will bring down the implementation costs.

- **Reactions & Separations** (catalysts, membrane technologies, water management)
  New technologies to provide process efficiencies and lower energy intensity
- **High-Temperature Processing** (lower-energy approaches)
  Non-thermal or lower-energy alternatives to conventional high-temperature processing technologies
- **Waste Heat Recovery** (steam generation, heat utilization)
  Technology advances in ultra-efficient steam production, high-performance furnaces, and waste-heat recovery
- **Smart and Sustainable Manufacturing** (material efficiency, ICT, automation/wireless sensors to optimize systems)
  Novel manufacturing capabilities that enable in situ monitoring for product quality control, and continuous operations



Technology Deployment

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- Accelerate deployment of innovative technologies in U.S. manufacturing by effecting a culture change in how energy is valued, measured, and managed.
- Provide tools, training, and resources that support manufacturers to continuously improve energy productivity, reduce carbon, and increase competitiveness.
- Strategic initiatives
  - Pledge and recognition programs to foster corporate energy savings
  - Support for Superior Energy Performance to certify facility conformance with the energy management standard (ISO 50001) and verify sustained energy performance improvements
  - University-based assessments to train emerging workforce
  - Partnerships with states, utilities, associations, and other federal agencies; analytic tools; and supply chain outreach

Thank You

Industrial Energy Efficiency Strategy

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Build the Foundation for Next-Generation Manufacturing Based on Scientific and Technological Innovation

- Develop game-changing manufacturing and materials technologies that drive transformational process improvements and improve U.S. industrial competitiveness
- Reduce the energy "embodied" in manufactured products and double the energy productivity of U.S. businesses
- Develop innovative, low-carbon processes to capture worldwide markets hungry for clean products and solutions

R&D Priorities

- Invest in next-generation materials (materials by design, conventional rare earth substitutes, low embodied energy cement, inexpensive carbon fiber, titanium, etc.)
- Invest in next-generation production systems (smart manufacturing, next-generation catalysts, nano, bio, information technology)
- Assist in achieving major cost reductions in the manufacture of energy efficiency devices (lighting, windows, batteries) and renewable energy components (wind blades, power conversion, PV arrays)

Moving Markets

- Build a robust infrastructure (e.g., workforce, financing, tools, information) that applies to successive generations of technology and accelerates their market entry
- Build a culture of corporate energy management
- Focus assistance on CHP and small- and medium-sized businesses
- Leverage NIST's Manufacturing Extension Partnerships

Technical Assistance

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Leverage state, utility, and local resources to help manufacturers reduce energy use and carbon emissions today—and **create a corporate culture** that fosters continuous improvement.

Creatas Power and Energy stock CD image 005720

Technical Assistance

- Tracking and managing energy intensity
- Project feasibility analysis
- Resource referrals

Tools

- Energy and Carbon Baselining
- Software Tools for Energy Management

Training

- Basic
- Advanced
- Qualified Specialists

Photo from MicroSoft clip art

Standards & Recognition

- Superior Energy Performance (SEP)
- Assessment standards, protocols, and metrics
- *Save Energy Now* LEADER Partnership

Assessments

- Expert energy savings assessments
- Industrial Assessment Centers
- States/Utilities

Information

- Tip sheets, case studies
- Website, webcasts, databases
- EERE Information Center
- Supply chain guidance

Superior Energy Performance

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A market-based, ANSI/ANAB-accredited certification program providing industrial and commercial facilities with a roadmap for achieving continual improvement in energy efficiency while boosting competitiveness.

