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APPENDICES

Appendix A Programming Model for Grass-Roots Design

```
$TITLE  HEN design- Automatic parameter calculation
$OFFUPPER
$ONTEXT
*****************************************************************************
$OFFTEXT
*****************************************************************************
*****************************************************************************
* INPUT SETS
*****************************************************************************
*****************************************************************************
SETS
 Z transfer zones       /Z1*Z2/
*_____________________________________________
*ALWAYS DEFINE THE HOT STREAMS FIRST, AND THEN THE COLD STREAMS
 I Hot streams          /I1*I3/
 J cold streams         /J1*J3/
*ALWAYS DEFINE THE UTILITIES WITH THE HIGHEST INDEX
 HU(I) Heating utilities /I3/
 CU(J) Cooling utilities /J3/
*_____________________________________________
 M temperature intervals /M1*M112/
 S SCENARIO             /S1/
 K exchangers per pair of stremas in each zone /K1*K1/
 FREEH(I)  HOT STREAMS INCLUDED IN THIS RUN /I1,I2,I3/
 FREEC(J)  COLD STREAMS INCLUDED IN THIS RUN /J1,J2,J3/
*****************************************************************************
*****************************************************************************
* INPUT PARAMETERS
*****************************************************************************
```

```
**************************************************************************
PARAMETERS
NIZ(S,Z,I) NUMBER OF INTERVALS DESIRED FOR HOT STREAMS IN EACH ZONE
/
S1.Z1.I1 32
S1.Z1.I2 16
S1.Z1.I3 6
/
NJZ(S,Z,J) NUMBER OF INTERVALS DESIRED FOR COLD STREAMS IN EACH ZONE
/
S1.Z1.J1 32
S1.Z1.J2 20
S1.Z1.J3 6
/
HI(S,I) HEAT TRANSFER COEFFICIENT FOR HOT STREAMS
/
S1.I1 0.2
S1.I2 0.2
S1.I3 0.2
/
HJ(S,J)  HEAT TRANSFER COEFFICIENT FOR COLD STREAMS
/
S1.J1 0.2
S1.J2 0.2
S1.J3 0.2
/
TIH(S,I) SUPPLY (INLET) TEMPERATURE FOR HOT STREAMS
/
S1.I1  175.0000
S1.I2  125.0000
S1.I3  180.0000
/
TOH(S,I) TARGET (FINAL) TEMPERATURE FOR HOT STREAMS
```

/

S1.I1 45.0000

S1.I2 65.0000

S1.I3 179.0000

/

TIC(S,J) SUPPLY (INLET) TEMPERATURE FOR COLD STREAMS

/

S1.J1 20.0000

S1.J2 40.0000

S1.J3 15.0000

/

TOC(S,J) TARGET (FINAL) TEMPERATURE FOR COLD STREAMS

/

S1.J1 155.0000

S1.J2 112.0000

S1.J3 25.0000

/

TIHZ(S,Z,I) SUPPLY (INLET) TEMPERATURE FOR HOT STREAMS IN EACH ZONE

/

S1.Z1.I1 175.0000

S1.Z1.I2 125.0000

S1.Z1.I3 180.0000

/

TOHZ(S,Z,I) TARGET (FINAL) TEMPERATURE FOR HOT STREAMS IN EACH ZONE

/

S1.Z1.I1 45.0000

S1.Z1.I2 65.0000

S1.Z1.I3 179.0000

/

TICZ(S,Z,J) SUPPLY (INLET) TEMPERATURE FOR COLD STREAMS IN EACH ZONE

/

S1.Z1.J1 20.0000

S1.Z1.J2 40.0000

S1.Z1.J3 15.0000

/

TOCZ(S.Z.J) TARGET (FINAL) TEMPERATURE FOR COLD STREAMS IN EACH ZONE

/

S1.Z1.J1 155.0000

S1.Z1.J2 112.0000

S1.Z1.J3 25.0000

/

FH(S.I) FCp (FLOW*Cp) FOR HOT STREAMS.

*USE THE MAXIMUM FCp FOR THE UTILITIES

/

S1.I1 10

S1.I2 40

S1.I3 605

/

FC(S,J) FCp (FLOW*Cp) FOR COLD STREAMS

*USE THE MAXIMUM FCp FOR THE UTILITIES

/

S1.J1 20

S1.J2 15

S1.J3 52.5

/

BIF(Z,I,J) ALLOW MORE THAN ONE EXCHANGER IN EACH ZONE

/

Z1.I1.J1 0

/

SPH(I) ALLOW SPLITTING FOR HOT STREAMS (SH in paper)

/

I1 1

I2 1

I3 1

/

SPC(J) ALLOW SPLITTING FOR COLD STREAMS (SC in paper)

```
/
J1      1
J2      1
J3      1
/
NIH(I)   NON ISOTHERMAL MIXING FOR HOT STREAMS
/
I1      0
/
NIC(J)   NON ISOTHERMAL MIXING FOR COLD STREAMS
/
J1      0
/
DTVIO(I,J)  SET TO ZERO IF TEMPERATURE FEASIBILITY CHECKING IS NOT NEEDED
* THAT IS, WHEN STREAM TEMPERATURES DO NOT OVERLAP.
/
I1.J1    1
I1.J2    1
I1.J3    1
I2.J1    1
I2.J2    1
I2.J3    1
I3.J1    1
I3.J2    1
/
KMAX(Z,I,J) MAXIMUM NUMBER OF EXCHANGERS PER MATCH WHEN ALLOWED (BIF=1)
/
Z1.I1.J1    1
/
DTHU(I)    TEMPERATURE CHANGE OF HOT UTILITY
/
I3      1
/
```

DTCU(J) TEMPERATURE CHANGE OF COLD UTILITY

/

J3 10

/

FMAX_HU(I) MAXIMUM FLOW OF HOT UTILITY

/

I3 605

/

FMAX_CU(J) MAXIMUM FLOW OF COLD UTILITY

/

J3 52.5

/

CHU(I) COST OF HOT UTILITY (PER UNIT FLOW)

/

I3 19.750

/

CCU(J) COST OF COLD UTILITY (PER UNIT FLOW)

/

J3 1.861

/

CF FIXED COST PER SHELL

/5291.9/

CA COST PER UNIT AREA

/77.788/

QLHMIN MINIMUM HEAT THAT CAN BE TRANSFERRED IN EACH HOT STREAM INTERVAL

/0.00/

QLCMIN MINIMUM HEAT THAT CAN BE TRANSFERRED IN EACH COLD STREAM INTERVAL

/0.00/

AMAX MAXIMUM AREA PER EXCHANGER

/20000/

ASHELLMAX MAXIMUM AREA PER SHELL

/5000/

TOTNEXCHMAX MAXIMUM NUMBER OF EXCHANGERS IN THE NETWORK (ALL ZONES)

```
/909/
TOTNEXCHMIN  MINIMUM NUMBER OF EXCHANGERS IN THE NETWORK (ALL ZONES)
/0/
DTMIN  MINUMUM APPROACH TEMPERATURE IN ALL MATCHES (HRAT)
/20/;
*-------------------------------------------------------------------------
*                    END OF INPUT PARAMETERS
*              START OF AUTOMATIC CALCULATION OF PARAMETERS
*-------------------------------------------------------------------------
 ALIAS (M,N,L,O)
 ALIAS (I,II)
 ALIAS (J,JJ)
 ALIAS (K,KK)
 ALIAS (Z,ZZ);

SCALARS Si, Zi, Mi, Ic, Ji

PARAMETERS IHminZ(S,Z,I),IHmaxZ(S,Z,I),IHmax(S,I),IHmin(S,I),
       HOT(S,I,M). HOT2(S,M). HOTZ(S,Z,I,M),ICminZ(S,Z,J),ICmaxZ(S,Z,J).
       ICmin(S,J),ICmax(S,J},COLD(S,J,M),COLD2(S,M), COLDZ(S,Z,J,M),
       H_I(S,I,M), H_J(S,J,M)
* WE FIRST CALCULATE THE STARTING INTERVALS FOR EACH STREAM FOR EACH
* SCENARIO IN EACH ZONE: IHminZ(S,Z,I)

FOR(Si=1 TO CARD(S),
  FOR(Zi=1 TO CARD(Z),
    FOR(Ic=1 TO CARD(I),
      IHminZ(S,Z,I)$[ORD(S)=Si AND ORD(I)=1 AND ORD(Z)=1]=
                                  0+ 1$[NIZ(S,Z,I)>=1];
      IHminZ(S,Z,I)$[ORD(S)=Si AND ORD(I)>1 AND ORD(Z)=1]=
       0+ {SUM((ZZ,II)$[ORD(II)<ORD(I)],NIZ(S,ZZ,II))+1}$[NIZ(S,Z,I)>=1];
      IHminZ(S,Z,I)$[ORD(S)=Si AND ORD(Z)>1]=
       0+ {SUM((ZZ,II)$[ORD(II)<ORD(I)],NIZ(S,ZZ,II))+
```

```
        SUM(ZZ$[ORD(ZZ)< Zi],NIZ(S,ZZ,I))+1}$[NIZ(S,Z,I)>=1];
    IHmaxZ(S,Z,I)$[ORD(S)=Si AND ORD(I)=Ic AND ORD(Z)=Zi]=
      0+ {IHminZ(S,Z,I)+NIZ(S,Z,I)-1}$[NIZ(S,Z,I)>=1];
    IHmin(S,I)$[ORD(S)=Si AND ORD(I)=Ic]=
      SUM[Z${SUM(ZZ$[ORD(ZZ)<=ORD(Z)-1],NIZ(S,ZZ,I))=0},IHminZ(S,Z,I)];
    IHmax(S,I)$[ORD(S)=Si AND ORD(I)=Ic]=
      SUM[Z${SUM(ZZ$[ORD(ZZ)>=ORD(Z)+1],NIZ(S,ZZ,I))=0},IHmaxZ(S,Z,I)];

    FOR(Mi=1 TO CARD(M),
      HOT(S,I,M)$[ORD(S)=Si AND ORD(I)=Ic AND ORD(M)=Mi]=
            0+ 1$[ORD(M)>= IHmin(S,I) AND ORD(M)<=IHmax(S,I)];
      HOT2(S,M)$[ORD(S)=Si AND ORD(M)=Mi]=
            0+ 1$[ORD(M)<= SUM(I$(ORD(I)=CARD(I)),IHmax(S,I))];
      HOTZ(S,Z,I,M)$[ORD(S)=Si AND ORD(I)=Ic AND ORD(M)=Mi
                                AND ORD(Z)=Zi]=
          0+ 1$[ORD(M)>= IHminZ(S,Z,I) AND ORD(M)<=IHmaxZ(S,Z,I)];
      H_I(S,I,M)$[ORD(S)=Si AND ORD(I)=Ic AND ORD(M)=Mi
                          AND HOT(S,I,M)=1] = HI(S,I) ;
    ));
  FOR(Ji=1 TO CARD(J),
    ICminZ(S,Z,J)$[ORD(S)=Si AND ORD(J)=1AND ORD(Z)=1]=
      0+ {SUM(I$[ORD(I)=CARD(I)],IHmax(S,I))+1}$[NJZ(S,Z,J)>=1];
    ICminZ(S,Z,J)$[ORD(S)=Si AND ORD(J)>1AND ORD(Z)=1]=
      0+ {SUM(I$[ORD(I)=CARD(I)],IHmax(S,I)}
       +SUM((ZZ,JJ)$[ORD(JJ)<ORD(J)],NJZ(S,ZZ,JJ))+1}$[NJZ(S,Z,J)>=1];
    ICminZ(S,Z,J)$[ORD(S)=Si AND ORD(Z)>1]=
      0+ {SUM(I$[ORD(I)=CARD(I)],IHmax(S,I)}
       + SUM((ZZ,JJ)$[ORD(JJ)<ORD(J)],NJZ(S,ZZ,JJ))
       + SUM(ZZ$[ORD(ZZ)< Zi],NJZ(S,ZZ,J))+1}$[NJZ(S,Z,J)>=1];
    ICmaxZ(S,Z,J)$[ORD(S)=Si AND ORD(J)=Ji AND ORD(Z)=Zi]=
      0+ {ICminZ(S,Z,J)+NJZ(S,Z,J)-1}$[NJZ(S,Z,J)>=1];
    ICmin(S,J)$[ORD(S)=Si AND ORD(J)=Ji]=
      SUM[Z${SUM(ZZ$[ORD(ZZ)<=ORD(Z)-1],NJZ(S,ZZ,J))=0},ICminZ(S,Z,J)];
```

```
        ICmax(S,J)$[ORD(S)=Si AND ORD(J)=Ji]=
          SUM[Z$(SUM(ZZ$[ORD(ZZ)>=ORD(Z)+1],NJZ(S,ZZ,J))=0},ICmaxZ(S,Z,J)];

        FOR(Mi=1 TO CARD(M).
          COLD(S.J.M)$[ORD(S)=Si AND ORD(J)=Ji AND ORD(M)=Mi]=
              0+ 1$[ORD(M)>= ICmin(S.J) AND ORD(M)<=ICmax(S.J)];
          COLD2(S.M)$[ORD(S)=Si AND ORD(M)=Mi]=
              0+ 1$[ORD(M)>SUM(I$(ORD(I)=CARD(I)),IHmax(S,I))
                  AND ORD(M)<= SUM(J$(ORD(J)=CARD(J)),ICmax(S,J))];
          COLDZ(S.Z,J,M)$[ORD(S)=Si AND ORD(J)=Ji AND ORD(M)=Mi
            AND ORD(Z)=Zi]= 0+ 1$[ORD(M)>= ICminZ(S,Z,J)
                                AND ORD(M)<=ICmaxZ(S,Z,J)];
          H_J(S,J,M)$[ORD(S)=Si AND ORD(J)=Ji AND ORD(M)=Mi
                                AND COLD(S,J,M)=1] = HJ(S,J) ;
  ))));

PARAMETERS DT(S,M),TU(S,M),TL(S,M),CPH(S,I,M),CPC(S,J,M),DHH(S,I,M),DHC(S,J,M) ;

*WE ALWAYS DEFINE Cp AS 1; USER IS TOLD TO ENTER F*Cp

 CPH(S,I,M)$[HOT(S,I,M)=1] = 1;
 CPC(S,J,M)$[COLD(S,J,M)=1] = 1;

DT(S,M) = SUM((Z,I)$[HOTZ(S,Z,I,M)=1],
            {[TIHZ(S,Z,I)-TOHZ(S,Z,I)]/[IHmaxZ(S,Z,I)-IHminZ(S,Z,I)+1]})
                                $[HOT2(S,M)=1]+
      SUM((Z,J)$[COLDZ(S,Z,J,M)=1],
            {[TOCZ(S,Z,J)-TICZ(S,Z,J)]/[ICmaxZ(S,Z,J)-ICminZ(S,Z,J)+1]})
                                $[COLD2(S,M)=1];

FOR(Si= 1 TO CARD(S),
   FOR (Mi=1 TO CARD(M),
      TU(S,M)$[ORD(S)=Si AND ORD(M)=Mi]=
```

```
{SUM((Z,I)$[HOTZ(S,Z,I,M)=1 AND ORD(M)=
        IHminZ(S,Z,I)],TIHZ(S,Z,I)$[ORD(M)=IHminZ(S,Z,I)])
+ SUM((Z,I)$[HOTZ(S,Z,I,M)=1 AND ORD(M)>IHminZ(S,Z,I)
        AND ORD(M)<=IHmaxZ(S,Z,I)].
    [TIHZ(S,Z,I)-(ORD(M)-IHminZ(S,Z,I))*DT(S,M)]
        $[ORD(M)>IHminZ(S,Z,I) AND ORD(M)<=
        IHmaxZ(S,Z,I)])}$[HOT2(S,M)=1]
+{SUM((Z,J)$[COLDZ(S,Z,J,M)=1 AND ORD(M)=ICminZ(S,Z,J)].
        TOCZ(S,Z,J)$[ORD(M)=ICminZ(S,Z,J)])
+ SUM((Z,J)$[COLDZ(S,Z,J,M)=1 AND ORD(M)>ICminZ(S,Z,J)
        AND ORD(M)<=ICmaxZ(S,Z,J)].
    [TOCZ(S,Z,J)-(ORD(M)-ICminZ(S,Z,J))*DT(S,M)]
        $[ORD(M)>ICminZ(S,Z,J) AND ORD(M)<=
        ICmaxZ(S,Z,J)])}$[COLD2(S,M)=1];
TL(S,M)$[ORD(S)=Si AND ORD(M)=Mi]=
    {SUM((Z,I)$[HOTZ(S,Z,I,M)=1 AND ORD(M)=
        IHmaxZ(S,Z,I)],TOHZ(S,Z,I)$[ORD(M)=IHmaxZ(S,Z,I)])
+ SUM((Z,I)$[HOTZ(S,Z,I,M)=1 AND ORD(M)<IHmaxZ(S,Z,I)
        AND ORD(M)>=IHminZ(S,Z,I)].
    [TOHZ(S,Z,I)+(IHmaxZ(S,Z,I)-ORD(M))*DT(S,M)]
        $[ORD(M)<IHmaxZ(S,Z,I)AND ORD(M)>=
        IHminZ(S,Z,I)])}$[HOT2(S,M)=1]
+{SUM((Z,J)$[COLDZ(S,Z,J,M)=1 AND ORD(M)=ICmaxZ(S,Z,J)].
        TICZ(S,Z,J)$[ORD(M)=ICmaxZ(S,Z,J)])
+ SUM((Z,J)$[COLDZ(S,Z,J,M)=1 AND ORD(M)<ICmaxZ(S,Z,J)
        AND ORD(M)>=ICminZ(S,Z,J)].
    [TICZ(S,Z,J)+(ICmaxZ(S,Z,J)-ORD(M))*DT(S,M)]
        $[ORD(M)<ICmaxZ(S,Z,J)AND ORD(M)>=
        ICminZ(S,Z,J)])}$[COLD2(S,M)=1];
FOR(Ic=1 TO CARD(I),
  DHH(S,I,M)$[ORD(S)=Si AND ORD(M)=Mi AND ORD(I)=Ic
        AND HOT(S,I,M)=1]=
    FH(S,I)*CPH(S,I,M)*[TU(S,M)-TL(S,M)] ;
```

```
    ).
  FOR(Ji=1 TO CARD(J),
    DHC(S,J,M)$[ORD(S)=Si AND ORD(M)=Mi AND ORD(J)=Ji
                              AND COLD(S,J,M)=1]=
                    FC(S,J)*CPC(S,J,M)*[TU(S,M)-TL(S,M)] ;
   ))).


PARAMETER HHEAD(S,M,N),CHEAD(S,M,N),LMTD(S,M,N),D(S,Z,M,N),
    ALLOW(S,Z,I,J). ALLOW_H(S,Z,I,M,J),ALLOW_C(S,Z,J,M,I), ALLOW_2(Z,I,J);

*D(S,Z,M,N)=1 MATCH BETWEEN INTERVALS M AND N ALLOWED BASED ON LMTD

*HHEAD(S,M,N) = {TU(S,M)-TU(S,N) + DTmin}$[HOT2(S,M) AND COLD2(S,N)];
*CHEAD(S,M,N) = {TL(S,M)-TL(S,N) + DTmin}$[HOT2(S,M) AND COLD2(S,N)]    ;
HHEAD(S,M,N) = {TU(S,M)-TU(S,N) }$[HOT2(S,M) AND COLD2(S,N)];
CHEAD(S,M,N) = {TL(S,M)-TL(S,N) }$[HOT2(S,M) AND COLD2(S,N)]    :

*LMTD(S,M,N)= {[HHEAD(S,M,N)-CHEAD(S,M,N)]/LOG[HHEAD(S,M,N)/CHEAD(S,M,N)]}
*         $[HHEAD(S,M,N)> 0 AND CHEAD(S,M,N)>0 AND HHEAD(S,M,N)> CHEAD(S,M,N)]
*        + {[HHEAD(S,M,N)+CHEAD(S,M,N)]/2}$[HHEAD(S,M,N)>0 AND CHEAD(S,M,N)>0
*           AND (HHEAD(S,M,N)< CHEAD(S,M,N)OR HHEAD(S,M,N)= CHEAD(S,M,N))];
LMTD(S,M,N)= {[HHEAD(S,M,N)-CHEAD(S,M,N)]/LOG[HHEAD(S,M,N)/CHEAD(S,M,N)]}
       $[HHEAD(S,M,N)> 0 AND CHEAD(S,M,N)>0
         AND ( HHEAD(S,M,N)> CHEAD(S,M,N)+0.0001
         OR HHEAD(S,M,N)< CHEAD(S,M,N)-0.0001 )]
       + {[HHEAD(S,M,N)+CHEAD(S,M,N)]/2}$[HHEAD(S,M,N)>0 AND CHEAD(S,M,N)>0
         AND HHEAD(S,M,N)< CHEAD(S,M,N)+0.0001 AND HHEAD(S,M,N)> CHEAD(S,M,N)-0.0001];

D(S,Z,M,N)= 1$[  {HOT2(S,M)=1 AND HOT2(S,N)=1 AND SUM[I$(HOT(S,I,M)=1
         AND HOT(S,I,N)=1),HOTZ(S,Z,I,M)]=1 AND SUM[I$(HOT(S,I,N)=1
         AND HOT(S,I,M)=1),HOTZ(S,Z,I,N)]=1}
       OR {COLD2(S,M)=1 AND COLD2(S,N)=1 AND SUM[J$(COLD(S,J,M)=1
```

```
            AND COLD(S,J,N)=1),COLDZ(S,Z,J,M)]=1 AND SUM[J$(COLD(S,J,N)=1
            AND COLD(S,J,M)=1),COLDZ(S,Z,J,N)]=1}
          OR {(HHEAD(S,M,N)>=0.0001 AND CHEAD(S,M,N)>=0.0001)
*         OR {(HHEAD(S,M,N)>=(-0.0001+DTMIN) AND CHEAD(S,M,N)>=(-0.0001+DTMIN))
            AND SUM[I$(HOT(S,I,M)=1),HOTZ(S,Z,I,M)]=1
            AND SUM[J$(COLD(S,J,N)=1),COLDZ(S,Z,J,N)]=1}];

FOR(Si= 1 TO CARD(S),
  FOR(Zi=1 TO CARD(Z),
    FOR(Ic=1 TO CARD(I),
      FOR(Ji=1 TO CARD(J),
        ALLOW(S,Z,I,J)$[ORD(S)=Si AND ORD(Z)=Zi AND ORD(I)=Ic
              AND ORD(J)=Ji]= 0+ 1${SUM[(M,N)$[HOT(S,I,M)=1
              AND COLD(S,J,N)=1],D(S,Z,M,N)] >0
              AND NOT[HU(I) AND CU(J)]};
        FOR (Mi=1 TO CARD(M),
          ALLOW_H(S,Z,I,M,J)$[ORD(S)=Si AND ORD(Z)=Zi AND ORD(I)=Ic
                AND ORD(J)=Ji AND ORD(M)=Mi
                AND HOT(S,I,M)=1]=
            0+ 1${SUM[N$[COLD(S,J,N)=1],D(S,Z,M,N)] >0
                  AND NOT[HU(I)AND CU(J)]};
          ALLOW_C(S,Z,J,M,I)$[ORD(S)=Si AND ORD(Z)=Zi AND ORD(I)=Ic
                AND ORD(J)=Ji AND ORD(M)=Mi
                AND COLD(S,J,M)=1]=
            0+ 1${SUM[N$[HOT(S,I,N)=1],D(S,Z,N,M)] >0
                  AND NOT[HU(I)AND CU(J)]};
          )))));
FOR(Zi=1 TO CARD(Z),
  FOR(Ic=1 TO CARD(I),
    FOR(Ji=1 TO CARD(J),
      ALLOW_2(Z,I,J)$[ORD(Z)=Zi AND ORD(I)=Ic AND ORD(J)=Ji]=
      0+ 1${SUM[S,ALLOW(S,Z,I,J)] >0 AND NOT[HU(I)AND CU(J)]};
  )));
```

```
*---------- ---------- ------------------------------------------------------------------

VARIABLES

   TCOST

   PAR(Z,I,J)       AREA

   Q(S,Z,I,M,J,N)     HEAT LOAD FOR PROCESS-PROCESS MATCH

   QNEW_M(S,Z,I,J,M)

   QNEW_N(S,Z,I,J,N)

   QNEW2_M(S,Z,I,J,M)

   QNEW2_N(S,Z,I,J,N)

   Y_M(S,Z,I,J,M)

   Y_N(S,Z,I,J,N)

   Y_M_B(S,Z,I,J,M)

   Y_N_B(S,Z,I,J,N)

   NHE_M0(S,Z,I,J,M)

   NHE_M1(S,Z,I,J,M)

   NHE_N0(S,Z,I,J,N)

   NHE_N1(S,Z,I,J,N)

   NHE_M0_B(S,Z,I,J,M)

   NHE_M1_B(S,Z,I,J,M)

   NHE_N0_B(S,Z,I,J,N)

   NHE_N1_B(S,Z,I,J,N)

   NHE(S,Z,I,J)

   ALFA_M(S,Z,I,J,M)

   ALFA_N(S,Z,I,J,N)

   FHU(I)          HOT UTILITY USAGE FCP (MJ_h_C)

   FCU(J)          COLD UTILITY FCP (MJ_h_C)

   B1(S,Z,I,M,J,N)    X(imjn) in the paper

   QH(S,Z,I,M,N)

   QC(S,Z,J,M,N)

   Q2(S,Z,I,M,J,N)

   X1_B(S,Z,I,J,M)

   X_B(S,K,Z,I,J,M)

   PAR_B(K,Z,I,J)
```

```
    USHELL(Z,I,J)
    USHELL_B(K,Z,I,J)
;

 POSITIVE VARIABLE Q,QNEW2_M,QNEW2_N,QC,QH,Q2,PAR1,PAR2
 BINARY VARIABLE NHE_M0_B,NHE_M1_B,NHE_N0_B,NHE_N1_B,Y_M,Y_N,X1_B,X_B
 INTEGER VARIABLE USHELL,USHELL_B

 EQUATIONS
HBHU(S,I,M)
HBCU(S,J,N)
HBHS(S,I,M)
HBCS(S,J,N)
TRANSFOR_M(S,Z,I,J,M)
TRANSFOR_N(S,Z,I,J,N)
HBHS_NI(S,I,M)
HBCS_NI(S,J,N)
NOISOH(S,I,M)
NOISOC(S,J,N)
BINARY_M1(S,Z,I,J,M)
BINARY_M2(S,Z,I,J,M)
BINARY_M1_B(S,Z,I,J,M)
BINARY_M2_B(S,Z,I,J,M)
BINARY_N1(S,Z,I,J,N)
BINARY_N2(S,Z,I,J,N)
BINARY_N1_B(S,Z,I,J,N)
BINARY_N2_B(S,Z,I,J,N)
BINARY_M5(S,Z,I,J,M)
BINARY_M5b(S,Z,I,J,M)
BINARY_M3(S,Z,I,J,M)
BINARY_M4(S,Z,I,J,M)
BINARY_M8(S,Z,I,J,M)
```

