Test and modification of ELFOPack system

Introduction

With multifunction aeraulic heat pump system working, the ELFOPack unit can provide for all the comfort functions of the house, including heating, cooling, DHW production, dehumidification, controlled mechanical ventilation and air purification. ELFOPack unit was tested under a variety of operating conditions to characterize the heating and cooling capacities. The purpose was to test the capabilities of the existing ELFOPack System and identify specific areas that need modification for it to satisfy the performance requirements of NYSERDA.

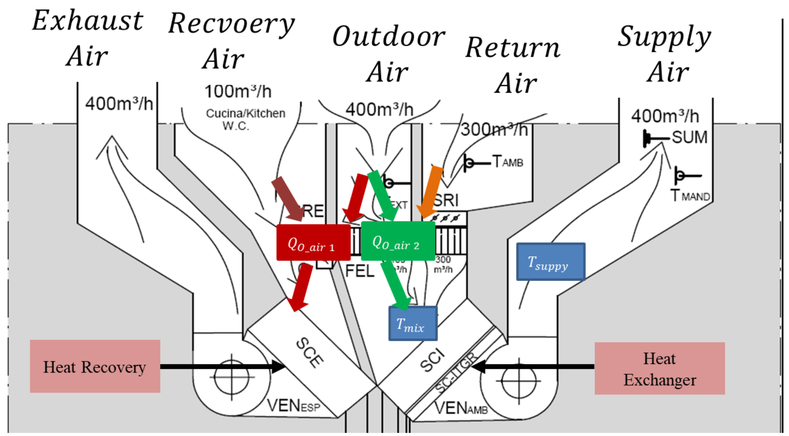
Functions

Requirements of NYSERDA

Table 4: Heating and Cooling Loads by Climate Zone

Loads		Cooling		Heating	
Zone	HDD	Btu/hr per 1000 ft2	tons/1000 ft2	Btu/hr per 1000 ft2	tons/1000 ft2
4	5200	2470	0.21	5930	0.5
5	5400	2250	0.19	5640	0.5
	7200	2190	0.18	6800	0.6
6	7200	1820	0.15	5980	0.5
	9000	690	0.06	6780	0.6

Heating/Cooling capacity



Comparison of performance

Measurement→	External temperature	°C	0	5	10	15	20
	Heating capacity	W	3165.0	2509.6	2055.8	1510.1	691.4
	DHW heating capacity	W	90.7	42.1	332.3	537.5	185.8
	Ventilation capacity	W	615.9	105.3	73.4	29.1	31.9
	Transmission capacity	W	2458.3	2362.2	1506.9	943.5	473.6
	Absorbed power	W	612	523.2	481.2	312	84
	COP		5.17	4.80	4.50	4.84	8.23
	Room supply temperature	°C	36.4	37.4	35.9	33	31.8

Measurement→ Requirement ↓

Performance

External Air Temperature	℃	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Heating capacity	W	2713	2560	2407	2254	2130	2006	1882	1790	1698	1607	1446	1285	1362	1201	1041	290
DHW heating capacity	W	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290	290
Ventilation heating capacity	W	643	600	557	515	472	429	386	343	300	257	214	172	129	86	43	0
Transmission heating capacity	W	1780	1670	1560	1450	1368	1287	1206	1157	1108	1059	942	824	943	826	708	0
Absorbed power	W	869	796	722	649	605	561	517	471	425	379	330	280	371	322	272	80
Thermodynamic COP		3,12	3,22	3,33	3,47	3,52	3,58	3,64	3,80	4,00	4,24	4,39	4,58	3,67	3,73	3,82	3,63
Room supply temperature	℃	36	35	34	33	32	31	30	28	27	26	25	24	23	22	21	20

Measurement→	External temperature	°C	27	28	29	30	31	32
	Cooling capacity	W	79.4	200.7	557.1	808.7	958.2	1157.0
	Ventilation capacity	W	2.2	49.9	75.8	132.0	157.8	168.8
	DHW heating capacity	W	290	290	290	290	290	290
	Transmission capacity	W	77.1	150.8	481.3	676.7	800.4	988.2
	Absorbed power	W	77	152	255.4	329.6	409.4	511.8
	COP		3.7	3.2	3.3	3.3	3.0	2.8
	Room supply temperature	°C	24.6	24.8	22.3	22.3	21.3	19.5

Measurement→ Requirement ↓

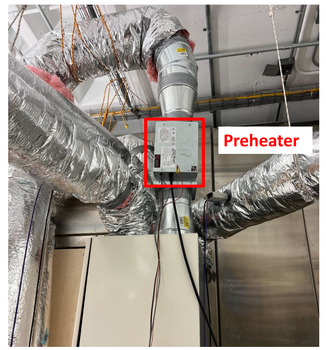
Performance

External Air Temperature	℃	27	28	29	30	31	32	33	34	35
Cooling capacity	W	0	268	536	804	1073	1341	1609	1877	2145
DHW heating capacity	W	290	290	290	290	290	290	290	290	290
Ventilation cooling capacity	W	0	30	59	89	118	148	177	207	236
Transmission cooling capacity	W	0	239	477	716	955	1193	1432	1671	1909
Absorbed power	W	80	166	257	352	444	542	652	779	964
Total thermodynamic efficiency		3,63	3,36	3,22	3,11	3,07	3,01	2,91	2,78	2,53
Room supply temperature	℃	27	26	24	22	21	20	19	18	17

