Modeling HVAC Systems in HOT3000

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Modification to the ESP-r Configuration File

In order to specify that there is an HVAC system associated with the problem, the configuration file has to include the entry ***hvac ../hvac/hvacfilename.hvac**. Figure 2 shows a section of a configuration with the addition associated with the HVAC file.

```
* CONFIGURATION3.0
# ESRU system configuration defined by file
# bld basic.cfg
*date Thu Dec 14 13:28:08 2000 # latest file modification
*root bld basic
*zonpth ../zones
                                  # path to zones
*netpth ../networks
                                 # path to networks
*ctlpth ../ctl
                                 # path to controls
*radpth ./
                                # path to radiance files
*imgpth ../images
                                 # path to project images
*indx 1 # Building only
51.700 -0.500 # Latitude & Longitude (diff from meridian)
    2 0.200 # Site exposure & ground reflectivity
* DATABASES
*prm /usr/esru/esp-r/databases/constr.db2
*mlc /usr/esru/esp-r/databases/multicon.db2
*opt /usr/esru/esp-r/databases/optics.db2
*prs /usr/esru/esp-r/databases/pressc.db1
*evn /usr/esru/esp-r/databases/profiles.db1
*clm /usr/esru/esp-r/climate/clm67
*pdb /usr/esru/esp-r/databases/plantc.db1
*hvac ../hvac/hvacfilename.hvac
*ctl ../ctl/bld basic.ctl
*year 1967 # assessment year
```

Specification of HVAC file in ESP-r configuration file

Furnace/Boiler System

```
a 1 0.
b 1 1 2
c 7 2 1 1. 2 0. 2000. 0.75 1 300 0. 500. 1
```

Figure 1: Sample ESP-r HVAC file for furnace/boiler system simulation

Table 1: Variables in HVAC file for furnace/boiler system simulation

Data	Field	Description	.hvac	Case	Туре	Comments
Row			file value			
А	1	Number of HVAC systems	1		Integer	
	2	Site altitude	0.		Real	
В	1	HVAC system type	1	Furnace	Integer	Beginning of furnace/boiler data
			2	Boiler		
	2	System priority	1	Primary	Integer	Priority is set to 2 when system is backup
	3	Number of zones served by HVAC system			Integer	File in Figure 1 has two zones
С	1	Furnace type	1	Advanced air tight wood	Integer	Not all furnace types work with each of the fuel
			2	converter		- For electric furnaces, the
			3	Flame retention		valid furnace type numbers is 12
			4	Flue vent damper	-	the valid furnace type numbers are 5,6,7,8, and
			5	Spark ignition	-	10 - For oil furnaces, the
			6	Spark ignition and		numbers are 3,4,8,9,11, and 14
			7	Continuous	-	- For propane furnaces,
				pilot	_	numbers are 5.6.7.8 and
			8	Condensing	_	10
			9	Direct vent		- For wood furnaces, the
				condensing		valid furnace type
			10	Induced draft	-	numbers are 1,2, and 13
			11	Mid	-	
				efficiency		
			12	Electric		
				forced air	_	
			13	Wood		
			14	furnace	4	
			14	or Boiler		
	2	Fuel type	1	Flectric	Integer	Make sure the correct
	2	i doi type	2	Natural gas		combinations listed above
			3	Oil	1	for fuel types and furnace
			4	Propane	1	types are satisfied

			5	Wood		
	3	Number of first zone			Integer	This is the number in the ESP-r cfg file associated with zone
	4	Fraction of equipment capacity to first zone	0.5		Real	Not used now but value needed
	5	Number of second zone			Integer	Only needed when there are two zones
	6	Fraction of equipment capacity to second zone	0.5		Real	Not used now but value needed
						Only needed when there are two zones
						Continue after this entry with zone numbers and fractions if number of zones is more than 2. Use value for fraction of 0.5
-	7	Equipment capacity			Real	In Watts
	8	Steady-state efficiency			Real	
	9	Circulation fan mode	1	Auto	Integer	
			2	Continuous		
			0	No fan		
	10	Circulation fan power			Real	If < 0, power is estimated internally If the fan is in continuous mode, fan power need to be included as internal gain in the ESP-r opr file
	11	Draft fan power			Real	In Watts
						This is > 0 only for induced draft and condensing furnaces/ boilers. If not known, 75 W is ok
						For furnaces/boilers other than condensing and induced draft, enter 0
	12	Pilot energy			Real	In Watts
\vdash	12	Dent met an C	1		Tutos	It not known, 500 W is ok
	15	Duct system flag			Integer	needed
						End of furnace/boiler data

Baseboard System

```
      a
      1 0.

      b
      3 1 2

      c
      1 1. 2 0. 2000 0.75 1 300
```