BINARY_M9(S,Z,I,J,M)

BINARY_M6(S,Z,I,J,M)

BINARY_M7(S,Z,I,J,M)

BINARY_M3_B(S,Z,I,J,M)

BINARY_N5(S,Z,I,J,N)

BINARY_N5b(S,Z,I,J,N)

BINARY_N3(S,Z,I,J,N)

BINARY_N4(S,Z,I,J,N)

BINARY_N8(S,Z,I,J,N)

BINARY_N9(S,Z,I,J,N)

BINARY_N6(S,Z,I,J,N)

BINARY_N7(S,Z,I,J,N)

BINARY_N3_B(S,Z,I,J,N)

HE_COUNT_M0(S,Z,I,J)

HE_COUNT_N0(S,Z,I,J)

HE_COUNT_M1(S,Z,I,J)

HE_COUNT_N1(S,Z,I,J)

NEXCH(S,Z,I,J)

NEXCH_B(S,Z,I,J)

BIF_1(S,Z,I,J,M,N)

BIF_2(S,Z,I,J,M,N)

BIF_3(S,Z,I,J,M,N)

BIF_4(S,Z,I,J,M,N)

BIF_11(S,Z,I,J,M)

BIF_12(S,Z,I,J,N)

BIF_6(S,Z,I,J,M)

BIF_9(S,Z I,J,M)

BIF_5(S,Z,I,J,M)

BIF_8(S,Z,I,J,N)

BIF_10(S,Z,I,J,N)

BIF_7(S,Z,I,J,N)

FEAS_M_01(S,Z,I,J.M)

FEAS_M_01_B(S,Z,I,J,M)

FEAS_M_02(S,Z,I,J,M)

FEAS_M_02_B(S,Z,I,J,M)

FEAS_M_03(S,Z,I,J,M)

FEAS_M_03_B(S,Z,I,J,M)

FEAS_M_04(S,Z,I,J,M)

FEAS_M_2(S,Z,I,J,M)

FEAS_M_1(S,Z,I,J,M)

FEAS_M_3(S,Z,I,J,M)

FEAS_M_4(S,Z,I,J,M)

FEAS_M_3_B_2(S,Z,I,J,M)

FEAS_M_3_B_1(S,Z,I,J,M)

FEAS_M_4_B(S,Z,I,J,M)

FEAS_M_1_SP(S,Z,I,J,M)

FEAS_M_1_SP_B(S,Z,I,J,M)

FEAS_N_01(S,Z,I,J,N)

FEAS_N_01_B(S,Z,I,J,N)

FEAS_N_02(S,Z,I,J,N)

FEAS_N_02_B(S,Z,I,J,N)

FEAS_N_03(S,Z,I,J,N)

FEAS_N_03_B(S,Z,I,J,N)

FEAS_N_04(S,Z,I,J,N)

FEAS_N_2(S,Z,I,J,N)

FEAS_N_1(S,Z,I,J,N)

FEAS_N_3(S,Z,I,J,N)

FEAS_N_4(S,Z,I,J,N)

FEAS_N_3_B_2(S,Z,I,J,N)

FEAS_N_3_B_1(S,Z,I,J,N)

FEAS_N_4_B(S,Z,I,J,N)

FEAS_N_1_SP(S,Z,I,J,N)

FEAS_N_1_SP_B(S,Z,I,J,N)

FEAS_BEG_SP(S,Z,I,J,M,N)

FEAS_BEG_B_SP(S,Z,I,J,M,N)

FEAS_END_SP(S,Z,I,J,M,N)

FEAS_END_B_SP(S,Z,I,J,M,N)

FEAS_BEG3(S,Z,I,J,M,N)

FEAS_BEG(S,Z,I,J,M,N)

FEAS_BEG2(S,Z,I,J,M,N)

FEAS_END3(S,Z,I,J,M,N)

FEAS_END(S,Z,I,J,M,N)

FEAS_END2(S,Z,I,J,M,N)

FEAS_BEG4_B(S,Z,I,J,M,N)

FEAS_BEG2_B(S,Z,I,J,M,N)

FEAS_BEG1_B(S,Z,I,J,M,N)

FEAS_BEG3_B(S,Z,I,J,M,N)

FEAS_END3_B(S,Z,I,J,M,N)

FEAS_END_B(S,Z,I,J,M,N)

FEAS_END2_B(S,Z,I,J,M,N)

PAREQ(S,Z,I,J)

BIF_13_2(S,K,Z,I,J,M)

BIF_13_1(S,K,Z,I,J,M)

BIF_14(S,K,Z,I,J)

BIF_15(S,Z,I,J,M)

BIF_16(S,Z,I,J,M)

BIF_17(S,Z,I,J,M)

BIF_18(S,Z,I,J,M,N)

SHELL(Z,I,J)

SHELL_B(K,Z,I,J)

KMAX1(S,Z,I,J)

KMAX2(S,Z,I,J)

TOTALCOST

* EXTRA EQUATIONS NOT IN PAPER

*FCU_MAX

TOTNEXCH_MAX

TOTNEXCH_MIN

;

*---

```
*EQ (1)
HBHU(S,I,M)$(HOT(S,I,M)=1 AND HU(I) AND FREEH(I))..
 FHU(I)*(TU(S,M)-TL(S,M)) =E=
       SUM((Z,N,J)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND COLD(S,J,N)=1
       AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1
                              AND FREEC(J)),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (2)
HBCU(S,J,N)$(COLD(S,J,N)=1 AND CU(J) AND FREEC(J))..
 FCU(J)*(TU(S,N)-TL(S,N)) =E=
       SUM((Z,M,I)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
       AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1
                              AND FREEH(I)),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (3)
HBHS(S,I,M)$(HOT(S,I,M)=1 AND NOT HU(I) AND FREEH(I) AND NIH(I)=0)..
 DHH(S,I,M)=E=SUM((Z,N,J)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND COLD(S,J,N)=1
        AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (4)
HBCS(S,J,N)$(COLD(S,J,N)=1 AND NOT CU(J) AND FREEC(J) AND NIC(J)=0)..
 DHC(S,J,N)=E=SUM((Z,M,I)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
        AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (5)
TRANSFOR_M(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND FREEH(I)
              AND FREEC(J))..
 QNEW_M(S,Z,I,J,M) =E=
           SUM(N$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND COLD(S,J,N)=1
                AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (6)
TRANSFOR_N(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND FREEH(I)
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```
                AND FREEC(J)).
QNEW_N(S,Z,I,J,N)=E=SUM(M$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
                AND ALLOW_H(S,Z,I,M,J)=1),Q(S,Z,I,M,J,N));

*-------------------------------------------------------------------------
*EQ (7)
HBHS_NI(S,I,M)$(HOT(S,I,M)=1 AND NOT HU(I) AND FREEH(I) AND NIH(I)=1)..
 DHH(S,I,M)=E=
    SUM((Z,N,J)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND COLD(S,J,N)=1
        AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N))
   + SUM((Z,N)$(D(S,Z,M,N)=1 AND HOT(S,I,N)=1 AND ORD(N) GT ORD(M)).
                                    QH(S,Z,I,N,M))
   - SUM((Z,N)$(D(S,Z,M,N)=1 AND HOT(S,I,N)=1 AND ORD(N) LT ORD(M)),
                                    QH(S,Z,I,M,N));
*-------------------------------------------------------------------------
*EQ (8)
HBCS_NI(S,J,N)$(COLD(S,J,N)=1 AND NOT CU(J) AND FREEC(J) AND NIC(J)=1)..
 DHC(S,J,N)=E=
    SUM((Z,M,I)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
        AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N))
   + SUM((Z,M)$(D(S,Z,M,N)=1 AND COLD(S,J,M)=1 AND ORD(M) LT ORD(N)),
                                    QC(S,Z,J,M,N))
   - SUM((Z,M)$(D(S,Z,M,N)=1 AND COLD(S,J,M)=1 AND ORD(M) GT ORD(N)),
                                    QC(S,Z,J,N,M));
*-------------------------------------------------------------------------
*EQ (9)
NOISOH(S,I,M)$(HOT(S,I,M)=1 AND NOT HU(I) AND FREEH(I) AND NIH(I)=1)..
SUM((Z,N)$(D(S,Z,M,N)=1 AND HOT(S,I,N)=1 AND ORD(N) LT ORD(M)),QH(S,Z,I,M,N))=L=
 SUM((Z,N,J)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND COLD(S,J,N)=1
    AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (10)
NOISOC(S,J,N)$(COLD(S,J,N)=1 AND NOT CU(J) AND FREEC(J) AND NIC(J)=1)..
```

```
SUM((Z,M)$(D(S,Z,M,N)=1 AND COLD(S,J,M)=1 AND ORD(M)GT ORD(N)),QC(S,Z,J,N,M))=L=
    SUM((Z,M,I)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
     AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),Q(S,Z,I,M,J,N));
*-------------------------------------------------------------------------
*EQ (11a and 13a)  Case of BIF(I,J)=0   (i,j) not belonging to set B.

BINARY_M1(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0
            AND FREEH(I) AND FREEC(J)).
QNEW_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M)*DHH(S,I,M)$(NOT HU(I))
            -Y_M(S,Z,I,J,M)*FMAX_HU(I)*DTHU(I)$(HU(I))=L=0;
*-------------------------------------------------------------------------
*EQ (11b and 13b)       Case of BIF(I,J)=0  (i,j) not belonging to set B
BINARY_M2(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0
   AND FREEH(I) AND FREEC(J)).. QNEW_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M)*QLHMIN=G=0;

*-------------------------------------------------------------------------
*EQ (11a and 13a) Case of BIF(I,J)=1    (i,j) belonging to set B
BINARY_M1_B(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
            AND FREEH(I) AND FREEC(J) ).
QNEW_M(S,Z,I,J,M)-Y_M_B(S,Z,I,J,M)*DHH(S,I,M)$(NOT HU(I))
            -Y_M_B(S,Z,I,J,M)*FMAX_HU(I)*DTHU(I)$(HU(I))=L=0;
*-------------------------------------------------------------------------
*EQ (11b and 13b) Case of BIF(I,J)=1    (i,j) belonging to set B
BINARY_M2_B(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
AND FREEH(I) AND FREEC(J)).. QNEW_M(S,Z,I,J,M)-Y_M_B(S,Z,I,J,M)*QLHMIN =G= 0;
*-------------------------------------------------------------------------
*EQ (12a and 14a) Case of BIF(I,J)=0    (i,j) not belonging to set B

BINARY_N1(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0
            AND FREEH(I) AND FREEC(J)).
QNEW_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N)*DHC(S,J,N)$(NOT CU(J))
          -Y_N(S,Z,I,J,N)*FMAX_CU(J)*DTCU(J)$(CU(J))=L=0;
*-------------------------------------------------------------------------
```

```
*EQ (12b and 14b) Case of BIF(I,J)=0   (i,j) not belonging to set B
 BINARY_N2(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0
 AND FREEH(I) AND FREEC(J)).. QNEW_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N)*QLCMIN=G=0;
*-------------------------------------------------------------------------
*EQ (12a and 14a) Case of BIF(I,J)=1   (i,j) belonging to set B
BINARY_N1_B(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J) )..
    QNEW_N(S,Z,I,J,N)-Y_N_B(S,Z,I,J,N)*DHC(S,J,N)$(NOT CU(J))
       -Y_N_B(S,Z,I,J,N)*FMAX_CU(J)*DTCU(J)$(CU(J))=L=0;
*-------------------------------------------------------------------------
*EQ (12b and 14b) Case of BIF(I,J)=1   (i,j) belonging to set B
BINARY_N2_B(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J)).. QNEW_N(S,Z,I,J,N)-Y_N_B(S,Z,I,J,N)*QLCMIN=G=0;
*-------------------------------------------------------------------------
*EQ (15) NOT NEEDED
*          GAMS WRITES IT AUTOMATICALLY WHEN IT WRITES EQUATION (18)
*-------------------------------------------------------------------------
*EQ (16)
BINARY_M5(S,Z,I,J,M)$(HOT(S,I,M)=1 AND HOT(S,I,M-1) AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J)).
            NHE_M0(S,Z,I,J,M)=L=2-Y_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M-1);
*-------------------------------------------------------------------------
*EQ (17) IS IN REALITY NOT NEEDED, BUT WAS ADDED TO ENFORCE K=0 WHEN Y=0
*AND HOT(S,I,M-1) AND ALLOW_H(S,Z,I,M-1,J) AND ALLOW_H(S,Z,I,M,J)=1
*AND ALLOW_H(S,Z,I,M,J)=1

BINARY_M5b(S,Z,I,J,M)$(HOT(S,I,M)=1AND ALLOW_H(S,Z,I,M,J)=1AND BIF(Z,I,J)=0
          AND FREEH(I) AND FREEC(J)).
                NHE_M0(S,Z,I,J,M) =L= Y_M(S,Z,I,J,M);

*   IT TURNS OUT THAT THIS EQUATION ONLY FORCES THE VALUES OF K TO BE ZERO
*   WHEN Y=0, WHICH HAPPENS NATURALLY IF ONE IS MINIMIZING THE NUMBER OF
*   EXCHANGERS OR BECAUSE THE FIXED COSTS ARE BEING MINIMIZED.
```

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*     EVEN IF NOT DRIVEN TO ZERO BY THE OBJECTIVE FUNCTION IT IS HARMELESS.
* HOWEVER, IT TURNS OUT THAT IT COULD MAKE EXTENSIONS OF THE MODEL HAVE
* PROBLEMS. SO, ALTHOUGH THE EQUATION IS NOT NEEDED, IT GIVES SOME EXTRA VALUES
* OF K WHEN THEY DO NOT REALLY MATTER.
*-------------------------------------------------------------------------
*EQ (18)
BINARY_M3(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0
 AND FREEH(I) AND FREEC(J))..
 NHE_M0(S,Z,I,J,M) =G= Y_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M-1)$(HOT(S,I,M-1)
                              AND ALLOW_H(S,Z,I,M-1,J)) ;
*-------------------------------------------------------------------------
*EQ (19)
BINARY_M4(S,Z,I,J,M)$(HOT(S,I,M)=1 AND HOT(S,I,M-1) AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..
                              NHE_M0(S,Z,I,J,M)=G=0;
*-------------------------------------------------------------------------
*EQ (20) NOT NEEDED
*          GAMS WRITES IT AUTOMATICALLY WHEN IT WRITES EQUATION (18)
*-------------------------------------------------------------------------
*EQ (21)
BINARY_M8(S,Z,I,J,M)$(HOT(S,I,M)=1 AND HOT(S,I,M+1) AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M+1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..
              NHE_M1(S,Z,I,J,M)=L=2-Y_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M+1);
*-------------------------------------------------------------------------
*EQ (22) : ORIGINALLY NOT NEEDED, BUT ADDED TO ENFORCE K=0 WHEN Y=0
*       AND HOT(S,I,M-1) AND ALLOW_H(S,Z,I,M-1,J)
BINARY_M9(S,Z,I,J,M)$(HOT(S,I,M)=1AND ALLOW_H(S,Z,I,M,J)=1AND BIF(Z,I,J)=0
            AND FREEH(I)AND FREEC(J))..
                          NHE_M1(S,Z,I,J,M) =L= Y_M(S,Z,I,J,M) ;

