Public Workshop
on
Residential Furnace and Boiler Venting

May 8, 2002

The following slides provide back-up material in preparation to the venting workshop.

List of Topics

- **Venting Code Background**
- **Difference Between SSE and AFUE**
- **NFGC Tables at Higher SSE**

Venting Research Sources

Several sources have been reviewed.

Organization	Title	Author (s)	Report Type	Year
ANSI	ANSI Standard Gas-fired Central Furnaces	ANSI Z21.47-2001	ANSI Standard	2001
NFPA & ANSI	National Fuel Gas Code	ANSI Z21.47-2001 NFPA 54-1999	NFPA & ANSI Standard	1999
Indiana Community Action Association	Codes for Venting Combustion Appliances	Andrews, T.	Affordable Comfort Conference	1999
GRI	Assessment of Technology for Improving the Efficiency of Residential Gas Furnaces and Boilers	Jakob, F.E., J.J.. Crisafulli, et al.	GRI-94/0175	1994
GRI	Venting Gas Appliances into Exterior Masonry Chimneys	Phillips, D. B., A. L. Rutz, et al.	GRI-94/0193	1994
GRI	Corrosion Test Method for Gas Furnaces and Vents	Talbert, S. G. and B. Hindin	GRI-94/0050	1993
GRI	Presentation of the Vent-II Solution Methodology	Rutz, A. L., R. D. Fischer, et al.	GRI-92/0149	1992
GRI	Analysis of the Effects of Dilution Air and Appliance Efficiency on Venting Cat I Appliances	Rutz, A. L., G. R. Whiacre, et al.	GRI-92/0357	1992
GRI	A Reappraisal of Categorization Criteria for Venting Gas Appliances	Borgeson, R. A.	GRI-90/0150	1990
GRI	User's Manual for Vent-II (Version 4.1)	Rutz, A. L., et al.	GRI-90-0178	1990
GRI	Venting Guidelines for Category 1 Gas Appliances w/ Fan-Assisted Comb Systems	D. D. Paul, G.L.Whitacre, et al.	GRI-89/0016	1989

List of Topics

- Venting Code Background
- **Difference Between SSE and AFUE**
- NFGC Tables at Higher SSE

Difference Between SSE and AFUE

ADL-commissioned ITS test results (teardown units).

	Modulating	Jacket Loss	SSE-AFUE	Input Capacity (Btu/hr)
Unit 1	Y	0.22%	0.7%	75,000
Unit 2	Y	0.44%	1.4%	66,000
Unit 3	Y	0.17%	N/A	75,000

Difference Between SSE and AFUE

Results of tests from the ADL database.

	Modulating	SSE-AFUE	Input Capacity (Btu/hr)
Unit 1	N	1.2%	75,000
Unit 2	N	-0.1%	100,000
Unit 3	N	0.1%	75,000
Unit 4	N	2.4%	46,000
Unit 5	N	1.5%	45,000
Unit 6	N	1.8%	50,000
Unit 7	N	0.5%	75,000
Unit 8	N	2%	50,000
Unit 9	N	1.9%	40,000

Difference Between SSE and AFUE

GAMA submitted test results.

	Jacket Loss	Input Capacity (Btu/hr)
Unit 1	0.75%	40,000
Unit 2	0.40%	40,000
Unit 3	0.39%	50,000
Unit 4	0.48%	60,000
Unit 5	0.52%	60,000
Unit 6	0.42%	75,000
Unit 7	0.23%	80,000
Unit 8	0.23%	80,000
Unit 9	0.11%	100,000
Unit 10	0.33%	100,000
Unit 11	0.50%	100,000
Unit 12	0.57%	100,000
Unit 13	0.41%	100,000
Unit 14	0.33%	115,000

