Track: Commercial Natural Gas I

Unit 14: Converting from Oil to Natural Gas

(Note that this training unit is a supplement for those ESC members that have heating oil prevalent in their service territory. It is not required to complete the program and there is no test for this training unit.)

An overview of the energy and hidden costs associated with oil heating

Eric Burgis, Energy Solutions Center

Presentation Outline

- Oil overview
- Grades of heating oil
- Historic and forecasted energy pricing
- Other costs associated with burning oil
- Oil storage tanks
- Boiler conversion

Crude Oil

- America is extremely dependent on Foreign Crude Oil
- Refineries in America separate 'Crack' the crude into many more usable fuels:
  - The lightest fuels derived are gaseous – ethane & methane
  - Next – Propane and Gasoline in liquid form
  - A number of different grades of oil are then derived from Kerosene the lightest then #2 oil (Diesel) through #6 oil which is the heaviest oil
  - Lastly comes a product called coke which is either cracked further or used as a solid form of fuel similar to coal

Crude Oil

- **Barrel**
  - One barrel = 42 Gallons

Composition by Weight

Element	Percent Range
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

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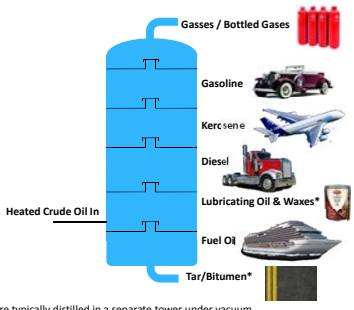
Crude Oil Refining



* These are typically distilled in a separate tower under vacuum

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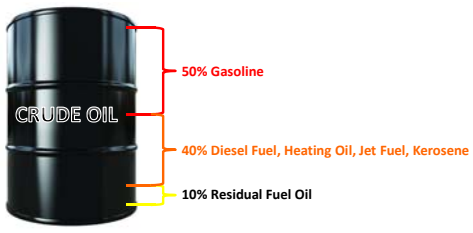
Typical U.S. Refinery Yield



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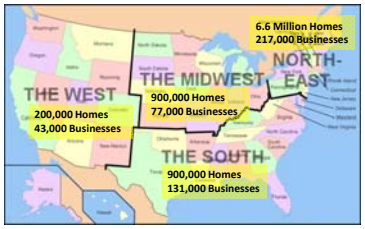
Where is the Oil Being Used?



Commercial Building Stats:

- **5,557,000 total buildings**
- **467,000 use oil (8.4%)**
- **270,000 have oil heat**
- **205,000 primarily heat with oil**
- **77,000 have oil water heating (1.4%)**

- Est. a total of 130 million homes & 5.6 million commercial buildings in the US
- Est. 8.7 million homes and 270,000 commercial buildings heat with oil
- Most of the country no longer uses heating oil

*# of homes uses Census data, while commercial building data comes from CBECS data released in 2016

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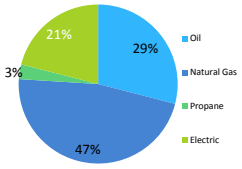
Residential Heating Energy

~ 8,700,000 U.S. Residential Homes Consume Oil

- 8.5 Million for heating
- 4.7 Million for Hot Water

Average homes consume 589 Gallons of Oil per year or 81.7 MMBTU.

N.E. Home Energy Use



Source: EIA

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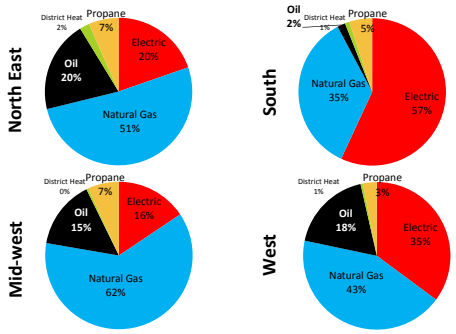
Commercial Building Primary Heating

(Number of buildings)



Source: EIA, CBECS Table B3
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Shale Gas Resources

The U.S. has an abundant supply of natural gas.