* SEE COMMENTS ON EQUATION (17)

*-------------------------------------------------------------------------
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*EQ (23)
BINARY_M6(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0
AND FREEH(I) AND FREEC(J)).. NHE_M1(S,Z,I,J,M)=G=Y_M(S,Z,I,J,M)-Y_M(S,Z,I,J,M+1)
                $(HOT(S,I,M+1) AND ALLOW_H(S,Z,I,M+1,J)) ;
*---------------------------------------------------------------------------
*EQ (24)
BINARY_M7(S,Z,I,J,M)$(HOT(S,I,M)=1 AND HOT(S,I,M+1) AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M+1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J)).
                NHE_M1(S,Z,I,J,M)=G=0;
*---------------------------------------------------------------------------
*EQ (25)
BINARY_M3_B(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J)).
 Y_M_B(S,Z,I,J,M) =E= SUM(O$(HOT(S,I,O)=1 AND ORD(O) LE ORD(M)
        AND ALLOW_H(S,Z,I,O,J)=1),NHE_M0_B(S,Z,I,J,O))
       -SUM(O$(HOT(S,I,O)=1 AND ORD(O) LE [ORD(M)-1]
        AND ALLOW_H(S,Z,I,O,J)=1),NHE_M1_B(S,Z,I,J,O));
*---------------------------------------------------------------------------
*EQ (26) NOT NEEDED
*       GAMS WRITES IT AUTOMATICALLY WHEN IT WRITES EQUATION (18)
*---------------------------------------------------------------------------
*EQ (27)
BINARY_N5(S,Z,I,J,N)$(COLD(S,J,N)=1 AND COLD(S,J,N-1) AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J)).
        NHE_N0(S,Z,I,J,N)=L=2-Y_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N-1);
*---------------------------------------------------------------------------
*EQ (28) NOT NEEDED, BUT ADDED TO ENFORCE K=0 WHEN Y=0
*       AND COLD(S,J,N-1) AND ALLOW_C(S,Z,J,N-1,I)
BINARY_N5b(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0
        AND FREEH(I) AND FREEC(J)).
                NHE_N0(S,Z,I,J,N) =L= Y_N(S,Z,I,J,N);

* SEE COMMENTS ON EQUATION (17)
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*-------------------------------------------------------------------------

*EQ (29)

BINARY_N3(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0

 AND FREEH(I) AND FREEC(J))..

                NHE_N0(S,Z,I,J,N) =G= Y_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N-1)

                    $(COLD(S,J,N-1) AND ALLOW_C(S,Z,J,N-1,I));

*-------------------------------------------------------------------------

*EQ (30)

BINARY_N4(S,Z,I,J,N)$(COLD(S,J,N)=1 AND COLD(S,J,N-1) AND ALLOW_C(S,Z,J,N,I)=1

 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

                                NHE_N0(S,Z,I,J,N)=G=0;

*-------------------------------------------------------------------------

*EQ (31) NOT NEEDED

*           GAMS WRITES IT AUTOMATICALLY WHEN IT WRITES EQUATION (18)

*-------------------------------------------------------------------------

*EQ (32)

 BINARY_N8(S,Z,I,J,N)$(COLD(S,J,N)=1 AND COLD(S,J,N+1) AND ALLOW_C(S,Z,J,N,I)=1

 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

                NHE_N1(S,Z,I,J,N)=L=2-Y_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N+1);

*-------------------------------------------------------------------------

*EQ (33) NOT NEEDED BUT ADDED TO ENFORCE K=0 WHEN Y=0

*      AND COLD(S,J,N-1)  AND ALLOW_C(S,Z,J,N-1,I)

BINARY_N9(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1AND BIF(Z,I,J)=0

            AND FREEH(I) AND FREEC(J))..

                            NHE_N1(S,Z,I,J,N) =L= Y_N(S,Z,I,J,N);


*  SEE COMMENTS ON EQUATION (17)

*-------------------------------------------------------------------------

*EQ (34)

BINARY_N6(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0

 AND FREEH(I) AND FREEC(J))..

                NHE_N1(S,Z,I,J,N)=G=Y_N(S,Z,I,J,N)-Y_N(S,Z,I,J,N+1)

                    $(COLD(S,J,N+1) AND ALLOW_C(S,Z,J,N+1,I));
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*-------------------------------------------------------------------------

*EQ (35)

BINARY_N7(S,Z,I,J,N)$(COLD(S,J,N)=1 AND COLD(S,J,N+1) AND ALLOW_C(S,Z,J,N,I)=1

 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

                                NHE_N1(S,Z,I,J,N)=G=0;

*-------------------------------------------------------------------------

*EQ (36)

BINARY_N3_B(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1

 AND FREEH(I)AND FREEC(J))..

 Y_N_B(S,Z,I,J,N)=E=SUM(O$(COLD(S,J,O) AND ORD(O) LE ORD(N)

 AND ALLOW_C(S,Z,J,O,I)),NHE_N0_B(S,Z,I,J,O)) - SUM(O$(COLD(S,J,O) AND ORD(O) LE

            ORD(N)-1 AND ALLOW_C(S,Z,J,O,I)),NHE_N1_B(S,Z,I,J,O));

*-------------------------------------------------------------------------

*EQ (37)

 HE_COUNT_M0(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

 NHE(S,Z,I,J)=E=SUM(M$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1),

  NHE_M0_B(S,Z,I,J,M))

  + SUM(M$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0),

                                NHE_M0(S,Z,I,J,M));

*-------------------------------------------------------------------------


*-------------------------------------------------------------------------

*EQ (38)

 HE_COUNT_N0(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

 NHE(S,Z,I,J)=E=SUM(N$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1),

  NHE_N0_B(S,Z,I,J,N)) + SUM(N$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0),

                                NHE_N0(S,Z,I,J,N));

*-------------------------------------------------------------------------

*EQ (39)

HE_COUNT_M1(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

 NHE(S,Z,I,J)=E=SUM(M$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1),

  NHE_M1_B(S,Z,I,J,M)) + SUM(M$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=0),

                                NHE_M1(S,Z,I,J,M));
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*-------------------------------------------------------------------------

*EQ (40)

HE_COUNT_N1(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

 NHE(S,Z,I,J)=E=SUM(N$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1),

 NHE_N1_B(S,Z,I,J,N)) + SUM(N$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1

                                AND BIF(Z,I,J)=0),

                                 NHE_N1(S,Z,I,J,N));

*-------------------------------------------------------------------------

*EQ (41)

NEXCH(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND BIF(Z,I,J)=0 AND FREEH(I)

  AND FREEC(J))..NHE(S,Z,I,J)=L=1;

*-------------------------------------------------------------------------

*EQ (42)

NEXCH_B(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND BIF(Z,I,J)=1 AND FREEH(I)

  AND FREEC(J))..NHE(S,Z,I,J)=L=KMAX(Z,I,J);

*-------------------------------------------------------------------------

*EQ (43)

BIF_1(S,Z,I,J,M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1

 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1

 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  SUM(L$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M) AND HOT(S,I,L)=1

                                AND ALLOW_H(S,Z,I,L,J)=1),

    QNEW_M(S,Z,I,J,L)) - QNEW2_M(S,Z,I,J,M) =L=

  SUM(O$(D(S,Z,M,O)=1 AND ORD(O) LE ORD(N) AND COLD(S,J,O)

                                AND ALLOW_C(S,Z,J,O,I)),

    QNEW_N(S,Z,I,J,O)) - QNEW2_N(S,Z,I,J,N)

  + B1(S,Z,I,M,J,N) *4* max(SUM(L$(D(S Z,L,N)=1 AND ORD(L) LE ORD(M)

                AND HOT(S,I,L)=1 AND ALLOW_H(S,Z,I,L,J)=1),

               DHH(S,I,L)),SUM(O$(D(S,Z,M,O)=1 AND ORD(O) LE ORD(N)

               AND COLD(S,J,O) AND ALLOW_C(S,Z,J,O,I)),DHC(S,J,O)));

*-------------------------------------------------------------------------

*EQ (44)

BIF_2(S,Z,I,J,M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
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    AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1
    AND BIF(Z,I,J)=1 AND FREEH(I)AND FREEC(J))..
 SUM(L$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M) AND HOT(S,I,L)=1
      AND ALLOW_H(S,Z,I,L,J)=1),
    QNEW_M(S,Z,I,J,L)) - QNEW2_M(S,Z,I,J,M) =G=
 SUM(O$(D(S,Z,M,O)=1 AND ORD(O) LE ORD(N) AND COLD(S,J,O)
                              AND ALLOW_C(S,Z,J,O,I)),
    QNEW_N(S,Z,I,J,O)) - QNEW2_N(S,Z,I,J,N)
 -B1(S,Z,I,M,J,N) *4*  max(SUM(L$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M)
                    AND HOT(S,I,L)=1 AND ALLOW_H(S,Z,I,L,J)=1),
                DHH(S,I,L)),SUM(O$(D(S,Z,M,O)=1 AND ORD(O) LE ORD(N)
                AND COLD(S,J,O) AND ALLOW_C(S,Z,J,O,I)),DHC(S,J,O)));
*-------------------------------------------------------------------------
*EQ (45)
BIF_3(S,Z,I,J,M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
    AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1
    AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
 B1(S,Z,I,M,J,N) =E= 2- 0.25* SUM(L$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M)
                    AND HOT(S,I,L)=1 AND ALLOW_H(S,Z,I,L,J)=1),
           NHE_M1_B(S,Z,I,J,L))
         + 0.25 *SUM(O$(D(S,Z,M,O)=1 AND ORD(O) LE ORD(N) AND COLD(S,J,O)
                    AND ALLOW_C(S,Z,J,O,I)),NHE_N1_B(S,Z,I,J,O))
                     -NHE_M1_B(S,Z,I,J,M)-NHE_N1_B(S,Z,I,J,N);
*-------------------------------------------------------------------------
*EQ (46)
BIF_4(S,Z,I,J,M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND TL(S,N) GE TL(S,M)
 AND HOT(S,I,M)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
   SUM(L$(HOT(S,I,L)=1 AND ORD(L) LE ORD(M) AND ALLOW_H(S,Z,I,L,J)=1),
          NHE_M1_B(S,Z,I,J,L)) -SUM(O$(COLD(S,J,O) AND ORD(O) LE ORD(N)
                AND ALLOW_C(S,Z,J,O,I)),NHE_N1_B(S,Z,I,J,O))=G=0;

*-------------------------------------------------------------------------
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*EQ (47)
BIF_11(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
    SUM(O$(HOT(S,I,O)=1 AND ORD(O) LE ORD(M) AND ALLOW_H(S,Z,I,O,J)=1),
                NHE_M0_B(S,Z,I,J,O)-NHE_M1_B(S,Z,I,J,O))=L=1 ;
*-------------------------------------------------------------------------
*EQ (48)
BIF_12(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
        SUM(O$(COLD(S,J,O) AND ORD(O) LE ORD(N) AND ALLOW_C(S,Z,J,O,I)),
                NHE_N0_B(S,Z,I,J,O)-NHE_N1_B(S,Z,I,J,O))=L=1;
*-------------------------------------------------------------------------
*EQ (49)
BIF_6(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
                QNEW2_M(S,Z,I,J,M) =L= QNEW_M(S,Z,I,J,M);
*-------------------------------------------------------------------------
*EQ (50)
BIF_9(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
            QNEW2_M(S,Z,I,J,M) =L= NHE_M0_B(S,Z,I,J,M)*DHH(S,I,M);
*-------------------------------------------------------------------------
*EQ (51)
BIF_5(S,Z,I,J,M)$(HOT(S,I,M)=1AND ALLOW_H(S,Z,I,M,J)=1AND BIF(Z,I,J)=1
 AND FREEH(I)AND FREEC(J))..
            QNEW2_M(S,Z,I,J,M) =L= NHE_M1_B(S,Z,I,J,M)*DHH(S,I,M);
*-------------------------------------------------------------------------
*EQ (52)      NOT NEEDED. THE VARIABLE IS DECLARED POSITIVE
*-------------------------------------------------------------------------
*EQ (53)
BIF_8(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
                QNEW2_N(S,Z,I,J,N) =L= QNEW_N(S,Z,I,J,N);
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*-------------------------------------------------------------------------

*EQ (54)

BIF_10(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1

 AND FREEH(I) AND FREEC(J))..

                QNEW2_N(S,Z,I,J,N) =L= NHE_N0_B(S,Z,I,J,N)*DHC(S,J,N);

*-------------------------------------------------------------------------

*EQ (55)

BIF_7(S,Z,I,J,N)$(COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1

 AND FREEH(I) AND FREEC(J))..

                QNEW2_N(S,Z,I,J,N) =L= NHE_N1_B(S,Z,I,J,N)*DHC(S,J,N);

*-------------------------------------------------------------------------

*EQ (56)      NOT NEEDED. THE VARIABLE IS DECLARED POSITIVE

*-------------------------------------------------------------------------

*EQ (57)

 FEAS_M_01(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1

 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I)

 AND FREEC(J))..

            ALFA_M(S,Z,I,J,M)=L=1-NHE_M0(S,Z,I,J,M-1)-NHE_M0(S,Z,I,J,M);


 FEAS_M_01_B(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1

 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

          ALFA_M(S,Z,I,J,M)=L=1-NHE_M0_B(S,Z,I,J,M-1)-NHE_M0_B(S,Z,I,J,M);

*-------------------------------------------------------------------------

*EQ (58)

 FEAS_M_02(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1

 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I)

 AND FREEC(J))..

            ALFA_M(S,Z,I,J,M)=L=1-NHE_M1(S,Z,I,J,M-1)-NHE_M1(S,Z,I,J,M);

FEAS_M_02_B(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1

 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

          ALFA_M(S,Z,I,J,M)=L=1-NHE_M1_B(S,Z,I,J,M-1)-NHE_M1_B(S,Z,I,J,M);

*-------------------------------------------------------------------------

*EQ (59)
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FEAS_M_03(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
    ALFA_M(S,Z,I,J,M)=G=Y_M(S,Z,I,J,M)-NHE_M0(S,Z,I,J,M-1)-NHE_M0(S,Z,I,J,M) -
                        NHE_M1(S,Z,I,J,M-1)-NHE_M1(S,Z,I,J,M);
FEAS_M_03_B(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J)) ..
 ALFA_M(S,Z,I,J,M)=G=Y_M_B(S,Z,I,J,M)-NHE_M0_B(S,Z,I,J,M-1)-NHE_M0_B(S,Z,I,J,M)
                    - NHE_M1_B(S,Z,I,J,M-1)-NHE_M1_B(S,Z,I,J,M);
*-------------------------------------------------------------------------------
*EQ (60)
FEAS_M_04(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND
ALLOW_H(S,Z,I,M-1,J) AND (BIF(Z,I,J)=1 OR SPH(I)=1) AND FREEH(I) AND FREEC(J))..
                                ALFA_M(S,Z,I,J,M)=G=0;
*-------------------------------------------------------------------------------
*EQ (61)
FEAS_M_2(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)/(TU(S,M)-TL(S,M)) =L= QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)
                                *(TU(S,M-1)-TL(S,M-1)))
      +(1-ALFA_M(S,Z,I,J,M))*DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)));
*-------------------------------------------------------------------------------
*EQ (62)
FEAS_M_1(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))
 +(1-ALFA_M(S,Z,I,J,M))*DHH(S,I,M) /(CPH(S,I,M)*(TU(S,M)-TL(S,M)))
          =G= QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1)));
*-------------------------------------------------------------------------------
*EQ (63)
FEAS_M_3(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
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  - QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1)))
  + QNEW_M(S,Z,I,J,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))
  +(1+ NHE_M1(S,Z,I,J,M-1) + NHE_M1(S,Z,I,J,M) - NHE_M0(S,Z,I,J,M-1))
   *DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))*1.00001 =G= 0;
*---------------------------------------------------------------------------
*EQ (64)
FEAS_M_4(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
 - QNEW_M(S,Z,I,J,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))
 + QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1)))
 +(1+ NHE_M0(S,Z,I,J,M-1)+NHE_M0(S,Z,I,J,M)-NHE_M1(S,Z,I,J,M))
  *DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))*1.00001 =G= 0;
*---------------------------------------------------------------------------
*EQ (65)
FEAS_M_3_B_2(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
  QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1)))=L=
  QNEW_M(S,Z,I,J,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))
  +(1+NHE_M1_B(S,Z,I,J,M-1)+NHE_M1_B(S,Z,I,J,M)-NHE_M0_B(S,Z,I,J,M-1))
   *DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)));
*---------------------------------------------------------------------------
*EQ (66)
FEAS_M_3_B_1(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
  QNEW2_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1))) =L=
  QNEW_M(S,Z,I,J,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)))+ (2 + NHE_M1_B(S,Z,I,J,M)
  + NHE_M1_B(S,Z,I,J,M)-NHE_M0_B(S,Z,I,J,M-1)-Y_M_B(S,Z,I,J,M-1))
    *DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)));
*---------------------------------------------------------------------------
*EQ (67)
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FEAS_M_4_B(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I)
 AND FREEC(J))..
 (QNEW_M(S,Z,I,J,M)-QNEW2_M(S,Z,I,J,M))/(CPH(S,I,M)*(TU(S,M)-TL(S,M))) =L=
  QNEW_M(S,Z,I,J,M-1)/(CPH(S,I,M-1)*(TU(S,M-1)-TL(S,M-1)))
 +(2 + NHE_M0_B(S,Z,I,J,M-1)
 + NHE_M0_B(S,Z,I,J,M)-NHE_M1_B(S,Z,I,J,M)-Y_M_B(S,Z,I,J,M))
  *DHH(S,I,M)/(CPH(S,I,M)*(TU(S,M)-TL(S,M)));
*-------------------------------------------------------------------------
*EQ (68)
FEAS_M_1_SP(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND HOT(S,I,M+1)
 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J) AND ALLOW_H(S,Z,I,M+1,J)
 AND BIF(Z,I,J)=0 AND SPH(I)=0 AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)=G=(Y_M(S,Z,I,J,M)-
                NHE_M0(S,Z,I,J,M) + NHE_M1(S,Z,I,J,M))*DHH(S,I,M);
FEAS_M_1_SP_B(S,Z,I,J,M)$(HOT(S,I,M-1) AND HOT(S,I,M)=1 AND HOT(S,I,M+1)
 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M-1,J) AND ALLOW_H(S,Z,I,M+1,J) AND BIF(Z,I,J)=1 AND SPH(I)=0
 AND FREEH(I) AND FREEC(J)).. QNEW_M(S,Z,I,J,M)=G=(Y_M_B(S,Z,I,J,M)-
                NHE_M0_B(S,Z,I,J,M)+NHE_M0_B(S,Z,I,J,M))*DHH(S,I,M);
*-------------------------------------------------------------------------
*EQ (69)
FEAS_N_01(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I)
 AND FREEC(J))..
        ALFA_N(S,Z,I,J,N) =L= 1-NHE_N0(S,Z,I,J,N)-NHE_N0(S,Z,I,J,N-1);
FEAS_N_01_B(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,i) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
        ALFA_N(S,Z,I,J,N)=L=1-NHE_N0_B(S,Z,I,J,N)-NHE_N0_B(S,Z,I,J,N-1);
*-------------------------------------------------------------------------
*EQ (70)
FEAS_N_02(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I)
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 AND FREEC(J))
              ALFA_N(S,Z,I,J,N)=L=1-NHE_N1(S,Z,I,J,N)-NHE_N1(S,Z,I,J,N-1);
FEAS_N_02_B(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J)) .
          ALFA_N(S,Z,I,J,N)=L=1-NHE_N1_B(S,Z,I,J,N)-NHE_N1_B(S,Z,I,J,N-1);
*-------------------------------------------------------------------------------
*EQ (71)
FEAS_N_03(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I)
 AND FREEC(J))..
   ALFA_N(S,Z,I,J,N)=G=Y_N(S,Z,I,J,N)-NHE_N0(S,Z,I,J,N)-NHE_N0(S,Z,I,J,N-1)
                    - NHE_N1(S,Z,I,J,N)-NHE_N1(S,Z,I,J,N-1);
FEAS_N_03_B(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
 ALFA_N(S,Z,I,J,N)=G=Y_N_B(S,Z,I,J,N)-NHE_N0_B(S,Z,I,J,N)-NHE_N0_B(S,Z,I,J,N-1)
                   -NHE_N1_B(S,Z,I,J,N)-NHE_N1_B(S,Z,I,J,N-1);
*-------------------------------------------------------------------------------
*EQ (72)
FEAS_N_04(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND (BIF(Z,I,J)=1 OR SPC(J)=1)
 AND FREEH(I) AND FREEC(J))..
                          ALFA_N(S,Z,I,J,N)=G=0;
*-------------------------------------------------------------------------------
*EQ (73)
FEAS_N_2(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..
 QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))=L=
    QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
       +(1-ALFA_N(S,Z,I,J,N))*DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)));
*-------------------------------------------------------------------------------
*EQ (74)
FEAS_N_1(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..
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 QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))
    +(1-ALFA_N(S,Z,I,J,N))*DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))=G=
            QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)));
*-------------------------------------------------------------------------
*EQ (75)
FEAS_N_3(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I)
 AND FREEC(J))..
 -QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
 +QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))
   +(1+NHE_N1(S,Z,I,J,N-1)+NHE_N1(S,Z,I,J,N)
 -NHE_N0(S,Z,I,J,N-1))*DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))*1.00001 =G= 0;
*-------------------------------------------------------------------------
*EQ (76)
FEAS_N_4(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I)
 AND FREEC(J))..
 -QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))
 +QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
 +(1+NHE_N0(S,Z,I,J,N-1)  + NHE_N0(S,Z,I,J,N)
 -NHE_N1(S,Z,I,J,N))*DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))*1.00001=G=0;
*-------------------------------------------------------------------------
*EQ (77)
FEAS_N_3_B_2(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1
 AND FREEH(I) AND FREEC(J))..
 -QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
 +QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))
 +(1 + NHE_N1_B(S,Z,I,J,N-1)+ NHE_N1_B(S,Z,I,J,N)-NHE_N0_B(S,Z,I,J,N-1))
  *DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))=G=0;
*-------------------------------------------------------------------------
*EQ (78)
FEAS_N_3_B_1(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1
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 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1
 AND FREEH(I) AND FREEC(J))..
 -QNEW2_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
 +QNEW_N(S,Z,I,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))+(2 + NHE_N1_B(S,Z,I,J,N)
 + NHE_N1_B(S,Z,I,J,N-1)-NHE_N0_B(S,Z,I,J,N-1)-Y_N_B(S,Z,I,J,N-1))
  *DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))=G=0;
*---------------------------------------------------------------------------
*EQ (79)
FEAS_N_4_B(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1 AND FREEH(I)
 AND FREEC(J))..
 -(QNEW_N(S,Z,I,J,N)-QNEW2_N(S,Z,I,J,N))/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))
 + QNEW_N(S,Z,I,J,N-1)/(CPC(S,J,N-1)*(TU(S,N-1)-TL(S,N-1)))
 +(2 + NHE_N0_B(S,Z,I,J,N-1)
 + NHE_N0_B(S,Z,I,J,N) -NHE_N1_B(S,Z,I,J,N)-Y_N_B(S,Z,I,J,N))
  *DHC(S,J,N)/(CPC(S,J,N)*(TU(S,N)-TL(S,N)))=G=0;
*---------------------------------------------------------------------------
*EQ (80)
 FEAS_N_1_SP(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND COLD(S,J,N+1)AND
 ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND ALLOW_C(S,Z,J,N+1,I)
 AND BIF(Z,I,J)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..
    QNEW_N(S,Z,I,J,N) =G=
   (Y_N(S,Z,I,J,N)-NHE_N0(S,Z,I,J,N)-NHE_N1(S,Z,I,J,N))*DHC(S,J,N);