Figure 2: Sample ESP-r HVAC file for baseboard system simulation

Table 2: Variables in ESP-r HVAC file for baseboard system simulation

Data Row	Field	Description	.hvac file	Case	Туре	Comments
			value			
A	1	Number of HVAC systems	1		Integer	
	2	Site altitude	0.		Real	
В	1	HVAC system type	3		Integer	Beginning of baseboard system data
	2	System priority	1	Primary	Integer	Priority is set to 2 when system is backup
	3	Number of zones served by HVAC system			Integer	File in Figure 2 has two zones
С	1	Number of first zone			Integer	This is the number in the ESP-r cfg file associated with zone
	2	Fraction of equipment capacity to first zone	0.5		Real	Not used now but value needed
	3	Number of second zone			Integer	Only needed when there are two zones
	4	Fraction of equipment capacity to second zone	0.5		Real	Not used now but value needed
						Only needed when there are two zones
						Continue after this entry with zone numbers and fractions if number of zones is more than 2. Use
	5	Equipment capacity			Real	In Watts
	6	Steady-state efficiency			Real	This is 1 for electric baseboard
	7	Circulation fan mode	1	Auto	Integer	
			2	Continuous	1	
			0	No fan	1	

8	Circulation fan power		Real	In Watts
				If < 0, power is estimated internally
				If the fan is in continuous mode, fan power need to be included as internal gain in the ESP-r opr file
				End of Baseboard system data

Heat Pump System (Heating Mode) with Furnace/Boiler Backup

```
а
      2 0.
b
      1 2 2
С
      7 2 1 0.6 2 0.4 2000. 0.75 1 300 0. 500. 1
d
      7
        1 2
е
      1 1 1 0.6 2 0.4
f
      1000. 3.
      1. 1.5 1 1 300. 400. 300. 1 -1
g
h
      1 0. 1 1
```

Figure 3: Sample ESP-r HVAC file for HP/furnace system simulation

Table 3: Variables in ESP-r HVAC file for HP/furnace system simulation

Data Row	Field	Description	.hvac file	Case	Туре	Comments
110 11			value			
А	1	Number of HVAC	2			Figure 3 is for a furnace
	2	Site altitude	0.		Real	
В	1	HVAC system type	1	Furnace	Integer	Beginning of
		5 51	2	Boiler	Ũ	furnace/boiler data
	2	System priority	2	Backup	Integer	Priority is set to 1 when system is primary
						Always list backup
						system data before HP
						data
	3	Number of zones served by HVAC system			Integer	File in Figure 3 has two zones
С	1	Furnace/boiler type	1	Advanced air	Integer	Not all furnace types
				tight wood		work with each of the
			2	Catalytic		fuel types.
				converter		- For electric furnaces,
			3	Flame		the valid furnace type
				retention		numbers is 12
			4	head		- For natural gas
			4	Flue vent		furnace type numbers
			5	Sport		are 5.6.7.8 and 10
			3	Spark		- For oil furnaces the
			6	Spark		valid furnace type
			0	ignition and		numbers are 3,4,8,9,11,
				vent damper		and 14
			7	Continuous	_	- For propane furnaces,
				pilot		the valid furnace type
			8	Condensing		numbers are 5,6,7,8,
			9	Direct vent		and 10
				non		- For wood furnaces,
				condensing		the valid furnace type
			10	Induced draft	1	numbers are 1,2, and 13
			11	Mid		
				efficiency	4	
			12	Electric		
				forced air	1	

		13	Wood		
			furnace		
		14	Oil Furnace		
			or Boiler		
2	Furnace/boiler fuel type	1	Electric	Integer	Make sure the correct
		2	Natural gas		combinations listed
		3	Oil		above for fuel types and
		4	Propane	-	furnace types are
		5	Wood	_	satisfied
3	Number of first zone	5	1100 u	Integer	This is the number in
5	i tumber of mist zone			integer	the ESP-r cfg file
					associated with zone
1	Eraction of equipment	0.5		Peol	Not used now but
4	capacity to first zone	0.5		Kear	valued needed
5	Number of second zone			Integer	Only needed when
3	Number of second zone			Integer	there are true period
6		0.5		D 1	there are two zones
6	Fraction of equipment	0.5		Real	Not used now but value
	capacity to second zone				needed
					Only needed when
					there are two zones
					Continue after this
					entry with zone
					numbers and fractions
					if number of zones is
					more than 2. Use value
					for fraction of 0.5
7	Furnace/boiler heating			Real	In Watts
	capacity				
8	Furnace/boiler steady-			Real	
	state efficiency				
9	Circulation fan mode	1	Auto	Integer	
		2	Continuous		
		0	No fan	_	
10	Circulation fan power	Ū	110 1011	Real	In Watts
10					
					If < 0 power is
					estimated internally
					estimated internativ
					If the fan is in
					continuous mode fan
					nower need to be
					included as internal
					menuded as internal
					gain in the ESP-r opr
11	Europea / heilen dur A. C			Deel	
11	Furnace/boiler draft fan			Keal	In watts
	power				
					This is > 0 only for
					induced draft and
					condensing furnaces/
					Boilers. If not known,
					75 W is ok
					For furnaces/boilers
					other than condensing
					and induced draft, enter
					0

