



# Measured Performance of Combi Systems at Syracuse FTGU Houses

Syracuse COE Symposium

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# What is a “Combi” System

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- Uses one appliance to meet space heating and domestic water heating (DHW) loads
- Makes sense NOW because space and DHW loads are similar magnitude in new homes
- Benefits
  - Better combined efficiency
    - DHW efficiency gets better
  - Lower installed cost
    - put that saved money into insulation!
  - Enables premium comfort systems
    - In floor heating

# “From the Ground Up” Houses

- Design Competition Among Architecture Firms
  - run by Syracuse University School of Architecture
  - highly energy efficient designs, all approx 1200 sq ft + basement
- Syracuse Center of Excellence in Energy and Environmental Systems received DOE funding for Monitoring



TED House



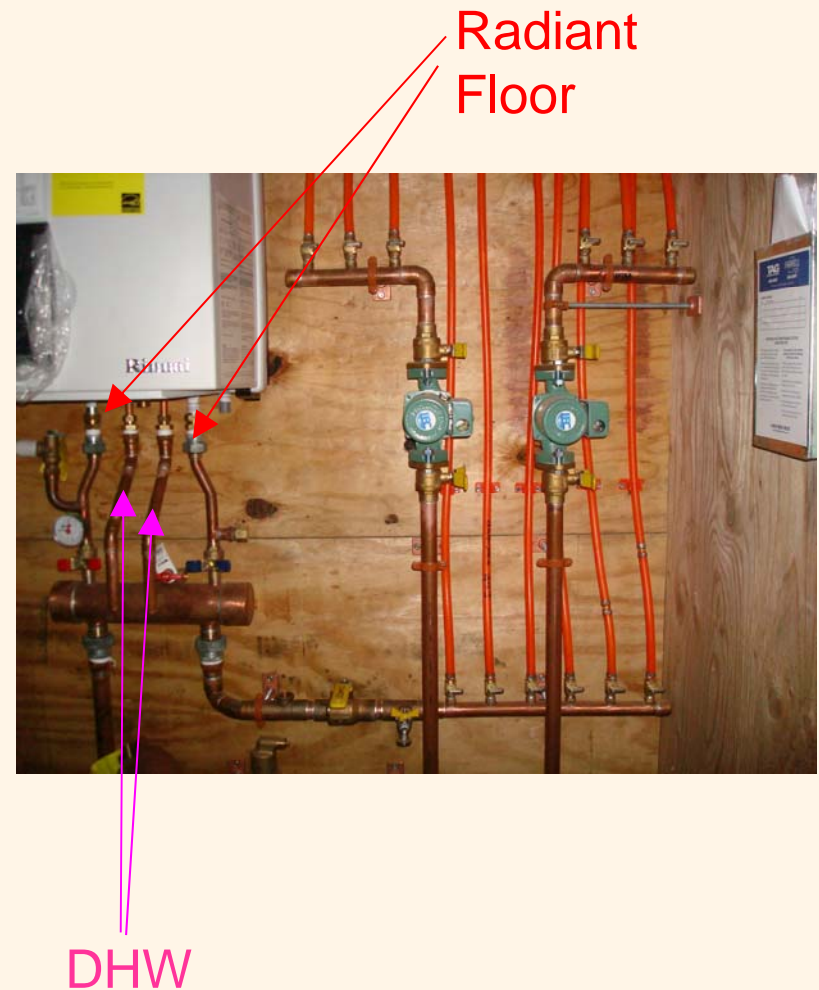
R-House



LiveWork House <sup>3</sup>

# TED House

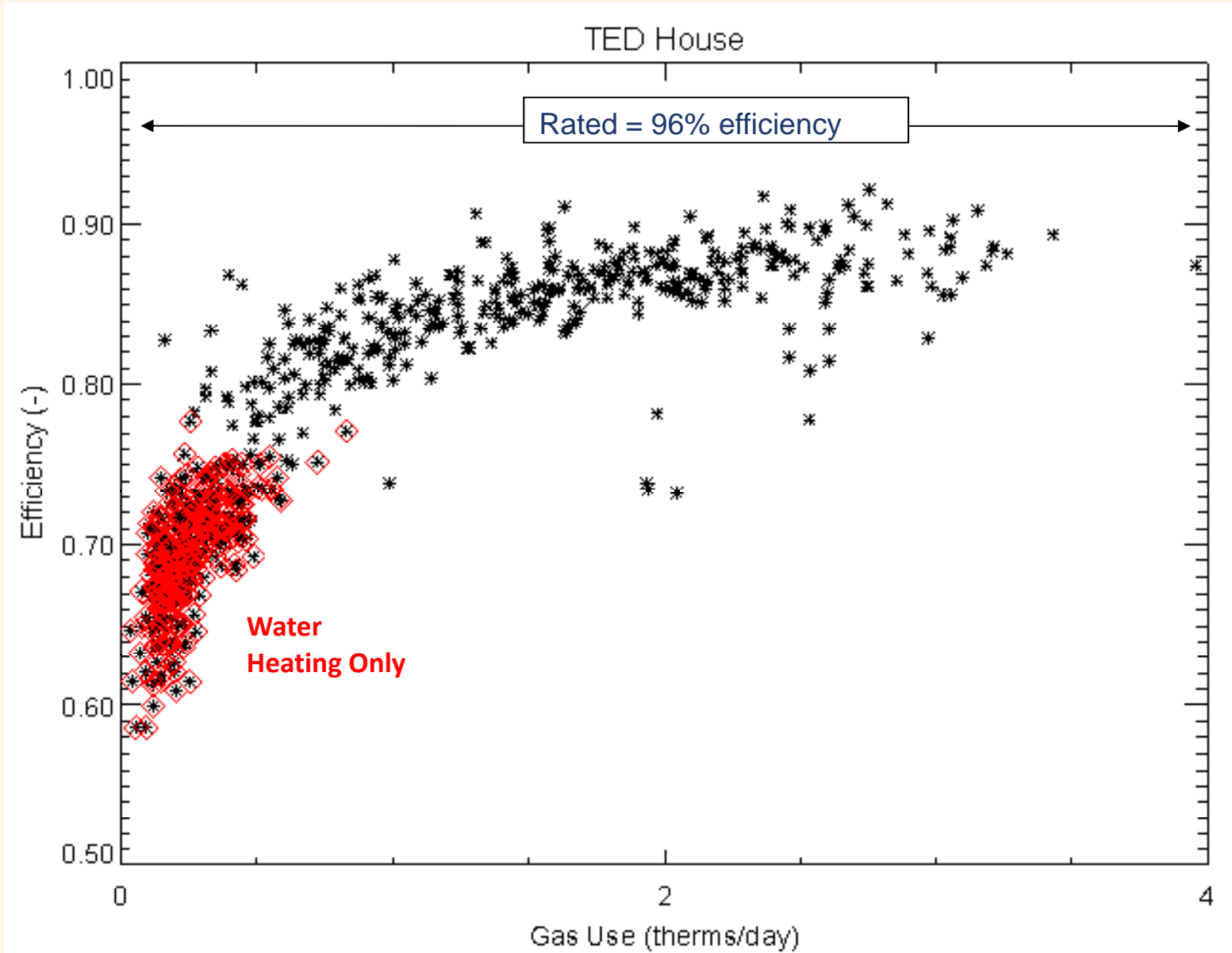
- Rinnai E75C “Combi” (75 MBtu/h)
  - space heating via radiant floor (2 zones)
  - Separate DHW circuit