 FEAS_N_1_SP_B(S,Z,I,J,N)$(COLD(S,J,N-1) AND COLD(S,J,N)=1 AND COLD(S,J,N+1)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND ALLOW_C(S,Z,J,N+1,I)
 AND BIF(Z,I,J)=1 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..
    QNEW_N(S,Z,I,J,N) =G=
   (Y_N_B(S,Z,I,J,N)-NHE_N0_B(S,Z,I,J,N)-NHE_N1_B(S,Z,I,J,N))*DHC(S,J,N);
*---------------------------------------------------------------------------
*EQ (81)
FEAS_BEG_SP(S,Z,I,J,M,N)$(TL(S,N) LE TU(S,M) AND TU(S,N) GE TL(S,M)
 AND HOT(S,I,M)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1
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 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0 AND SPH(I)=0 AND SPC(J)=0
 AND FREEH(I) AND FREEC(J))..
  TL(S,M) - TL(S,N) - QNEW_N(S,Z,I,J,N)/(FC(S,J)*CPC(S,J,N))
 + QNEW_M(S,Z,I,J,M)/(FH(S,I)*CPH(S,I,M))
 + (2-NHE_M0(S,Z,I,J,M)-NHE_N0(S,Z,I,J,N))*TU(S,N)=G=0;

FEAS_BEG_B_SP(S,Z,I,J,M,N)$(TL(S,N) LE TU(S,M) AND TU(S,N) GE TL(S,M)
 AND HOT(S,I,M)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1 AND SPH(I)=0 AND SPC(J)=0
 AND FREEH(I) AND FREEC(J))..
  TL(S,M) - TL(S,N) -QNEW_N(S,Z,I,J,N)/(FC(S,J)*CPC(S,J,N))
 + QNEW_M(S,Z,I,J,M)/(FH(S,I)*CPH(S,I,M))
 + (2-NHE_M0_B(S,Z,I,J,M)-NHE_N0_B(S,Z,I,J,N))*TU(S,N)=G=0;
*-------------------------------------------------------------------------
*EQ (82)
FEAS_END_SP(S,Z,I,J,M,N)$(TL(S,N) LE TU(S,M) AND TU(S,N) GE TL(S,M)
 AND HOT(S,I,M)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=0 AND SPH(I)=0 AND SPC(J)=0
 AND FREEH(I) AND FREEC(J))..
  TU(S,M)-TU(S,N)
 -QNEW_M(S,Z,I,J,M)/(FH(S,I)*CPH(S,I,M)) +QNEW_N(S,Z,I,J,N)/(FC(S,J)*CPC(S,J,N))
                +(2-NHE_M1(S,Z,I,J,M)-NHE_N1(S,Z,I,J,N))*TU(S,N)=G=0;
FEAS_END_B_SP(S,Z,I,J,M,N)$(TL(S,N) LE TU(S,M) AND TU(S,N) GE TL(S,M)
 AND HOT(S,I,M)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_C(S,Z,J,N,I)=1 AND BIF(Z,I,J)=1 AND SPH(I)=0 AND SPC(J)=0
 AND FREEH(I) AND FREEC(J))..
  TU(S,M)-TU(S,N)
-QNEW_M(S,Z,I,J,M)/(FH(S,I)*CPH(S,I,M)) + QNEW_N(S,Z,I,J,N)/(FC(S,J)*CPC(S,J,N))
              +(2-NHE_M1_B(S,Z,I,J,M)-NHE_N1_B(S,Z,I,J,N))*TU(S,N)=G=0;
*-------------------------------------------------------------------------
*EQ (83)
FEAS_BEG3(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
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 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=0
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
          NHE_N1(S,Z,I,J,N)=L=(2-NHE_M0(S,Z,I,J,M)-NHE_N0(S,Z,I,J,N));
*-------------------------------------------------------------------------
*EQ (84)
FEAS_BEG(S,Z,I,J,M,N)$(DTVIO(I,J)=1  AND D(S,Z,M,N)=1 AND D(S,Z,M,N)=1
 AND TL(S,N) LT TU(S,M) AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1)
 AND COLD(S,J,N)=1 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1
 AND ALLOW_H(S,Z,I,M+1,J) AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I)
 AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
   QNEW_N(S,Z,I,J,N)/(TU(S,M)-TL(S,N))=L=
     QNEW_N(S,Z,I,J,N+1)/(TU(S,N+1)-TL(S,N+1))* CPC(S,J,N)/CPC(S,J,N+1)
       +(2-NHE_M0(S,Z,I,J,M)-NHE_N0(S,Z,I,J,N))*DHC(S,J,N)/(TU(S,M)-TL(S,N));
*-------------------------------------------------------------------------
*EQ (85)
FEAS_BEG2(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=0
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)/(MIN(TU(S,M),TU(S,N))-TL(S,M))=G=
    QNEW_M(S,Z,I,J,M+1)/(TU(S,M+1)-TL(S,M+1))
  *CPH(S,I,M)/CPH(S,I,M+1)-(2-NHE_M0(S,Z,I,J,M)-NHE_N0(S,Z,I,J,N))
  *DHH(S,I,M+1)/(TU(S,M+1)-TL(S,M+1));
*-------------------------------------------------------------------------
*EQ (86)
FEAS_END3(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
 AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
          NHE_M0(S,Z,I,J,M)=L=(2-NHE_M1(S,Z,I,J,M)-NHE_N1(S,Z,I,J,N));
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*-------------------------------------------------------------------------

*EQ (87)

FEAS_END(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
 AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)/(TU(S,M)-TL(S,N))=L=
    QNEW_M(S,Z,I,J,M-1)/(TU(S,M-1)-TL(S,M-1))
      *CPH(S,I,M)/CPH(S,I,M-1)+(2-NHE_M1(S,Z,I,J,M)-NHE_N1(S,Z,I,J,N))
      *DHH(S,I,M)/(TU(S,M)-TL(S,N));
*-------------------------------------------------------------------------

*EQ (88)

FEAS_END2(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
 AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=0
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 QNEW_N(S,Z,I,J,N)/(TU(S,N)-MAX(TL(S,M),TL(S,N)))=G=
    QNEW_N(S,Z,I,J,N-1)/(TU(S,N-1)-TL(S,N-1))
     *CPC(S,J,N)/CPC(S,J,N-1)-(2-NHE_M1(S,Z,I,J,M)-NHE_N1(S,Z,I,J,N))
     *DHC(S,J,N-1)/(TU(S,N-1)-TL(S,N-1));
*-------------------------------------------------------------------------

*EQ (89)

FEAS_BEG4_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=1
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
    NHE_N1_B(S,Z,I,J,N) =L=
          (1+Y_N_B(S,Z,I,J,N)-NHE_M0_B(S,Z,I,J,M)-NHE_N0_B(S,Z,I,J,N));
*-------------------------------------------------------------------------

*EQ (90)
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```
FEAS_BEG2_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=1
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 QNEW_N(S,Z,I,J,N)/(TU(S,M)-TL(S,N))=L=
   QNEW_N(S,Z,I,J,N+1)/(TU(S,N+1)-TL(S,N+1))
     *CPC(S,J,N)/CPC(S,J,N+1)+(1+Y_N_B(S,Z,I,J,N)
   -NHE_M0_B(S,Z,I,J,M)-NHE_N0_B(S,Z,I,J,N))*DHC(S,J,N)/(TU(S,M)-TL(S,N));
*-------------------------------------------------------------------------
*EQ (91)
FEAS_BEG1_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=1
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
  QNEW2_N(S,Z,I,J,N)/(TU(S,M)-TL(S,N))=L=
     QNEW_N(S,Z,I,J,N+1)/(TU(S,N+1)-TL(S,N+1))
  *CPC(S,J,N)/CPC(S,J,N+1)+(2-NHE_M0_B(S,Z,I,J,M)-NHE_N0_B(S,Z,I,J,N))
  *DHC(S,J,N)/(TU(S,M)-TL(S,N));
*-------------------------------------------------------------------------
*EQ (92)
FEAS_BEG3_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M+1) AND COLD(S,J,N)=1
 AND COLD(S,J,N+1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M+1,J)
 AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N+1,I) AND BIF(Z,I,J)=1
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 QNEW_M(S,Z,I,J,M)/(MIN(TU(S,M),TU(S,N))-TL(S,M))=G=
 QNEW_M(S,Z,I,J,M+1)/(TU(S,M+1)-TL(S,M+1))
 *CPH(S,I,M)/CPH(S,I,M+1)-(2-NHE_M0_B(S,Z,I,J,M)-NHE_N0_B(S,Z,I,J,N))
 *DHH(S,I,M+1)/(TU(S,M+1)-TL(S,M+1));
*-------------------------------------------------------------------------
*EQ (93)
```

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FEAS_END3_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
 AND TU(S,N) GT TL(S,M) AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
 AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
 AND ALLOW_C(S,Z,J,N,I) AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1
 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
  NHE_M0_B(S,Z,I,J,M)=L=
            (1+Y_M_B(S,Z,I,J,M)-NHE_M1_B(S,Z,I,J,M)-NHE_N1_B(S,Z,I,J,N));
*-------------------------------------------------------------------------
*EQ (94)
FEAS_END_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
  AND TU(S,N) GT TL(S,M)  AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
  AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
  AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1
  AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
     (QNEW_M(S,Z,I,J,M)-QNEW2_M(S,Z,I,J,M))/(TU(S,M)-TL(S,N))=L=
       QNEW_M(S,Z,I,J,M-1)/(TU(S,M-1)-TL(S,M-1))*CPH(S,I,M)/CPH(S,I,M-1)+
     (2-NHE_M1_B(S,Z,I,J,M)-NHE_N1_B(S,Z,I,J,N))*DHH(S,I,M)/(TU(S,M)-TL(S,N));
*-------------------------------------------------------------------------
*EQ (95)
FEAS_END2_B(S,Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M)
  AND TU(S,N) GT TL(S,M)  AND HOT(S,I,M)=1 AND HOT(S,I,M-1) AND COLD(S,J,N)=1
  AND COLD(S,J,N-1) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_H(S,Z,I,M-1,J)
  AND ALLOW_C(S,Z,J,N,I)=1 AND ALLOW_C(S,Z,J,N-1,I) AND BIF(Z,I,J)=1
  AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..
 (QNEW_N(S,Z,I,J,N)-QNEW2_N(S,Z,I,J,N))/(TU(S,N)-MAX(TL(S,M),TL(S,N)))=G=
  QNEW_N(S,Z,I,J,N-1)/(TU(S,N-1)-TL(S,N-1))*CPC(S,J,N)/CPC(S,J,N-1)
-(2-NHE_M1_B(S,Z,I,J,M)-NHE_N1_B(S,Z,I,J,N))*DHC(S,J,N-1)/(TU(S,N-1)-TL(S,N-1));
*-------------------------------------------------------------------------
*EQ (96)
PAREQ(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
 PAR(Z,I,J)=E=SUM((M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),
              Q(S,Z,I,M,J,N)*(1/H_I(S,I,M)+1/H_J(S,J,N))/LMTD(S,M,N));
```

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*-------------------------------------------------------------------------
*EQ (97)
BIF_13_2(S,K,Z,I,J,M)$(ORD(K) LT KMAX(Z,I,J) AND HOT(S,I,M)=1
 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  PAR_B(K,Z,I,J)=L=
       SUM((L,N)$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M) AND TL(S,N) LT TU(S,L)
  AND HOT(S,I,L)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,L,J)=1
  AND ALLOW_C(S,Z,J,N,I)=1),
  (Q(S,Z,I,L,J,N)-Q2(S,Z,I,L,J,N))*(1/H_I(S,I,L)+1/H_J(S,J,N))/LMTD(S,L,N))
          +AMAX*(2-NHE_M1_B(S,Z,I,J,M)-X1_B(S,Z,I,J,M)-
       SUM(KK$(ORD(KK) GT 1 AND ORD(KK) LT ORD(K)),X_B(S,KK,Z,I,J,M)));
*-------------------------------------------------------------------------
*EQ (98)
BIF_13_1(S,K,Z,I,J,M)$(ORD(K) LT KMAX(Z,I,J) AND HOT(S,I,M)=1
 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  PAR_B(K,Z,I,J)=G=
       SUM((L,N)$(D(S,Z,L,N)=1 AND ORD(L) LE ORD(M) AND TL(S,N) LT TU(S,L)
  AND HOT(S,I,L)=1 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,L,J)=1
  AND ALLOW_C(S,Z,J,N,I)=1),
  (Q(S,Z,I,L,J,N)-Q2(S,Z,I,L,J,N))*(1/H_I(S,I,L)+1/H_J(S,J,N))/LMTD(S,L,N))
          -AMAX*(2-NHE_M1_B(S,Z,I,J,M)-X1_B(S,Z,I,J,M)-
       SUM(KK$(ORD(KK) GT 1 AND ORD(KK) LT ORD(K)),X_B(S,KK,Z,I,J,M)));
*-------------------------------------------------------------------------
*EQ (99)
BIF_14(S,K,Z,I,J)$(ORD(K) EQ KMAX(Z,I,J) AND ALLOW(S,Z,I,J)=1 AND FREEH(I)
 AND FREEC(J) AND BIF(Z,I,J)=1)..
   PAR_B(K,Z,I,J)=E=PAR(Z,I,J)-SUM(KK$(ORD(KK) LT ORD(K)),PAR_B(KK,Z,I,J));
*-------------------------------------------------------------------------
*EQ (100)
BIF_15(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
   X1_B(S,Z,I,J,M)+SUM(K$(ORD(K) GT 1 AND ORD(K) LE KMAX(Z,I,J)),
   ORD(K)*X_B(S,K,Z,I,J,M))=E= SUM(L$(HOT(S,I,L)=1 AND ORD(L) LE ORD(M) AND
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    ALLOW_H(S,Z,I,L,J)=1),NHE_M0_B(S,Z,I,J,L))+1-Y_M_B(S,Z,I,J,M) ;
*-------------------------------------------------------------------------------
*EQ (101)
BIF_17(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
  SUM(N$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1 AND COLD(S,J,N)=1
      AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),
                        Q2(S,Z,I,M,J,N))=E=QNEW2_M(S,Z,I,J,M);
*-------------------------------------------------------------------------------
*EQ (102)
 BIF_16(S,Z,I,J,M)$(HOT(S,I,M)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND BIF(Z,I,J)=1
 AND FREEH(I) AND FREEC(J))..
    X1_B(S,Z,I,J,M)=L=1;
*-------------------------------------------------------------------------------
*EQ (103)
BIF_18(S,Z,I,J,M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND HOT(S,I,M)=1
 AND COLD(S,J,N)=1 AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1
 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
                        Q2(S,Z,I,M,J,N)=L=Q(S,Z,I,M,J,N);
*-------------------------------------------------------------------------------
*EQ (104)
SHELL(Z,I,J)$(SUM[S,ALLOW(S,Z,I,J)]>= 1 AND FREEH(I) AND FREEC(J) AND
 BIF(Z,I,J)=0)..
                        PAR(Z,I,J)=L=ASHELLMAX*USHELL(Z,I,J);
*-------------------------------------------------------------------------------
*EQ (105)
SHELL_B(K,Z,I,J)$(SUM[S,ALLOW(S,Z,I,J)]>= 1 AND FREEH(I) AND FREEC(J)
 AND BIF(Z,I,J)=1)..
                    PAR_B(K,Z,I,J)=L=ASHELLMAX*USHELL_B(K,Z,I,J);
*-------------------------------------------------------------------------------
*EQ (106)
TOTALCOST.. TCOST =E=  SUM(I$(HU(I) AND FREEH(I)),CHU(I)*FHU(I)*DTHU(I))
          + SUM(J$(CU(J) AND FREEC(J)),CCU(J)*FCU(J)*DTCU(J))
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  + SUM((Z,I,J)$(SUM[S,ALLOW(S,Z,I,J)]>= 1 AND FREEH(I) AND FREEC(J)
      AND BIF(Z,I,J)=0),  CF*USHELL(Z,I,J))
  + SUM((K,Z,I,J)$(SUM[S,ALLOW(S,Z,I,J)]>= 1 AND FREEH(I) AND FREEC(J)
      AND BIF(Z,I,J)=1).  CF*USHELL_B(K,Z,I,J))
  + SUM((Z,I,J)$(SUM[S,ALLOW(S,Z,I,J)]>= 1 AND FREEH(I) AND FREEC(J) ),
     CA*PAR(Z,I,J)),
*-------------------------------------------------------------------------
*EQ (107) CONSISTENCY: Number of exchangers smaller than the number of shells
* Needed because the exchangers are related to the values of K.