- Foster a corporate culture of **continuous improvement** in energy efficiency
- Use **ISO 50001** standard as foundational tool for energy management
- Establish a **tiered program** that provides an entry point for companies at all levels of experience with energy management
- Create a **verified record** of energy performance improvement.
- Potentially **create value** for corporate energy savings and carbon reductions in utility, state, regional, national, and international trading markets

Roles within Superior Energy Performance

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Industry

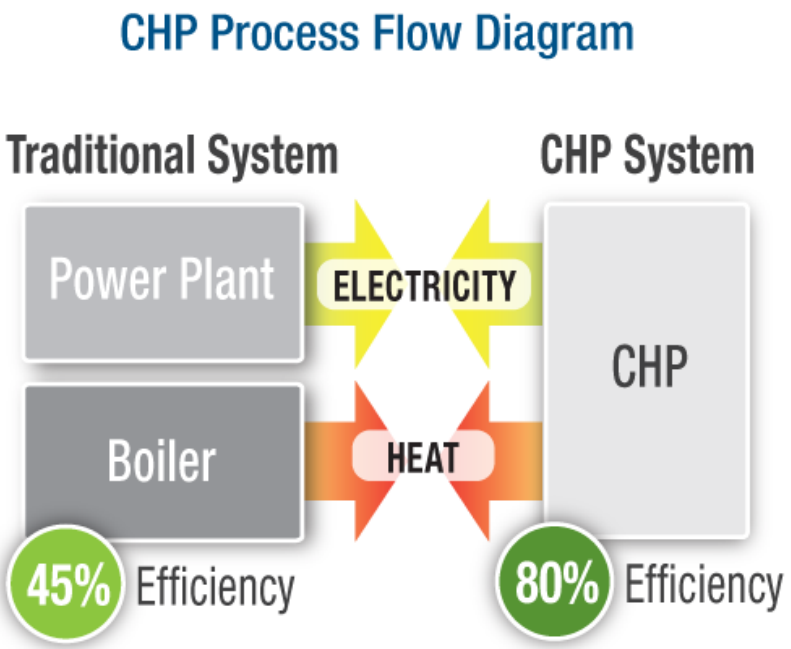
- Drives strategy through **U.S. Council for Energy Efficient Manufacturing**
- Pilots elements of Superior Energy Performance prior to program launch
- Adopts the Superior Energy Performance program by getting plants certified to ANSI/ANAB-accredited Superior Energy Performance program

Government

- Facilitates industry collaboration to develop Superior Energy Performance program: fund program development activities, e.g., standards development, pilot projects
- Cost-shares Superior Energy Performance program start-up
- Leverages Superior Energy Performance program to deploy federal energy programs, e.g., *Save Energy Now* LEADER

What is CHP?

- Combined Heat and Power (CHP) is the sequential production of electricity and thermal energy from a single source of energy
- It is located at or near point of use
- Outputs include electricity, hot water, steam, chilled water, and dehumidification
- Fuels include natural gas, other fossil fuels, landfill gas, biomass, biogas, and other locally-sourced and renewable fuels.
- Technologies include: Engines, Turbines, Microturbines, Fuel Cells



CHP is a proven high-efficient alternative to separate power and thermal energy production

Combined Heat and Power

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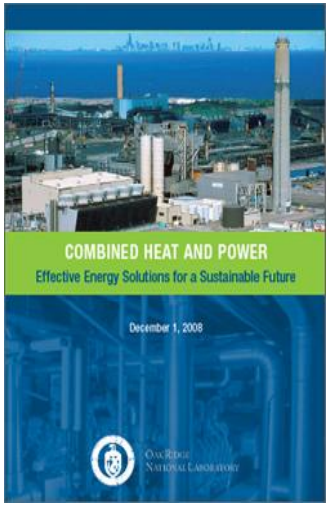
Increasing CHP efficiency and applicability will increase market uptake and reduce primary energy use and carbon emissions.

Applications for CHP:

- Industries where coincident power and thermal energy is needed; current industrial capacity is in chemicals, food, paper, and metals; additional capacity is in commercial and institutional applications.

Systems:

- Identified by their prime movers or technology types, including reciprocating engines, advanced combustion or gas turbines, steam turbines, microturbines, and fuel cells.

Increased Fuel Flexibility:

- CHP systems can use a variety of fuels, including natural gas, coal, oil, and alternative fuels, to produce shaft power or mechanical energy. Thermal energy from the system can be used directly or indirectly to produce steam, hot water, hot air for drying, refrigeration, or chilled water for process cooling.