- High Efficiency Envelope
  - 0.475 ACH50
  - Serious windows ( $U=0.14$ )
  - 4 in foam & 15 in cellulose
  - ICF foundation
- Two adult occupants



# TED House Energy Use

	<b>Total (kWh)</b>	<b>Boiler Elec Use (kWh)</b>	<b>Space Heating (MBtu)</b>	<b>Water Heating (MBtu)</b>	<b>Hot Water Use (gal/day)</b>	<b>Boiler Gas Use (therm)</b>
Dec-10	200	88	4,821	-	-	58
Jan-11	394	136	6,690	88	6	79
Feb-11	491	108	5,247	793	38	89
Mar-11	458	87	4,395	873	34	61
Apr-11	395	38	1,277	1,040	44	28
May-11	498	31	152	808	35	13
Jun-11	481	34	-	619	31	9
Jul-11	633	35	-	512	28	7
Aug-11	584	35	-	383	22	6
Sep-11	545	32	-	769	42	11
Oct-11	469	50	1,781	691	34	30
Nov-11	423	70	2,438	727	34	37
Dec-11	472	111	4,807	547	23	59
Jan-12	436	112	4,968	654	25	63
Feb-12	378	100	4,130	571	24	54
Mar-12	368	55	1,962	621	25	31
Apr-12	387	54	1,909	679	29	31
May-12	436	22	42	475	21	7
Jun-12	497	34	468	392	20	11
Jul-12	489	23	84	318	18	6
Aug-12	366	32	378	352	21	10
Sep-12	344	26	300	355	20	9
Oct-12	504	63	2,073	673	33	34
Nov-12	420	85	3,155	512	24	44
Dec-12	416	80	3,737	619	26	52
Jan-13	414	108	4,830	392	15	62
Annual 2011	5,842	763	26,586	7,847	31	408
Annual 2012	5,041	687	23,202	6,221	24	351