	12	Furnace/boiler pilot			Real	In Watts
		energy				TA 1 500 TV
						If not known, 500 W is
	12	Duat quatam flag	1		Integer	OK Not used new but velue
	15	Duct system hag	1		Integer	Not used now but value
						neeueu
						End of furnace/boiler
						data
D	1	HVAC system type	7	ASHP	Integer	Beginning of HP
			8	GSHP		heating mode data
			9	GCEP		
	2	System priority	1	Primary	Integer	Primary system
	3	Number of zones served	2		Integer	File in Figure 3 has two
		by HVAC system				zones
Е	1	Unit function	1		Integer	Heating function as
	-		1	A CLUD	.	opposed to cooling
	2	Heat pump type	1	ASHP	Integer	
			2	A SHR Good		
			2	ASHF 0000		
			3	ASHP Poor	-	
			4	GCEP		
	3	Number of first zone		UCEI	Integer	This is the number in
	5				integer	the ESP-r cfg file
						associated with zone
	4	Fraction of equipment	0.5		Real	Not used now but value
		capacity to first zone				needed
	5	Number of second zone			Integer	Only needed when
						there are two zones
	6	Fraction of equipment	0.5		Real	Not used now but value
		capacity to second zone				needed
						Only needed when
						there are two zones
						Continue after this
						entry with zone
						numbers and fractions
						if number of zones is
						more than 2. Use value
f	1	UD haating consists			Pool	Ior fraction of 0.5
1	2	Heating mode COP			Real	
σ	1	Flow rate			Real	If < 0 value is set
Б	1	110 W 1000			icoui	internally
	2	Flow rate at rating	-1.		Real	If < 0 , value is set
		conditions				internally
	3	Circulation fan mode	1	Auto	Integer	Same mode as that for
			2	Continuous	1	backup system
			0	No fan	1	
	4	Circulation fan position	1	Blow through	Integer	Currently not used but
		1	2	Draw through	1	value needed

	5	Total circulation fan			Real	In Watts
		power				
						If power < 0 , value is
						estimated internally
						If the fen is in
						n ule fail is ill
						nower need to be
						included as internal
						gain in the ESP-r opr
						file
						If $\mathbf{r} = \mathbf{r} + \mathbf{r} + \mathbf{r}$
						value for primary and
						secondary system
	6	Outdoor fan power			Real	This is the fan for the
		1				outdoor evaporator of
						the heat pump
						Not used for ashn in
						heating but value
						needed
	7	Fan power associated			Real	Not used for ashp in
		with auto mode				heating mode. Value
						still needed.
	8	Position of circulation	1	Blow through	Integer	Currently not used but
	-	fan during rating test	2	Draw through	D 1	value needed
	9	Power of circulation fan			Real	In Watts
		during rating test				If nower < 0 value is
						estimated internally
						2
						Not used but value
1	-			D 1 1		needed
h	1	Temperature control	1	Balanced	Integer	
			2	Restricted		
			2	Uprestricted		
	2	Cutoff temperature	5	Onestreted	Real	In ^o C
	3	Type of backup system	1	Furnace	Integer	m c
			2	Boiler		
			3	Baseboards		
	4	0 / 1	5	Dascooalds	T /	TE1 : : .1
	4	System number			Integer	I his is the system
		system				file associated with
		system				backup system
						Backup system data has
						to be listed before HP
						uata III IIvat IIIt
						End of HP heating
						mode data

Heat Pump System (Heating Mode) with Baseboard Backup

```
      a
      2 0.

      b
      3 1 2

      c
      1 1. 2 0. 2000 0.75 1 300

      d
      7 1 2

      e
      1 1 1 0.6 2 0.4

      f
      1000. 3.

      g
      1. 1.5 1 1 300. 400. 300. 1 -1

      h
      1 0. 1 1
```

Figure 4: Sample ESP-r HVAC file for HP/baseboard system simulation

Table 4: Variables in ESP-r HVAC file for HP/baseboard system simulation

Data Row	Field	Description	.hvac file	Case	Туре	Comments
			value			
А	1	Number of HVAC	2			Figure 4 is for a
		systems				baseboard backup
	2	Site altitude	0.		Real	
В	1	HVAC system type	3		Integer	Beginning of baseboard system data
	2	System priority	2	Backup	Integer	Priority is set to 1 when system is primary
						Always list backup system data before HP data
	3	Number of zones served by HVAC system			Integer	File in Figure 4 has two zones
С	1	Number of first zone			Integer	This is the number in the ESP-r cfg file associated with zone
	2	Fraction of equipment capacity to first zone	0.5		Real	Not used now but value needed
	3	Number of second zone			Integer	Only needed when there are two zones
	4	Fraction of equipment capacity to second zone	0.5		Real	Not used now but value needed
						Only needed when there are two zones
						Continue after this entry with zone numbers and fractions if number of zones is more than 2. Use value for fraction of 0.5
	5	Equipment capacity			Real	In Watts
	6	Steady-state efficiency			Real	This is 1 for electric baseboard
	7	Circulation fan mode	1	Auto	Integer	
			2	Continuous		
			0	No fan	1	