Abundant supply means low and stable natural gas prices.

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Oil Grades

	Lighter	Cleaner	Lower	Higher
#2 Oil	Viscosity ↓	Environmental Friendliness ↓	Heating Value ↓	Retail Pricing ↑
#4 Oil				
#5 Oil				
#6 Oil	Heavier	Dirtier	Higher	Lower

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"It costs more for the cleaner, but lower BTU oil"

Oil Grades

- **Grades: #2, #4, #5, or #6**
  - #2 Oil (Heating Oil)
    - The lightest oil – used for residential, commercial and light industrial
    - Most popular grade used in Boilers predominately
    - Used in commercial market sector, retail, offices, etc.

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Oil Grades

- **Grades #2, #4, #5, or #6**
  - #6 Oil
    - The heaviest and thickest oil – typically industrial fuel
    - Less expensive than #2 oil – has higher BTU content
    - Requires that it be kept hot during storage and additional heating before burning
    - Used in larger boilers or industrial applications, hospitals, etc.

Oil Grades

- **Grades**
  - **Diesel**
    - Used to power diesel engines
    - Same characteristics as #2 oil (difference being taxation of the different fuels and #2 oil is dyed a different color for government monitoring)
    - Used for back up generators and transportation fuel

Oil Factors

- Heating oil BTU values vary by quality & grade of fuel
- Oil today likely has less BTU's per gallon than years ago primarily due to additives and government requirements of lower sulfur/gallon
- EIA currently references the Bureau of Mines Standard Average Heating Values of Various Fuels from 1/3/1950
  - Distillate Fuel (#2 oil) = 5.825 MMBtu per barrel = **138,690 BTU/Gallon**
  - Residual Fuel (#6 oil) = 6.287 MMBtu per barrel = 149,690 BTU/Gallon
- Natural Gas averages 1,028 BTU/Cubic Foot

Converting Gas Price to Oil Price

- **Natural Gas to #2 Oil**
  - $/MCF Gas X 138,690 BTU/Gal#2 / 1,028,000 BTU/MCF = $/Gal Equivalent
  - #2 Oil = 7.41 gallon per MCF
- **Natural Gas to #6 Oil**
  - $/MCF Gas X 149,690 BTU/Gal#6 / 1,028,000 BTU/MCF = $/Gal Equivalent
  - #6 Oil = 6.86 gallon per MCF

(Assumes worst case EIA BTU values)

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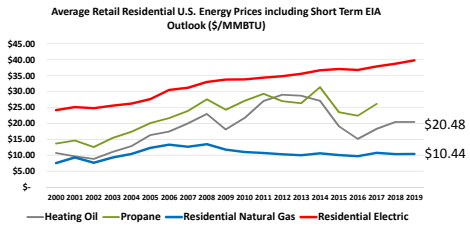
Residential Gas vs. Oil Pricing

Home Heating Oil is Approximately 2X the price of Natural Gas



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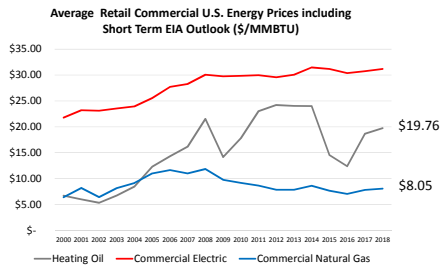
Commercial Gas vs. Oil Pricing

#2 Oil is Approximately 2.5X the price of Natural Gas



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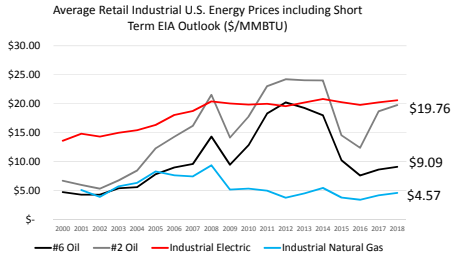
Industrial Market Gas vs. Oil Pricing