# TED - Actual Boiler Efficiency



# R-House

- Passive House design
  - ACH50 < 1
  - R70 Cellulose Walls
- 45 gallon HW tank
  - Bradford White CDW2TW50
  - Side circuit for Space Heating
- Zehnder HRV with fresh air distribution
- Additional electric heat was intended (but never installed)

space heating circuit on side of WH Tank



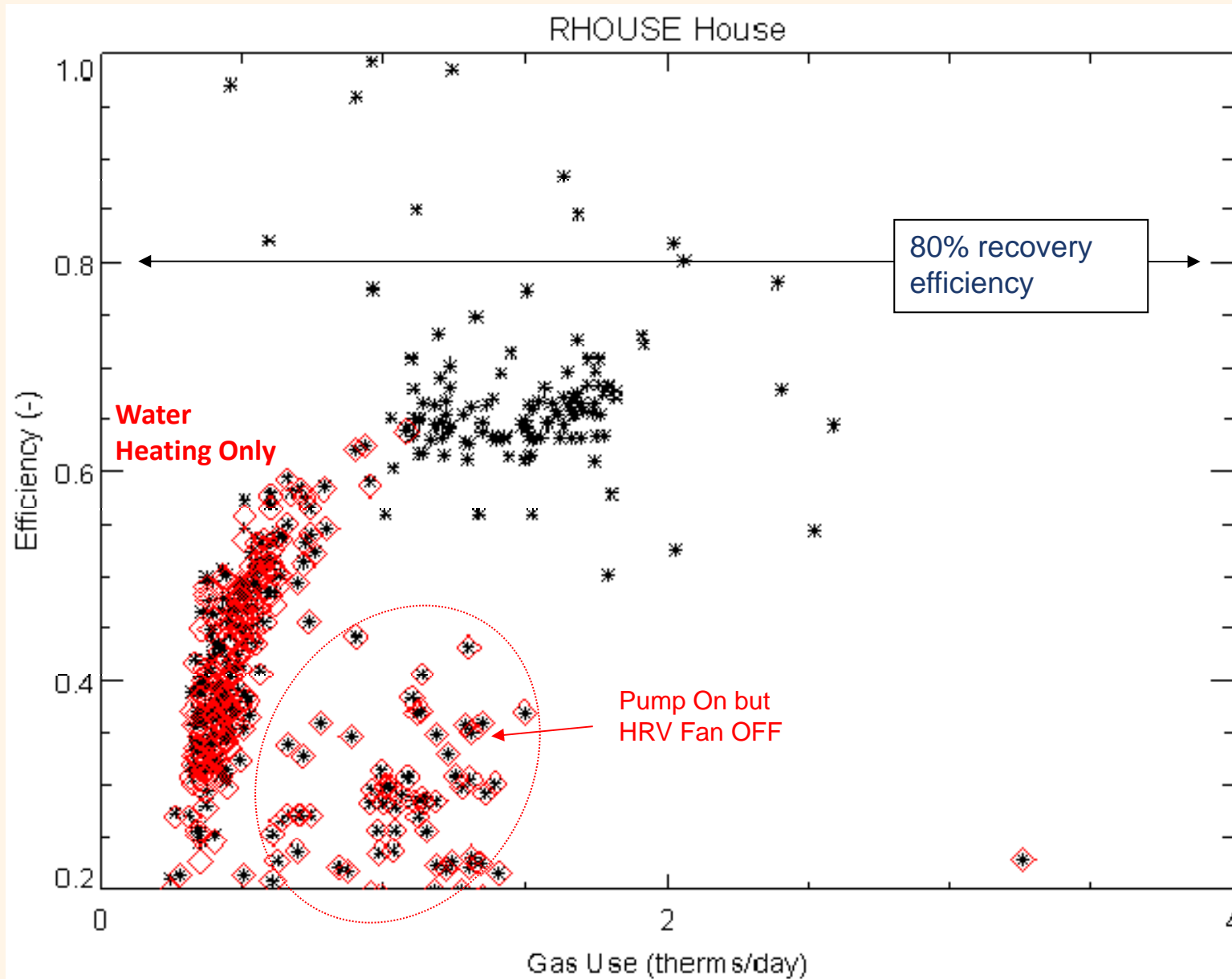
HW Coil for space heating (fresh air inlet)

