DG/CHP: Clean Energy Systems For Green Buildings

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Catalytica ENERGY SYSTEMS

Topics

- DG/CHP Benefits
- DG Characteristics
- CHP Characteristics
- Applications for Green Buildings
- Economic Feasibility
- LEED Rating Contribution

DG/CHP Benefits

DG Benefits to Building Owner

- Improved and controllable power reliability & quality, important for computers, communications, day-to-day functions
- Offer more choice in fuel supply options
- Reduces chances of blackouts from grid: DG can act to peak shave in high-demand times to avoid blackouts

CHP Benefits to Building Owner

- Clean energy: lower NO_x, SO_x, CO_2, CO, etc.
- Cut energy costs for end-users while controlling systems based on real-time price signals
- Energy efficiency gains from using “waste” heat to cool building (chiller technology) and provide hot water

DG/CHP Benefits

CHP in America

- Currently produce 8% of electric power
- Save building/facility owners over $5 billion/year in fuel costs
- Decrease energy use by almost 1.3 trillion BTU's/year
- Reduce NO_x emissions by 0.4 million tons/year and SO_2 emissions by over 0.9 million tons/year
- Prevent release of over 35 million metric tons of carbon equivalent into the atmosphere
- 77.3 GW of CHP potential in the commercial/institutional sector

Source: USCHPA

Prime Movers (distributed power/heat generators)

Microturbine

Reciprocating Engine

Combustion Turbine

Back Pressure Steam Turbine

Fuel Cell

Organic Rankine Cycle

Stirling Engine

DG Performance Characteristics, Costs and Fuels

Table 2-1. Cost and Performance of CHP Systems

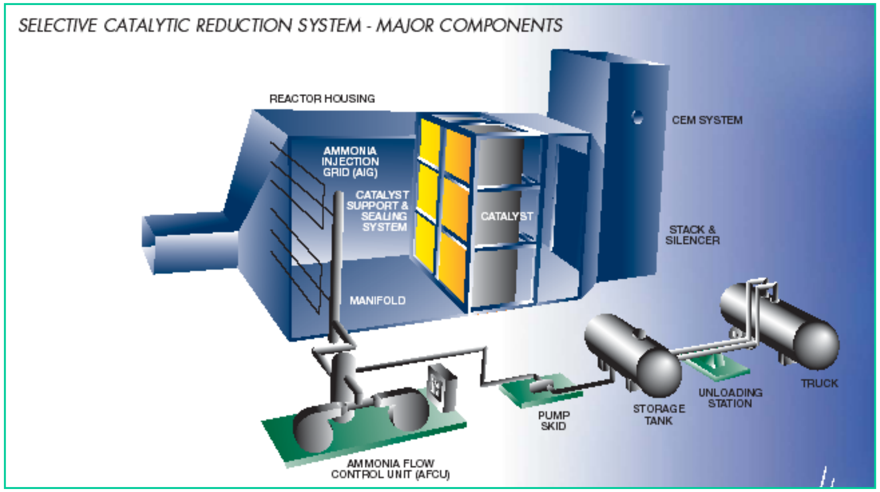
Technology	Engine	Turbine and Microturbine	Fuel Cell
Size	30kW – 8MW	30kW - 20+MW	100-3000kW
Installed Cost ($/kW)[1]	300-1500	350-1500	2000-5000
Elec. Efficiency (LHV)	28-42%	14-40%	40-57%
Overall Efficiency[2]	~80-85%	~85-90%	~80-85%
Variable O&M ($/kWh)	.0075 - .02	.004-.01	.002-.05
Footprint (sqft/kW)	.22-.31	.15-.35	.9
Emissions (lb / kWh unless otherwise noted)	Diesel: NO_x: .022-.025 CO: .001-.002 NG: NO_x: .0015-.037 CO: .004-.006	NO_x: 3-50ppm CO: 3-50ppm	NO_x: <.00005 CO: <.00002
Fuels	Diesel, NG, gasoline, digester gas, biomass and landfill gas; larger units can use dual fuel (NG/Diesel) or heavy fuels	NG, diesel, kerosene, naphtha, methanol, ethanol, alcohol, flare gas, digester gas, biomass and landfill gas	NG, propane, digester gas, biomass and landfill gas (potentially)

[1]Cost varies significantly based on siting and interconnection requirements, as well as unit size and configuration.
[2]Assuming CHP.

