Solar Turbines
A Caterpillar Company

Global Workshop on Grid Connected Combined Heat and Power

A Concept for Economic and Energy Co-Development

Micro-Enterprises & CHP

Richard Brent

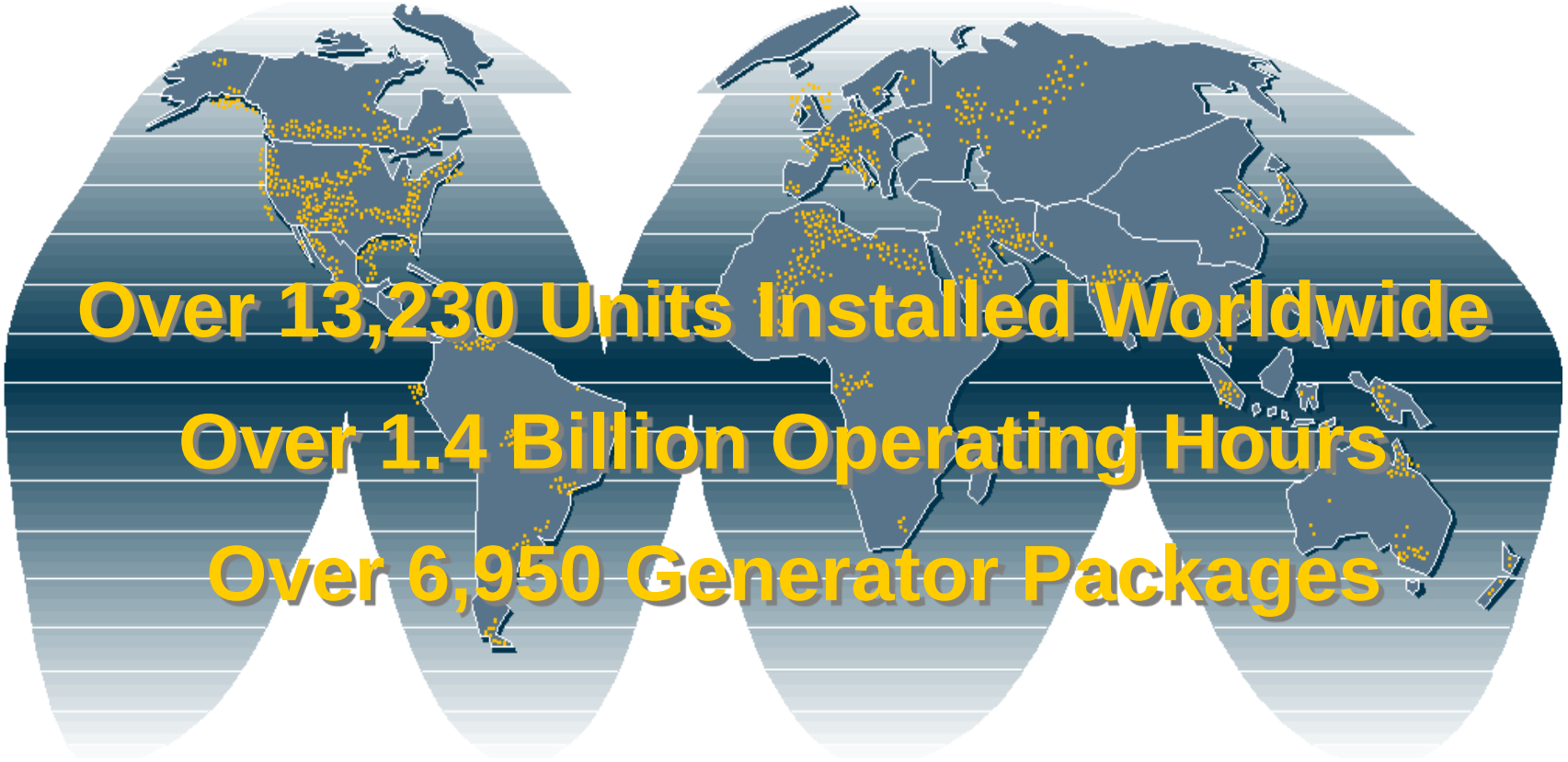
Solar Turbines, Incorporated

A Caterpillar Company

September 1, 2009

CATERPILLAR®
TODAY'S WORK. TOMORROW'S WORLD.™

Solar Turbomachinery Systems



Over 13,230 Units Installed Worldwide

Over 1.4 Billion Operating Hours

Over 6,950 Generator Packages

The Concept

Micro-Enterprise, Micro Grid & CHP

- ✓ Supports industrial development and job creation
- ✓ Provides local power to serve local needs
- ✓ Complements existing power grid
- ✓ State-of-the-art concept for global replication

CHP Guidelines

- Reliable Power Requirement
- Use of Thermal Energy
- Ratio of Thermal Energy (lbs/hr) to Electrical Energy (kW) ≥ 1:1
- Ratio of Purchased Electrical Energy ($/kW-hr) to Purchased Fuel Cost ($MMBtu) > 2:1
- High Operating Hours

What Are the Benefits of CHP?