# R-House Energy Use

	Total (kWh)	Boller System Use (kWh)	ERV Space Heating (MBtu)	Water Heating (MBtu)	Hot Water Use (gal/day)	Boller Gas Use (therms)	Heat Pump Use (kWh)
Nov-10	291	7	-	416	29	12	
Dec-10	718	41	-	701	45	29	
Jan-11	580	77	-	985	53	40	
Feb-11	493	58	1,588	1,129	58	45	
Mar-11	398	20	2,372	1,043	49	52	
Apr-11	328	19	1,721	828	44	38	
May-11	230	16	2,134	735	39	41	
Jun-11	212	11	2,381	539	36	27	
Jul-11	357	9	967	432	37	19	
Aug-11	378	7	8	472	35	13	
Sep-11	301	7	14	520	37	13	
Oct-11	288	11	15	521	33	13	
Nov-11	298	52	1	884	40	15	
Dec-11	447	73	8	851	43	18	
Jan-12	589	48	1,570	1,213	58	32	
Feb-12	322	18	2,199	1,465	74	49	0
Mar-12	400	10	1,027	1,683	76	63	71
Apr-12	332	18	1,850	1,489	77	50	17
May-12	488	16	708	1,158	69	28	159
Jun-12	418	7	3	898	49	13	154
Jul-12	429	5	1	398	32	9	193
Aug-12	409	5	2	352	30	8	186
Sep-12	391	6	9	471	36	10	141
Oct-12	297	9	1,473	628	42	18	45
Nov-12	371	15	1,940	735	46	22	34
Dec-12	505	47	1,093	577	32	29	52
Jan-13	517	44	2,287	934	45	38	68
Feb-13	362	47	2,085	935	49	35	26
Annual 2011	4,283	357	11,204	8,736	41	333	-
Annual 2012	4,917	236	14,177	9,921	49	309	1,146