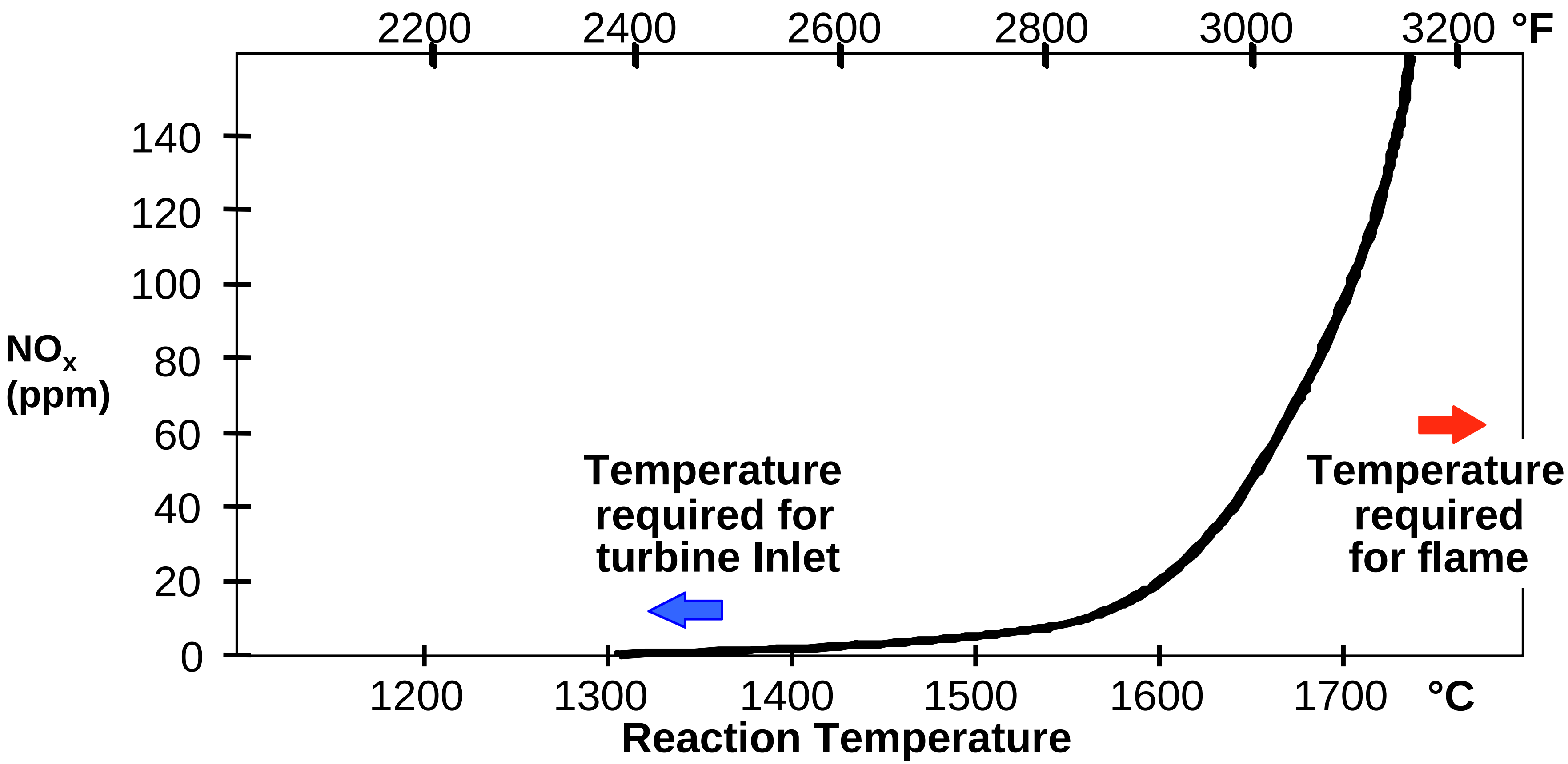
Source: Resource Dynamics Corporation, "Integrated Energy Systems (IES) for Buildings: A Market Assessment," August 2002.

SCR and "Cool Combustion" to Reduce Emissions

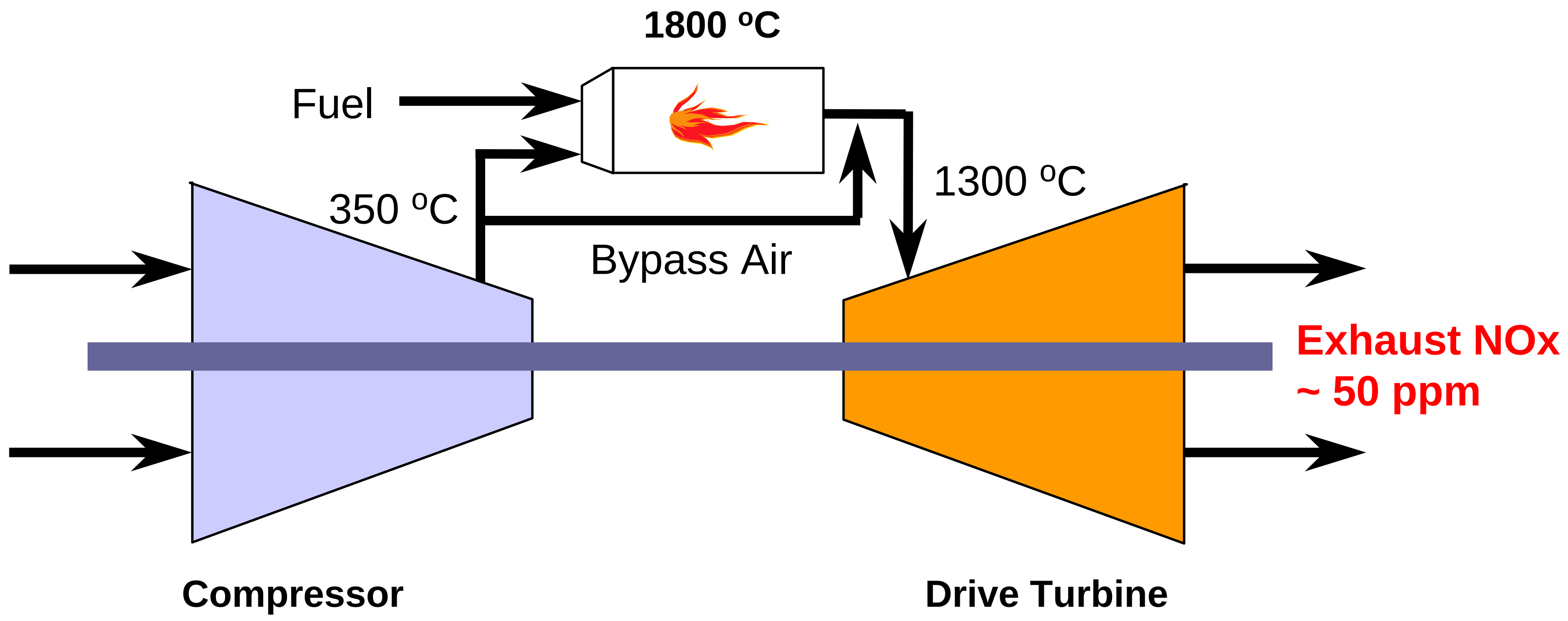
- Selective Catalytic Reduction (SCR) uses ammonia to reduce the NO_x created during the combustion process
- "Cool Combustion" reduces temperature of combustion and formation of NO_x in atmosphere because no NO_x is created during combustion