#6 Oil is Approximately 2.5X the price of Natural Gas



Equivalent Pricing

Number 2 Oil Price Equivalents

- **$8 / MCF Gas Rate = $1.07 / gal #2**
  - ($8 / MCF) X (138,690 BTU/Gallon #2 oil) / (1,028,000 BTU/MCF)
  - Compare to $2.50/Gallon #2 local cost

- **Number 6 Oil Price Equivalents**
- **$8 / MCF Gas Rate = $1.16 / gal #6**
  - ($8 / MCF) X (149,690 BTU/Gallon #6 oil) / (1,028,000 BTU/MCF)
  - Compare to $1.75/Gallon #6 local cost

Other Costs Associated with Oil

- Environmental costs are possible for air permits or underground storage tank insurance
- Cleaning/maintenance costs for oil boilers are typically higher than for natural gas fired boilers
- Degradation of efficiency as soot builds up in the oil boiler between cleanings:
  - Soot build up is an insulator that reduces heat transfer capability and therefore reduces boiler efficiency
  - Approx ¼" of soot reduces efficiency by about 25 %

Degrading Boiler Efficiency

Month	Oil Use Scenario (Gallons)	Boiler Efficiency over season	Oil Use at constant 78% efficiency
October	4,000	78%	4,000
November	7,000	75%	6,731
December	10,000	72%	9,231
January	12,000	69%	10,615
February	9,000	66%	7,615
March	8,000	63%	6,462
	50,000	(15% reduction)	44,654

Boiler consumed approx. 12% more oil during the season as a result of efficiency drop of 15% between cleanings

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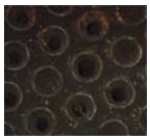
Operating & Maintenance

- O&M cost associated with burning oil:
  - Add approx. 2.8% to cost for #2 oil
  - Add approx. 6.6% to cost for #6 oil



Data taken from "An Analysis of the Losses and Costs Associated with Oil Versus natural gas Firing, an Update on a Nationwide Boiler program", 6/18/90

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Operating Costs Using Oil

Loss From	Description	#2 Oil	#6 Oil
Oil Pumping	Cost of electric required to pump oil from tank to boiler	.32 %	.32%
Oil Inventory	Oil is paid for and stored before use compared to being billed after use	.6%	.6%
Atomization	The cost to atomize oil into small droplets & mix with combustion air	1.88%	1.88%
Oil Pre-Heating	Heating oil to 200 – 250 deg F so that it may be atomized		.78%
Storage Heating	Cost to heat and keep heavier grades of oil at 125 Deg F or more		2.0%
Make up Water	Water used for storage heating, soot blowing, etc.		.22%
Oil Additives	Additives to the heavier oils to boilers operate properly		.8%
	Total	2.8%	6.6%

Data taken from "An Analysis of the Losses and Costs Associated with Oil Versus natural gas Firing, an Update on a Nationwide Boiler program", 6/18/90

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What is My Effective Cost of Oil Due to O&M Costs?

- $2.50 per gallon #2 oil actually costs about **$2.57/gallon** ($2.50 X 1.028)
  - $8/MCF Natural Gas = $1.07/Gallon #2
  - **Save 58% on Fuel and O&M alone vs. #2 Oil**
- $1.75 per gallon #6 oil actually costs about **$ 1.87/gallon** ($1.75 X 1.066)
  - $8/MCF Natural Gas = $1.16/Gallon #6
  - **Save 38% on Fuel and O&M alone vs. #6 Oil**

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Add It Up …

	Oil	Natural Gas
Energy Consumption (YR)	50,000 Gal. #2	
Use at Constant Efficiency	44,654 Gal. #2	6,001 MCF
Average Price	$ 2.50 /Gal. #2	$ 8.00 /MCF
Cost of Energy (Fuel for fuel)	$ 111,635	$ 48,008
Cost of degrading efficiency	$ 13,365	
Additional Operating Costs	$ 3,500	$ -
Annual Boiler Cleaning	$ 1,500	$ 1,200
Total Cost	$ 130,000	$ 49,208
Savings with Gas		$ 80,792 /Yr

Does this surprise you?

