The Interchangeability of Shale Gases with Traditional Pipeline Supplies

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Interchangeability is "the ability to substitute one gaseous fuel for another in a combustion application without materially changing operational safety, efficiency, performance or materially increasing air pollutant emissions."

- The Wobbe number has been broadly accepted as a key index of natural gas interchangeability.

$$Wo = \frac{HHV}{\sqrt{\text{Specific Gravity}}}$$

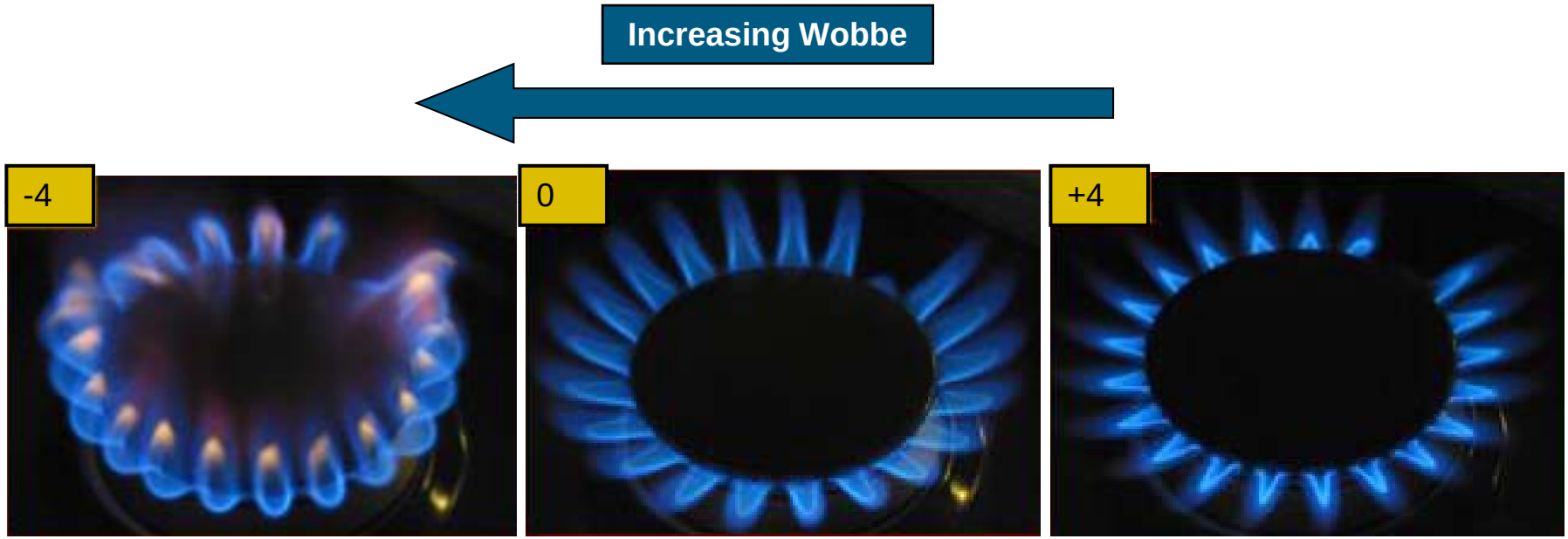
- The fuel energy input to combustion equipment (when the gas manifold pressure is held constant) is directly proportional to the Wobbe number.
- Many important combustion phenomena can be related to the Wobbe number.

The introduction of new natural gas supplies can impact the performance of certain combustion equipment.