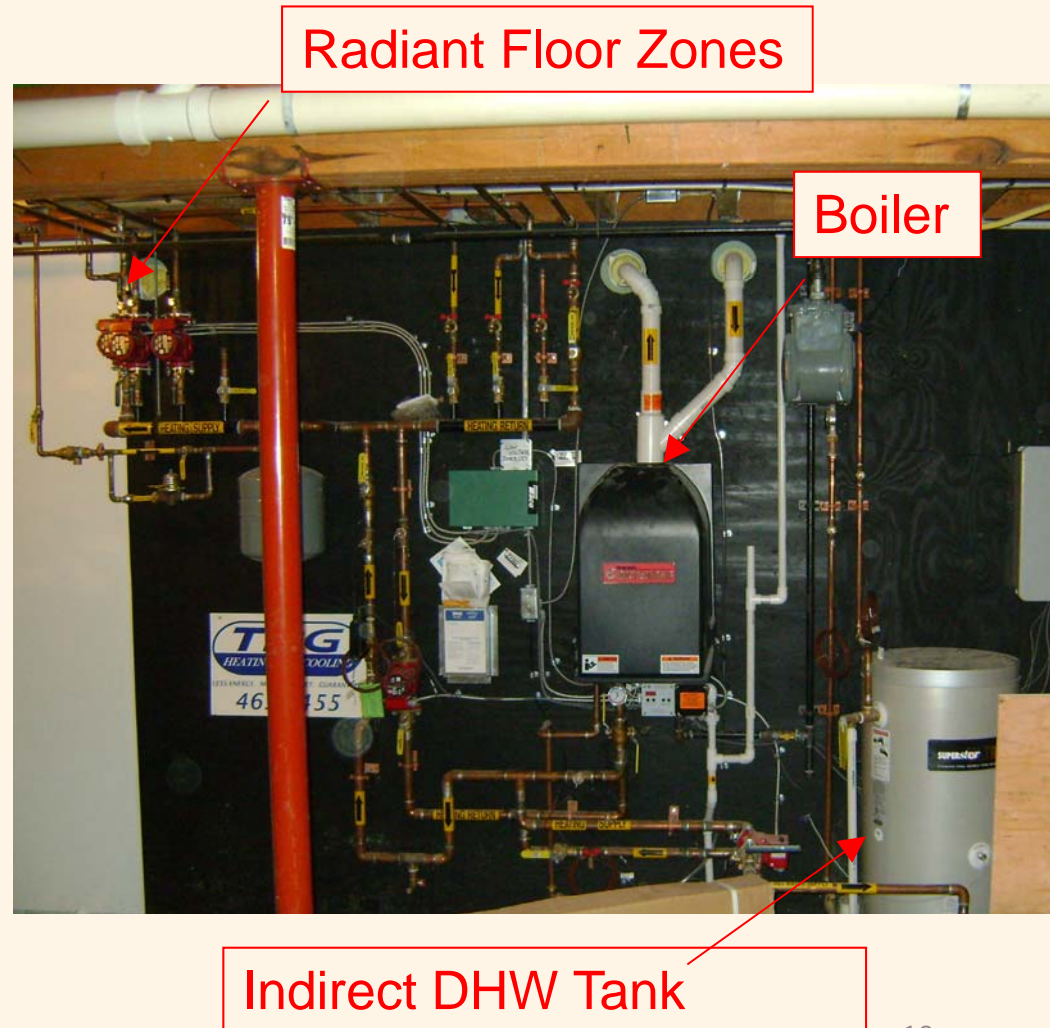


# R-House - Actual Efficiency



# LiveWork House

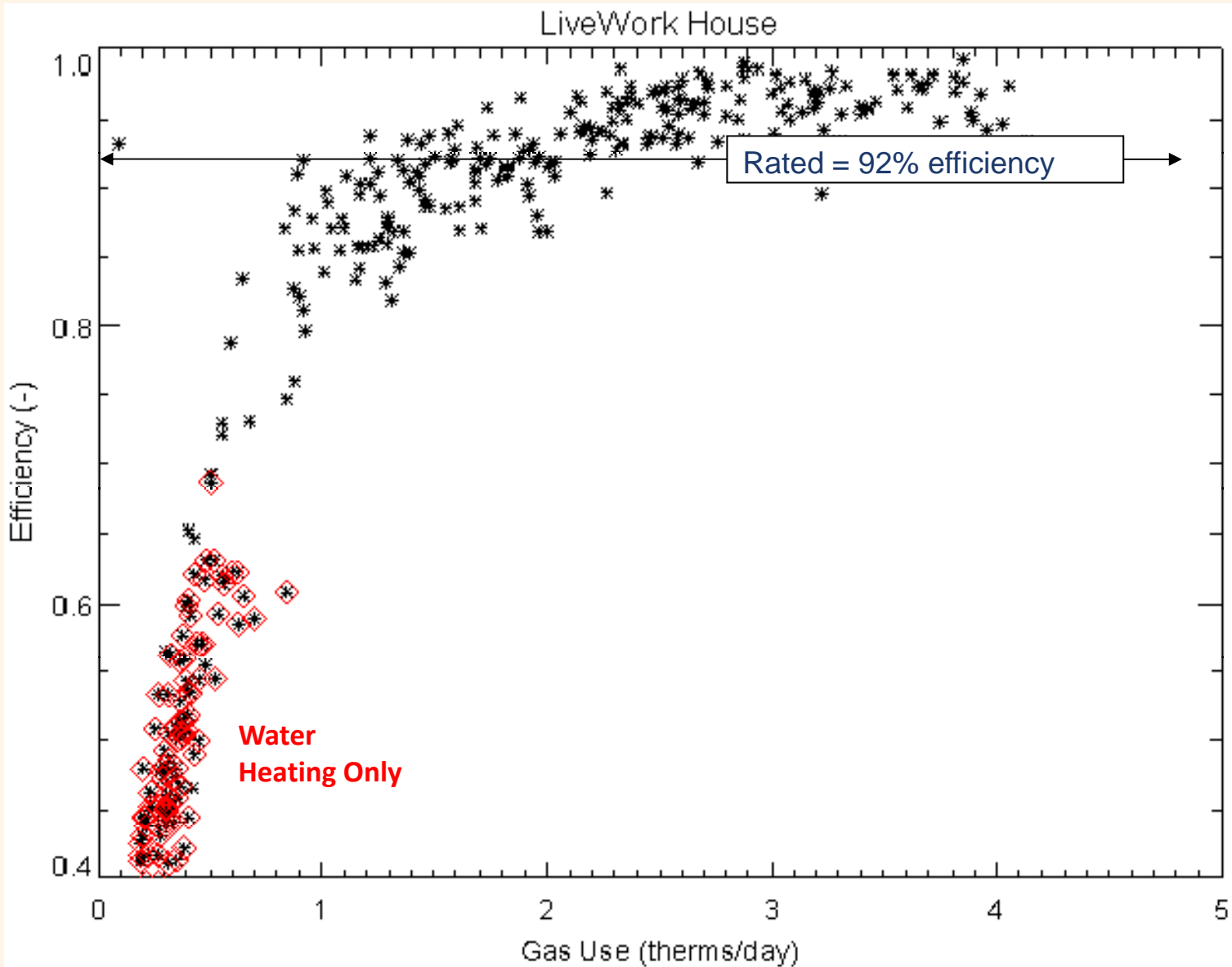
- Energy Efficient House Design
  - Stress skin panels
  - ICF basement
  - HRV
- Wall-Hung Boiler
  - Muchkin Contender (MC-80)
  - 3 radiant floor zones
  - Indirect water heating