	8	Circulation fan power			Real	In Watts
						If < 0 , power is
						estimated internally
						If the fan is in
						continuous mode fan
						power need to be
						included as internal
						gain in the ESP-r opr
						file
						End of begaboard
						system data
d	1	HVAC system type	7	ASHP	Integer	Beginning of HP
	-		8	GSHP	8	heating mode data
			9	GCEP		
	2	System priority	1	Primary	Integer	Primary system
	3	Number of zones served	2		Integer	File in Figure 4 has two
		by HVAC system				zones
e	1	Unit function	1		Integer	Heating function as
			1	A CHID	T /	opposed to cooling
	2	Heat pump type	1	ASHP	Integer	
			2	A SHP Good	-	
			2	ASHP Poor	-	
			4	GSHP or		
				GCEP		
	3	Number of first zone			Integer	This is the number in
						the ESP-r cfg file
						associated with zone
	4	Fraction of equipment	0.5		Real	Not used now but value
	5	Number of second zone			Integer	Only needed when
	5	Number of second zone			Integer	there are two zones
	6	Fraction of equipment	0.5		Real	Not used now but value
		capacity to second zone				needed
						Only needed when
						there are two zones
						Continue after this
						entry with zone
						numbers and fractions
						if number of zones is
						more than 2. Use value
£	1	IID hasting consulty			Deel	for fraction of 0.5
1	2	Heating mode COP			Real	III watts
g	1	Flow rate	+		Real	If < 0, value is set
Ð						internally
	2	Flow rate at rating	-1.		Real	If < 0 , value is set
		conditions				internally
	3	Circulation fan mode	1	Auto	Integer	Same mode as that for
			2	Continuous		backup system
			0	No fan		
	4	Circulation fan position	1	Blow through	Integer	Currently not used but
			2	Draw through		value needed

	-					
	5	Total circulation fan			Real	In Watts
		power				
						If power < 0 , value is
						estimated internally
						If the fan is in
						continuous mode fan
						power need to be
						included as internal
						gain in the ESP-r opr
						file
						If power > 0 , use same
						value for primary and
						secondary system
	6	Outdoor fan power			Real	This is the outdoor fan
						for the evaporator
	7	Fan power associated			Real	Not used for ashp in
		with auto mode				heating mode but value
	-					needed
	8	Position of circulation	1	Blow through	Integer	Currently not used but
	0	fan during rating test	2	Draw through	D 1	value needed
	9	Power of circulation fan			Real	In Watts
		during rating test				If now < 0 , volve is
						If power < 0 , value is
						estimated internativ
						Not used but value
						needed
h	1	Temperature control	1	Balanced	Integer	
		1		Point	C C	
			2	Restricted		
			3	Unrestricted		
	2	Cutoff temperature			Real	In °C
	3	Type of backup system	1	Furnace	Integer	
			2	Boiler		
			3	Baseboards		
	4	System number	5	Buscoourus	Integer	This is the system
	4	system number			Integer	number in HVAC input
		system				file associated with
		system				hackup system
						Suckup System
						Backup system data has
						to be listed before HP
						data in hvac file
						End of HP heating
			1			mode data

Heat Pump System (Cooling Mode)

This is also used to model an air-conditioner

1 0. а 7 1 2 b 2 1 1 0.6 2 0.4 С 2000. 1.5 d 1. -1 1 1 300. 400. 300. 1 -1 е f 0.75 1 g 1 1 8760 h 24 0.25 Ι i 1 1

Figure 5: Sample ESP-r HVAC file for HP cooling mode system simulation

Data Row	Field	Description	.hvac file value	Case	Туре	Comments
a	1	Number of HVAC systems	1			
	2	Site altitude	0		Real	
b	1	HVAC system type	7	ASHP	Integer	Beginning of HP
			8	GSHP		cooling mode data
			9	GCEP		
	2	System priority	1	Primary	Integer	Primary system
	3	Number of zones served by HVAC system	2		Integer	File in Figure 5 has two zones
с	1	Unit function	2		Integer	Cooling as opposed to heating
	2	Heat pump type	1	ASHP Typical	Integer	
			2	ASHP Good		
			3	ASHP Poor		
			4	GSHP or GCEP		
	3	Number of first zone			Integer	This is the number in the ESP-r cfg file associated with zone
	4	Fraction of equipment capacity to first zone	0.5		Real	Not used now but value needed
	5	Number of second zone			Integer	Only needed when there are two zones
	6	Fraction of equipment capacity to second zone	0.5		Real	Not used now but value needed
						Only needed when
						there are two zones
						Continue after this
						entry with zone
						numbers and fractions
						if number of zones is
						more than 2. Use value
						for fraction of 0.5