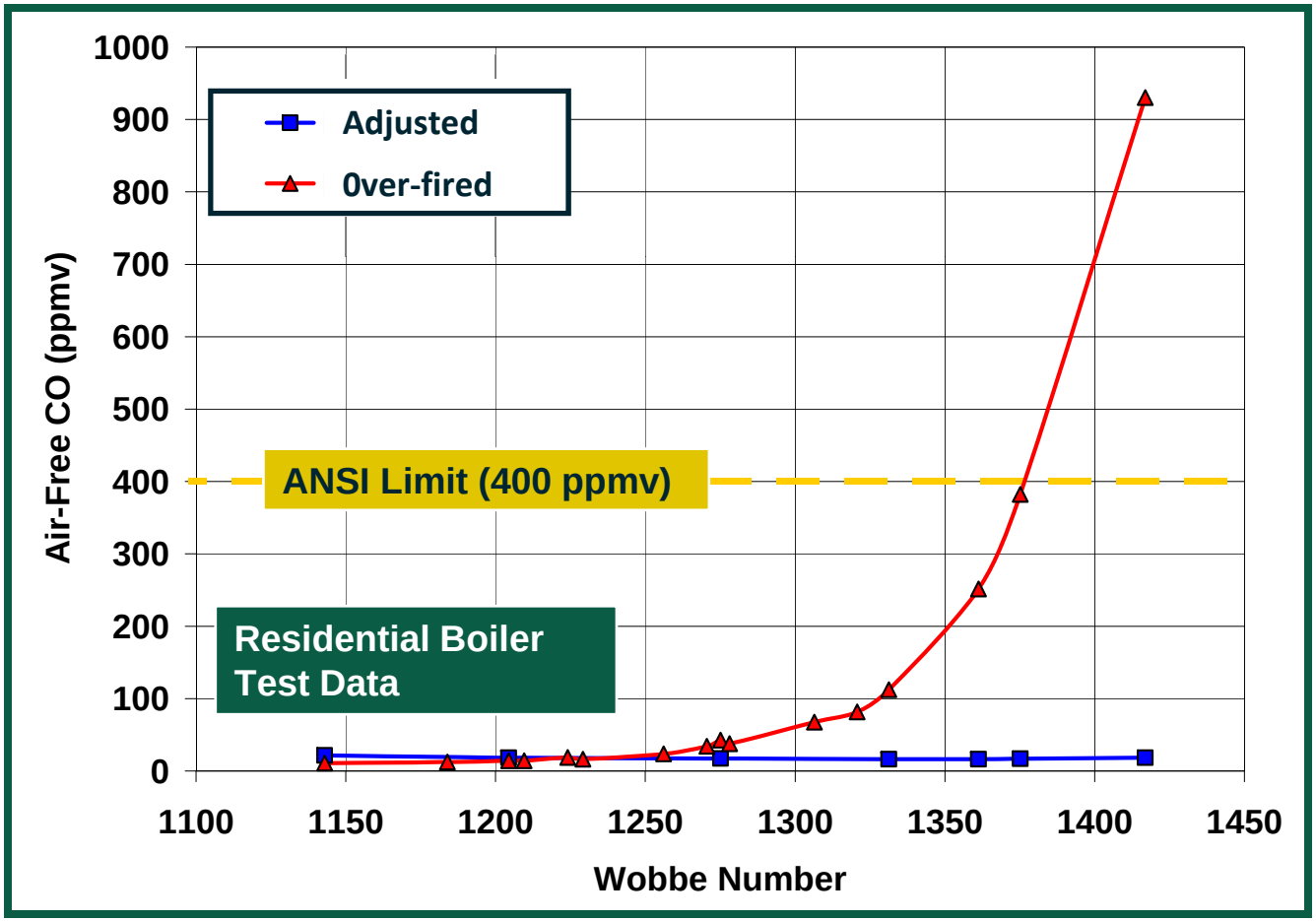
- Combustion equipment may be sensitive to changes in gas composition, due to…
  - Equipment design
  - Adjustment practices
  - Lack of maintenance
- Higher Wobbe number gas may have the following impacts:
  - Energy input (firing rate) may increase.
  - Excess air level may decrease.
  - Carbon monoxide (CO) emissions may increase.
  - Soot generation may increase.
  - NO_x emissions may change.
  - Heat exchanger temperatures may rise.
- Lower Wobbe number gases generally have the opposite effect. However…
  - Flame lifting may increase.
  - Carbon monoxide emissions may increase.