- **CHP is more efficient than separate generation of electricity and thermal energy**
- Higher efficiency translates to lower operating cost
- Higher efficiency reduces emissions of all pollutants, including CO_2, NO_X and SO_2
- CHP can increase power reliability and enhance power quality
- On-site electric generation can help reduce grid congestion

Solar Turbines
A Caterpillar Company

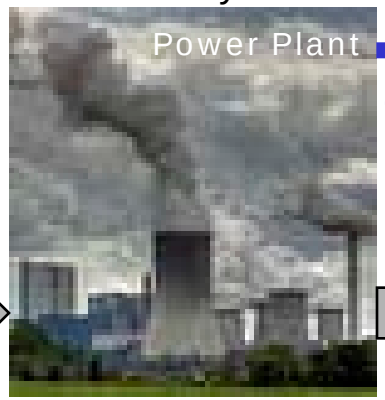
CO_2 Emissions Reductions from CHP

Conventional Generation

Efficiency: 31%

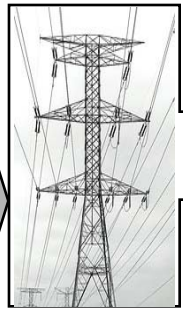
Power Station Fuel (U.S. Fossil Mix)

289 kg/MW-hr

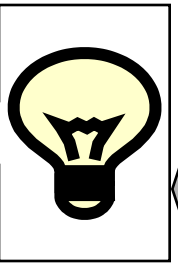


CO_2 Emissions

49k Tonnes/yr



6.1 MWe



Combined Heat & Power:
Taurus 65 Gas Turbine
Efficiency: 84%

CHP Fuel (Gas)

182 kg/MW-hr

Efficiency: 80%

Boiler Fuel (Gas)

182 kg/MW-hr

Boiler

Heat

Heat

9.2 MWth

CO_2 Emissions

18k Tonnes/yr

CO_2 Emissions

32k Tonnes/yr

67k Tonnes

32k Tonnes

…TOTAL ANNUAL CO_2 EMISSIONS…

35k Tonnes Saved/Year

CATERPILLAR®
TODAY'S WORK. TOMORROW'S WORLD.™

The Value Proposition

Value Attribute	General Ability to MicroGrids to Support MicroEnterprises
Reliability	Increased energy reliability achieved through dedication of power sources to critical loads and parallel operation with electric grid.
Customization	Enables customers and service providers establish individual value propositions that include enhanced electric reliability and low cost thermal energy from waste heat.
Cost Savings	Use of waste heat and higher efficiency enables cost savings, modular designs lessens financial risks.
Power Quality	Creates opportunities for improved power quality, particularly for locations at the end of feeder lines, or where high inductive lead to high needs for reactive power
Energy Efficiency	Use of waste for CHP improve overall energy efficiency for some customers, and can lower overall emissions
Capacity	Can relieve congestion or constraints on the electric grid, enabling industrial growth in otherwise energy constrained areas.
Independence	Provides independence from the grid, but can also take advantage of the interconnection for needed energy imports and exports.
Survivability	Enhances survivability when relevant features are engineered to ensure islanded operation for prolonged periods of time, when needed.
Flexibility	Supports operational flexibility and management of energy resources.
Environmental	Can reduce emissions through higher efficiencies, CHP, and potential use of renewable resources.