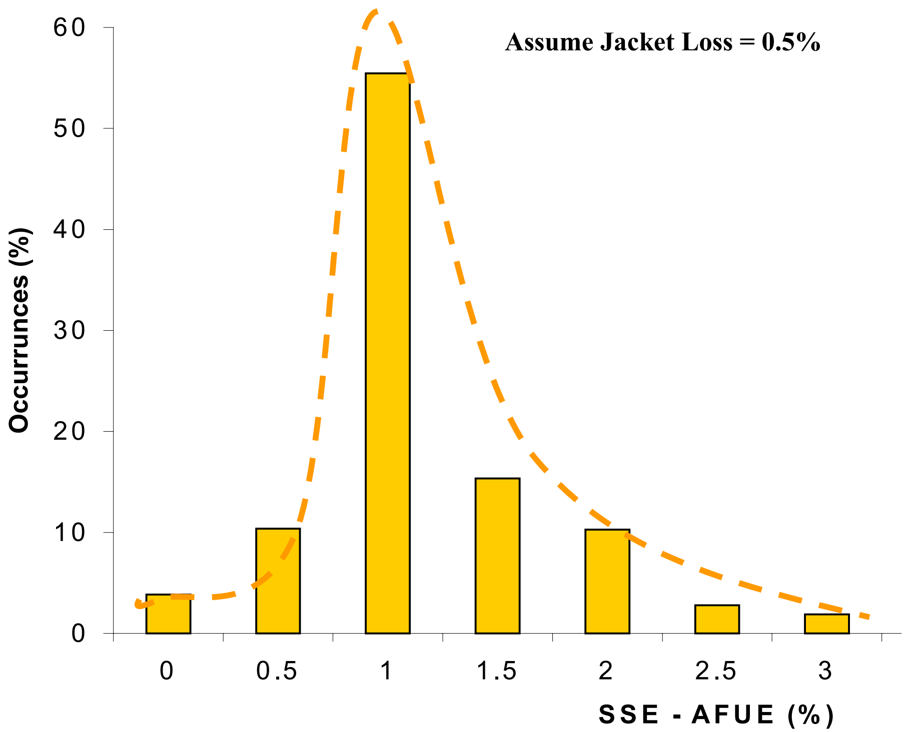
Difference Between SSE and AFUE

Test data gathered through ASHRAE SPC 103.

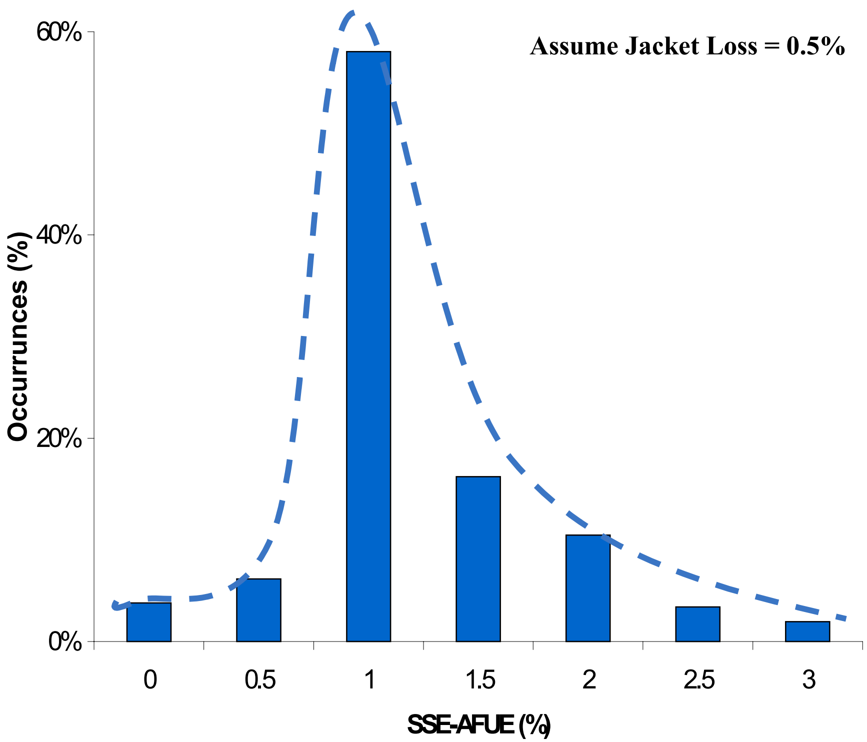
	Modulating	Jacket Loss	SSE-AFUE	Input Capacity (Btu/hr)
Unit 1	Y	0.75%	1.36%	60,000
Unit 2	Y	0.40%	-0.02%	100,000
Unit 3	Y	0.39%	0.07%	80,000
Unit 4	Y	0.48%	0.65%	100,000
Unit 5	Y	0.52%	0.65%	80,264
Unit 6	Y	0.42%	0.48%	99,612
Unit 7	Y	0.23%	0.94%	125,250
Unit 8	Y	0.23%	0.84%	100,588

Difference Between SSE and AFUE

The GAMA directory and the CEC directory show a similar distribution of SSE-AFUE values.