Residential appliances and DLN gas turbines are often the most sensitive classes of end-use equipment.

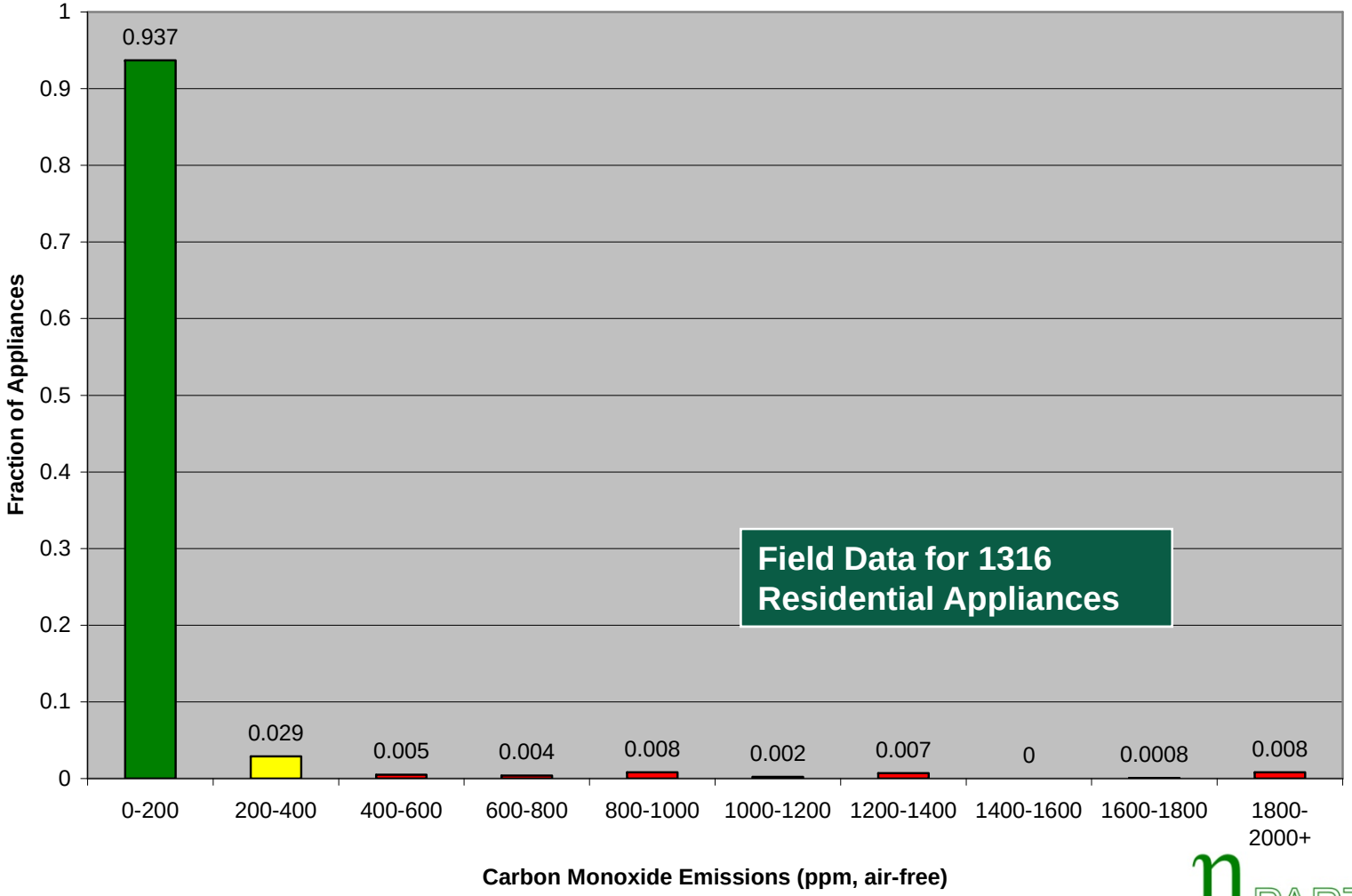
Increasing Wobbe Number tends to increase yellow tipping and decrease lifting.