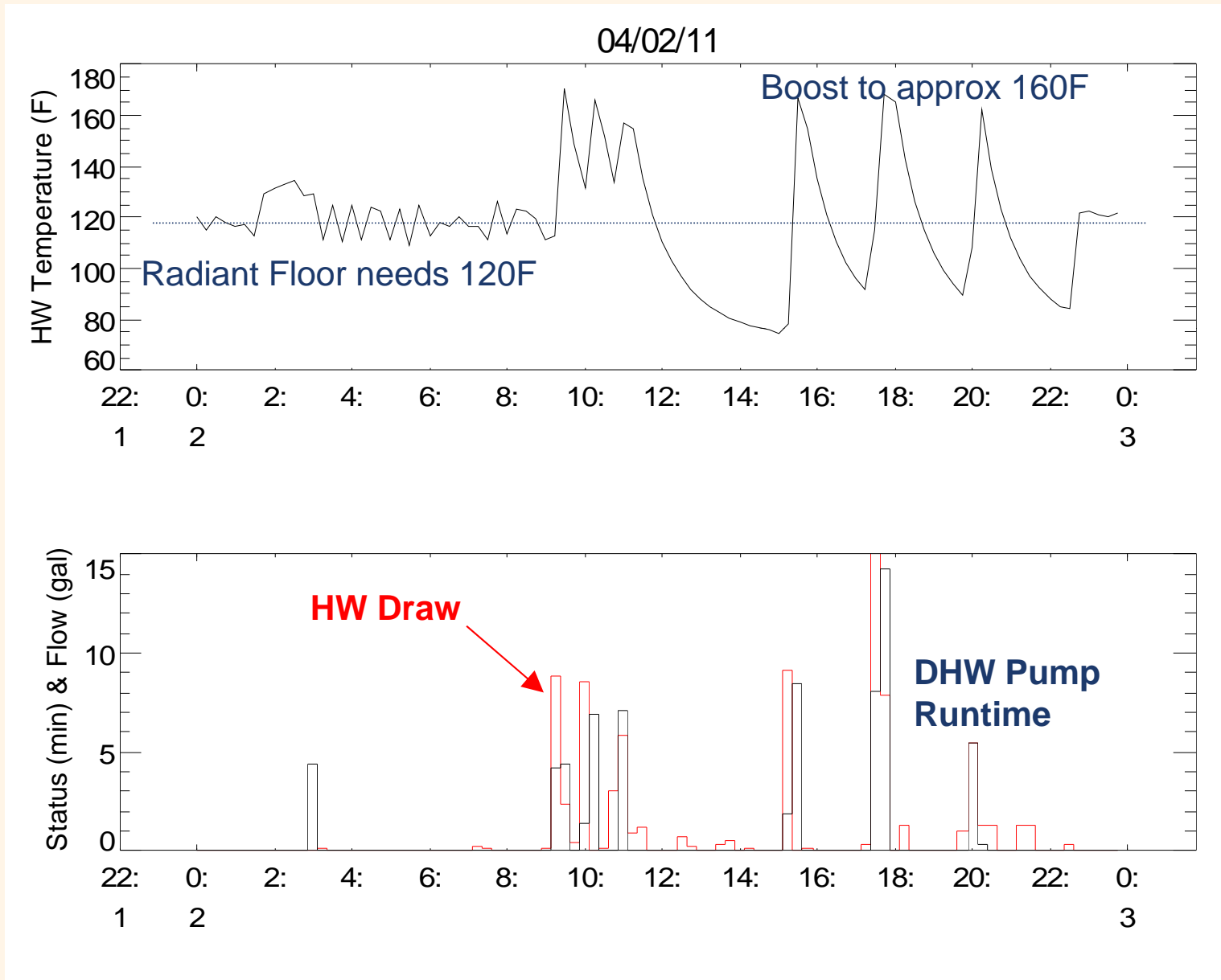
# LiveWork Energy Use

	Total (kWh)	Boiler Electric Use (kWh)	Space Heating (MBtu)	Water Heating (MBtu)	Hot Water Use (gal/day)	Boiler Gas Use (therms)
Dec-10	597	295	9,245	-	-	104
Jan-11	676	230	8,581	584	28	97
Feb-11	624	191	7,463	539	29	84
Mar-11	648	155	5,814	493	24	67
Apr-11	579	85	2,958	505	29	40
May-11	534	28	738	444	24	17
Jun-11	637	17	-	455	29	10
Jul-11	1,009	18	-	434	29	9
Aug-11	740	18	-	381	28	9
Sep-11	644	19	65	374	26	9
Oct-11	622	67	2,931	379	24	38
Nov-11	631	78	3,424	470	28	43
Dec-11	711	149	6,539	453	24	73
Jan-12	752	153	7,105	638	31	82
Feb-12	615	141	6,113	517	27	70
Mar-12	619	88	3,418	624	31	45
Apr-12	704	88	2,890	520	27	39
May-12	674	24	318	549	29	14
Jun-12	757	17	-	378	24	9
Jul-12	821	18	-	394	27	9
Aug-12	593	18	-	312	23	8
Sep-12	520	20	199	377	27	11
Oct-12	577	50	2,085	377	24	29
Nov-12	651	127	5,930	472	27	67
Dec-12	635	126	5,751	347	19	64
Jan-13	805	180	7,119	458	24	79
Feb-13	768	133	6,113	545	30	70
Annual 2011	8,056	1,035	38,511	5,530	26.5	494
Annual 2012	7,918	867	33,787	5,502	26.3	446

# LiveWork - Actual Efficiency



# Temperature Boost Logic - LiveWork



# Comparing Measured Space & DHW Loads

	Hot Water Use (gal/day)		
	R-House	LiveWork House	Ted House
Nov-10	29		
Dec-10	45	-	-
Jan-11	53	28	6
Feb-11	58	29	38
Mar-11	49	24	34
Apr-11	44	29	44
May-11	39	24	35
Jun-11	38	29	31
Jul-11	31	29	28
Aug-11	35	28	22
Sep-11	37	28	42