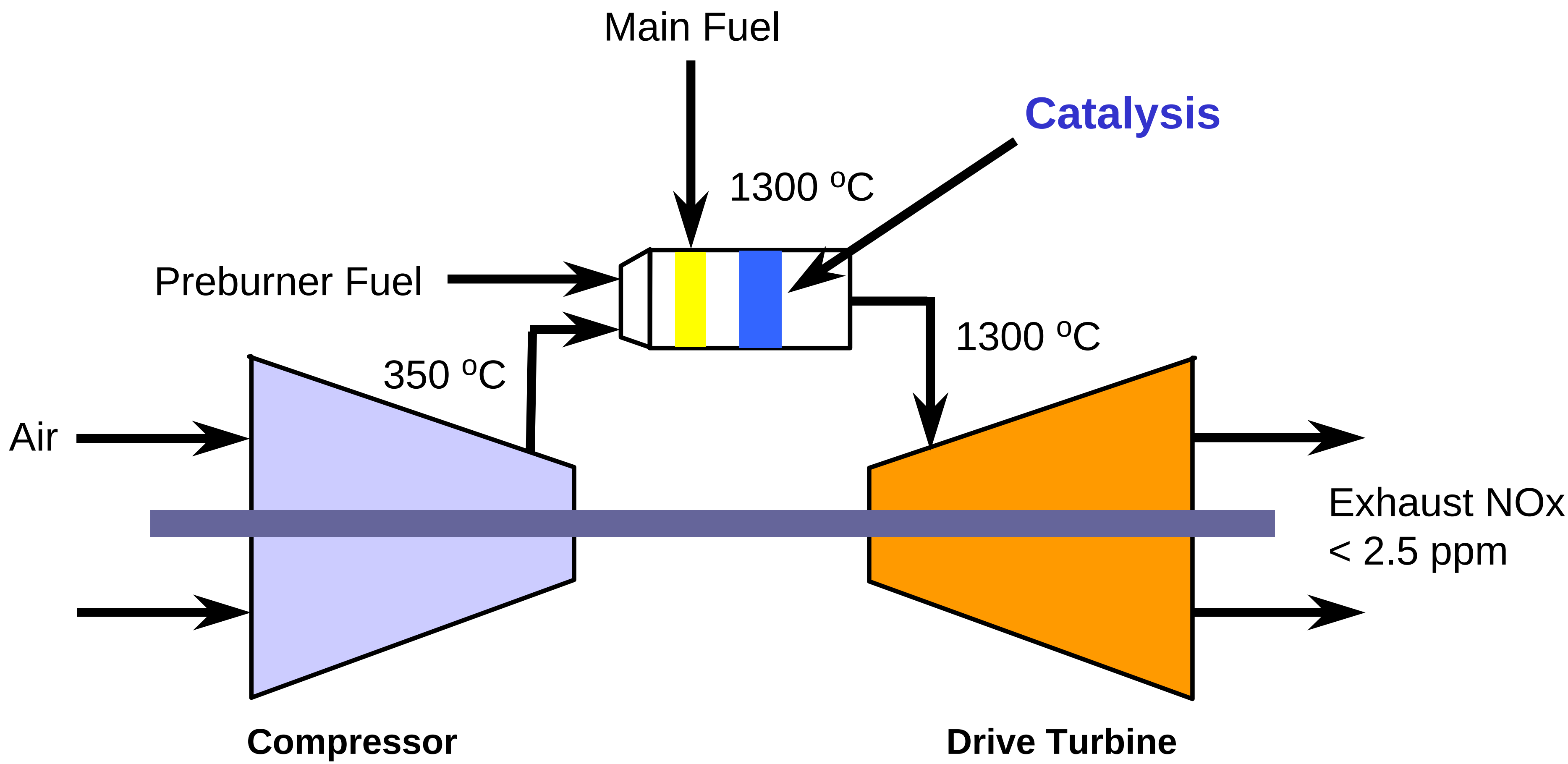
High Flame Temperature Causes High NO_x



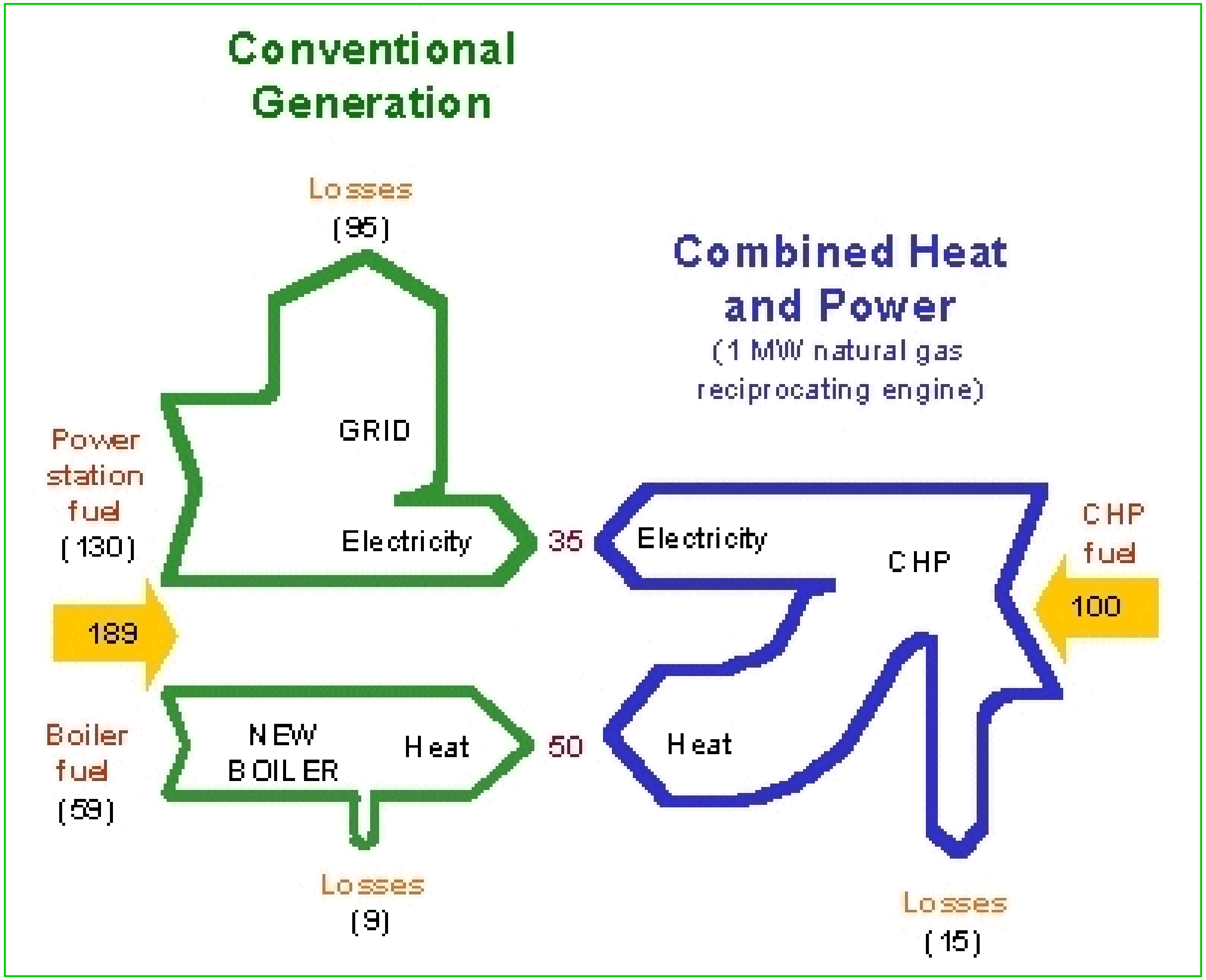
Conventional Flame Combustion Generates High NO_x



No Flame In The “Cool” Combustor



Energy Efficiency Can Be Doubled with CHP

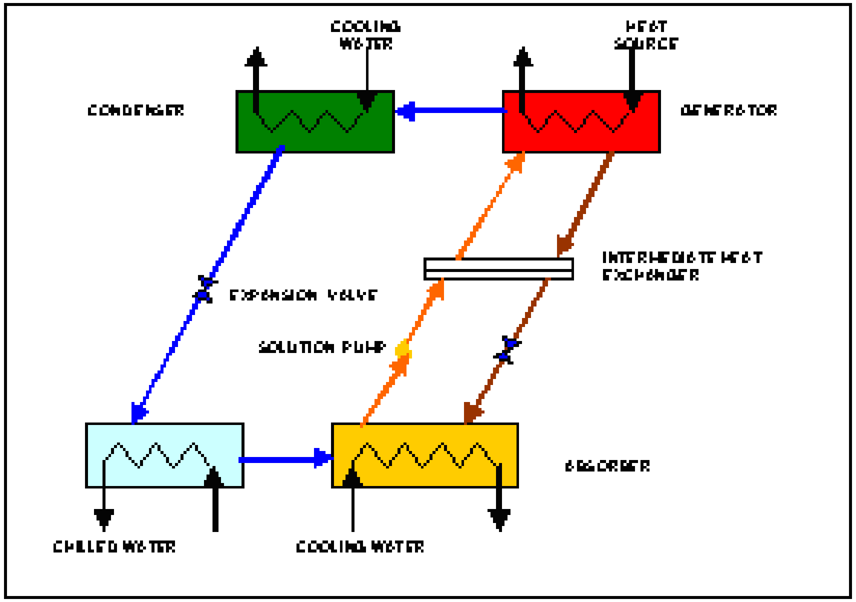


Absorption Chillers

- "Waste" heat from prime mover used to make chilled water
- Lower cost, reliable air conditioning for commercial, institutional, college, university, multifamily, and government buildings

Absorption Chiller Process

- Low-temp liquid refrigerant—LiBr—absorbs heat from warmer water
  - Resulting vapor is compressed to a higher pressure using waste heat
  - Vapor converted back into a liquid
  - LiBr expanded to a low-pressure mixture of liquid and vapor, absorbing heat and producing chilled water for space conditioning



A single-effect absorption cycle.