Table 5: Variables in ESP-r HVAC file for HP cooling mode system simulation

d	1	HP cooling capacity			Real	In Watts
						Capacity does not include effect of circulation fan. This is then the total cooling capacity at the evaporator coil.
						This is capacity at ARI rating conditions (26.7 °C Tdb and 19.4 Twb °C)
	2	Cooling mode COP			Real	COP does not include effect of indoor circulation fan. It accounts for compressor power and power of outdoor fan. This is at ARI rating conditions (26.7 °C Tdb and 19.4 Twb °C)
e	1	Flow rate			Real	If < 0 , value is set internally
	2	Flow rate at rating conditions	-1.		Real	If < 0 , value is set internally
	3	Circulation fan mode	1 2 0	Auto Continuous No fan	Integer	
	4	Circulation fan position	1 2	Blow through	Integer	
	5	Total circulation fan power			Real	In Watts
						If power < 0, value is estimated internally
						If the fan is in continuous mode, fan power need to be included as internal gain in the ESP-r opr file
						If fan has one low continuous speed and one higher auto speed when the heat pump is on, enter fan power when heat pump is on here. In this case, fan operation is specified as auto. The fan power at low speed which is on continuously, needs to be specified as 100% convective
						internal gains in the operation file.

	6	Outdoor fan power			Real	This is the outdoor fan
						power associated with
						the condenser of the
	7	For norman according to dowith			Deel	unit In Wette
	/	ran power associated with			Real	in watts
		automode				If power < 0 value is
						estimated internally
						···· ,
						This entry is used to
						deal with fans with a
						low continuous speed
						when heat pump is off
						when heat nump is on
						when heat pump is on.
						This is equal to the
						total fan power (fan
						power at high speed)
						minus fan power at
						low speed.
						If the fan has a single
						speed, this entry is
						equal to the total fan
						fan specified under
	Q	Desition of circulation fan	1	Blow through	Integer	item 15.
	0	during rating test	2	Draw through	meger	
	9	Power of circulation fan	-	Dian unough	Real	In Watts
		during rating test				
						If power < 0, value is
						estimated internally
						Power of circulation
						fan at rating test can
						be different from
						actual fan power
C	1	0 11 1 4 4			D 1	installed
I	1	Sensible neat ratio			Keal	1 nis is capacity at ARI
						^o C Tdb and 19 4 Twb
						°C)
	2	Cooling type	1	Conventional	Integer	- /
			2	Economizer		
		Begin f.	2 = Convention	onal condition		
g	1	Number of outdoor air day			Integer	This is the number of
		types				different day types for
						the description of the
						through the duct
						system
h	1	Number of different			Integer	This is the number of
		periods in day type 1			0-	periods that make up
						day type 1

	2	Hour of the year for end of			Integer	This is a number out
		day type 1				of 8760. The hour
						indicates the hour of
						the year after which
						any type 1 is not valid
						anymore
						Repeat h1 and h2
						above as many times
						as there are day types
						in the outdoor air schedule. All of this
						data is entered on
						record h
i	1	End hour for period 1 for			Integer	This is an hour
		day type 1				number from 24. This
						is the hour after which
						is not valid anymore
	2	Outdoor air flow rate for			Real	In m ³ /s
	_	period 1 of day type 1				/ #
						Repeat entries i1 and
						i2 above as many
						times as there are
						All the data for day
						type 1 is entered on
						the same record
						D 1
						Repeat record 1 as
						are day types for the
						outdoor air schedule
		End of f.	2 = Conventi	onal condition		
	1	Begin f	2 = Economic	zer condition	T (
g	1	Economizer control type	1	Indoor/Outdo	Integer	
				integrated		
				compressor		
				control and		
				option of		
				outdoor dry-		
				bulb temp		
			2	Indoor/Outdo	1	
			-	or Temp non-		
				integrated		
				compressor		
				control and		
				option outdoor dry-		
				bulb temp		
				limit control		
			3	Enthalpy		
				integrated		
				compressor		
				control and enthalow limit		
				control		

			4	Enthalpy				
				non-				
				integrated				
				compressor				
				control and				
				control and				
				enthalpy limit				
				control				
		Beg	$\ln g l = l \text{ or } 2$	2 condition		2.		
g	2	Economizer minimum			Real	m ³ /s		
		outdoor air flow						
	3	Economizer indoor space			Real	°C		
		set point						
						This is the indoor		
						temperature set point		
						below which the		
						economizer is tuned		
						off		
	1	Economizer outdoor			Real	00C		
	-	temperature limit			ittai			
						This is the outdoor dry		
						buib temperature		
						above which the		
						economizer is turned		
						off		
End of $g1 = 1$ or 2 condition								
	Begin of $g1 = 3$ or 4 condition							
g	2	Economizer minimum			Real	m^3/s		
-		outdoor air flow						
	3	Economizer indoor space			Real	°C		
		set point						
		1				This is the indoor		
						temperature set point		
						below which the		
						economizer is tuned		
						off		
	4	Economizer outdoor			Deel			
	4	Economizer outdoor			Real	Ј/КВ		
		enthalpy limit control						
						This is the outdoor air		
						enthalpy above which		
						the economizer is		
						turned off		
		End	of $g1 = 3$ or	4 condition				
		End f2	2 = Economiz	zer condition				
j or h	1	System number for heating	1		Integer	This is not used when		
-		mode			L L	heat pump is only used		
						in cooling mode but		
						need to enter value		
	2	Control function number			Integer	This is the control		
	-	for cooling mode			integer	function number in		
						FSD r ot filo		
						associated with heat		
						pump operation in		
						cooling mode		
						End of HP cooling		
						mode data		