Oct-11	33	24	34
Nov-11	40	28	34
Dec-11	43	24	23
Jan-12	58	31	25
Feb-12	74	27	24
Mar-12	76	31	25
Apr-12	77	27	29
May-12	69	29	21
Jun-12	49	24	20
Jul-12	32	27	18
Aug-12	30	23	21
Sep-12	38	27	20
Oct-12	42	24	33
Nov-12	48	24	24
Dec-12	32	30	26
Annual 2011	41	27	31
Annual 2012	52	27	24

	Space Heating Load (MBtu)		
	R-House	LiveWork House	Ted House
Nov-10	-		
Dec-10	-	9,245	4,621
Jan-11	-	8,581	6,690
Feb-11	1,588	7,463	5,247
Mar-11	2,372	5,814	4,395
Apr-11	1,721	2,958	1,277
May-11	2,134	738	152
Jun-11	2,381	-	-
Jul-11	967	-	-
Aug-11	6	-	-
Sep-11	14	65	-
Oct-11	15	2,931	1,781
Nov-11	1	3,424	2,438
Dec-11	6	6,539	4,607
Jan-12	1,570	7,105	4,966
Feb-12	2,199	6,113	4,130
Mar-12	1,927	3,418	1,962
Apr-12	1,850	2,890	1,909
May-12	708	316	42
Jun-12	3	-	468
Jul-12	1	-	84
Aug-12	2	-	378
Sep-12	9	199	300
Oct-12	1,473	2,065	2,073
Nov-12	1,940	7,119	3,155
Dec-12	1,893	6,113	3,737
Annual 2011	11,204	38,511	26,586
Annual 2012	13,574	35,338	23,202

# Rated vs Actual Efficiency

House	Rated Efficiency	DHW-Only Efficiency	Overall or Actual Efficiency	Peak Efficiency
R-House (low eff DHW Tank)	80%	30-60%	60%	~70%
LiveWork House (wall-hung boiler / indirect tank)	92%	40-60%	89%	97%
Ted House (wall-hung boiler / tankless DHW)	96.5%	60-75%	84%	90%

- All systems lower than rated
- DHW efficiency typically lower than space heating efficiency
- Efficiency sensitive to DHW temperatures (TED = 150° F) and DHW Usage