Absorption Chiller Cost & Performance Data

Cost and Performance of Single-Effect, Indirect-Fired Absorption Chillers

Tons	Cost ($/ton)	Electric Use (kW/ton)	Thermal Input (Mbtu/ton)	MaintenanceCost ($/ton annual)
10-100	700-1,200	.02-.04	17-19	30-80
100-500	400-700	.02-.04	17-18	20-50
500-2,000	300-500	.02-.05	17-18	10-30

Source: Resource Dynamics Corporation, "Integrated Energy Systems (IES) for Buildings: A Market Assessment," August 2002.

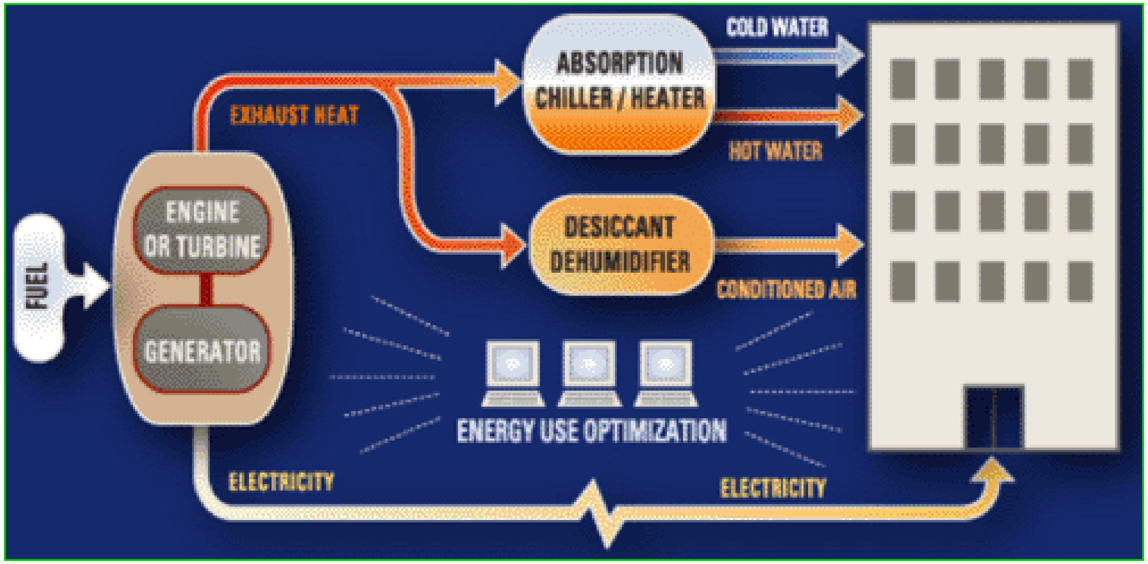
Packaged Systems Save Installation Time & Costs

• Cut installation time by up to 2/3 with easier integration into building

• Aim is to reduce capital costs with pre-engineered prime mover and chiller technologies

• Are modular and adaptable to various capacity and space requirements

•Three chiller companies are working to make packaged systems



Applications for Green Buildings

Commercial Buildings

Over 4 million commercial buildings in U.S.

- Consume about 18% of nation's energy
- Over $100 billion in annual utility bills