KMAX1(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=0)..
 NHE(S,Z,I,J) =L= USHELL(Z,I,J) ;

KMAX2(S,Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=1)..
 NHE(S,Z,I,J) =L= SUM(K,USHELL_B(K,Z,I,J)) ;
*-------------------------------------------------------------------------
*-------------------------------------------------------------------------
* EXTRA EQUATIONS NOT IN PAPER BUT NEEDED
*-*-----------------------------------------------------------------------
*EQ (extra 1)  LIMIT THE NUMBER OF EXCHANGERS
TOTNEXCH_MAX(S).. SUM((Z,I,J)$(ALLOW(S,Z,I,J)= 1 AND FREEH(I) AND FREEC(J)),
 NHE(S,Z,I,J))=L=TOTNEXCHMAX;
*-------------------------------------------------------------------------
*EQ (extra 2)    MINIMUM NUMBER OF EXCHANGERS
TOTNEXCH_MIN(S).. SUM((Z,I,J)$(ALLOW(S,Z,I,J)=1 AND FREEH(I) AND FREEC(J)),
NHE(S,Z,I,J))=G=TOTNEXCHMIN;


MODEL MPERIOD /ALL/ ;

 OPTION LIMROW =5000;
 OPTION LIMCOL =5000;
 OPTION SOLPRINT = OFF;
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 OPTION OPTCR=0   ;
 OPTION OPTCA=0   ;
 OPTION RESLIM = 1000;
 OPTION ITERLIM = 10000000;
*  PMATCH.PRIOR(Z,I,J) = 0.5;
*  HUMATCH.PRIOR(Z,S,J)=0.75;
*  CUMATCH.PRIOR(Z,I,W)=0.75;

SOLVE MPERIOD USING MIP MINIMIZING TCOST ;

PARAMETER QMATCH(S,Z,I,J);
QMATCH(S,Z,I,J)=SUM((M,N)$(D(S,Z,M,N)=1 AND TL(S,N) LT TU(S,M) AND D(S,Z,M,N)=1
AND COLD(S,J,N) AND ALLOW_H(S,Z,I,M,J)=1 AND ALLOW_C(S,Z,J,N,I)=1),
                                        Q.L(S,Z,I,M,J,N));

PARAMETER FH_H(S,Z,I,J,M) Flowrate of hot stream per HEx;
FH_H(S,Z,I,J,M)$[HOT(S,I,M)]=QNEW_M.L(S,Z,I,J,M)/[(TU(S,M)-TL(S,M))*CPH(S,I,M)]

PARAMETER FC_C(S,Z,J,I,M) Flowrate of hot stream per HEx;
FC_C(S,Z,J,I,M)$[COLD(S,J,M)]=QNEW_N.L(S,Z,I,J,M)/[(TU(S,M)-TL(S,M))*CPC(S,J,M)]

PARAMETER NHE2(S,Z,J,I);
      NHE2(S,Z,J,I)= NHE.L(S,Z,I,J);
*$ONTEXT
OPTION DHH:3:0:1; DISPLAY DHH;
OPTION DHC:3:0:1; DISPLAY DHC;
OPTION HHEAD:3:2:1; DISPLAY HHEAD;
OPTION CHEAD:3:2:1; DISPLAY CHEAD;
OPTION ALLOW:3:0:1; DISPLAY ALLOW;
OPTION ALLOW_H:3:0:1; DISPLAY ALLOW_H;
OPTION ALLOW_C:3:0:1; DISPLAY ALLOW_C;
OPTION ALLOW_2:2:0:1; DISPLAY ALLOW_2;
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OPTION Q:3:0:1; DISPLAY Q.L;
OPTION QNEW_M:3:0:1; DISPLAY QNEW_M.L;
OPTION QNEW_N:3:0:1; DISPLAY QNEW_N.L;
OPTION QNEW2_M:3:0:1; DISPLAY QNEW2_M.L;
OPTION QNEW2_N:3:0:1; DISPLAY QNEW2_N.L;
OPTION Y_M:3:0:1; DISPLAY Y_M.L;
OPTION Y_N:3:0:1; DISPLAY Y_N.L;
OPTION NHE_M0:3:0:1; DISPLAY NHE_M0.L;
OPTION NHE_M1:3:0:1; DISPLAY NHE_M1.L;
OPTION NHE_N0:3:0:1; DISPLAY NHE_N0.L;
OPTION NHE_N1:3:0:1; DISPLAY NHE_N1.L;
OPTION Y_M_B:3:0:1; DISPLAY Y_M_B.L;
OPTION Y_N_B:3:0:1; DISPLAY Y_N_B.L;
OPTION NHE_M0_B:3:0:1; DISPLAY NHE_M0_B.L;
OPTION NHE_M1_B:3:0:1; DISPLAY NHE_M1_B.L;
OPTION NHE_N0_B:3:0:1; DISPLAY NHE_N0_B.L;
OPTION NHE_N1_B:3:0:1; DISPLAY NHE_N1_B.L;
OPTION ALFA_M:3:0:1; DISPLAY ALFA_M.L;
OPTION ALFA_N:3:0:1; DISPLAY ALFA_N.L;
OPTION NHE:3:0:1; DISPLAY NHE.L;
OPTION QH:3:0:1; DISPLAY QH.L;
OPTION QC:3:0:1; DISPLAY QC.L;
OPTION X1_B:3:0:1; DISPLAY X1_B.L;
OPTION X_B:3:0:1; DISPLAY X_B.L;
OPTION Q2:3:0:1; DISPLAY Q2.L;
OPTION FHU:3:0:1; DISPLAY FHU.L;
OPTION FCU:3:0:1; DISPLAY FCU.L;
* OPTION PAR1:3:0:1; DISPLAY PAR1.L;
* OPTION PAR2:3:0:1; DISPLAY PAR2.L;
OPTION NHE2:3:0:1; DISPLAY NHE2;
OPTION PAR:3:0:1; DISPLAY PAR.L;
OPTION PAR_B:3:0:1; DISPLAY PAR_B.L;
OPTION QMATCH:3:0:1; DISPLAY QMATCH;
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OPTION FH_H:3:0:1; DISPLAY FH_H;
OPTION FC_C:3:0:1; DISPLAY FC_C;
OPTION LMTD:3:0:1; DISPLAY LMTD;
 OPTION D:3:0:1; DISPLAY D;
OPTION DT:3:0:1; DISPLAY DT;
OPTION TU:3:0:1; DISPLAY TU;
OPTION TL:3:0:1; DISPLAY TL;
OPTION CPH:3:0:1; DISPLAY CPH;
OPTION CPC:3:0:1; DISPLAY CPC;
OPTION FREEC:3:0:1; DISPLAY FREEC;
OPTION COLD:3 0:1; DISPLAY COLD;
OPTION HOT:3:0:1; DISPLAY HOT;
OPTION CU:3:0:1; DISPLAY CU;
OPTION NIC:3:0:1; DISPLAY NIC;
OPTION IHminZ:3:0:1; DISPLAY IHminZ;
OPTION IHmaxZ:3:0:1; DISPLAY IHmaxZ;
OPTION IHmax:3:0:1; DISPLAY IHmax;
OPTION IHmin:3:0:1; DISPLAY IHmin;
OPTION ICminZ:3:0:1; DISPLAY ICminZ;
OPTION ICmaxZ:3:0:1; DISPLAY ICmaxZ;
OPTION TIHZ:3:0:1; DISPLAY TIHZ;
OPTION TOCZ:3:0:1; DISPLAY TOCZ;
OPTION TOHZ:3:0:1; DISPLAY TOHZ;
OPTION TICZ:3:0:1; DISPLAY TICZ;
OPTION HOTZ:3:0:1; DISPLAY HOTZ;
OPTION HOT2:3:0:1; DISPLAY HOT2;
OPTION COLDZ:3:0:1; DISPLAY COLDZ;
OPTION COLD2:3:0:1; DISPLAY COLD2;

*$offtext
```

Appendix B Programming Model for Retrofit Heat Exchanger Network

```
$TITLE  HEN retrofit- Automatic parameter calculation
$OFFUPPER

*************************************************************************
*************************************************************************
* INPUT SETS
*************************************************************************
*************************************************************************
SETS
 Z transfer zones       /Z1/
*_____________________________________________
*ALWAYS DEFINE THE HOT STREAMS FIRST, AND THEN THE COLD STREAMS
 I Hot streams          /I1*I4/
 J cold streams         /J1*J3/
*ALWAYS DEFINE THE UTILITIES WITH THE HIGHEST INDEX
 HU(I) Heating utilities /I4/
 CU(J) Cooling utilities /J3/
*_____________________________________________
 M temperature intervals /M1*M171/

 K exchangers per pair of stremas in each zone /K1/
 FREEH(I)  HOT STREAMS INCLUDED IN THIS RUN /I1,I2,I3,I4/
 FREEC(J)  COLD STREAMS INCLUDED IN THIS RUN /J1,J2,J3/
*************************************************************************
*************************************************************************
* INPUT PARAMETERS
*************************************************************************
*************************************************************************
PARAMETERS
NIZ(Z,I) NUMBER OF INTERVALS DESIRED FOR HOT STREAMS IN EACH ZONE
/
```

Z1.I1 32

Z1.I2 27

Z1.I3 24

Z1.I4 19

/

NJZ(Z,J) NUMBER OF INTERVALS DESIRED FOR COLD STREAMS IN EACH ZONE

/

Z1.J1 28

Z1.J2 23

Z1.J3 18

/

TIH(I) SUPPLY (INLET) TEMPERATURE FOR HOT STREAMS

/

I1 432

I2 540

I3 616

I4 773

/

TOH(I) TARGET (FINAL) TEMPERATURE FOR HOT STREAMS

/

I1 350

I2 361

I3 363

I4 772

/

TIC(J) SUPPLY (INLET) TEMPERATURE FOR COLD STREAMS

/

J1 299

J2 391

J3 293

/

TOC(J) TARGET (FINAL) TEMPERATURE FOR COLD STREAMS

```
/
J1 400
J2 538
J3 313
/
TIHZ(Z,I) SUPPLY (INLET) TEMPERATURE FOR HOT STREAMS IN EACH ZONE
/
Z1.I1 432
Z1.I2 540
Z1.I3 616
Z1.I4 773
/
TOHZ(Z,I) TARGET (FINAL) TEMPERATURE FOR HOT STREAMS IN EACH ZONE
/
Z1.I1 350
Z1.I2 361
Z1.I3 363
Z1.I4 772
/
TICZ(Z,J) SUPPLY (INLET) TEMPERATURE FOR COLD STREAMS IN EACH ZONE
/
Z1.J1 299
Z1.J2 391
Z1.J3 293
/
TOCZ(Z,J) TARGET (FINAL) TEMPERATURE FOR COLD STREAMS IN EACH ZONE
/
Z1.J1 400
Z1.J2 538
Z1.J3 313
/
PARAMETER FH(I)
/
```

```
I1    228.5
I2    20.4
I3    53.8
/

PARAMETER FC(J)
/
J1    93.3
J2    196.1
/


PARAMETER HI(I)
/
I1    0.4
I2    0.3
I3    0.25
I4    0.53
/

PARAMETER HJ(J)
/
J1    0.15
J2    0.5
J3    0.53
/
BIF(Z,I,J)   ALLOW MORE THAN ONE EXCHANGER IN EACH ZONE
/
Z1.I1.J1    0
/
SPH(I)   ALLOW SPLITTING FOR HOT STREAMS (SH in paper)
/
I1    0
```

I2 0

I3 0

I4 0

/

SPC(J) ALLOW SPLITTING FOR COLD STREAMS (SC in paper)

/

J1 1

J2 1

J3 1

/

NIH(I) NON ISOTHERMAL MIXING FOR HOT STREAMS

/

I1 0

/

NIC(J) NON ISOTHERMAL MIXING FOR COLD STREAMS

/

J1 0

/

DTVIO(I,J) SET TO ZERO IF TEMPERATURE FEASIBILITY CHECKING IS NOT NEEDED

* THAT IS, WHEN STREAM TEMPERATURES DO NOT OVERLAP.

/

I1.J1 1

I1.J2 1

I1.J3 1

I2.J1 1

I2.J2 1

I2.J3 1

I3.J1 1

I3.J2 1

I3.J3 1

I4.J1 1

I4.J2 1

```
I4.J3    1
/
KMAX(Z,I,J) MAXIMUM NUMBER OF EXCHANGERS PER MATCH WHEN ALLOWED (BIF=1)
/
Z1.I1.J1    1
/
PARAMETER AEX(Z,I,J)
/
Z1.I1.J1  1001.34
Z1.I1.J3  1048.28
Z1.I2.J2  121.53
Z1.I2.J3  133.56
Z1.I3.J1  584.15
Z1.I3.J2  603.71
Z1.I4.J2  246.81
/
PARAMETER AEX_B(K,Z,I,J)
/
K1.Z1.I1.J1      1001.34
/

PARAMETER NHE0(Z,I,J)
/
Z1.I1.J1  1
Z1.I1.J3  1
Z1.I2.J2  1
Z1.I2.J3  1
Z1.I3.J1  1
Z1.I3.J2  1
Z1.I4.J2  1
/
```

```
PARAMETER AEX_U(Z,I,J)
/
Z1.I1.J1  1502.01
Z1.I1.J3  1572.42
Z1.I2.J2  182.295
Z1.I2.J3  200.34
Z1.I3.J1  876.225
Z1.I3.J2  905.565
Z1.I4.J2  370.215
/

PARAMETER AEX_U_B(K,Z,I,J)
/
K1.Z1.I1.J1   1502.01
/

DTHU(I)    TEMPERATURE CHANGE OF HOT UTILITY
/
I4     1
/
DTCU(J)    TEMPERATURE CHANGE OF COLD UTILITY
/
J3     20
/
FMAX_HU(I)  MAXIMUM FLOW OF HOT UTILITY
/
I4     10000
/
FMAX_CU(J)  MAXIMUM FLOW OF COLD UTILITY
/
J3     10000
/
CHU(I)  COST OF HOT UTILITY (PER UNIT FLOW)
```

```
/
I4      95.04
/
CCU(J) COST OF COLD UTILITY (PER UNIT FLOW)
/
J3      20
/
CF FIXED COST PER SHELL
/3460/
CAN COST PER UNIT AREA
/171.4/
CAE
/171.4/

QLHMIN   MINIMUM HEAT THAT CAN BE TRANSFERRED IN EACH HOT STREAM INTERVAL
/0.00/
QLCMIN MINIMUM HEAT THAT CAN BE TRANSFERRED IN EACH COLD STREAM INTERVAL
/0.00/
AMAX  MAXIMUM AREA PER EXCHANGER
/20000/
ASHELLMAX  MAXIMUM AREA PER SHELL
/5000/
TOTNEXCHMAX  MAXIMUM NUMBER OF EXCHANGERS IN THE NETWORK (ALL ZONES)
/900/
TOTNEXCHMIN  MINIMUM NUMBER OF EXCHANGERS IN THE NETWORK (ALL ZONES)
/0/

*-------------------------------------------------------------------------
*                    END OF INPUT PARAMETERS
*              START OF AUTOMATIC CALCULATION OF PARAMETERS
*-------------------------------------------------------------------------

 ALIAS (M,N,L,O)
```

```
ALIAS (I,II)
ALIAS (J,JJ)
ALIAS (K,KK)
ALIAS (Z,ZZ);

SCALARS Zi, Mi, Ic, Ji

PARAMETERS IHminZ(Z,I),IHmaxZ(Z,I),IHmax(I),IHmin(I),
        HOT(I,M), HOT2(M), HOTZ(Z,I,M),ICminZ(Z,J),ICmaxZ(Z,J),
        ICmin(J),ICmax(J),COLD(J,M),COLD2(M), COLDZ(Z,J,M),
        H_I(I,M), H_J(J,M)
* WE FIRST CALCULATE THE STARTING INTERVALS FOR EACH STREAM FOR EACH
* SCENARIO IN EACH ZONE: IHminZ(S,Z,I)


  FOR(Zi=1 TO CARD(Z),
    FOR(Ic=1 TO CARD(I),
      IHminZ(Z,I)$[ORD(I)=1 AND ORD(Z)=1]=
                                  0+ 1$[NIZ(Z,I)>=1];
      IHminZ(Z,I)$[ORD(I)>1 AND ORD(Z)=1]=
       0+ {SUM((ZZ,II)$[ORD(II)<ORD(I)],NIZ(ZZ,II))+1}$[NIZ(Z,I)>=1];
      IHminZ(Z,I)$[ORD(Z)>1]=
       0+ {SUM((ZZ,II)$[ORD(II)<ORD(I)],NIZ(ZZ,II))+
          SUM(ZZ$[ORD(ZZ)< Zi],NIZ(ZZ,I))+1}$[NIZ(Z,I)>=1];
      IHmaxZ(Z,I)$[ORD(I)=Ic AND ORD(Z)=Zi]=
       0+ {IHminZ(Z,I)+NIZ(Z,I)-1}$[NIZ(Z,I)>=1];
      IHmin(I)$[ORD(I)=Ic]=
        SUM[Z${SUM(ZZ$[ORD(ZZ)<=ORD(Z)-1],NIZ(ZZ,I))=0},IHminZ(Z,I)];
      IHmax(I)$[ORD(I)=Ic]=
        SUM[Z${SUM(ZZ$[ORD(ZZ)>=ORD(Z)+1],NIZ(ZZ,I))=0),IHmaxZ(Z,I)];

      FOR(Mi=1 TO CARD(M),
        HOT(I,M)$[ORD(I)=Ic AND ORD(M)=Mi]=
```

```
            0+ 1$[ORD(M)>= IHmin(I) AND ORD(M)<=IHmax(I)];
    HOT2(M)$[ORD(M)=Mi]=
            0+ 1$[ORD(M)<= SUM(I$(ORD(I)=CARD(I)),IHmax(I))];
    HOTZ(Z,I,M)$[ORD(I)=Ic AND ORD(M)=Mi
                                AND ORD(Z)=Zi]=
          0+ 1$[ORD(M)>= IHminZ(Z,I) AND ORD(M)<=IHmaxZ(Z,I)];
    H_I(I,M)$[ORD(I)=Ic AND ORD(M)=Mi
                          AND HOT(I,M)=1] = HI(I) ;
));
FOR(Ji=1 TO CARD(J),
  ICminZ(Z,J)$[ORD(J)=1AND ORD(Z)=1]=
    0+ {SUM(I$[ORD(I)=CARD(I)],IHmax(I))+1}$[NJZ(Z,J)>=1];
  ICminZ(Z,J)$[ORD(J)>1AND ORD(Z)=1]=
    0+ {SUM{I$[ORD(I)=CARD(I)],IHmax(I)}
     +SUM((ZZ,JJ)$[ORD(JJ)<ORD(J)],NJZ(ZZ,JJ))+1}$[NJZ(Z,J)>=1];
  ICminZ(Z,J)$[ORD(Z)>1]=
    0+ {SUM{I$[ORD(I)=CARD(I)],IHmax(I)}
     + SUM((ZZ.JJ$[ORD(JJ)<ORD(J)],NJZ(ZZ,JJ))
     + SUM(ZZ$[ORD(ZZ)< Zi],NJZ(ZZ,J))+1}$[NJZ(Z,J)>=1];
  ICmaxZ(Z,J)$[ORD(J)=Ji AND ORD(Z)=Zi]=
    0+ {ICminZ(Z,J)+NJZ(Z,J)-1}$[NJZ(Z,J)>=1];
  ICmin(J)$[ ORD(J)=Ji]=
    SUM[Z${SUM(ZZ$[ORD(ZZ)<=ORD(Z)-1],NJZ(ZZ,J))=0},ICminZ(Z,J)];
  ICmax(J)$[ORD(J)=Ji]=
    SUM[Z${SUM(ZZ$[ORD(ZZ)>=ORD(Z)+1],NJZ(ZZ,J))=0},ICmaxZ(Z,J)];

  FOR(Mi=1 TO CARD(M),
    COLD(J,M)$[ORD(J)=Ji AND ORD(M)=Mi]=
        0+ 1$[ORD(M)>= ICmin(J) AND ORD(M)<=ICmax(J)];
    COLD2(M)$[ORD(M)=Mi]=
        0+ 1$[ORD(M)>SUM(I$(ORD(I)=CARD(I)),IHmax(I))
            AND ORD(M)<= SUM(J$(ORD(J)=CARD(J)),ICmax(J))];
    COLDZ(Z,J,M)$[ORD(J)=Ji AND ORD(M)=Mi
```

```
            AND ORD(Z)=Zi]- 0+ 1$[ORD(M)>= ICminZ(Z,J)
                                    AND ORD(M)<=ICmaxZ(Z,J)];
        H_J(J,M)$[ ORD(J)=Ji AND ORD(M)=Mi
                                    AND COLD(J,M)=1] = HJ(J) ;
 )));