## FTGU Combi Summary

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- Space heating
  - All under 25 Btu per square foot per year
  - Peak loads from 10 to 20 MBtu/h at 0° F
- Hot water use ranged from 24 to 52 gal/day

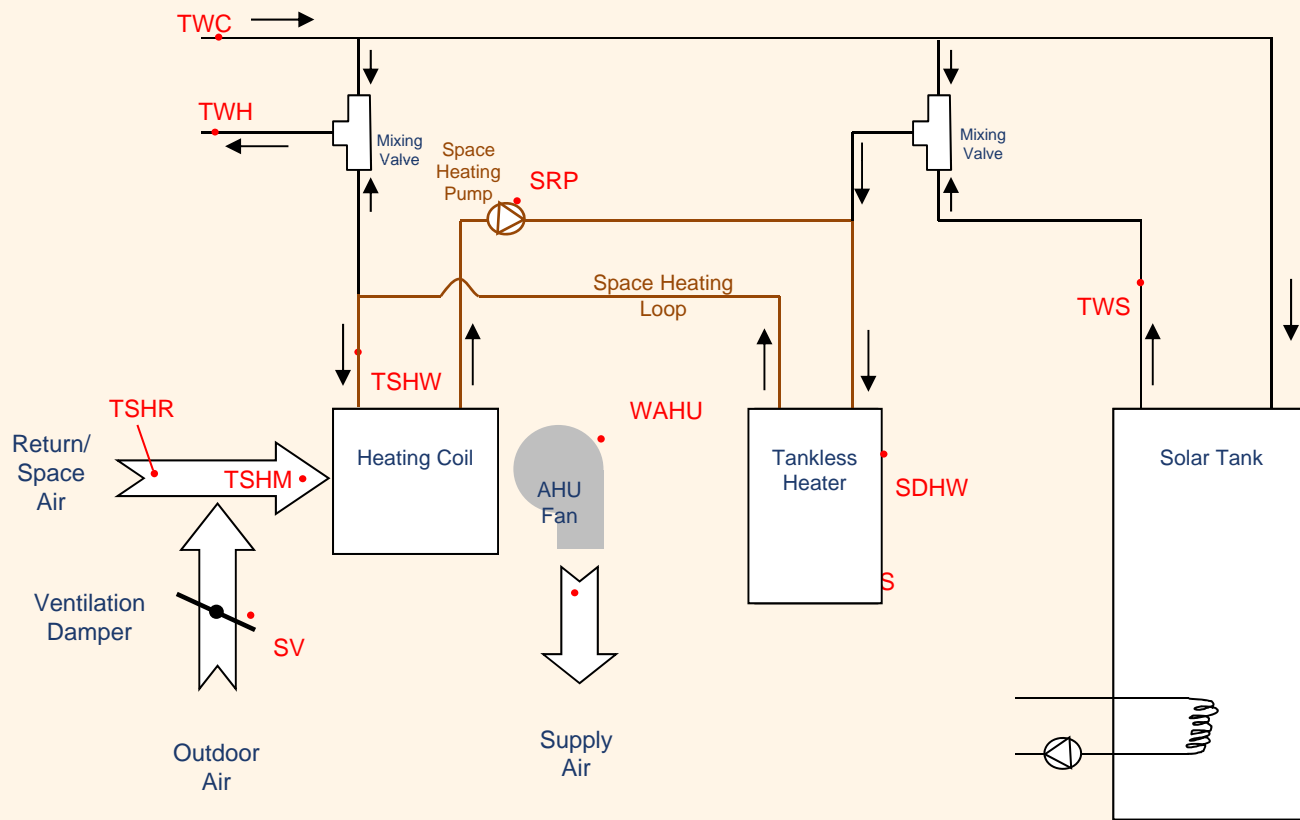


## The “Other” Kind of Combi

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- Use same “Potable” for space heating
- Issues (or fears) with Codes in some places (e.g., City of Syracuse)
- Reduces system cost and complexity (no HX)
- Health and corrosion must be managed
- ....Focus of other speakers

# Solar Combi System - using Potable Water Liverpool, NY



# Solar Combi System had Several Issues



- Space heating coil in AHU too small... so water temperature very high (170-180° F)
- Solar can not contribute to space heating loads (only DHW)
- Many components ... plumbers dream, homeowners nightmare

# Overall Lessons

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- Space heating and DHW loads are NOW comparable ... makes sense to use one appliance
  - Better combined efficiency
  - Lower installed costs
- Still need to get several issues right
  - Keep temperatures low
  - Limit DHW standby losses
  - Need simple controls and simple system arrangement