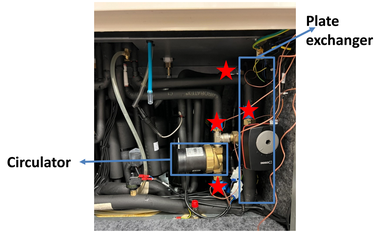
Modification with preheater

Measurement

External temperature	℃	- 12	- 10	- 8	- 6	- 4	- 2
Heating capacity	W	3321	3239	3142	3250	3251	3262
Recovery capacity	W	24.1	96.7	41.0	17.3	5.9	19.9
Ventilation capacity	W	704.3	675.4	670.8	663.2	668.7	672.7
Transmission capacity	W	2592.9	2466.8	2430.2	2569.7	2578.4	2569.3
ELFOPack power	W	517.6	511.0	505.6	516.6	534.3	536.2
Preheater power	W	468.0	446.6	421.8	336.3	201.3	87.1
COP		3.37	3.38	3.39	3.81	4.42	5.23
Room supply temperature	°C	37.64	37.61	36.82	37.83	37.77	37.78

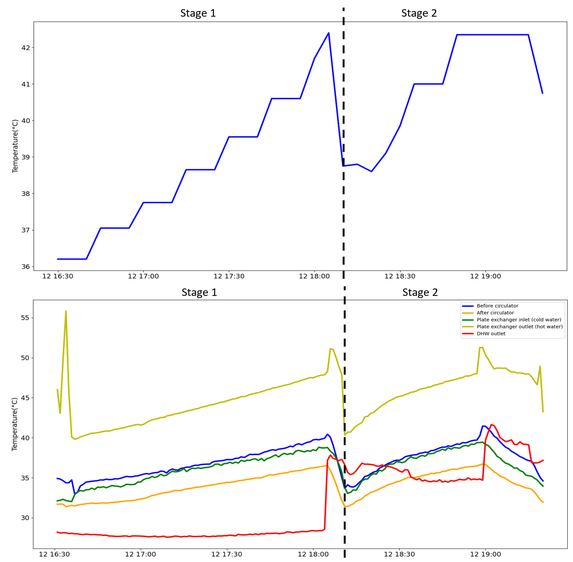


Domestic hot water test



Measurement

Outdoor temperature	℃	0	- 5	- 10
Stage 1 heating capacity	W	2642	2870	2841
Recovery capacity	W	187	322	296
DHW heat input	W	1147	619	818
Absorbed power *	W	584	873	1109
COP		4.52	3.29	2.71
Stage 2 heating capacity	W	2862	3042	3252
Recovery capacity	W	144	134	109
DHW heat input	W	1210	758	1300
Absorbed power *	W	603	1002	1234
COP		4.75	3.04	2.63



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NEW YORK STATE OF OPPORTUNITY. NYSERDA

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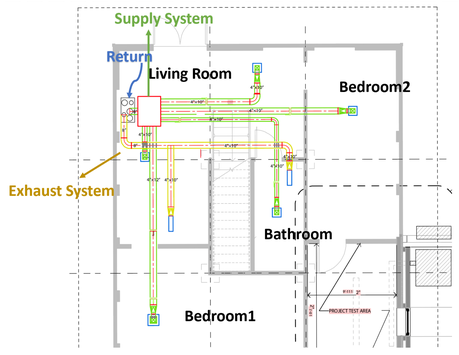
Design and implement occupancy-based control for ELFOPack system

Introduction

Space heating accounted for 38% of energy delivered in buildings, much more than any other end-use. Meanwhile, electricity used for space cooling by residential sectors was about 10% of total US electricity consumption. With energy-saving and sustainability demands, we need optimal control for the HVAC systems in residential buildings. The potential for energy saving through occupancy control of ventilation and hot water system varies from 5% to 20% based on previous studies. The purpose was to test the potential energy efficiency in residential buildings equipped ELFOPack with an occupancy sensor in NYS.