Heat Pump System (Heating/Cooling Mode) with Furnace Backup

This is also the same when modeling an HP in heating mode with a furnace backup and a HP in cooling mode. If the HP in the heating mode has a baseboard system as backup, replace furnace data with baseboard data from Table 2.

```
3 0.
а
      1 2 2
b
      7 2 1 0.6 2 0.4 2000. 0.75 1 300 0. 500. 1
С
      7 1 2
d
      1 1 1 0.6 2 0.4
е
f
      1000. 3.
      1. 1.5 1 1 300. 400. 300. 1 -1
g
      1 0. 1 1
h
i
      7 1 2
j
      2 1 1 0.6 2 0.4
k
      2000. 1.5
      1. -1 1 1 300. 400. 300. 1 -1
1
      0.75 1
m
      1
n
0
      1 8760
      24 0.25
р
      1 1
q
```

Figure 6: Sample ESP-r HVAC file for HP (heating/cooling mode) with furnace backup simulation

Table 6: Variables in ESP-r HVAC file for ASHP (heating/cooling)(Air Source Heat Pump), GSHP (Ground Source Heat Pump) or GCEP (Ground Coupling Ecole Polytechnique) with furnace backup system simulation

Data	Field	Description	.hvac file	Case	Туре	Comments
Row			value			
а	1	Number of HVAC	3			
		systems				
	2	Site altitude	0.		Real	
b	1	HVAC system type	1	Furnace	Integer	Beginning of furnace/boiler
			2	Boiler		data
	2	System priority	2	Backup	Integer	Priority is set to 1 when system is primary
						Always list backup system data before HP data
	3	Number of zones served by HVAC system			Integer	File in Figure 6 has two zones
с	1	Furnace/boiler type	1	Advanced air tight wood	Integer	Not all furnace types work with each of the fuel types.
			2	Catalytic		- For electric furnaces, the valid furnace type numbers is
			3	Flame retention		12 - For natural gas furnaces, the

		4	Flue vent		valid furnace type numbers
			damper		are 5,6,7,8, and 10
		5	Spark ignition		- For oil furnaces, the valid
		6	Spark ignition		furnace type numbers are
			and vent		3,4,8,9,11, and 14
		_	damper		- For propane turnaces, the
		7	Continuous		valid furnace type numbers
		-	pilot		Erry wood formasses the
		8	Condensing		- For wood furnaces, the
		9	Direct vent non		are 1.2 and 13
		10	condensing	-	are 1,2, and 15
		10	Induced draft	-	
		11	Mid efficiency	-	
		12	Electric forced		
		10	air		
		13	Wood furnace	-	
		14	Oil Furnace or		
			Boiler		
2	Furnace/boiler fuel type	1	Electric	Integer	Make sure the correct
		2	Natural gas	-	combinations listed above for
		3	Oil		fuel types and furnace types
		4	Propane		are satisfied
		5	Wood		
3	Number of first zone			Integer	This is the number in the ESP r of a file associated with
					zone
4	Fraction of equipment	0.5		Real	Not used now but value
	capacity to first zone				needed
5	Number of second zone			Integer	Only needed when there are two zones
6	Fraction of equipment	0.5		Real	Not used now but value
	capacity to second zone				needed
					Only needed when there are
					two zones
					Continue after this entry with
					zone numbers and fractions if
					number of zones is more than
					$2. \cup$ se value for fraction of 0.5
7	Furnace/hoiler heating			Real	U.J In Watts
1	canacity			iccai	III Walls
8	Furnace/boiler steady-			Real	
0	state efficiency			1.001	
9	Circulation fan mode	1	Auto	Integer	
		2	Continuous		
		0	No fan	1	
10	Circulation fan power			Real	In Watts
	1				
					If < 0 , power is estimated
					internally
					If the fan is in continuous
					mode, fan power need to be
				1	
					included as internal gain in