62% savings

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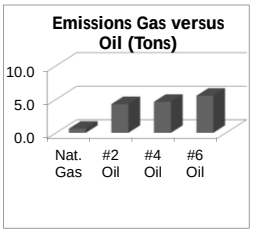
Environmental Emissions

- Lower emissions from Natural Gas than oil
  - Here is an example: 50,000 Gallons of #2 oil compared to other fuels

Emissions	Uncontrolled			
(Pounds)	Nat. Gas	#2 Oil	#4 Oil	#6 Oil
Part	20.20	100.00	347.97	555.91
PM10	20.20	54.00	223.69	361.34
SOx	4.04	7180.00	7456.45	7347.26
NOx	942.55	1000.00	994.19	2547.92
VOC	18.85	17.00	16.90	52.35
CO	235.64	250.00	248.55	231.63
Lead	0.00	0.02	0.02	0.19
Total #s	**1,241**	**8,601**	**9,288**	**11,097**



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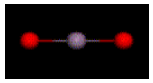
What About CO_2?

- Emissions EPA Factors
  - 22,300 # CO_2/1000 Gal #2
  - 25,000 # CO_2/1000 Gal #6
  - 116.8 # CO_2 per MMBTU Natural Gas
- Example: 50,000 Gallons #2 Oil
  - 557 Tons of CO_2 from #2 Oil
  - 392 Tons of CO_2 from equivalent Natural Gas
- **Save 165 Tons CO_2 with Natural Gas**



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Oil Storage

- Underground Storage Tanks are viewed as a liability
- Clean up costs associated with a leak can be substantial
- Indemnification insurance was not included in previous savings analysis


Oil spills: Don't be left out in the cold

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Underground Storage Tanks

- ***All USTs*** installed after December 1988 must have leak detection when installed
- USTs installed before December 1988 had to meet leak detection compliance deadlines that were phased in over 5 years. **By December 1993, *all of these USTs* had to have leak detection**
- As of November 2017 there were 555,079 active USTs (at approximately 200,000 sites) which are regulated by EPA's UST program

*EPA: Straight Talk on Tanks

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UST Program State Contacts

https://www.epa.gov/ust/underground-storage-tank-ust-contacts#states

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UST State UST Program Info

https://www.epa.gov/ust/state-underground-storage-tank-ust-programs

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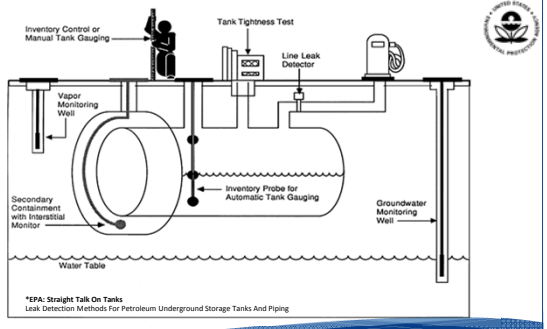
Leak Detection



*EPA: Straight Talk On Tanks
Leak Detection Methods For Petroleum Underground Storage Tanks And Piping

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Leak Detection Methods

Secondary Containment With Interstitial Monitoring

Automatic Tank Gauging Systems

Vapor Monitoring

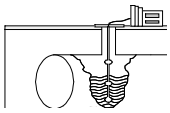
Groundwater Monitoring

Other methods

*EPA: Straight Talk on Tanks

Tank Tightness Testing

- When performed according to the manufacturer's specifications, periodic tank tightness testing combined with monthly inventory control can ***temporarily*** meet the federal leak detection requirements for ***tanks*** (this method does not detect piping leaks).
- Be carful not to perform the test while your boiler is running or the test could come up inconclusive or fail