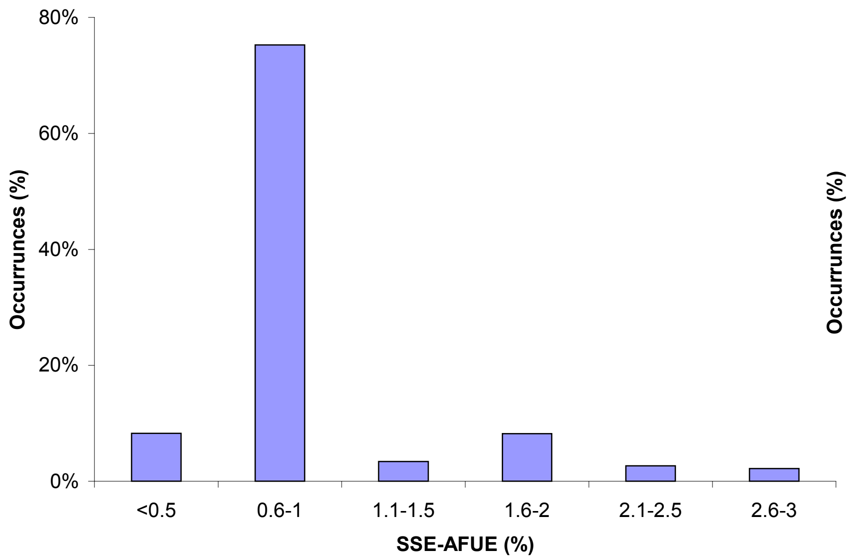
GAMA

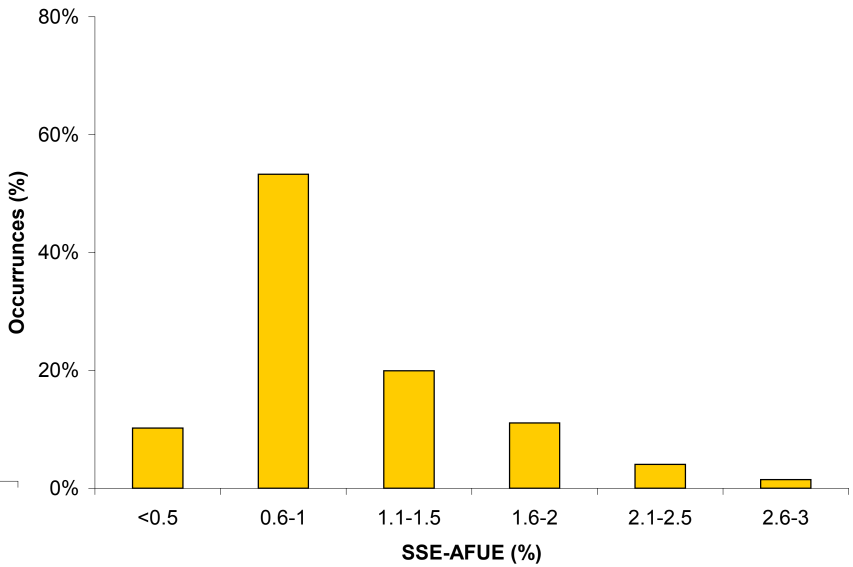


CEC

Tubular vs. Clam Shell Heat Exchanger

From a preliminary analysis of the GAMA directory, furnaces with clam-shell heat exchangers appear to have lower SSE-AFUE values than appliances with tubular heat exchangers.