PARAMETERS DT(M),TU(M),CPH(I,M),CPC(J,M),TL(M),DHH(I,M),DHC(J,M) ;

*WE ALWAYS DEFINE Cp AS 1; USER IS TOLD TO ENTER F*Cp

 CPH(I,M)$[HOT(I,M)=1] = 1;
 CPC(J,M)$[COLD(J,M)=1] = 1;

DT(M) = SUM((Z,I)$[HOTZ(Z,I,M)=1],
          {[TIHZ(Z,I)-TOHZ(Z,I)]/[IHmaxZ(Z,I)-IHminZ(Z,I)+1]})
                                    $[HOT2(M)=1]+
      SUM((Z,J)$[COLDZ(Z,J,M)=1],
          {[TOCZ(Z,J)-TICZ(Z,J)]/[ICmaxZ(Z,J)-ICminZ(Z,J)+1]})
                                    $[COLD2(M)=1];


  FOR (Mi=1 TO CARD(M),
    TU(M)$[ORD(M)=Mi]=
        {SUM((Z,I)$[HOTZ(Z,I,M)=1 AND ORD(M)=
            IHminZ(Z,I)],TIHZ(Z,I)$[ORD(M)=IHminZ(Z,I)])
        + SUM((Z,I)$[HOTZ(Z,I,M)=1 AND ORD(M)>IHminZ(Z,I)
                    AND ORD(M)<=IHmaxZ(Z,I)],
            [TIHZ(Z,I)-(ORD(M)-!HminZ(Z,I))*DT(M)]
                $[ORD(M)>IHminZ(Z,I) AND ORD(M)<=
                    IHmaxZ(Z,I)])}$[HOT2(M)=1]
        +{SUM((Z,J)$[COLDZ(Z,J,M)=1 AND ORD(M)=ICminZ(Z,J)],
                TOCZ(Z,J)$[ORD(M)=ICminZ(Z,J)])
        + SUM((Z,J)$[COLDZ(Z,J,M)=1 AND ORD(M)>ICminZ(Z,J)
```

```
                                AND ORD(M)<=ICmaxZ(Z,J)],
                        [TOCZ(Z,J)-(ORD(M)-ICminZ(Z,J))*DT(M)]
                            $[ORD(M)>ICminZ(Z,J) AND ORD(M)<=
                                ICmaxZ(Z,J)])}$[COLD2(M)=1];
    TL(M)$[ORD(M)=Mi]=
        {SUM((Z,I)$[HOTZ(Z,I,M)=1 AND ORD(M)=
            IHmaxZ(Z,I)],TOHZ(Z,I)$[ORD(M)=IHmaxZ(Z,I)])
        + SUM((Z,I)$[HOTZ(Z,I,M)=1 AND ORD(M)<IHmaxZ(Z,I)
                AND ORD(M)>=IHminZ(Z,I)],
            [TOHZ(Z,I)+(IHmaxZ(Z,I)-ORD(M))*DT(M)]
                $[ORD(M)<IHmaxZ(Z,I)AND ORD(M)>=
                    IHminZ(Z,I)])}$[HOT2(M)=1]
        +{SUM((Z,J)$[COLDZ(Z,J,M)=1 AND ORD(M)=ICmaxZ(Z,J)],
                TICZ(Z,J)$[ORD(M)=ICmaxZ(Z,J)])
        + SUM((Z,J)$[COLDZ(Z,J,M)=1 AND ORD(M)<ICmaxZ(Z,J)
                AND ORD(M)>=ICminZ(Z,J)],
            [TICZ(Z,J)+(ICmaxZ(Z,J)-ORD(M))*DT(M)]
                $[ORD(M)<ICmaxZ(Z,J)AND ORD(M)>=
                    ICminZ(Z,J)])}$[COLD2(M)=1];
    FOR(Ic=1 TO CARD(I),
      DHH(I,M)$[ORD(M)=Mi AND ORD(I)=Ic
                    AND HOT(I,M)=1]=
                FH(I)*CPH(i,M)*[TU(M)-TL(M)] ;
      );
    FOR(Ji=1 TO CARD(J),
      DHC(J,M)$[ORD(M)=Mi AND ORD(J)=Ji
                    AND COLD(J,M)=1]=
                FC(J)*CPC(J,M)*[TU(M)-TL(M)] ;
      ));


PARAMETER HHEAD(M,N),CHEAD(M,N),LMTD(M,N),D(Z,M,N),
    ALLOW(Z,I,J), ALLOW_H(Z,I,M,J),ALLOW_C(Z,J,M,I), ALLOW_2(Z,I,J);
```

```
*D(S,Z,M,N)=1 MATCH BETWEEN INTERVALS M AND N ALLOWED BASED ON LMTD


*HHEAD(S,M,N) = {TU(S,M)-TU(S,N) + DTmin}$[HOT2(S,M) AND COLD2(S,N)];
*CHEAD(S,M,N) = {TL(S,M)-TL(S,N) + DTmin}$[HOT2(S,M) AND COLD2(S,N)]    ;
HHEAD(M,N) = {TU(M)-TU(N) }$[HOT2(M) AND COLD2(N)];
CHEAD(M,N) = {TL(M)-TL(N) }$[HOT2(M) AND COLD2(N)]    ;


*LMTD(S,M,N)= {[HHEAD(S,M,N)-CHEAD(S,M,N)]/LOG[HHEAD(S,M,N)/CHEAD(S,M,N)]}
*          $[HHEAD(S,M,N)> 0 AND CHEAD(S,M,N)>0 AND HHEAD(S,M,N)> CHEAD(S,M,N)]
*         + {[HHEAD(S,M,N)+CHEAD(S,M,N)]/2}$[HHEAD(S,M,N)>0 AND CHEAD(S,M,N)>0
*             AND (HHEAD(S,M,N)< CHEAD(S,M,N)OR HHEAD(S,M,N)= CHEAD(S,M,N))];
LMTD(M,N)= {[HHEAD(M,N)-CHEAD(M,N)]/LOG[HHEAD(M,N)/CHEAD(M,N)]}
         $[HHEAD(M,N)> 0 AND CHEAD(M,N)>0
           AND ( HHEAD(M,N)> CHEAD(M,N)+0.0001
           OR HHEAD(M,N)< CHEAD(M,N)-0.0001 )]
        + {[HHEAD(M,N)+CHEAD(M,N)]/2}$[HHEAD(M,N)>0 AND CHEAD(M,N)>0
           AND HHEAD(M,N)< CHEAD(M,N)+0.0001 AND HHEAD(M,N)> CHEAD(M,N)-0.0001];


D(Z,M,N)= 1$[  {HOT2(M)=1 AND HOT2(N)=1 AND SUM[I$(HOT(I,M)=1
           AND HOT(I,N)=1),HOTZ(Z,I,M)]=1 AND SUM[I$(HOT(I,N)=1
           AND HOT(I,M)=1),HOTZ(Z,I,N)]=1}
        OR {COLD2(M)=1 AND COLD2(N)=1 AND SUM[J$(COLD(J,M)=1
           AND COLD(J,N)=1),COLDZ(Z,J,M)]=1 AND SUM[J$(COLD(J,N)=1
           AND COLD(J,M)=1),COLDZ(Z,J,N)]=1}
        OR {(HHEAD(M,N)>=0.0001 AND CHEAD(M,N)>=0.0001)
*         OR {(HHEAD(S,M,N)>=(-0.0001+DTMIN) AND CHEAD(S,M,N)>=(-0.0001+DTMIN))
           AND SUM[I$(HOT(I,M)=1),HOTZ(Z,I,M)]=1
           AND SUM[J$(COLD(J,N)=1),COLDZ(Z,J,N)]=1}];



  FOR(Zi=1 TO CARD(Z),
    FOR(Ic=1 TO CARD(I),
```

```
        FOR(Ji=1 TO CARD(J),
          ALLOW(Z,I,J)$[ORD(Z)=Zi AND ORD(I)=Ic
                  AND ORD(J)=Ji]= 0+ 1${SUM[(M,N)$[HOT(I,M)=1
                  AND COLD(J,N)=1],D(Z,M,N)] >0
                  AND NOT[HU(I) AND CU(J)]};
          FOR (Mi=1 TO CARD(M),
            ALLOW_H(Z,I,M,J)$[ORD(Z)=Zi AND ORD(I)=Ic
                    AND ORD(J)=Ji AND ORD(M)=Mi
                    AND HOT(I,M)=1]=
              0+ 1${SUM[N$[COLD(J,N)=1],D(Z,M,N)] >0
                      AND NOT[HU(I)AND CU(J)]};
            ALLOW_C(Z,J,M,I)$[ORD(Z)=Zi AND ORD(I)=Ic
                    AND ORD(J)=Ji AND ORD(M)=Mi
                    AND COLD(J,M)=1]=
              0+ 1${SUM[N$[HOT(I,N)=1],D(Z,N,M)] >0
                      AND NOT[HU(I)AND CU(J)]};
          ))));
FOR(Zi=1 TO CARD(Z),
  FOR(Ic=1 TO CARD(I),
    FOR(Ji=1 TO CARD(J),
      ALLOW_2(Z,I,J)$[ORD(Z)=Zi AND ORD(I)=Ic AND ORD(J)=Ji]=
      0+ 1${ALLOW(Z,I,J) >0 AND NOT[HU(I)AND CU(J)]};
  )));
*-------------------------------------------------------------------------

 VARIABLES
    TCOST
    PAR(Z,I,J)
    Q(Z,I,M,J,N)
    QNEW_M(Z,I,J,M)
    QNEW_N(Z,I,J,N)
    QNEW2_M(Z,I,J,M)
```

QNEW2_N(Z,I,J,N)

Y_M(Z,I,J,M)

Y_N(Z,I,J,N)

Y_M_B(Z,I,J,M)

Y_N_B(Z,I,J,N)

NHE_M0(Z,I,J,M)

NHE_M1(Z,I,J,M)

NHE_N0(Z,I,J,N)

NHE_N1(Z,I,J,N)

NHE_M0_B(Z,I,J,M)

NHE_M1_B(Z,I,J,M)

NHE_N0_B(Z,I,J,N)

NHE_N1_B(Z,I,J,N)

NHE(Z,I,J)

ALFA_M(Z,I,J,M)

ALFA_N(Z,I,J,N)

FHU(I)

FCU(J)

B1(Z,I,M,J,N)

QH(Z,I,M,N)

QC(Z,J,M,N)

Q2(Z,I,M,J,N)

X1_B(Z,I,J,M)

X_B(K,Z,I,J,M)

DPAR_E(Z,I,J)

PAR_N(Z,I,J)

PAR_B(K,Z,I,J)

DPAR_E_B(K,Z,I,J)

PAR_N_B(K,Z,I,J)

NHE_S(Z,I,J)

DELTA(K,K)

POSITIVE VARIABLE Q,QNEW2_M,QNEW2_N,QC,QH,Q2,X1_B,DPAR_E,DPAR_E_B,PAR_N,PAR_N_B

BINARY VARIABLE NHE_M0_B,NHE_M1_B,NHE_N0_B,NHE_N1_B,Y_M,Y_N,X_B,NHE_S,DELTA

EQUATIONS

HBHS(I,M)

HBCS(J,N)

HBHS_NI(I,M)

HBCS_NI(J,N)

NOISOH(I,M)

NOISOC(J,N)

HBHU(I,M)

HBCU(J,N)

PAREQ(Z,I,J)

TRANSFOR_M(Z,I,J,M)

BINARY_M1(Z,I,J,M)

BINARY_M2(Z,I,J,M)

BINARY_M3(Z,I,J,M)

BINARY_M4(Z,I,J,M)

BINARY_M5(Z,I,J,M)

BINARY_M6(Z,I,J,M)

BINARY_M7(Z,I,J,M)

BINARY_M8(Z,I,J,M)

BINARY_M1_B(Z,I,J,M)

BINARY_M2_B(Z,I,J,M)

BINARY_M3_B(Z,I,J,M)

HE_COUNT_M0(Z,I,J)

HE_COUNT_M1(Z,I,J)

TRANSFOR_N(Z,I,J,N)

BINARY_N1(Z,I,J,N)

BINARY_N2(Z,I,J,N)

BINARY_N3(Z,I,J,N)

BINARY_N4(Z,I,J,N)

BINARY_N5(Z,I,J,N)

BINARY_N6(Z,I,J,N)

BINARY_N7(Z,I,J,N)

BINARY_N8(Z,I,J,N)

BINARY_N1_B(Z,I,J,N)

BINARY_N2_B(Z,I,J,N)

BINARY_N3_B(Z,I,J,N)

HE_COUNT_N0(Z,I,J)

HE_COUNT_N1(Z,I,J)

FEAS_M_01(Z,I,J,M)

FEAS_M_02(Z,I,J,M)

FEAS_M_03(Z,I,J,M)

FEAS_M_01_B(Z,I,J,M)

FEAS_M_02_B(Z,I,J,M)

FEAS_M_03_B(Z,I,J,M)

FEAS_M_04(Z,I,J,M)

FEAS_M_1(Z,I,J,M)

FEAS_M_2(Z,I,J,M)

FEAS_M_3(Z,I,J,M)

FEAS_M_4(Z,I,J,M)

FEAS_M_3_B_1(Z,I,J,M)

FEAS_M_3_B_2(Z,I,J,M)

FEAS_M_4_B(Z,I,J,M)

FEAS_M_1_SP(Z,I,J,M)

FEAS_M_1_SP_B(Z,I,J,M)

FEAS_M_2_SP_B(Z,I,J,M)

FEAS_N_01(Z,I,J,N)

FEAS_N_02(Z,I,J,N)

FEAS_N_03(Z,I,J,N)

FEAS_N_01_B(Z,I,J,N)

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      FEAS_N_02_B(Z,I,J,N)
      FEAS_N_03_B(Z,I,J,N)
      FEAS_N_04(Z,I,J,N)
      FEAS_N_1(Z,I,J,N)
      FEAS_N_2(Z,I,J,N)
      FEAS_N_3(Z,I,J,N)
      FEAS_N_4(Z,I,J,N)
      FEAS_N_3_B_1(Z,I,J,N)
      FEAS_N_3_B_2(Z,I,J,N)
      FEAS_N_4_B(Z,I,J,N)
      FEAS_N_1_SP(Z,I,J,N)
      FEAS_N_1_SP_B(Z,I,J,N)
      FEAS_N_2_SP_B(Z,I,J,N)
      FEAS_BEG_SP(Z,I,J,M,N)
      FEAS_BEG_B_SP(Z,I,J,M,N)
      FEAS_END_SP(Z,I,J,M,N)
      FEAS_END_B_SP(Z,I,J,M,N)
      FEAS_BEG(Z,I,J,M,N)
      FEAS_BEG2(Z,I,J,M,N)
      FEAS_BEG3(Z,I,J,M,N)
*     FEAS_BEG4(Z,I,J,M,N,JJ)
*     FEAS_BEG5(Z,I,J,M,N,JJ)
      FEAS_BEG1_B(Z,I,J,M,N)
      FEAS_BEG2_B(Z,I,J,M,N)
      FEAS_BEG3_B(Z,I,J,M,N)
      FEAS_BEG4_B(Z,I,J,M,N)
*     FEAS_BEG5_B(Z,I,J,M,N,JJ)
*     FEAS_BEG6_B(Z,I,J,M,N,JJ)
      FEAS_END(Z,I,J,M,N)
      FEAS_END2(Z,I,J,M,N)
      FEAS_END3(Z,I,J,M,N)
*     FEAS_END4(Z,I,J,M,N,II)
*     FEAS_END5(Z,I,J,M,N,II)
```

* FEAS_END6(Z,I,J,M,N,II)

FEAS_END_B(Z,I,J,M,N)

FEAS_END2_B(Z,I,J,M,N)

FEAS_END3_B(Z,I,J,M,N)

* FEAS_END4_B(Z,I,J,M,N,II)

* FEAS_END5_B(Z,I,J,M,N,II)

* FEAS_END6_B(Z,I,J,M,N,II)

BIF_1(Z,I,J,M,N)

BIF_2(Z,I,J,M,N)

BIF_3(Z,I,J,M,N)

BIF_4(Z,I,J,M,N)

BIF_5(Z,I,J,M)

BIF_6(Z,I,J,M)

BIF_7(Z,I,J,N)

BIF_8(Z,I,J,N)

BIF_9(Z,I,J,M)

BIF_10(Z,I,J,N)

BIF_11(Z,I,J,M)

BIF_12(Z,I,J,N)

BIF_13_1(K,Z,I,J,M)

BIF_13_2(K,Z,I,J,M)

BIF_14(K,Z,I,J)

BIF_15(Z,I,J,M)

BIF_16(Z,I,J,M)

BIF_17(Z,I,J,M)

BIF_18(Z,I,J,M,N)

NEXCH(Z,I,J)

NEXCH_B(Z,I,J)

AREA_REST1(Z,I,J)

AREA_REST2(Z,I,J)

AREA_REST3(Z,I,J)

AREA_REST1_B(K,Z,I,J)

AREA_REST2_B(K,Z,I,J)

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     AREA_REST3_B(K,Z,I,J)
     AREA_REST4_B(K,Z,I,J)
     AREA_REST5_B(K,Z,I,J)
     AREA_REST6_B(Z,I,J)
     ADD_REST
     ADD_REST2(I,J)
     TOTNEXCH_MAX
     TOTNEXCH_MIN
*    SPLIT_LIMIT_M(Z,I,M)
*    SPLIT_LIMIT_M2(Z,I,M)
*    SPLIT_LIMIT_N(Z,J,N)
*    SPLIT_LIMIT_N2(Z,J,N)
    TOTALCOST;

 HBHU(I,M)$(HOT(I,M) AND HU(I) AND FREEH(I))..
  FHU(I)*(TU(M)-TL(M))=E=SUM((Z,N,J)$(D(Z,M,N) AND TL(N) LT TU(M) AND COLD(J,N) AND
ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND FREEC(J)),Q(Z,I,M,J,N));

 HBCU(J,N)$(COLD(J,N) AND CU(J) AND FREEC(J))..
  FCU(J)*(TU(N)-TL(N))=E=SUM((Z,M,I)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND ALLOW_H(Z,I,M,J)
AND ALLOW_C(Z,J,N,I) AND FREEH(I)),Q(Z,I,M,J,N));

 HBHS(I,M)$(HOT(I,M) AND NOT HU(I) AND FREEH(I) AND NIH(I)=0)..
  DHH(I,M)=E=SUM((Z,N,J)$(D(Z,M,N) AND TL(N) LT TU(M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N));

 HBCS(J,N)$(COLD(J,N) AND NOT CU(J) AND FREEC(J) AND NIC(J)=0)..
  DHC(J,N)=E=SUM((Z,M,I)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N));

 HBHS_NI(I,M)$(HOT(I,M) AND NOT HU(I) AND FREEH(I) AND NIH(I)=1)..
  DHH(I,M)=E= SUM((Z,N,J)$(D(Z,M,N) AND TL(N) LT TU(M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N))
        +SUM((Z,N)$(D(Z,M,N) AND HOT(I,N) AND ORD(N) GT ORD(M)),QH(Z,I,N,M))
        -SUM((Z,N)$(D(Z,M,N) AND HOT(I,N) AND ORD(N) LT ORD(M)),QH(Z,I,M,N));
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HBCS_NI(J,N)$(COLD(J,N) AND NOT CU(J) AND FREEC(J) AND NIC(J)=1)..

  DHC(J,N)=E= SUM((Z,M,I)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N))

        +SUM((Z,M)$(D(Z,M,N) AND COLD(J,M) AND ORD(M) LT ORD(N)),QC(Z,J,M,N))

        -SUM((Z,M)$(D(Z,M,N) AND COLD(J,M) AND ORD(M) GT ORD(N)),QC(Z,J,N,M));


NOISOH(I,M)$(HOT(I,M) AND NOT HU(I) AND FREEH(I) AND NIH(I)=1)..

  SUM((Z,N)$(D(Z,M,N) AND HOT(I,N) AND ORD(N) LT ORD(M)),QH(Z,I,M,N))=L=SUM((Z,N,J)$(D(Z,M,N) AND
TL(N) LT TU(M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N));


NOISOC(J,N)$(COLD(J,N) AND NOT CU(J) AND FREEC(J) AND NIC(J)=1)..

  SUM((Z,M)$(D(Z,M,N) AND COLD(J,M) AND ORD(M) GT ORD(N)),QC(Z,J,N,M))=L=SUM((Z,M,I)$(D(Z,M,N) AND
TL(N) LT TU(M) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N));


PAREQ(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  PAR(Z,I,J)=E=SUM((M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND
ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N)*(1/H_I(I,M)+1/H_J(J,N))/LMTD(M,N));


TRANSFOR_M(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND FREEH(I) AND FREEC(J))..