CHP commercial market potential breakdown

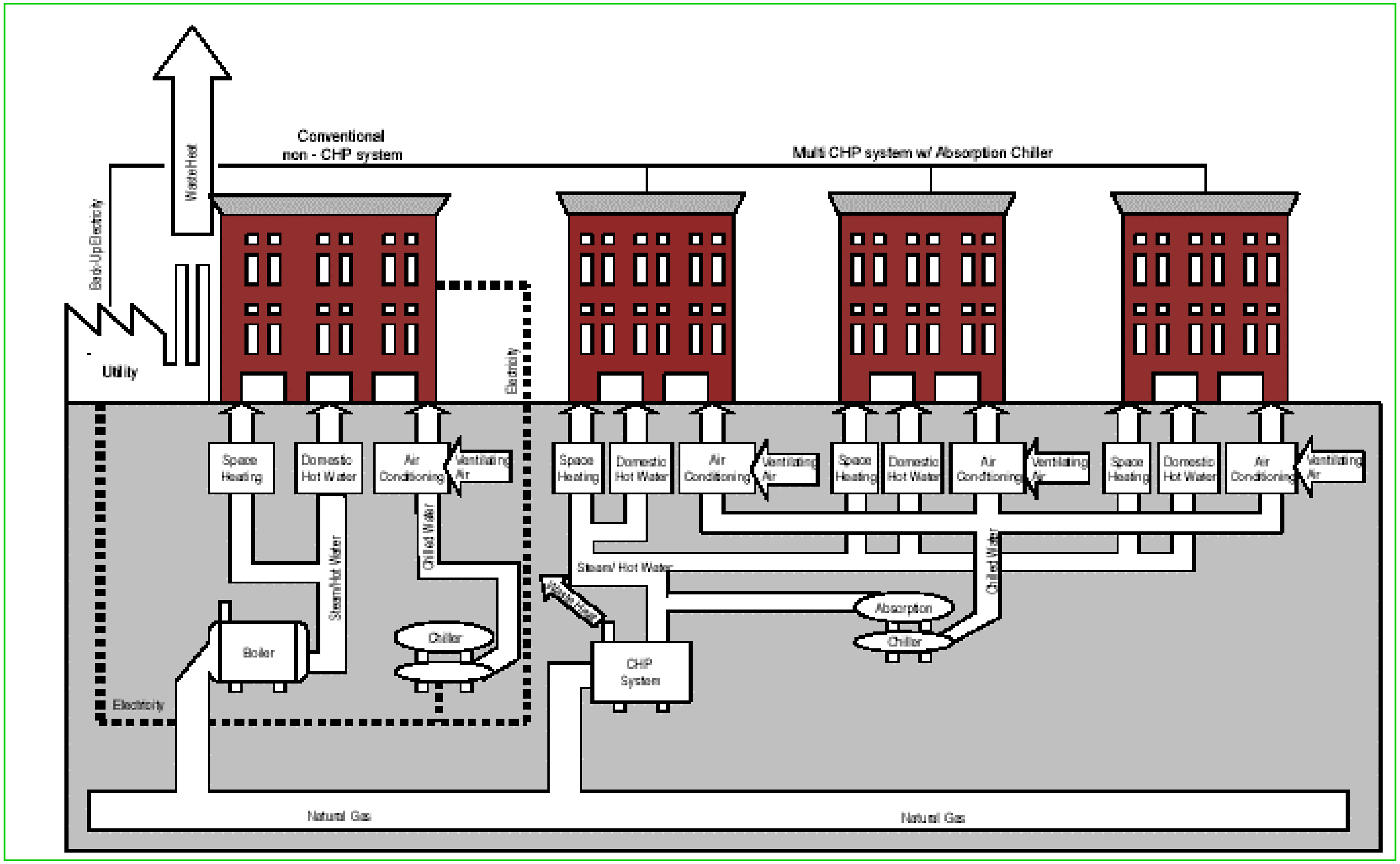
- 18.6 GW potential in office buildings
- 6.7 GW potential in hotels/motels
- 8.8 GW potential in hospitals
- 3.5 GW potential in health clubs/spas
- 3.4 GW potential in extended service restaurants
- 2.7 GW potential in correctional facilities
- 1.2 GW potential in supermarkets

Applications for Green Buildings

State and Local Governments

- 16 billion square feet of building space
- Over $11 billion on fixed-site energy costs, 75% of which is for electricity
- Some downtown government buildings configured for district energy, steam-based energy utilization

Thermal Energy Can Be Efficiently Distributed in Multiple, Nearby Buildings

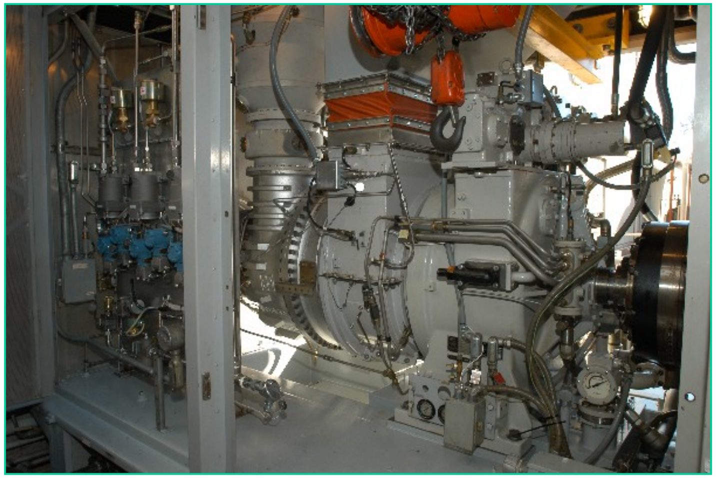


Source: Integrated Energy Systems (IES) for Buildings: A Market Assessment, Resource Dynamics Corporation, September 2002

Applications for Green Buildings

Sonoma Development Center

- Hospitals are ideal CHP candidates because of high electrical and thermal energy needs 24/7/365
- More than 200 hospitals and healthcare facilities use CHP to cut energy costs by 50% and decrease power interruptions and outages by up to 95%
- Sonoma Development Center generates 1.5 MW of power with natural gas turbine
- Produces 20,000 lbs/hr of steam for district heating and cooling loop
- Provides energy to campus consisting of over 100 buildings on 1,553 acres in Sonoma County, California



Applications for Green Buildings

Corporate Headquarters, Pleasantville, NY

- 650,000 sq/ft with 1,100 employees
- Data center power and cooling critical, 24/7
- 1400 kW gas turbine + absorption chillers
- Total energy consumption decreased from 252,000 MMBtu/yr to 202,500 MMBtu/yr; a reduction of 20%
- Total site NOx reduction from 6 tons/year to 2 tons/year

The Philadelphian High-Rise Condominium

- 1.55 MW reciprocating engine, 200-ton absorption chiller, 2 high efficiency electric chillers
- $0.20/sq. ft net yearly energy savings
- Recuperated CHP costs in 3rd year of operation