Properly adjusted appliances can accommodate a wide range of gas compositions. Maladjusted appliances can be sensitive to changes.



Residential appliance survey data typically indicate that a small percentage of the appliance population may be sensitive to gas composition changes.



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To provide additional measures of interchangeability for appliances, multiple index methods can be utilized.

- Two methods have been utilized in the U.S. for evaluating interchangeability:
  - AGA Multiple Index method (1946)
  - Weaver Multiple Index method (1951)
- The multiple index methods…
  - address important combustion phenomena (lifting, flashback, yellow tipping, incomplete combustion)
  - are based on appliance tests
- Interchangeability indices are calculated using two natural gas compositions:
  - Adjustment gas
  - Substitute gas
- Index limits have been prescribed by the index developers and by LDCs.

In 2005, the NGC+ Work Group recommended a transition plan and interim interchangeability guidelines:

- The interim guidelines are:
  - Wobbe number range: ±4%
  - Maximum Wobbe number: 1,400
  - Maximum higher heating value: 1110 Btu/scf
  - Maximum butanes+: 1.5 mole percent.
  - Maximum total inerts: 4 mole percent

Shale Gas Composition

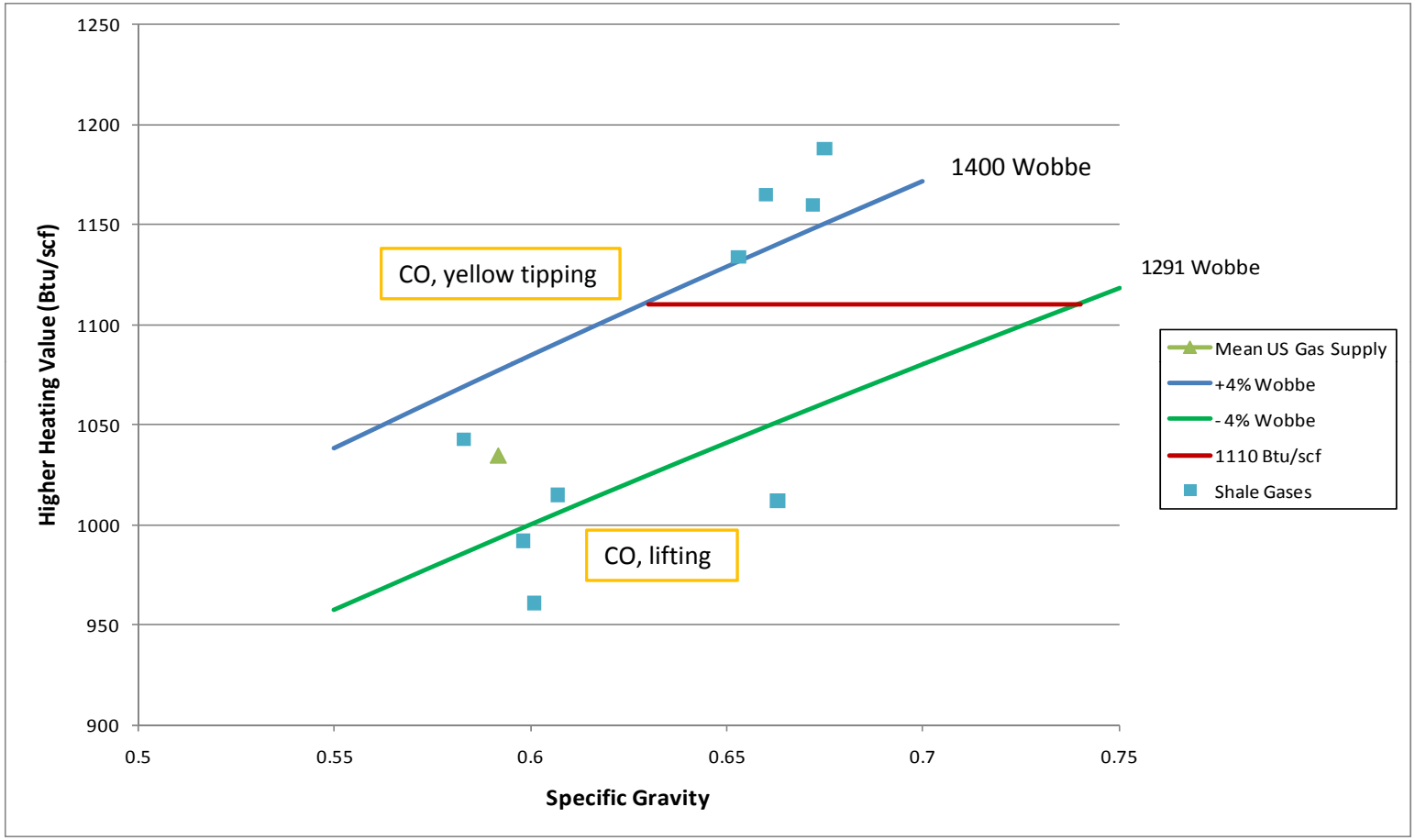
Elevated levels of ethane, propane, carbon dioxide, or nitrogen in certain shale gases are of concern regarding their interchangeability with traditional natural gas supplies.