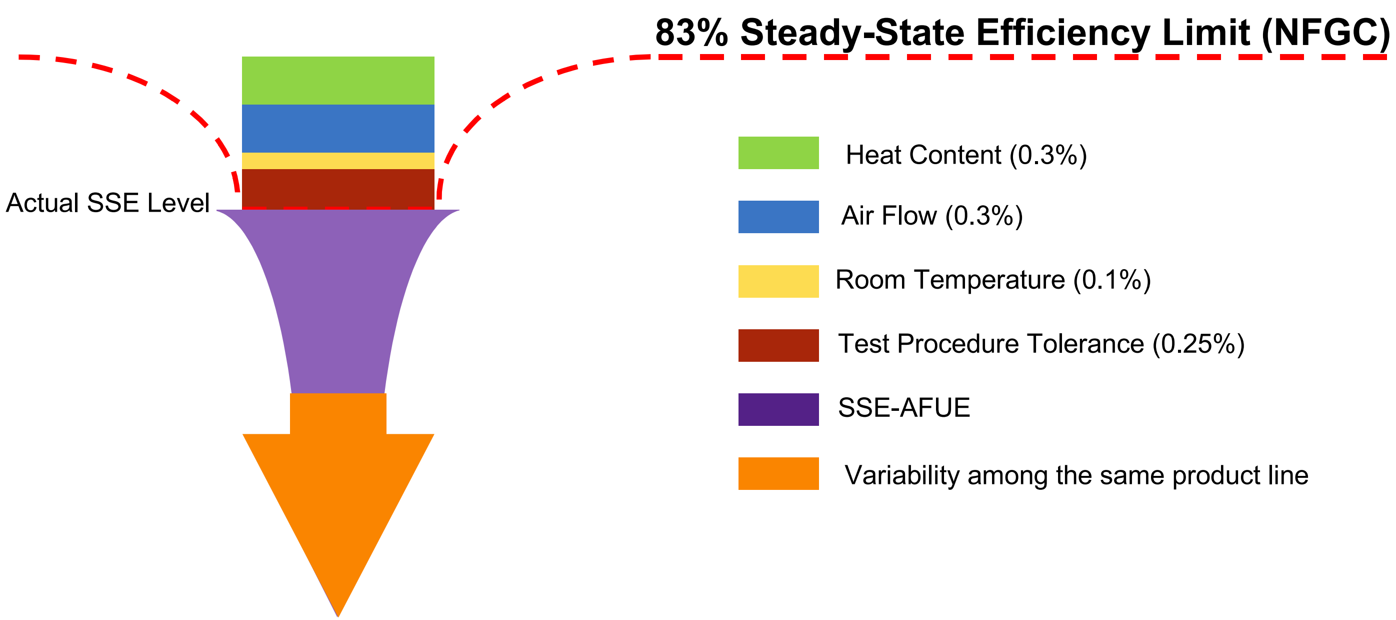
Clam Shell
(average SSE-AFUE = 0.6%)

Tubular
(average SSE-AFUE = 0.9%)

Non-condensing gas fired furnaces. Assume a 0.4% jacket loss to calculate SSE.
We assigned one kind of heat exchanger for each brand.

List of Topics

According to a GRI study*, tolerances need to be taken into account when setting a maximum SSE value.



* *Assessment of Technology for Improving the Efficiency of Residential Gas Furnaces and Boilers*, **1994, page 4-10.**

List of Topics

- Venting Code Background
- Difference Between SSE and AFUE
- **NFGC Tables at Higher SSE**