	11	Furnace/boiler draft fan			Real	In Watts
		power				
						This is > 0 only for induced
						draft and condensing
						furnaces/boilers. If not
						known, 75 W is ok
						For furnaces/boilers other
						than condensing and induced
	10	D'1 /			D 1	draft, enter 0
	12	Pilot energy			Real	In watts
						If not known 500 W is ok
	13	Duct system flag	1		Integer	Not used now but value
	10		-			needed
						End of furnace/boiler system
_						data
d	1	HVAC system type	7	ASHP	Integer	Beginning of HP heating
			8	GSHP		mode data
	2	Crustom unionites	9	GCEP	Interen	Deize organizatione
	2	Number of zones	1	Philliary	Integer	Fille in Figure 6 has two
	5	served by HVAC			meger	zones
		system				201105
е	1	Unit function	1		Integer	Heating as opposed to
					Ũ	cooling
	2	Heat pump type	1	ASHP Typical	Integer	
			2	ASHP Good		
			3	ASHP Poor		
			4	GSHP or GCEP		
	3	Number of first zone			Integer	This is the number in the
						ESP-r crg file associated with
	4	Fraction of equipment	0.5		Real	Not used now but value
		capacity to first zone	0.5		iteui	needed
	5	Number of second zone			Integer	Only needed when there are
					-	two zones
	6	Fraction of equipment	0.5		Real	Not used now but value
		capacity to second zone				needed
						Only we deduct on theme and
						two zones
						Continue after this entry with
						zone numbers and fractions if
						number of zones is more than
						2. Use value for fraction of
6	1				D 1	0.5
t	1	HP heating capacity			Real	In Watts
σ	2 1	Flow rate			Real	If < 0 value is set internally
B	2	Flow rate at rating	_1		Real	11 > 0, value is set internally If < 0 value is set internally
	2	conditions	-1.		iteat	11 × 0, value is set internally
	3	Circulation fan mode	1	Auto	Integer	Same mode as that for
			2	Continuous		backup system
			0	No fan		
	4	Circulation fan position	1	Blow through	Integer	Currently not used but value

			2	Draw through		needed
	5	Circulation fan power			Real	In Watts
						If power < 0, value is
						estimated internally
						If the fan is in continuous
						mode, fan power need to be
						included as internal gain in
						the ESP-r opr file
						If power > 0 , use same value
						system
	6	Outdoor fan power			Real	This is the fan for the outdoor
		1				evaporator of the heat pump
						Not used for ashp in heating
	7	Ten norman eres isted			D1	but value needed
	/	with auto mode			Real	heating mode but value
		with auto mode				needed
	8	Position of circulation	1	Blow through	Integer	Currently not used but value
		fan during rating test	2	Draw through		needed
	9	Power of circulation fan			Real	In Watts
		during rating test				
						If power < 0 , value is
						estimated internativ
						Not used but value needed
h	1	Temperature control	1	Balanced Point	Integer	
			2	Restricted		
		~ ~ ~	3	Unrestricted		
	2	Cutoff temperature			Real	ln °C
	3	Type of backup system	1	Furnace	Integer	
			2	Boiler		
	4	System number	3	Baseboards	Integer	This is the system number in
	4	associated with backup			Integer	HVAC input file associated
		system				with backup system
						Backup system data has to be
						listed before HP data in hvac
						file
						End of HP heating mode data
i	1	HVAC system type	7	ASHP	Integer	Beginning of HP cooling
			8	GSHP	8	mode data
			9	GCEP	<u> </u>	
	2	System priority	1	Primary	Integer	Primary system
	3	Number of zones	2		Integer	File in Figure 6 has two
		served by HVAC				zones
	1	system	2		Interes	Cooling on annoad to
	1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		1	Integer	L DOUNG as Opposed to
J	1	Unit function	Z		8	heating
J	1 2	Unit function Heat pump type	2	ASHP Typical	Integer	heating
J	1 2	Unit function Heat pump type	2 1 2	ASHP Typical ASHP Good	Integer	heating

			4	CSUD or CCED		
	-		4	GSHP of GCEP	T .	ment i di ta di
	3	Number of first zone			Integer	This is the number in the
						ESP-r cfg file associated with
						zone
	4	Fraction of equipment	0.5		Real	Not used now but value
		capacity to first zone				needed
	5	Number of second zone			Integer	Only needed when there are
	C					two zones
	6	Fraction of equipment	0.5		Deal	Not used now but value
	0	appoint to second zone	0.5		Keal	not used now but value
		capacity to second zone				needed
						Only needed when there are
						two zones
						Continue after this entry with
						zone numbers and fractions if
						number of zones is more than
						2. Use value for fraction of
						0.5
k	1	HP cooling capacity			Real	In Watts
						Capacity does not include
						effect of circulation fan. This
						is the total capacity at the
						evaporator coil
						evaporator con
						This is canacity at ARI rating
						applicitions (26.7 °C Tdb and
						$10.4 \text{ True }^{\circ}$
	2				D 1	19.4 TWD C)
	2	Cooling mode COP			Real	COP does not include effect
						of indoor circulation fan. It
						includes compressor power
						and outdoor fan power.
						This is at ARI rating
						conditions (26.7 °C Tdb and
						19.4 Twb °C)
1	1	Flow rate			Real	If < 0 , value is set internally
	2	Flow rate at rating	-1		Real	If < 0 value is set internally
	-	conditions	1.		icoui	i o, value is set internally
	3	Circulation fan mode	1	Auto	Integer	
			2	Continuous	-	
			0	No fan	1	
	4	Circulation fan position	1	Blow through	Integer	
			2	Draw through		
	1	1	<i>–</i>	Liun unougn	1	