	US Mean[1] Natural Gas	Shale Gases[2] (major components, before processing)								
		1	2	3	4	5	6	7	8	9
Methane (vol. %)	94.3	79.4	82.1	83.8	95.5	95	80.3	81.2	91.8	93.7
Ethane	2.7	16.1	14	12	3	0.1	8.1	11.8	4.4	2.6
Propane	0.6	4	3.5	3	1	0	2.3	5.2	0.4	0
Butane	0.2	-	-	-	-	-	-	-	-	-
Pentane	0.2	-	-	-	-	-	-	-	-	-
Carbon Dioxide	0.5	0.1	0.1	0.9	0.3	4.8	1.4	0.3	2.3	2.7
Nitrogen	1.5	0.4	0.3	0.3	0.2	0.1	7.9	1.5	1.1	1
Total	100	100	100	100	100	100	100	100	100	100
HHV (Btu/scf)	1035	1188	1165	1134	1043	961	1012	1160	1015	992
SG	0.592	0.675	0.66	0.653	0.583	0.601	0.663	0.672	0.607	0.598
Wobbe Number	1345	1445	1435	1404	1366	1239	1243	1415	1303	1284

1. Variability of Natural Gas Composition In Select Major Metropolitan Areas Of The United States, Final Report, GRI-92/0123, Gas Research Institute, 1992.
2. Compositional Variety Complicates Processing Plans for US Shale Gas; Oil and Gas Journal; March 9, 2009.

Shale Gas Interchangeability

Range of Acceptability



Processing to remove some ethane + propane or carbon dioxide + nitrogen or, when feasible, blending with other natural gases can shift shale gases into the "range of acceptability".

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In a NYSEARCH/NGA project, we are evaluating the impact of changing gas supplies on the performance of in-service residential appliances.

- The ability of in-place appliances to operate properly with gas supply changes is not sufficiently understood.
  - very wide range of appliance types and ages.
  - Installation, adjustment, and maintenance variability.
- The project team includes NYSEARCH, etaPartners, GTI, and fifteen local natural gas distribution (LDC) and pipeline companies.
- In Phase 1 we...
  - Characterized the population of appliances
  - Evaluated appliance servicing practices
  - Conducted field testing of about 2400 appliances located in three LDC service areas.
  - Evaluated the performance of the appliance population.
- In Phase 2 we are…
  - Conducting laboratory tests of used appliances, focusing on sensitive models and common maladjustments.
  - Developing guidelines for accommodating changing gas compositions.
  - Determining the most effective interchangeability indices for in-service appliances.