Underground Tank Resource

- Over 555,000 storage tank systems (USTs) in the United States contain petroleum or hazardous substances regulated by the U.S. Environmental Protection Agency (EPA)
- Many of these USTs have leaked or are currently leaking
- More USTs will leak unless owners and operators make sure their USTs meet the requirements

https://www.epa.gov/ust/musts-usts

Underground Tank Deadline

October 2018 Deadline

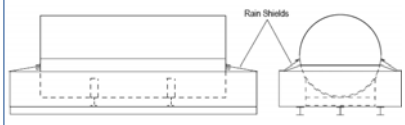
Where	Who	What
In States And Territories Without Program Approval		
10/13/2018	UST owners and operators in states and territories without program approval	Must meet remaining 2015 UST technical requirements • Implementation time frames
Ongoing	State and territorial UST programs without program approval	May apply for state program approval based on the 2015 federal UST regulations at any time • Apply for program approval
In States And Territories With Program Approval		
10/13/2018	States and territorial UST programs with approved programs	Must re-apply to retain approved program status • Re-apply for program approval
Ongoing	UST owners and operators in states with approved programs	Continue to follow their states' requirements, which may be different from the 2015 federal UST requirements • Map of states with approved programs

The 2015 UST regulation was effective 10/13/2015. Compliance deadlines range from 10/13/2015 to 10/13/2018. The 2015 SPA regulation requires states and territories reapply for state program approval by 10/13/2018.

https://www.epa.gov/ust/revising-underground-storage-tank-regulations-revisions-existing-requirements-and-new#compliance

Replacement Tanks

- Aboveground Dike Tanks
- Sizes from appox. 240-30,000 Gallon
- Typically sized for 110% containment



* Highland Tank & Mfg. Company

Boiler Conversions

- Boiler Replacement
- Conversion Burners

Old vs. New Boiler Efficiency

- Many boilers in operation today were installed in the 1960's and 1970's
  - Older boilers typically have efficiencies in the high 60% to low 70% range
  - Skin Loss
  - Combustion Loss
- New Boilers are more efficient
  - Minimum efficiency is 82%
  - High efficiency is 90% or more

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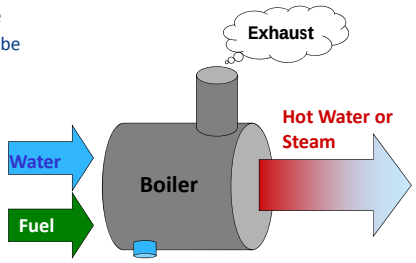
Major Boiler Configurations

- Sectional
- Fire Tube
- Water Tube
- Fin Tube



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Sectional Boilers

- Contains multiple cast sections
- Unit sizing up to 150 hp
- New Condensing Boilers available

Company	Size	Efficiency
Burnham Boiler	262 - 5,733 MBH	Up to 89%
Crown Boiler – Std. Efficiency	342 - 1,852 MBH	78%
Crown Boiler – BIMINI	70 - 425 MBH	96.1%

Multiple other manufacturers exist

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Fire / Water Tube Boilers

Fire Tube

- Combustion gases pass inside boiler tubes, and heat water around tubes
- Incorporate high efficiency burners and combustion controls

Water Tube

- Water passes through tubes
- Exhaust gases remain in the shell passing over the tube surfaces

Water/Fire Tube Boiler Mfgs.

Company	Size	Efficiency
Bryan Boilers – Flex Tube Atmos.	29 – 155 HP	80%
Bryan Boilers – Flex Tube Forced	6 – 527 HP	80-85%
Clayton Boilers – Water Tube	8 – 1000 HP	80-83%
Cleaver Brooks – Water/Fire Tube	100 – 1800 HP	82%
Cleaver Brooks – Super Boiler	3,600 – 29,000 lb/h	93-94%
Columbia Boiler – Water Tube	4 – 60 HP	80%
Hurst Boiler – Fire Tube	15 – 800 HP	81% min.
Johnston Boiler – Fire Tube	50 – 2500 HP	Up to 99%

Condensing Boilers

- Efficiencies of 90 to 96 percent
- Water vapor produced during combustion condenses back into liquid form, releasing the latent heat