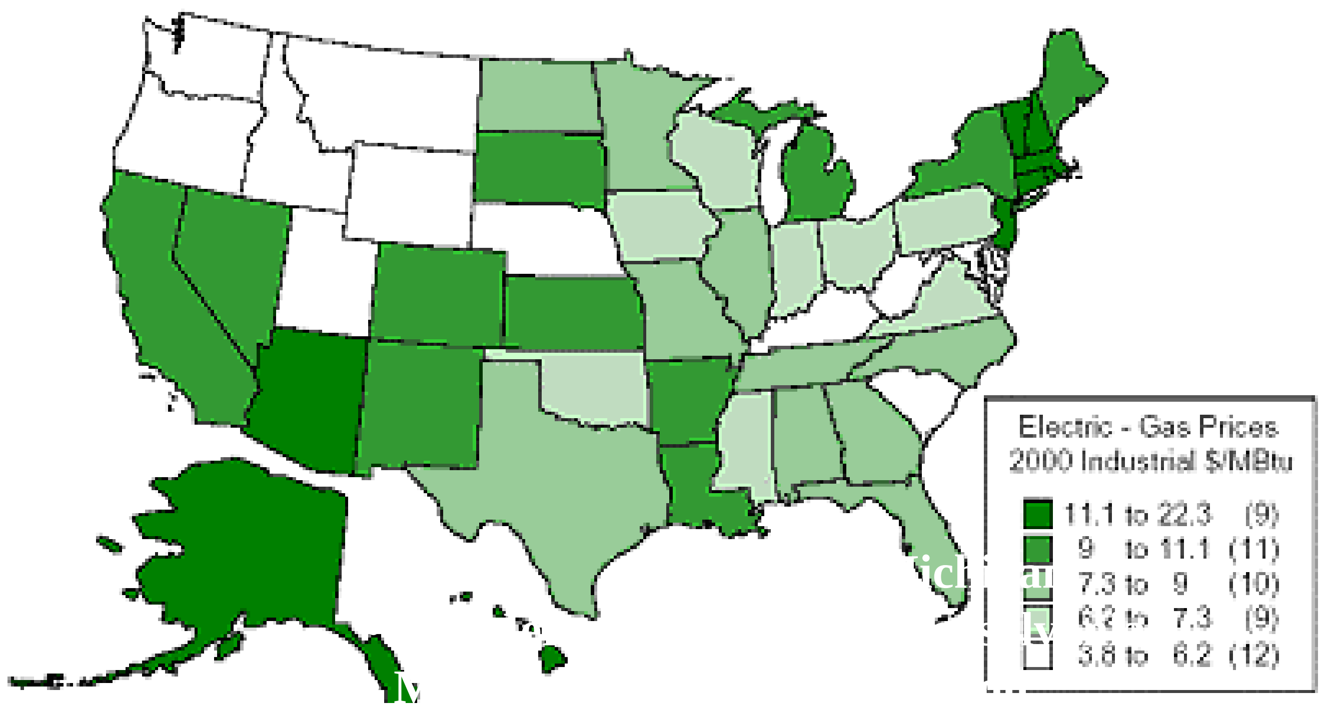
DG/CHP Tech Selection and Economic Feasibility Tools

- RECIPRO
- Cogeneration Ready Reckoner
- BCHP Screening Tool
- Building Energy Analyzer
- D-Gen Pro
- HeatMap Pro
- Many others….