  QNEW_M(Z,I,J,M)=E=SUM(N$(D(Z,M,N) AND TL(N) LT TU(M) AND COLD(J,N) AND
ALLOW_C(Z,J,N,I)),Q(Z,I,M,J,N));


BINARY_M1(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  QNEW_M(Z,I,J,M)-Y_M(Z,I,J,M)*DHH(I,M)$(NOT HU(I))-Y_M(Z,I,J,M)*FMAX_HU(I)*DTHU(I)$(HU(I))=L=0;


BINARY_M2(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  QNEW_M(Z,I,J,M)-Y_M(Z,I,J,M)*0.01=G=0;


BINARY_M3(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_M0(Z,I,J,M)=G=Y_M(Z,I,J,M)-Y_M(Z,I,J,M-1)$(HOT(I,M-1) AND ALLOW_H(Z,I,M-1,J)) ;


BINARY_M4(Z,I,J,M)$(HOT(I,M) AND HOT(I,M-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND
BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_M0(Z,I,J,M)=G=0;
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BINARY_M5(Z,I,J,M)$(HOT(I,M) AND HOT(I,M-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

NHE_M0(Z,I,J,M)=L=2-Y_M(Z,I,J,M)-Y_M(Z,I,J,M-1);

BINARY_M6(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

NHE_M1(Z,I,J,M)=G=Y_M(Z,I,J,M)-Y_M(Z,I,J,M+1)$(HOT(I,M+1) AND ALLOW_H(Z,I,M+1,J)) ;

BINARY_M7(Z,I,J,M)$(HOT(I,M) AND HOT(I,M+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

NHE_M1(Z,I,J,M)=G=0;

BINARY_M8(Z,I,J,M)$(HOT(I,M) AND HOT(I,M+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

NHE_M1(Z,I,J,M)=L=2-Y_M(Z,I,J,M)-Y_M(Z,I,J,M+1);

BINARY_M1_B(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)-Y_M_B(Z,I,J,M)*DHH(I,M)$(NOT HU(I))-Y_M_B(Z,I,J,M)*FMAX_HU(I)*DTHU(I)$(HU(I))=L=0;

BINARY_M2_B(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)-Y_M_B(Z,I,J,M)*0.01=G=0;

BINARY_M3_B(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

Y_M_B(Z,I,J,M)=E=SUM(O$(HOT(I,O) AND ORD(O) LE ORD(M) AND ALLOW_H(Z,I,O,J)),NHE_M0_B(Z,I,J,O))

-SUM(O$(HOT(I,O) AND ORD(O) LE ORD(M)-1 AND ALLOW_H(Z,I,O,J)),NHE_M1_B(Z,I,J,O)) ;

HE_COUNT_M0(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

NHE(Z,I,J)=E=SUM(M$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1),NHE_M0_B(Z,I,J,M))+

SUM(M$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0),NHE_M0(Z,I,J,M)) ;

```
HE_COUNT_M1(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  NHE(Z,I,J)=E=SUM(M$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1),NHE_M1_B(Z,I,J,M))+

        SUM(M$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=0),NHE_M1(Z,I,J,M)) ;


TRANSFOR_N(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND FREEH(I) AND FREEC(J))..

  QNEW_N(Z,I,J,N)=E=SUM(M$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND
ALLOW_H(Z,I,M,J)),Q(Z,I,M,J,N));


BINARY_N1(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  QNEW_N(Z,I,J,N)-Y_N(Z,I,J,N)*DHC(J,N)$(NOT CU(J))-Y_N(Z,I,J,N)*FMAX_CU(J)*DTCU(J)$(CU(J))=L=0;


BINARY_N2(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  QNEW_N(Z,I,J,N)-Y_N(Z,I,J,N)*0.01=G=0;


BINARY_N3(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N0(Z,I,J,N)=G=Y_N(Z,I,J,N)-Y_N(Z,I,J,N-1)$(COLD(J,N-1) AND ALLOW_C(Z,J,N-1,I)) ;


BINARY_N4(Z,I,J,N)$(COLD(J,N) AND COLD(J,N-1) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND
BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N0(Z,I,J,N)=G=0;


BINARY_N5(Z,I,J,N)$(COLD(J,N) AND COLD(J,N-1) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND
BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N0(Z,I,J,N)=L=2-Y_N(Z,I,J,N)-Y_N(Z,I,J,N-1);


BINARY_N6(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N1(Z,I,J,N)=G=Y_N(Z,I,J,N)-Y_N(Z,I,J,N+1)$(COLD(J,N+1) AND ALLOW_C(Z,J,N+1,I)) ;


BINARY_N7(Z,I,J,N)$(COLD(J,N) AND COLD(J,N+1) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND
BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N1(Z,I,J,N)=G=0;


BINARY_N8(Z,I,J,N)$(COLD(J,N) AND COLD(J,N+1) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND
BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..

  NHE_N1(Z,I,J,N)=L=2-Y_N(Z,I,J,N)-Y_N(Z,I,J,N+1);
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BINARY_N1_B(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  QNEW_N(Z,I,J,N)-Y_N_B(Z,I,J,N)*DHC(J,N)$(NOT CU(J))-Y_N_B(Z,I,J,N)*FMAX_CU(J)*DTCU(J)$(CU(J))=L=0;

BINARY_N2_B(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  QNEW_N(Z,I,J,N)-Y_N_B(Z,I,J,N)*0.01=G=0;

BINARY_N3_B(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  Y_N_B(Z,I,J,N)=E=SUM(O$(COLD(J,O) AND ORD(O) LE ORD(N) AND ALLOW_C(Z,J,O,I)),NHE_N0_B(Z,I,J,O))
      -SUM(O$(COLD(J,O) AND ORD(O) LE ORD(N)-1 AND ALLOW_C(Z,J,O,I)),NHE_N1_B(Z,I,J,O));

HE_COUNT_N0(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  NHE(Z,I,J)=E=SUM(N$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1),NHE_N0_B(Z,I,J,N))+
      SUM(N$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0),NHE_N0(Z,I,J,N)) ;

HE_COUNT_N1(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  NHE(Z,I,J)=E=SUM(N$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1),NHE_N1_B(Z,I,J,N))+
      SUM(N$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0),NHE_N1(Z,I,J,N)) ;

FEAS_M_01(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND
BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..
  ALFA_M(Z,I,J,M)=L=1-NHE_M0(Z,I,J,M-1)-NHE_M0(Z,I,J,M);

FEAS_M_02(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND
BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..
  ALFA_M(Z,I,J,M)=L=1-NHE_M1(Z,I,J,M-1)-NHE_M1(Z,I,J,M);

FEAS_M_03(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND
BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..
  ALFA_M(Z,I,J,M)=G=Y_M(Z,I,J,M)-NHE_M0(Z,I,J,M-1)-NHE_M0(Z,I,J,M)-NHE_M1(Z,I,J,M-1)-NHE_M1(Z,I,J,M);

FEAS_M_01_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND
BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..
  ALFA_M(Z,I,J,M)=L=1-NHE_M0_B(Z,I,J,M-1)-NHE_M0_B(Z,I,J,M);
```

FEAS_M_02_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_M(Z,I,J,M)=L=1-NHE_M1_B(Z,I,J,M-1)-NHE_M1_B(Z,I,J,M);

FEAS_M_03_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_M(Z,I,J,M)=G=Y_M_B(Z,I,J,M)-NHE_M0_B(Z,I,J,M-1)-NHE_M0_B(Z,I,J,M)-NHE_M1_B(Z,I,J,M-1)-NHE_M1_B(Z,I,J,M);

FEAS_M_04(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND (BIF(Z,I,J)=1 OR SPH(I)=1) AND FREEH(I) AND FREEC(J))..

ALFA_M(Z,I,J,M)=G=0;

FEAS_M_1(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)/(CPH(I,M)*(TU(M)-TL(M)))+(1-ALFA_M(Z,I,J,M))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)))=G=QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)));

FEAS_M_2(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)/(TU(M)-TL(M))=L=QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))+(1-ALFA_M(Z,I,J,M))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)));

FEAS_M_3(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

-QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))+QNEW_M(Z,I,J,M)/(CPH(I,M)*(TU(M)-TL(M)))

+(1+NHE_M1(Z,I,J,M-1)+NHE_M1(Z,I,J,M)+NHE_M0(Z,I,J,M-1))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)))*1.00000=G=0;

FEAS_M_4(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=0 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

-QNEW_M(Z,I,J,M)/(CPH(I,M)*(TU(M)-TL(M)))+QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))

+(1+NHE_M0(Z,I,J,M-1)+NHE_M0(Z,I,J,M)-NHE_M1(Z,I,J,M))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)))*1.00000=G=0;

FEAS_M_3_B_1(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

QNEW2_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))=L= QNEW_M(Z,I,J,M)/(CPH(I,M)*(TU(M)-TL(M)))

+(2+NHE_M1_B(Z,I,J,M-1)+NHE_M1_B(Z,I,J,M)-NHE_M0_B(Z,I,J,M-1)-Y_M_B(Z,I,J,M-1))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)));

FEAS_M_3_B_2(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))=L= QNEW_M(Z,I,J,M)/(CPH(I,M)*(TU(M)-TL(M)))

+(1+NHE_M1_B(Z,I,J,M-1)+NHE_M1_B(Z,I,J,M)-NHE_M0_B(Z,I,J,M-1))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)));

FEAS_M_4_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=1 AND FREEH(I) AND FREEC(J))..

(QNEW_M(Z,I,J,M)-QNEW2_M(Z,I,J,M))/(CPH(I,M)*(TU(M)-TL(M)))=L= QNEW_M(Z,I,J,M-1)/(CPH(I,M-1)*(TU(M-1)-TL(M-1)))

+(2+NHE_M0_B(Z,I,J,M-1)+NHE_M0_B(Z,I,J,M)-NHE_M1_B(Z,I,J,M)-Y_M_B(Z,I,J,M))*DHH(I,M)/(CPH(I,M)*(TU(M)-TL(M)));

FEAS_M_1_SP(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND HOT(I,M+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_H(Z,I,M+1,J) AND BIF(Z,I,J)=0 AND SPH(I)=0 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)=G=(Y_M(Z,I,J,M-1)+Y_M(Z,I,J,M)+Y_M(Z,I,J,M+1)-2)*DHH(I,M);

FEAS_M_1_SP_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=0 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)=G=ALFA_M(Z,I,J,M)*DHH(I,M);

FEAS_M_2_SP_B(Z,I,J,M)$(HOT(I,M-1) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND BIF(Z,I,J)=1 AND SPH(I)=0 AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M-1)=G=ALFA_M(Z,I,J,M)*DHH(I,M-1);

FEAS_N_01(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=L=1-NHE_N0(Z,I,J,N)-NHE_N0(Z,I,J,N-1);

FEAS_N_02(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=L=1-NHE_N1(Z,I,J,N)-NHE_N1(Z,I,J,N-1);

FEAS_N_03(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=G=Y_N(Z,I,J,N)-NHE_N0(Z,I,J,N)-NHE_N0(Z,I,J,N-1)-NHE_N1(Z,I,J,N)-NHE_N1(Z,I,J,N-1);

FEAS_N_01_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=L=1-NHE_N0_B(Z,I,J,N)-NHE_N0_B(Z,I,J,N-1);

FEAS_N_02_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=L=1-NHE_N1_B(Z,I,J,N)-NHE_N1_B(Z,I,J,N-1);

FEAS_N_03_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=G=Y_N_B(Z,I,J,N)-NHE_N0_B(Z,I,J,N)-NHE_N0_B(Z,I,J,N-1)-NHE_N1_B(Z,I,J,N)-NHE_N1_B(Z,I,J,N-1);

FEAS_N_04(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND (BIF(Z,I,J)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

ALFA_N(Z,I,J,N)=G=0;

FEAS_N_1(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))+(1-ALFA_N(Z,I,J,N))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))=G=QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)));

FEAS_N_2(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))=L=QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))+(1-ALFA_N(Z,I,J,N))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)));

FEAS_N_3(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

-QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))+QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))

+(1+NHE_N1(Z,I,J,N-1)+NHE_N1(Z,I,J,N)-NHE_N0(Z,I,J,N-1))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))*1.00000=G=0;

FEAS_N_4(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

-QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))+QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))

+(1+NHE_N0(Z,I,J,N-1)+NHE_N0(Z,I,J,N)-NHE_N1(Z,I,J,N))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))*1.00000=G=0;

FEAS_N_3_B_1(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

-QNEW2_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))+QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))

+(2+NHE_N1_B(Z,I,J,N-1)+NHE_N1_B(Z,I,J,N)-NHE_N0_B(Z,I,J,N-1)-Y_N_B(Z,I,J,N-1))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))=G=0;

FEAS_N_3_B_2(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

-QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))+QNEW_N(Z,I,J,N)/(CPC(J,N)*(TU(N)-TL(N)))

+(1+NHE_N1_B(Z,I,J,N-1)+NHE_N1_B(Z,I,J,N)-NHE_N0_B(Z,I,J,N-1))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))=G=0;

FEAS_N_4_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=1 AND FREEH(I) AND FREEC(J))..

-(QNEW_N(Z,I,J,N)-QNEW2_N(Z,I,J,N))/(CPC(J,N)*(TU(N)-TL(N)))+QNEW_N(Z,I,J,N-1)/(CPC(J,N-1)*(TU(N-1)-TL(N-1)))

+(2+NHE_N0_B(Z,I,J,N-1)+NHE_N0_B(Z,I,J,N)-NHE_N1_B(Z,I,J,N)-Y_N_B(Z,I,J,N))*DHC(J,N)/(CPC(J,N)*(TU(N)-TL(N)))=G=0;

FEAS_N_1_SP(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)=G=(Y_N(Z,I,J,N-1)+Y_N(Z,I,J,N)+Y_N(Z,I,J,N+1)-2)*DHC(J,N);

FEAS_N_1_SP_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)=G=ALFA_N(Z,I,J,N)*DHC(J,N);

FEAS_N_2_SP_B(Z,I,J,N)$(COLD(J,N-1) AND COLD(J,N) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N-1)=G=ALFA_N(Z,I,J,N)*DHC(J,N-1);

FEAS_BEG_SP(Z,I,J,M,N)$(TL(N) LE TU(M) AND TU(N) GE TL(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND SPH(I)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

TL(M)-TL(N)-(QNEW_N(Z,I,J,N)/(FC(J)*CPC(J,N))-QNEW_M(Z,I,J,M)/(FH(I)*CPH(I,M)))+(2-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N))*TU(N)=G=0;

FEAS_BEG_B_SP(Z,I,J,M,N)$(TL(N) LE TU(M) AND TU(N) GE TL(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND SPH(I)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

TL(M)-TL(N)-(QNEW_N(Z,I,J,N)/(FC(J)*CPC(J,N))-QNEW_M(Z,I,J,M)/(FH(I)*CPH(I,M)))+(2-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N))*TU(N)=G=0;

FEAS_END_SP(Z,I,J,M,N)$(TL(N) LE TU(M) AND TU(N) GE TL(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=0 AND SPH(I)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

TU(M)-TU(N)-(QNEW_M(Z,I,J,M)/(FH(I)*CPH(I,M))-QNEW_N(Z,I,J,N)/(FC(J)*CPC(J,N)))+(2-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N))*TU(N)=G=0;

FEAS_END_B_SP(Z,I,J,M,N)$(TL(N) LE TU(M) AND TU(N) GE TL(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND SPH(I)=0 AND SPC(J)=0 AND FREEH(I) AND FREEC(J))..

TU(M)-TU(N)-(QNEW_M(Z,I,J,M)/(FH(I)*CPH(I,M))-QNEW_N(Z,I,J,N)/(FC(J)*CPC(J,N)))+(2-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N))*TU(N)=G=0;

FEAS_BEG(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)/(TU(M)-TL(N))=L=QNEW_N(Z,I,J,N+1)/(TU(N+1)-TL(N+1))*CPC(J,N)/CPC(J,N+1)+(2-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N))*DHC(J,N)/(TU(M)-TL(N));

FEAS_BEG2(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)/(MIN(TU(M),TU(N))-TL(M))=G=QNEW_M(Z,I,J,M+1)/(TU(M+1)-TL(M+1))*CPH(I,M)/CPH(I,M+1)-(2-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N))*DHH(I,M+1)/(TU(M+1)-TL(M+1));

FEAS_BEG3(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND

ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

NHE_N1(Z,I,J,N)=L=(2-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N));

* FEAS_BEG4(Z,I,J,M,N,JJ)$(D(Z,M,N) AND ORD(JJ) NE ORD(J) AND ALLOW_H(Z,I,M,JJ) AND ALLOW_H(Z,I,M-1,JJ) AND BIF(I,JJ)=0 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_M(Z,I,JJ,M)=L=QNEW_M(Z,I,JJ,M-1)*(TU(M)-MIN(TU(M),TU(N)))/(TU(M-1)-TL(M-1))+(3-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N)-NHE_M1(Z,I,JJ,M))*DHH(I,M);

* FEAS_BEG5(Z,I,J,M,N,JJ)$(D(Z,M,N) AND ORD(JJ) NE ORD(J) AND ALLOW_H(Z,I,M,JJ) AND ALLOW_H(Z,I,M-1,JJ) AND BIF(I,JJ)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_M(Z,I,JJ,M)-QNEW2_M(Z,I,JJ,M)=L=QNEW_M(Z,I,JJ,M-1)*(TU(M)-MIN(TU(M),TU(N)))/(TU(M-1)-TL(M-1))+(3-NHE_M0(Z,I,J,M)-NHE_N0(Z,I,J,N)-NHE_M1_B(Z,I,JJ,M))*DHH(I,M);

FEAS_BEG1_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW2_N(Z,I,J,N)/(TU(M)-TL(N))=L=QNEW_N(Z,I,J,N+1)/(TU(N+1)-TL(N+1))*CPC(J,N)/CPC(J,N+1)+(2-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N))*DHC(J,N)/(TU(M)-TL(N));

FEAS_BEG2_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)/(TU(M)-TL(N))=L=QNEW_N(Z,I,J,N+1)/(TU(N+1)-TL(N+1))*CPC(J,N)/CPC(J,N+1)+(1+Y_N_B(Z,I,J,N)-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N))*DHC(J,N)/(TU(M)-TL(N));

FEAS_BEG3_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)/(MIN(TU(M),TU(N))-TL(M))=G=QNEW_M(Z,I,J,M+1)/(TU(M+1)-TL(M+1))*CPH(I,M)/CPH(I,M+1)-(2-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N))*DHH(I,M+1)/(TU(M+1)-TL(M+1));

FEAS_BEG4_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

NHE_N1_B(Z,I,J,N)=L=(1+Y_N_B(Z,I,J,N)-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N));

* FEAS_BEG5_B(Z,I,J,M,N,JJ)$(ORD(JJ) NE ORD(J) AND ALLOW_H(Z,I,M,JJ) AND ALLOW_H(Z,I,M-1,JJ) AND BIF(I,JJ)=0 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_M(Z,I,JJ,M)=L=QNEW_M(Z,I,JJ,M-1)*(TU(M)-MIN(TU(M),TU(N)))/(TU(M-1)-TL(M-1))+(3-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N)-NHE_M1(Z,I,JJ,M))*DHH(I,M);

* FEAS_BEG6_B(Z,I,J,M,N,JJ)$(ORD(JJ) NE ORD(J) AND ALLOW_H(Z,I,M,JJ) AND ALLOW_H(Z,I,M-1,JJ) AND BIF(I,JJ)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M+1) AND COLD(J,N) AND COLD(J,N+1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M+1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N+1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_M(Z,I,JJ,M)-QNEW2_M(Z,I,JJ,M)=L=QNEW_M(Z,I,JJ,M-1)*(TU(M)-MIN(TU(M),TU(N)))/(TU(M-1)-TL(M-1))+(3-NHE_M0_B(Z,I,J,M)-NHE_N0_B(Z,I,J,N)-NHE_M1_B(Z,I,JJ,M))*DHH(I,M);

FEAS_END(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_M(Z,I,J,M)/(TU(M)-TL(N))=L=QNEW_M(Z,I,J,M-1)/(TU(M-1)-TL(M-1))*CPH(I,M)/CPH(I,M-1)+(2-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N))*DHH(I,M)/(TU(M)-TL(N));

FEAS_END2(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

QNEW_N(Z,I,J,N)/(TU(N)-MAX(TL(M),TL(N)))=G=QNEW_N(Z,I,J,N-1)/(TU(N-1)-TL(N-1))*CPC(J,N)/CPC(J,N-1)-(2-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N))*DHC(J,N-1)/(TU(N-1)-TL(N-1));

FEAS_END3(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND

ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

NHE_M0(Z,I,J,M)=L=(2-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N));

* FEAS_END4(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=0 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J)).