	5	Circulation fan power			Real	In Watts
						If power < 0, value is estimated internally
						If the fan is in continuous mode, fan power need to be included as internal gain in the ESP-r opr file
						If fan has one low continuous speed and one higher auto speed when the heat pump is on, enter fan power when heat pump is on here. In this case, fan operation is specified as auto. The fan power at low speed which is on continuously, needs to be specified as 100% convective internal gains in the operation file.
-	6	Outdoor fan power			Real	This is the outdoor fan power associated with the condenser of the unit
	7	Fan power associated with auto mode			Real	In Watts
		white date mode				If power < 0, value is estimated internally
						This entry is used to deal with fans with a low continuous speed when heat pump is off and a high auto speed when heat pump is on.
						This is equal to the total fan power (fan power at high speed) minus fan power at low speed.
						If the fan has a single speed, this entry is equal to the total fan fan specified under item 13.
	8	Position of circulation fan during rating test	1 2	Blow through Draw through	Integer	
F	9	Power of circulation fan			Real	In Watts
		during rating test				If power < 0, value is estimated internally
m	1	Sensible heat ratio			Real	This is capacity at ARI rating conditions (26.7 °C Tdb and 19.4 Twb °C)
ľ	2	Cooling type	1	Conventional	Integer	
		Beg	$\frac{2}{\sin m^2 = Con}$	Economizer	n	

n	1	Number of outdoor air day types			Integer	This is the number of different day types for the description of the outdoor air schedule through the duct
0	1	Number of different			Integer	This is the number of periods
	2	Hour of the year for end of day type 1			Integer	This is a number out of 8760. The hour indicates the hour of the year after which day type 1 is not valid anymore
					-	Repeat o1 and o2 above as many times as there are day types in the outdoor air schedule. All of this data is entered on record o
р	1	End hour for period 1 for day type 1			Integer	This is an hour number from 24. This is the hour after which period 1 for day type 1 is not valid anymore
	2	Outdoor air flow rate for period 1 of day type 1			Real	In m ³ /s Repeat entries p1 and p2 above as many times as there are periods in day type 1. All the data for day type 1 is entered on the same record
						Repeat record p as many times as there are day types for the outdoor air schedule
		Enc	$\frac{1 \text{ of } m2 = Co}{2}$	nventional condition	on	
n	1	Be Economizer control	$egin m^2 = Ec$	Indeer/Outdeer	1 Integer	This is a temperature based
n	1	type	1	Temp integrated compressor control and option of outdoor dry- bulb temp limit control	Integer	control with the compressor and the economizer running together to meet the load when the economizer can not meet the load by itself
			2	Indoor/Outdoor Temp non- integrated compressor control and option outdoor dry-bulb temp limit control		This is a temperature based control with the compressor and the economizer not allowed to run together to meet the load when the economizer can not meet the load by itself
			3	Enthalpy integrated compressor control and enthalpy limit control		This is an enthyalpy based control with the compressor and the economizer running together to meet the load when the economizer can not meet the load by itself

			4	Enthalpy non-		This is an enthalpy based
				integrated		control with the compressor
				compressor		and the economizer not
				control and		allowed to run together to
				enthalpy limit		meet the load when the
				control		economizer can not meet the
						load by itself
			Begin n1 =	1 or 2 condition		
n	2	Economizer minimum	<u> </u>		Real	m ³ /s
	_	outdoor air flow				
	3	Economizer indoor			Real	°C
	5	space set point			Ittui	e
		space set point				This is the indoor
						temperature set point below
						which the economizer is
						tuned off
	4	Easy and an anti-			Deal	
	4	temperature limit			Real	C
		temperature minit				This is the outdoor dry hulb
						temperature above which the
						economizer is turned off
			End of $n1 =$	1 or 2 condition		ceonomizer is turned on
		1	$\frac{1}{2} \frac{1}{2} \frac{1}$	-3 or 1 condition		
	2	Economizor minimum			Deel	m^3/c
11	2	autdoor air flow			Keal	III /S
	2				Deal	°C
	3	Economizer indoor			Real	C
		space set point				TT1 · · · 1
						I his is the indoor
						temperature set point below
						which the economizer is
						tuned off
	4	Economizer outdoor			Real	J/kg
		enthalpy limit control				
						This is the outdoor air
						enthalpy above which the
						economizer is turned off
			End of $n1 =$	3 or 4 condition		
		E	nd m2 = Ecc	nomizer condition		
q or o	5	System number for			Integer	This is the system number in
		heating mode				HVAC input file associated
						with HP in heating mode
	6	Control function			Integer	This is the control function
		number for cooling				number in ESP-r ctl file
		mode				associated with heat pump
						operation in cooling mode
						1
						End of HP cooling mode data