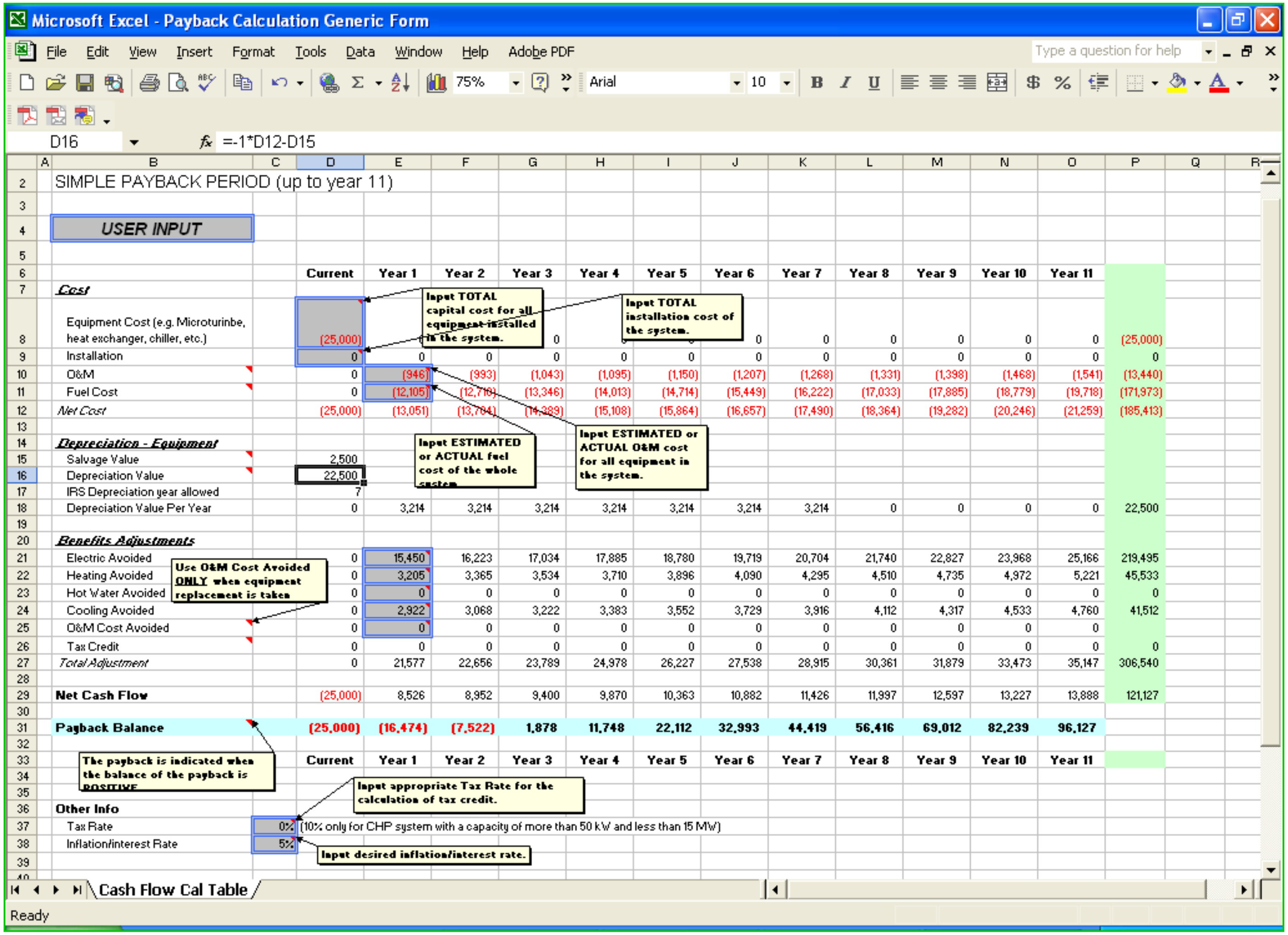
Spark Spread

Difference between costs of grid electricity and natural gas price—see FEMP chart below—is one indicator of CHP economic feasibility

Fig. 12: "Spark spread" difference in electric and gas prices in $/MBtu.



Payback Calculations



SIMPLE PAYBACK PERIOD (up to year 11)

USER INPUT

	Current	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	
Cost													
Equipment Cost (e.g. Microturinbe, heat exchanger, chiller, etc.)	(25,000)			0			0	0	0	0	0	0	(25,000)
Installation	0	0	0	0	0	0	0	0	0	0	0	0	0
O&M	0	(946)	(993)	(1,043)	(1,095)	(1,150)	(1,207)	(1,268)	(1,331)	(1,398)	(1,468)	(1,541)	(13,440)
Fuel Cost	0	(12,105)	(12,710)	(13,346)	(14,013)	(14,714)	(15,449)	(16,222)	(17,033)	(17,885)	(18,779)	(19,718)	(171,973)
Net Cost	(25,000)	(13,051)	(13,704)	(14,389)	(15,108)	(15,864)	(16,657)	(17,490)	(18,364)	(19,282)	(20,246)	(21,259)	(185,413)
Depreciation - Equipment													
Salvage Value	2,500												
Depreciation Value	22,500												
IRS Depreciation year allowed	7												
Depreciation Value Per Year	0	3,214	3,214	3,214	3,214	3,214	3,214	3,214	0	0	0	0	22,500
Benefits Adjustments													
Electric Avoided	0	15,450	16,223	17,034	17,885	18,780	19,719	20,704	21,740	22,827	23,968	25,166	219,495
Heating Avoided	0	3,205	3,365	3,534	3,710	3,896	4,090	4,295	4,510	4,735	4,972	5,221	45,533
Hot Water Avoided	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling Avoided	0	2,922	3,068	3,222	3,383	3,552	3,729	3,916	4,112	4,317	4,533	4,760	41,512
O&M Cost Avoided	0	0	0	0	0	0	0	0	0	0	0	0	
Tax Credit	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Adjustment	0	21,577	22,656	23,789	24,978	26,227	27,538	28,915	30,361	31,879	33,473	35,147	306,540
Net Cash Flow	(25,000)	8,526	8,952	9,400	9,870	10,363	10,882	11,426	11,997	12,597	13,227	13,888	121,127
Payback Balance	**(25,000)**	**(16,474)**	**(7,522)**	**1,878**	**11,748**	**22,112**	**32,993**	**44,419**	**56,416**	**69,012**	**82,239**	**96,127**	
	Current	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	

Other Info

Tax Rate	0%	(10% only for CHP system with a capacity of more than 50 kW and less than 15 MW)
Inflation/interest Rate	5%	

Payback can be calculated via inputs into spreadsheet

LEED Rating Contribution

Energy & Atmosphere

- Up to 10 points in Credit 1: Optimize Energy Performance
- 1 point in Credit 4: Ozone Protection
  - XONON is only turbine system pre-certified in CA, with some of nation's highest air quality regulations
  - XONON meets the CARB 2007 DG Standard – today
  - XONON is being recommended for BACT by the SCAQMD Science Committee

Closing Thoughts

Thanks for this opportunity to explain how DG and CHP can provide clean energy for green buildings.

More information at http://www.kawasaki.com/gtd/

Questions can be answered at table top.