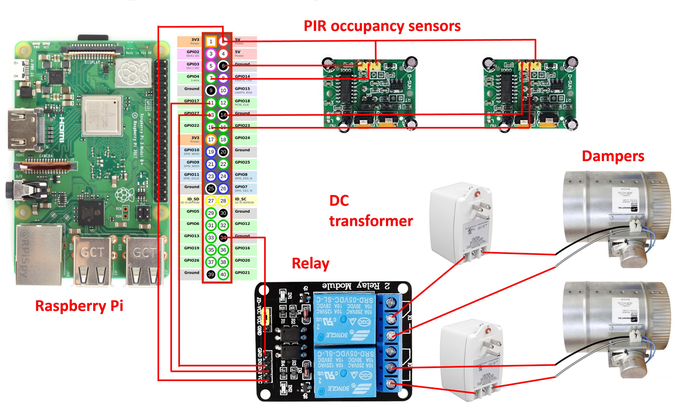
Lab testing

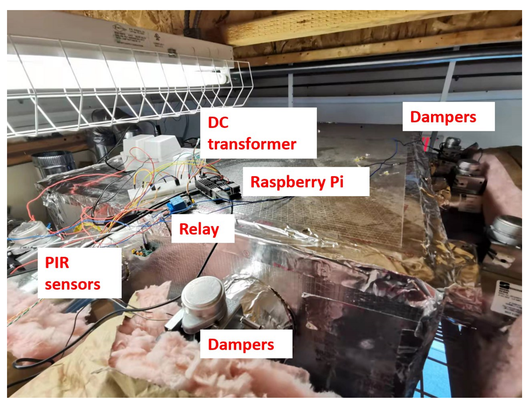
BEST Lab



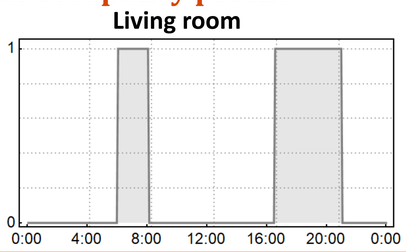
Floor plan

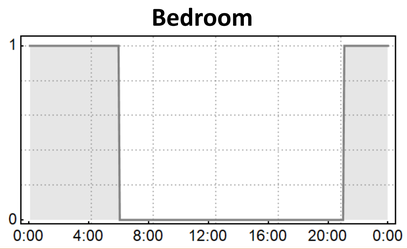
Damper control system



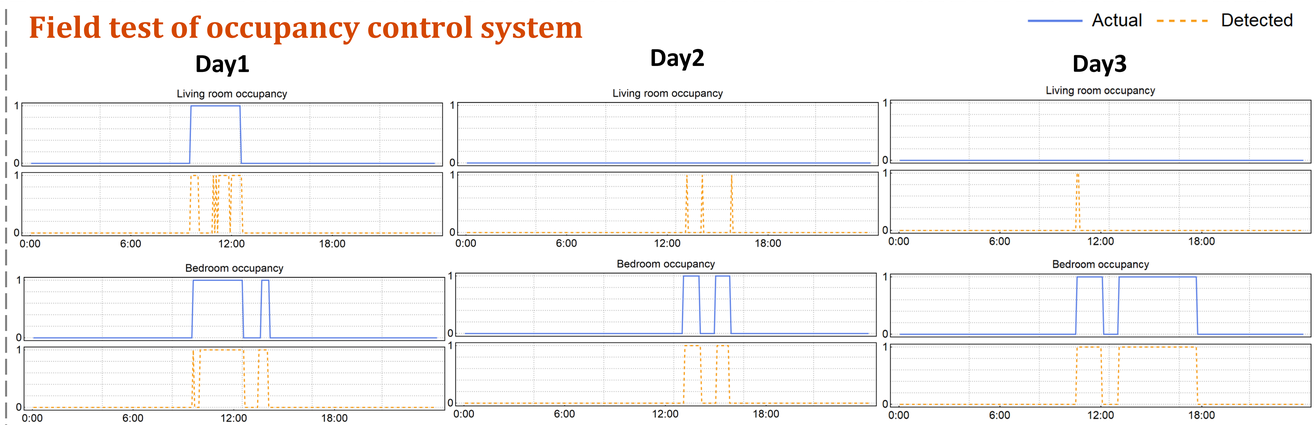


Typical occupancy profile



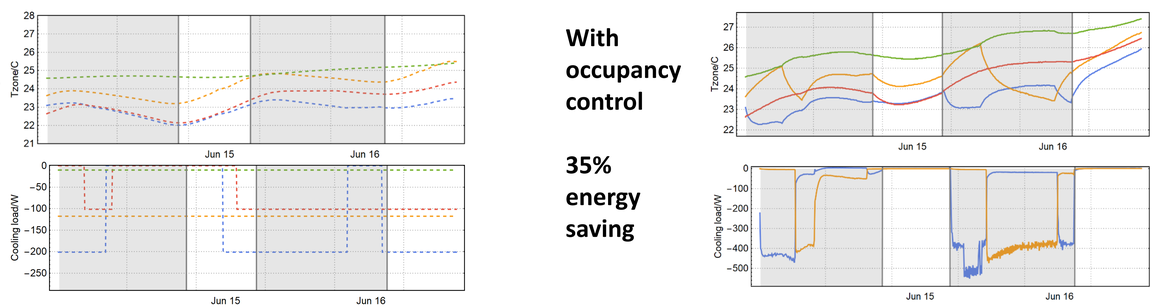


Field test of occupancy control system



		Actual	
		Unoccupied	Occupied
Detected	Unoccupied	966	10
	Occupied	22	154

Energy saving of occupancy control system



Cost-effective analysis

- Payback period is about 0.25 year in Syracuse when assuming $0.08/kWh

Sensors	Cost/$
Relay switch	6.8
PIR occupancy sensor	10*2
Converter	9.6
Raspberry Pi	128
Damper	12*4
Total	212.4

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