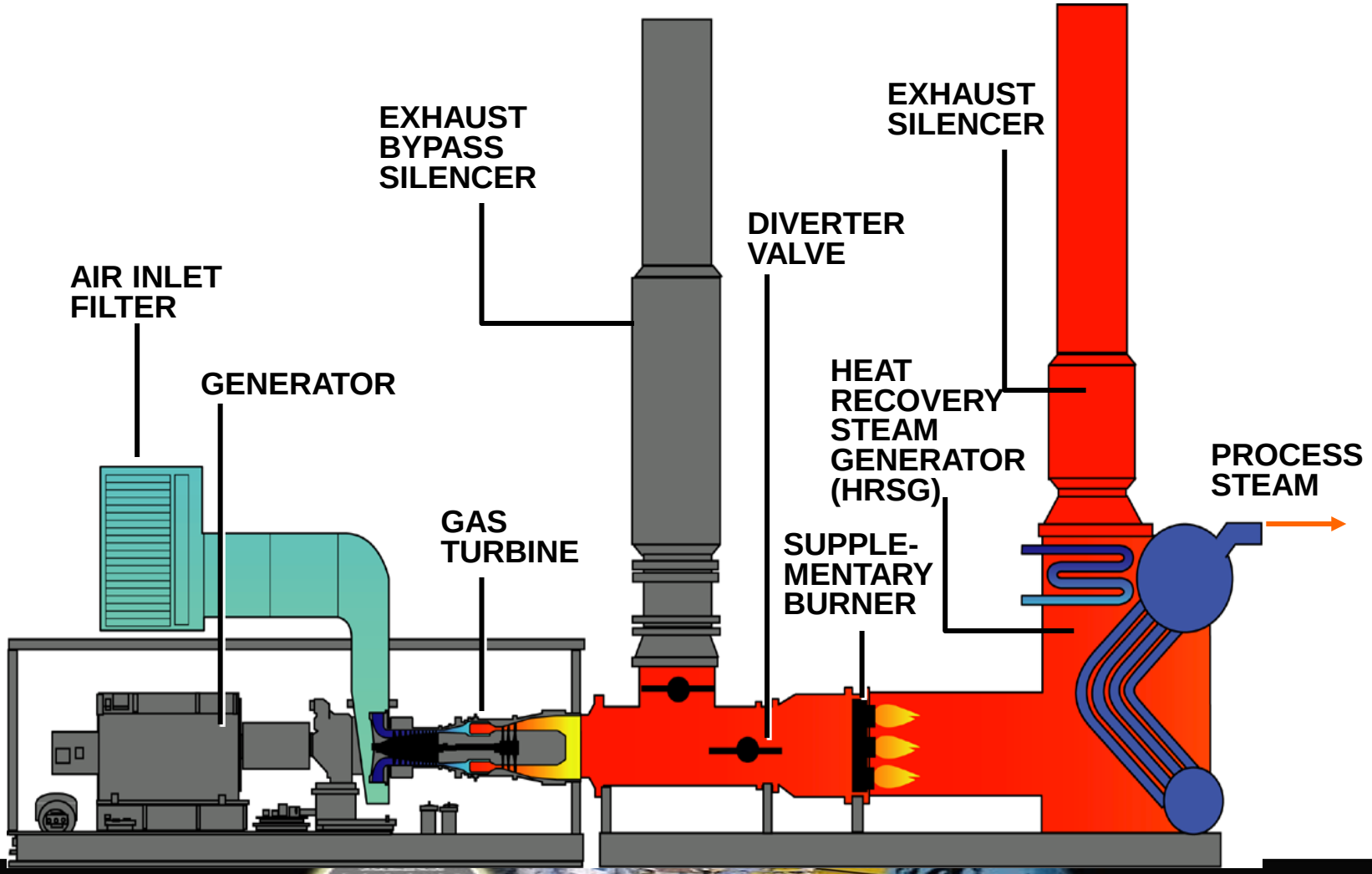
Solar® Turbines
A Caterpillar Company

Complete CHP Package

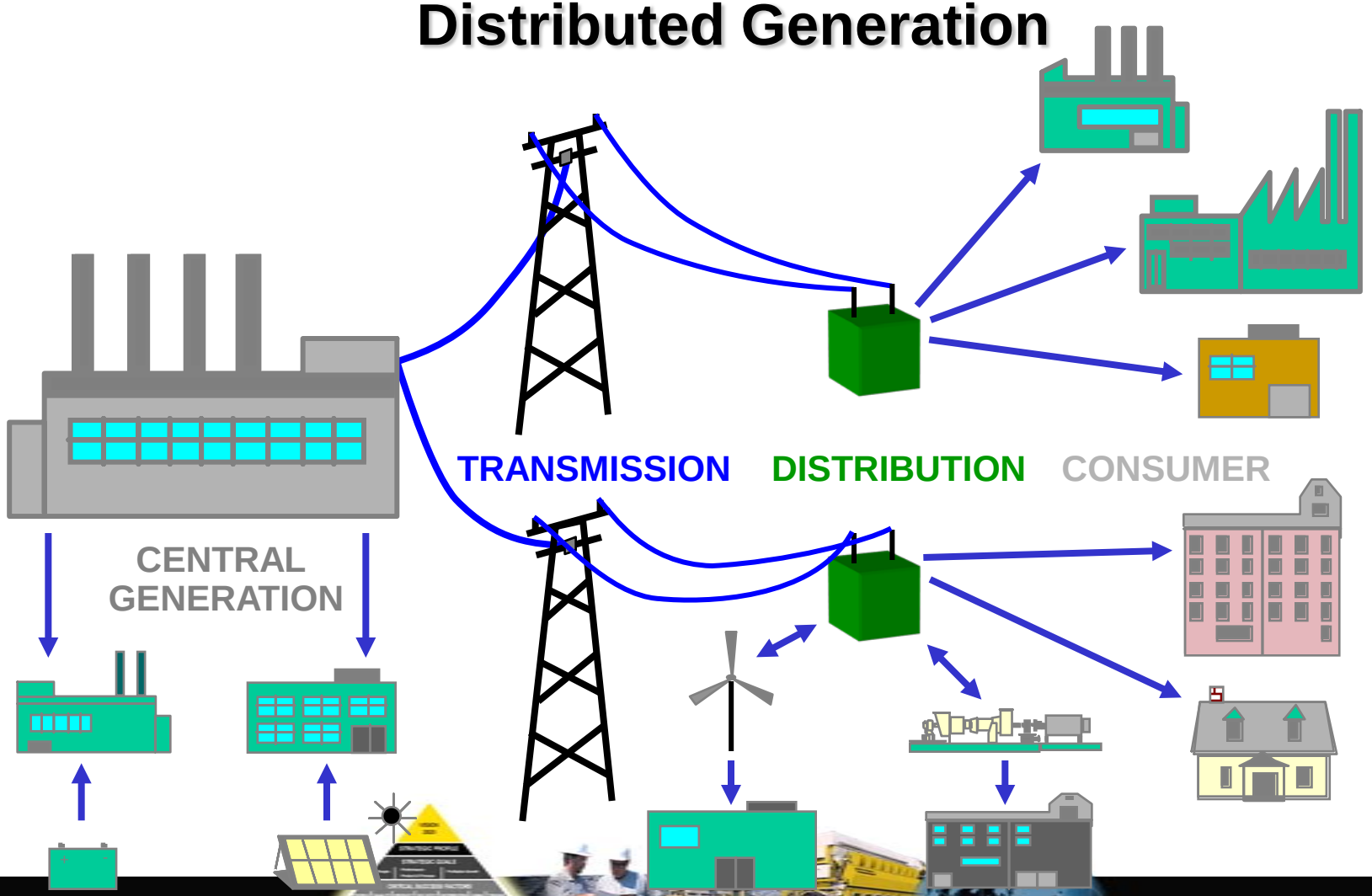
- 1250 KWe CHP System

CATERPILLAR®
TODAY'S WORK. TOMORROW'S WORLD.™

CHP


EXHAUST BYPASS SILENCER
EXHAUST SILENCER
DIVERTER VALVE
AIR INLET FILTER
GENERATOR
HEAT RECOVERY STEAM GENERATOR (HRSG)
PROCESS STEAM
GAS TURBINE
SUPPLE-MENTARY BURNER

Distributed Generation



- Load aggregation
  - Matching supply and demand
    - Electrical and thermal
- Utility interconnection
  - Technical issues
  - Buy/Sell contracts
- Siting and Permitting

- Analysis
  - Site selection
  - Mix of potential “tenants” (industrial, commercial, residential)
  - Energy profiling
  - Financials
  - Siting, permitting, utility interconnection
- Deployment scenarios
  - Market potential
  - Scale-up strategies
- Hand-off

Government Policy Considerations

- Financing
  - Due diligence
  - Technical Solutions that sustain their performance
  - National Government for express purpose –
    - Government(s) tender out for demonstration & deployment
      - Institutions, Gov. buildings, multifamily housing, etc.
- Interoperability
  - Grid Connection where Grid benefits
    - Ancillary services
    - Congestion relief – reduced demand on node

Thank you for the Opportunity

- Open the Dialogue
- Consider the Options
- Role for Participants
- Where Can the CHP Industry Help ?

rbrent@solarturbines.com