* QNEW_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(3-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N)-NHE_N0(Z,II,J,N))*DHC(J,N);

* FEAS_END5(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J)).

* QNEW_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(3-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N) NHE_N0_B(Z,II,J,N))*DHC(J,N);

* FEAS_END6(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=0 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J)).

* QNEW2_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(4-NHE_M1(Z,I,J,M)-NHE_N1(Z,I,J,N)-NHE_N0_B(Z,II,J,N)-NHE_N1_B(Z,II,J,N))*DHC(J,N);

FEAS_END_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J)).

(QNEW_M(Z,I,J,M)-QNEW2_M(Z,I,J,M))/(TU(M)-TL(N))=L=QNEW_M(Z,I,J,M-1)/(TU(M-1)-TL(M-1))*CPH(I,M)/CPH(I,M-1)+(2-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N))*DHH(I,M)/(TU(M)-TL(N));

FEAS_END2_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J)).

(QNEW_N(Z,I,J,N)-QNEW2_N(Z,I,J,N))/(TU(N)-MAX(TL(M),TL(N)))=G=QNEW_N(Z,I,J,N-1)/(TU(N-1)-TL(N-1))*CPC(J,N)/CPC(J,N-1)-(2-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N))*DHC(J,N-1)/(TU(N-1)-TL(N-1));

FEAS_END3_B(Z,I,J,M,N)$(DTVIO(I,J)=1 AND D(Z,M,N) AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

NHE_M0_B(Z,I,J,M)=L=(1+Y_M_B(Z,I,J,M)-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N));

* FEAS_END4_B(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=0 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(3-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N)-NHE_N0(Z,II,J,N))*DHC(J,N);

* FEAS_END5_B(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(3-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N)-NHE_N0_B(Z,II,J,N))*DHC(J,N);

* FEAS_END6_B(Z,I,J,M,N,II)$(D(Z,M,N) AND ORD(II) NE ORD(I) AND ALLOW_C(Z,J,N,II) AND ALLOW_C(Z,J,N+1,II) AND BIF(II,J)=1 AND DTVIO(I,J)=1 AND TL(N) LT TU(M) AND TU(N) GT TL(M) AND HOT(I,M) AND HOT(I,M-1) AND COLD(J,N) AND COLD(J,N-1) AND ALLOW_H(Z,I,M,J) AND ALLOW_H(Z,I,M-1,J) AND ALLOW_C(Z,J,N,I) AND ALLOW_C(Z,J,N-1,I) AND BIF(Z,I,J)=1 AND (SPH(I)=1 OR SPC(J)=1) AND FREEH(I) AND FREEC(J))..

* QNEW2_N(Z,II,J,N)=L=QNEW_N(Z,II,J,N+1)*(MAX(TL(M),TL(N))-TL(N))/(TU(N+1)-TL(N+1))+(4-NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N)-NHE_N0_B(Z,II,J,N)-NHE_N1_B(Z,II,J,N))*DHC(J,N);

BIF_1(Z,I,J,M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

SUM(L$(D(Z,L,N) AND ORD(L) LE ORD(M) AND HOT(I,L) AND ALLOW_H(Z,I,L,J)),QNEW_M(Z,I,J,L))-QNEW2_M(Z,I,J,M)=L=

SUM(O$(D(Z,M,O) AND ORD(O) LE ORD(N) AND COLD(J,O) AND ALLOW_C(Z,J,O,I)),QNEW_N(Z,I,J,O))-QNEW2_N(Z,I,J,N)

+B1(Z,I,M,J,N)*4*max(SUM(L$(D(Z,L,N) AND ORD(L) LE ORD(M) AND HOT(I,L) AND ALLOW_H(Z,I,L,J)),DHH(I,L)),

SUM(O$(D(Z,M,O) AND ORD(O) LE ORD(N) AND COLD(J,O) AND ALLOW_C(Z,J,O,I)),DHC(J,O)));

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BIF_2(Z,I,J,M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  SUM(L$(D(Z,L,N) AND ORD(L) LE ORD(M) AND HOT(I,L) AND ALLOW_H(Z,I,L,J)),QNEW_M(Z,I,J,L))-
QNEW2_M(Z,I,J,M)=G=

  SUM(O$(D(Z,M,O) AND ORD(O) LE ORD(N) AND COLD(J,O) AND ALLOW_C(Z,J,O,I)),QNEW_N(Z,I,J,O))-
QNEW2_N(Z,I,J,N)

  -B1(Z,I,M,J,N)*4*max(SUM(L$(D(Z,L,N) AND ORD(L) LE ORD(M) AND HOT(I,L) AND
ALLOW_H(Z,I,L,J)),DHH(I,L)),

        SUM(O$(D(Z,M,O) AND ORD(O) LE ORD(N) AND COLD(J,O) AND ALLOW_C(Z,J,O,I)),DHC(J,O)));


BIF_3(Z,I,J,M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  B1(Z,I,M,J,N)=E=2-0.25*SUM(L$(D(Z,L,N) AND ORD(L) LE ORD(M) AND HOT(I,L) AND
ALLOW_H(Z,I,L,J)),NHE_M1_B(Z,I,J,L))

        +0.25*SUM(O$(D(Z,M,O) AND ORD(O) LE ORD(N) AND COLD(J,O) AND
ALLOW_C(Z,J,O,I)),NHE_N1_B(Z,I,J,O))

        -NHE_M1_B(Z,I,J,M)-NHE_N1_B(Z,I,J,N);


BIF_4(Z,I,J,M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND TL(N) GE TL(M) AND HOT(I,M) AND COLD(J,N) AND
ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  SUM(L$(HOT(I,L) AND ORD(L) LE ORD(M) AND ALLOW_H(Z,I,L,J)),NHE_M1_B(Z,I,J,L))

  -SUM(O$(COLD(J,O) AND ORD(O) LE ORD(N) AND ALLOW_C(Z,J,O,I)),NHE_N1_B(Z,I,J,O))=G=0;


BIF_5(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_M(Z,I,J,M)=L=NHE_M1_B(Z,I,J,M)*DHH(I,M) ;


BIF_6(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_M(Z,I,J,M)=L=QNEW_M(Z,I,J,M);


BIF_7(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_N(Z,I,J,N)=L=NHE_N1_B(Z,I,J,N)*DHC(J,N) ;


BIF_8(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_N(Z,I,J,N)=L=QNEW_N(Z,I,J,N);
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BIF_9(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_M(Z,I,J,M)=L=NHE_M0_B(Z,I,J,M)*DHH(I,M) ;


BIF_10(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  QNEW2_N(Z,I,J,N)=L=NHE_N0_B(Z,I,J,N)*DHC(J,N) ;


BIF_11(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  SUM(O$(HOT(I,O) AND ORD(O) LE ORD(M) AND ALLOW_H(Z,I,O,J)),NHE_M0_B(Z,I,J,O)-
NHE_M1_B(Z,I,J,O))=L=1 ;


BIF_12(Z,I,J,N)$(COLD(J,N) AND ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  SUM(O$(COLD(J,O) AND ORD(O) LE ORD(N) AND ALLOW_C(Z,J,O,I)),NHE_N0_B(Z,I,J,O)-
NHE_N1_B(Z,I,J,O))=L=1;


BIF_13_1(K,Z,I,J,M)$(ORD(K) LT KMAX(Z,I,J) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND
FREEH(I) AND FREEC(J))..

  PAR_B(K,Z,I,J)=G= SUM((L,N)$(D(Z,L,N) AND ORD(L) LE ORD(M) AND TL(N) LT TU(L) AND HOT(I,L) AND
COLD(J,N) AND ALLOW_H(Z,I,L,J) AND ALLOW_C(Z,J,N,I)),(Q(Z,I,L,J,N)-
Q2(Z,I,L,J,N))*(1/H_I(I,L)+1/H_J(J,N))/LMTD(L,N))

        -10000*(2-NHE_M1_B(Z,I,J,M)-X1_B(Z,I,J,M)-SUM(KK$(ORD(KK) GT 1 AND ORD(KK) LT
ORD(K)),X_B(KK,Z,I,J,M)));


BIF_13_2(K,Z,I,J,M)$(ORD(K) LT KMAX(Z,I,J) AND HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND
FREEH(I) AND FREEC(J))..

  PAR_B(K,Z,I,J)=L= SUM((L,N)$(D(Z,L,N) AND ORD(L) LE ORD(M) AND TL(N) LT TU(L) AND HOT(I,L) AND
COLD(J,N) AND ALLOW_H(Z,I,L,J) AND ALLOW_C(Z,J,N,I)),(Q(Z,I,L,J,N)-
Q2(Z,I,L,J,N))*(1/H_I(I,L)+1/H_J(J,N))/LMTD(L,N))

        +10000*(2-NHE_M1_B(Z,I,J,M)-X1_B(Z,I,J,M)-SUM(KK$(ORD(KK) GT 1 AND ORD(KK) LT
ORD(K)),X_B(KK,Z,I,J,M)));


BIF_14(K,Z,I,J)$(ORD(K) EQ KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=1)..

  PAR_B(K,Z,I,J)=E=PAR(Z,I,J)-SUM(KK$(ORD(KK) LT ORD(K)),PAR_B(KK,Z,I,J)):


BIF_15(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

  X1_B(Z,I,J,M)+SUM(K$(ORD(K) GT 1 AND ORD(K) LE KMAX(Z,I,J)),ORD(K)*X_B(K,Z,I,J,M))=E=
SUM(L$(HOT(I,L) AND ORD(L) LE ORD(M) AND ALLOW_H(Z,I,L,J)),NHE_M0_B(Z,I,J,L))

                                +1-Y_M_B(Z,I,J,M) ;
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BIF_16(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

   X1_B(Z,I,J,M)=L=1;


BIF_17(Z,I,J,M)$(HOT(I,M) AND ALLOW_H(Z,I,M,J) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

   SUM(N$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I)),Q2(Z,I,M,J,N))=E=QNEW2_M(Z,I,J,M);


BIF_18(Z,I,J,M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND ALLOW_H(Z,I,M,J) AND
ALLOW_C(Z,J,N,I) AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..

   Q2(Z,I,M,J,N)=L=Q(Z,I,M,J,N);


NEXCH(Z,I,J)$(ALLOW(Z,I,J)=1 AND BIF(Z,I,J)=0 AND FREEH(I) AND FREEC(J))..NHE(Z,I,J)=L=1;


NEXCH_B(Z,I,J)$(ALLOW(Z,I,J)=1 AND BIF(Z,I,J)=1 AND FREEH(I) AND FREEC(J))..NHE(Z,I,J)=L=2;


TOTNEXCH_MAX..  SUM((Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND
FREEC(J)),NHE(Z,I,J))=L=SUM((Z,I,J)$(FREEH(I) AND FREEC(J)),NHE0(Z,I,J))+2;


TOTNEXCH_MIN..  SUM((Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND
FREEC(J)),NHE(Z,I,J))=G=SUM((Z,I,J)$(FREEH(I) AND FREEC(J)),NHE0(Z,I,J));


* SPLIT_LIMIT_M(Z,I,M)$(D(Z,M,M) AND HOT(I,M) AND NOT HU(I) AND ALLOW_(I,J)=1)..
*    SUM(J$(EX_COLD(M,J)),Y_M(Z,I,J,M))=L=1+SUM(J$(EX_COLD(M,J)),NHE_M0(Z,I,J,M));


* SPLIT_LIMIT_M2(Z,I,M)$(D(Z,M,M) AND HOT(I,M) AND NOT HU(I) AND ALLOW_(I,J)=1)..
*    SUM(J$(EX_COLD(M,J)),NHE_M0(Z,I,J,M))=L=1;


* SPLIT_LIMIT_N(Z,J,N)$(D(Z,N,N) AND COLD(J,N) AND NOT CU(J) AND ALLOW_(I,J)=1)..
*    SUM(I$(EX_HOT(N,I)),Y_N(Z,I,J,N))=L=1+SUM(I$(EX_HOT(N,I)),NHE_N0(Z,I,J,N));


* SPLIT_LIMIT_N2(Z,J,N)$(D(Z,N,N) AND COLD(J,N) AND NOT CU(J) AND ALLOW_(I,J)=1)..
*    SUM(I$(EX_HOT(N,I)),NHE_N0(Z,I,J,N))=L=1;
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AREA_REST1(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=0)..
  PAR(Z,I,J)=L=AEX(Z,I,J)+DPAR_E(Z,I,J)+PAR_N(Z,I,J);

AREA_REST2(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=0)..
  DPAR_E(Z,I,J)=L=AEX_U(Z,I,J)-AEX(Z,I,J);

AREA_REST3(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=0)..
  PAR_N(Z,I,J)=L=5000*(NHE(Z,I,J)+NHE_S(Z,I,J)$(NHE0(Z,I,J)=1)-NHE0(Z,I,J));

AREA_REST1_B(K,Z,I,J)$(ORD(K) LE KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1)..
  PAR_B(K,Z,I,J)=L=SUM(KK$(ORD(KK) LE
NHE0(Z,I,J)),AEX_B(KK,Z,I,J)*DELTA(KK,K))+DPAR_E_B(K,Z,I,J)+PAR_N_B(K,Z,I,J);

AREA_REST2_B(K,Z,I,J)$(ORD(K) LE KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1)..
  DPAR_E_B(K,Z,I,J)=L=SUM(KK$(ORD(KK) LE NHE0(Z,I,J)),(AEX_U_B(KK,Z,I,J)-
AEX_B(KK,Z,I,J))*DELTA(KK,K));

AREA_REST3_B(K,Z,I,J)$(ORD(K) LE KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1)..
  PAR_N_B(K,Z,I,J)=L=5000*(1-SUM(KK$(ORD(KK) LE NHE0(Z,I,J)),DELTA(KK,K)));

AREA_REST4_B(K,Z,I,J)$(ORD(K) LE KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1)..
  SUM(KK$(ORD(KK) LE NHE0(Z,I,J)),DELTA(KK,K))=L=1;

AREA_REST5_B(K,Z,I,J)$(ORD(K) LE NHE0(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1)..
  SUM(KK$(ORD(KK) LE KMAX(Z,I,J)),DELTA(K,KK))=L=1;

AREA_REST6_B(Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND BIF(Z,I,J)=1)..
  SUM((K,KK)$(ORD(K) LE KMAX(Z,I,J) AND ORD(KK) LE NHE0(Z,I,J)),DELTA(KK,K))=E= NHE0(Z,I,J);
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ADD_REST.
  SUM((Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J)),NHE(Z,I,J)-NHE0(Z,I,J))=L=2;

ADD_REST2(I,J)$(FREEH(I) AND FREEC(J))..
  SUM(Z$(ALLOW(Z,I,J)=1),NHE(Z,I,J)-NHE0(Z,I,J))=G=0;

TOTALCOST.. TCOST=E=SUM(I$(HU(I) AND FREEH(I)),CHU(I)*FHU(I)*DTHU(I))+SUM(J$(CU(J) AND
FREEC(J)),CCU(J)*FCU(J)*DTCU(J))
        +SUM((Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND
FREEC(J)),CF*(NHE(Z,I,J)+NHE_S(Z,I,J)$(NHE0(Z,I,J)=1)-NHE0(Z,I,J)))
        +SUM((Z,I,J)$(ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=0),CAE*DPAR_E(Z,I,J)+CAN*PAR_N(Z,I,J))
        +SUM((K,Z,I,J)$(ORD(K) LE KMAX(Z,I,J) AND ALLOW(Z,I,J)=1 AND FREEH(I) AND FREEC(J) AND
BIF(Z,I,J)=1),CAE*DPAR_E_B(K,Z,I,J)+CAN*PAR_N_B(K,Z,I,J));

MODEL MPERIOD /ALL/ ;

OPTION LIMROW = 0;
OPTION LIMCOL = 0;
OPTION SOLPRINT = OFF;
OPTION OPTCR = 0.00;
OPTION OPTCA = 0.00;
OPTION ITERLIM = 1000000000;
OPTION RESLIM = 1000000;
MPERIOD.OPTFILE = 1;
* MPERIOD.PRIOROPT= 1;

* PMATCH.PRIOR(Z,I,J) = 0.5;
* HUMATCH.PRIOR(Z,S,J)=0.75;
* CUMATCH.PRIOR(Z,I,W)=0.75;

SOLVE MPERIOD USING MIP MINIMIZING TCOST ;

PARAMETER QMATCH(Z,I,J);
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QMATCH(Z,I,J)=SUM((M,N)$(D(Z,M,N) AND TL(N) LT TU(M) AND HOT(I,M) AND COLD(J,N) AND
ALLOW_H(Z,I,M,J) AND ALLOW_C(Z,J,N,I)),Q.L(Z,I,M,J,N));

PARAMETER FH_H(Z,I,J,M) Flowrate of hot stream per HEx;

    FH_H(Z,I,J,M)$[HOT(I,M)] = QNEW_M.L(Z,I,J,M)/[(TU(M)-TL(M))*CPH(I,M)]

PARAMETER FC_C(Z,J,I,M) Flowrate of hot stream per HEx;

    FC_C(Z,J,I,M)$[COLD(J,M)] = QNEW_N.L(Z,I,J,M)/[(TU(M)-TL(M))*CPC(J,M)]

OPTION Q:3:0:1; DISPLAY Q.L;

OPTION QNEW_M:3:0:1; DISPLAY QNEW_M.L;

OPTION QNEW_N:3:0:1; DISPLAY QNEW_N.L;

OPTION QNEW2_M:3:0:1; DISPLAY QNEW2_M.L;

OPTION QNEW2_N:3:0:1; DISPLAY QNEW2_N.L;

OPTION Y_M:3:0:1; DISPLAY Y_M.L;

OPTION Y_N:3:0:1; DISPLAY Y_N.L;

OPTION NHE_M0:3:0:1; DISPLAY NHE_M0.L;

OPTION NHE_M1:3:0:1; DISPLAY NHE_M1.L;

OPTION NHE_N0:3:0:1; DISPLAY NHE_N0.L;

OPTION NHE_N1:3:0:1; DISPLAY NHE_N1.L;

OPTION Y_M_B:3:0:1; DISPLAY Y_M_B.L;

OPTION Y_N_B:3:0:1; DISPLAY Y_N_B.L;

OPTION NHE_M0_B:3:0:1; DISPLAY NHE_M0_B.L;

OPTION NHE_M1_B:3:0:1; DISPLAY NHE_M1_B.L;

OPTION NHE_N0_B:3:0:1; DISPLAY NHE_N0_B.L;

OPTION NHE_N1_B:3:0:1; DISPLAY NHE_N1_B.L;

OPTION ALFA_M:3:0:1; DISPLAY ALFA_M.L;

OPTION ALFA_N:3:0:1; DISPLAY ALFA_N.L;

OPTION PAR:3:0:1; DISPLAY PAR.L;

OPTION NHE:3:0:1; DISPLAY NHE.L;

OPTION QMATCH:3:0:1; DISPLAY QMATCH;

OPTION X1_B:3:0:1; DISPLAY X1_B.L;
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OPTION X_B:3:0:1; DISPLAY X_B.L;

OPTION DPAR_E:3:0:1; DISPLAY DPAR_E.L;

OPTION PAR_N:3:0:1; DISPLAY PAR_N.L;

OPTION PAR_B:3:0:1; DISPLAY PAR_B.L;

OPTION DPAR_E_B:3:0:1; DISPLAY DPAR_E_B.L;

OPTION PAR_N_B:3:0:1; DISPLAY PAR_N_B.L;

OPTION NHE_S:3:0:1; DISPLAY NHE_S.L;

OPTION DELTA:3:0:1; DISPLAY DELTA.L;

OPTION TCOST:3:0:1; DISPLAY TCOST.L;

OPTION FH_H:3:0:1; DISPLAY FH_H;

OPTION FC_C:3:0:1; DISPLAY FC_C;

OPTION TU:3:0:1; DISPLAY TU;

OPTION TL:3:0:1; DISPLAY TL;

OPTION CPH:3:0:1; DISPLAY CPH;

OPTION CPC:3:0:1; DISPLAY CPC;

OPTION DHH:3:0:1; DISPLAY DHH;

OPTION DHC:3:0:1; DISPLAY DHC;

OPTION LMTD:3:0:1; DISPLAY LMTD;

OPTION ALLOW:3:0:1; DISPLAY ALLOW;

OPTION ALLOW_H:3:0:1; DISPLAY ALLOW_H;

OPTION ALLOW_C:3:0:1; DISPLAY ALLOW_C;
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ต้นฉบับ หน้าขาดหาย