Company	Size	Efficiency
Cleaver Brooks - ClearFire	500 – 2500 MBH	Up to 99%
Crown Boiler – BIMINI	70 – 425 MBH	96.1%
Fulton -Pulse or Vantage	300 -6000 MBH	90 -99%
GasMaster	200 – 4000 MBH	92 – 99.8%
Hurst Boiler	6 – 100 HP	
Laars Heating Systems	150 – 2500 MBH	90 – 98%
Lochinvar	1000 – 1500 MBH	Up to 98%
Peerless -	80 – 1000 MBH	Up to 96.6%
Thermal Solutions - Evolution	750 – 3000 MBH	Up to 97%

High Efficiency Copper-Fin Tube Boilers

- Water tube design, flows through copper pipe fitted with fins
  - Increased heat transfer surface
  - Compact design
  - Fully-modulating with High-turndown (5:1)

Company	Size	Efficiency
Allied Boilers – AAE Series	480 – 3,000 MBH	80% min.
Allied Boilers – Mini-Star	70 - 280 MBH	86%
Lochinvar	400- 2,070 MBH	85%

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Conversion Burners

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Key Data Required for Burner Selection

- Boiler Make & Model
- Boiler Size
- Desired Firing Rate
- Available Gas Pressure
- Available Supply Voltage
- Fuels to be Fired
- Code Requirements – UL, FM, NFPA85, etc

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Wayne P250 Series Gas Conversion Burner

Ideal for upgrade or fuel conversion applications in furnaces, boilers and water heaters

- Direct ignition model
- Universal mounting flange adapts to any appliance
- Fully factory assembled and pre-wired
- 120v operation, 60Hz
- 50,000- 250,000 BTUH
- Price of $815

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Wayne Burners

From Residential sized to approximately 50 HP

GAS BURNERS MODEL	FIRING RATE CAPABILITIES BTU/HR. MINIMUM	MAXIMUM
SC80	10,000	85,000
P265F	65,000	200,000
P250AF	50,000	250,000
HSG200	60,000	200,000
HSG400	200,000	400,000
EHG	425,000	700,000
LC1500	700,000	1,500,000
LC2300	1,100,00	2,300,000

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Riello Gas Conversion Burner

40 Series Burner

- Many configurations available
- Designed to make installation and servicing easy
- Fully factory assembled and pre-wired
- 38,000- 70,000 BTUH
- Price around $1,000

RS/M 28-50

- 198,000-2,201,000 BTU

RS/M 70-190

- 512,000 to ~200 Horsepower

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Carlin Burners

Costs (Residential)

- Burner $450
- Materials $233
- Labor $190
- Overheads $577
- Total Installed Cost $1,459

Model EZ
50,000 – 275,000 BTU

Carlin Commercial Burners

Model 201
150,000 – 399,000 BTU

Model 301
401,000 – 1,100,000 BTU

Model 601
700,000 to 1,500,000 BTU

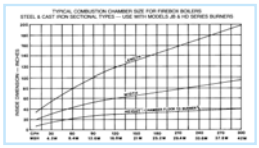
Commercial and Industrial Burners

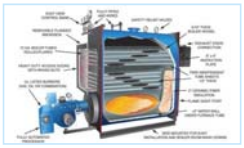
ALZETA	23 MBTU – 16.5 MBTU	Peabody Engineering	6.5 MMBTU – 71.7 MMBTU
COEN	20 MMBTU– 380 MMBTU	Power Flame	420 MBTU – 63 MMBTU
IC Industrial Combustion	1.2 MMBTU – 5.2 MMBTU	TODD	Up to 150 MMBTU
Faber Burner Company	10 MMBTU – 300 MMBTU	WEBSTER	Up to 105 MMBTU
Gordon-Piatt	8.4 MMBTU – 42 MMBTU	weishaupt	34 MBTU – 60 MMBTU

Burner Sizing

Ask an expert to help you size the burner, there are a lot of considerations

Furnace Chamber Size





Pressure Draft

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Burner Sizing

Ask an expert to help you size the burner, there are a lot of considerations

Gas Train

Controls

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Key Benefits of Using Natural Gas vs. Oil

- Price: Natural Gas is less expensive than oil
- Ease of conversion: Natural Gas equipment is easy and cost effective to convert oil-fired equipment
- Less operating and maintenance issues
- Better for the environment

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