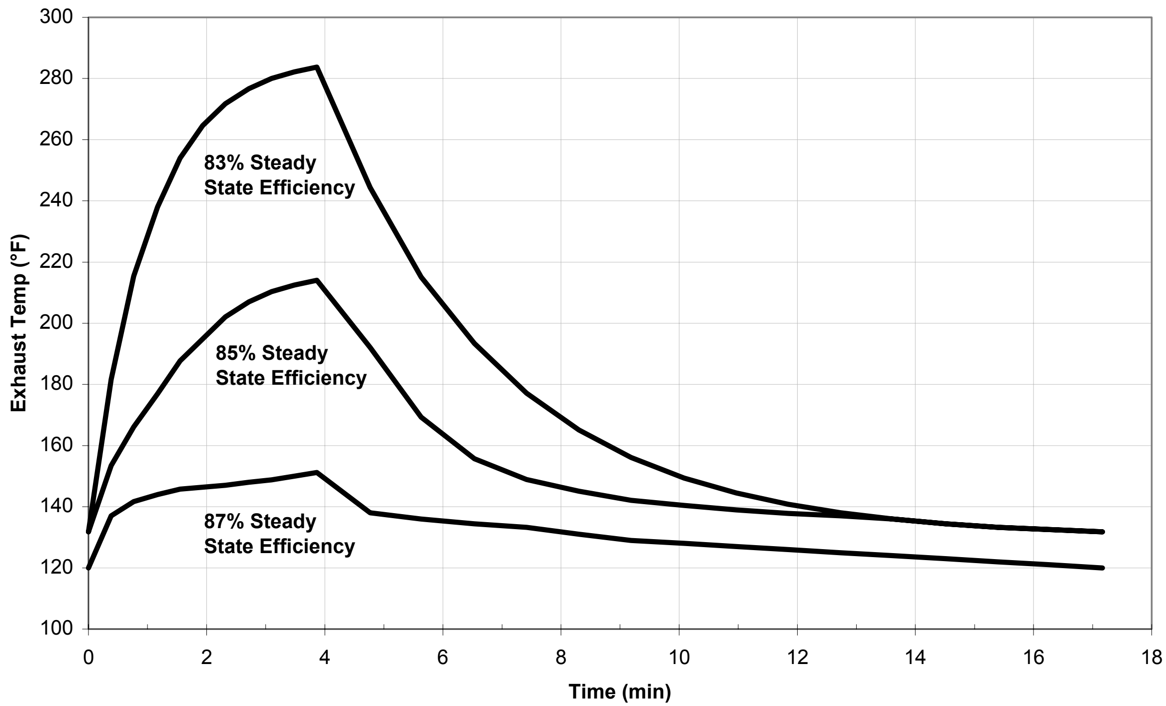
NFGC Tables at Higher SSE

The process of creating input temperature profile to be used in conjunction with VENT-II to generate tables at higher steady-state efficiency (SSE) consist of two tasks.

- **Replicate the shape of the temperature profile, assuming different peak temperatures depending on SSE.**
- **Validate the curves with experimental data.**

NFGC Tables at Higher SSE

Temperature profiles were created for steady state efficiencies greater than 83%, based on the NFGC input profile.



Higher steady-state efficiencies correspond to lower peak temperatures (see next slide).

NFGC Tables at Higher SSE

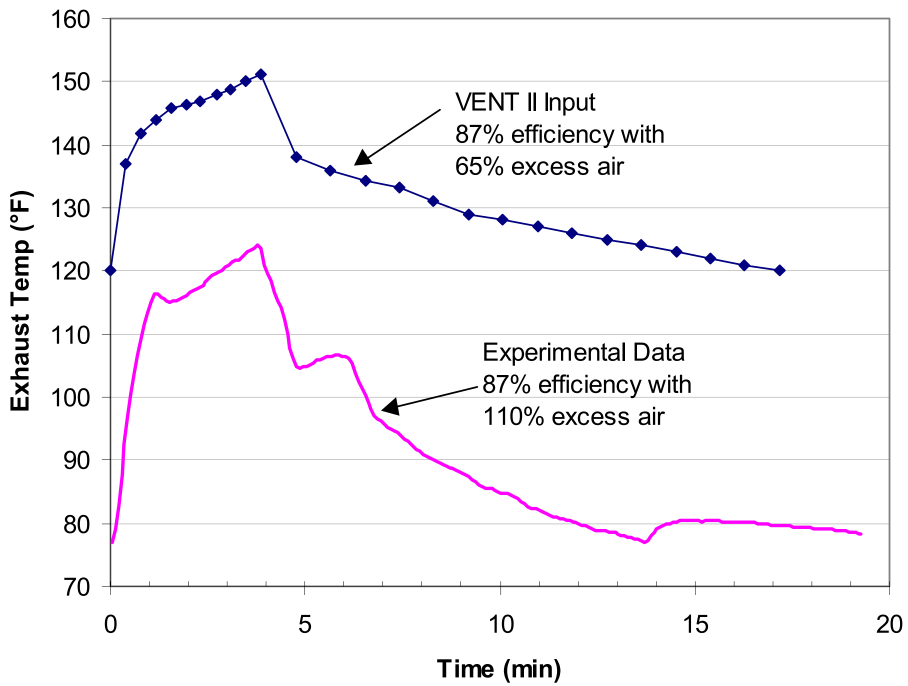
The peak temperature decreases at higher steady state efficiency.

We assumed:
- **65% excess air**
- **60°F ambient (typical operating condition)**

Steady State Efficiency (%)	Flue Temperature (°F)
81	339
82	308
83	277
84	245
85	214
86	183
87	151

NFGC Tables at Higher SSE

The practical necessity to use higher level of excess air when taking the experimental data resulted in lower exhaust temperatures.



However, the slopes of the heat up and cool down portions of the curves are very similar.

NFGC Tables at Higher SSE

By overlaying the two curves we noticed that the slope of the experimental curve closely matches the VENT II profile and validates the higher efficiency curves.