APPENDIX B

TRNSYS SIMULATIONS

TRNSYS Deck of System Size #2 With 2 Tank Configuration (w/ PV pump)

```
ASSIGN C:\KEARY\ANNUAL\SYS2.LST                6
ASSIGN C:\KEARY\ANNUAL\Hsys2PV.out             13
ASSIGN C:\KEARY\ANNUAL\WTHR91.DAT              14
ASSIGN C:\KEARY\ANNUAL\91DRAWS.dat             15
ASSIGN C:\KEARY\ANNUAL\MLKMAIN.DAT             16
ASSIGN C:\KEARY\ANNUAL\Dsys2PV.OUT             17
ASSIGN C:\KEARY\ANNUAL\Msys2PV.OUT             18
* 52 GALLON TANK B.U. for System #2 W/PV
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                  *
*        Analysis of Average Water Loads           *
*           An Annual 1991 Analysis                *
*      for Demand Reduction of SDHW Systems        *
*         Milwaukee, WI WEPCo Utility              *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
EQUATIONS 26
START=0.00
STOP=8760
STEP=1./6
TENV=18.0
TSET=60.0
*Solar TANK SIZE IN ACTUAL 80 GALLONS=>(3.7854*10^-3 m^3/1 gal)
TSIZE=0.302832
HGHT=1.2192
NODES=5
AREA=6.00
TI=6.9
*uloss is needed for the tank evaluation in kJ/HR-M2-C SO DIVIDE
*BY THE SURFACE AREA OF THE SOLAR GALLON TANK @ SAME STANDBY
LOSS
* WHICH YIELDS %/HR*DENS*Cp/2*PI*R*H =>KJ/HR-M2-C
ULOSS=3
*fractional loss is the (%/hour) rating for different dhw's
FRCTLOSS=0.7
*STANDBYLOSS=FRCLOSS(%/HR)/100%*VOL(GAL)*8.34(LB/GAL)*T(F)*1(BTU/
LB-F)
*STNDBY=KJ/HOUR =>(%/HR)/(%)*VOL(M3)*DENS(KG/M3)*T(C)*Cp(KJ/KG-C)
*THE bACK-UP TANK SIZE IS 52 GALLONS, WITH ITS ASSOCIATED LOSSES
BUTSIZE=0.19684
STBYLOSS=(FRCTLOSS/100)*(BUTSIZE)*1000*(TSET-TENV)*4.19
DAY=1.0
RHOG=2.0000E-01
SLOPE=2.30000E+01
GAMMAI=0.0000E+0
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```
SC=4871
SHIFT=0.0
LAT=3.85200E+01
*TEMPERING VALVE EQUATIONS FOLLOW: SO WATER NOT MORE THAN
TSET, IT
*IS MIXED WITH MAINS TEMPERATURE TO DELIVERY AT TSET ONLY.
* TMAINS IS FROM DATA READER 39 AND CHANGES MONTHLY
TDIFF=MAX(0.000001,([60,5]-[39,1]))
FLOWRATIO=MIN(1,((TSET-[39,1])/TDIFF))
MLOAD=[29,1]*FLOWRATIO
FACT=3.7853
SCALE=1.0*FACT
*SCALE IS WHAT THE WATER DRAW IS SCALED BY=>NORMALLY 69.3
GALLS
*FACT IS THE CONVERSION FROM GAL/HOUR TO KG/HR

SIMULATION START STOP STEP
Limits 25 25 25
TOLERANCES 0.001 0.001
WIDTH 72

UNIT 19 TYPE 9 DATA READER FOR MILKWAUKEE 1991 WEATHER
* 1/1/91 TO 12/31/91 WEATHER
PARAMETERS 20
* MODE  N  dT(HOURS)   DUMHOURS   Tdb(C) T_wb(C) Wind  I(kJ/M2-hr)
  -2    5    1          1 1 0    2 1 0  3 1 0   4 1 0  -5 1 0
*      LU FRMT
      14   0
*OUTPUTS: 2,Tdb 5,I
*TRACE 0,24

UNIT 29 TYPE 9 DATA READER FRO WATER DRAWS
*WATER DRAWS:  (GAL/HR) - CONVERT TO KG/HR
* USE FACTOR 3.7853
PARAMETERS 7
* MODE N   STEP   VAR   MULT   ADD   LU   FRMT
  2    1   STEP   -1    SCALE  0.    15    0
*OUTPUTS: 1,DRAW(KG/HR)
*TRACE 0,24

UNIT 39 TYPE 9 DATA READER FOR MILWAUKEE MAINS WATER
TEMPERATURE
* CHANGES MONTHLY BUT READ IN DAILY (24 HOURS) FROM F-CHART FILE
PARAMTERS 8
* MODE  N  dT(HOURS) TMAINS   LU  FRMT
```

```
  2   1    24    -1 1 0   16   0
*OUTPUTS: 1, TMAINS

UNIT 16 TYPE 16 RADIATION PROCESSOR
PARAMETERS 8
* RADMODE TRACKMODE TILTMODE DAY LAT SC SHIFT SMOOTH
   3        1        1     DAY LAT SC SHIFT   2
INPUTS 6
* I(kJ/m2-hr)  td1    td2    RHOG    BETA1    GAMMAI  INext 19,5 0.0
 19,5          19,19  19,20  RHOG    SLOPE    GAMMAI  19,25
 0.0           0.0    0.0    RHOG    SLOPE    GAMMAI  0.0
*OUTPUTS: 1,Io 2,THETAz 3,GAMMAs 4,I 5,Id 6,IT1 7,IbT1 8,IdT1 9,THETA1
*        10,BETA1 11,IT1
*TRACE 60,61

UNIT 1 TYPE 1 COLLECTOR
PARAMETERS 14
* MODE N AREA Cp  EFFMODE G   ao  a1  a2  EFF CpHX OPTMODE bo b1
  1   1 AREA  4.19  1    50 .7 15. 0.0 -1  4.19   1    0.1 0.0
INPUTS 10
* Ti  mCOLL(KG/HR) mHX  Tamb   It    I    Id    RHOG  THETA BETA(SLOPE)
 3,1  3,2          3,2  19,2  16,6 16,4  16,5   0,0    16,9   16,10
 TI   0.0          0.0  20.0   0.0  0.0   0.0    0.7    0.0    40.0
*OUPUTS: 1, To 2,mo 3,Qgain(KJ/HR) 4,Tco
*TRACE 60,61

UNIT 2 TYPE 2 PUMP CONTROLLER
PARAMETERS 4
* NSTK dThigh dTlow Tmax
  11  1.0  1.0    100
INPUTS 4
* Th   Tl    TIN  GAMMAI
  1,1  60,6  0,0  0,0
  15.  TI    TI  0.
*OUTPUTS: 1,GAMMAo (CONTROL FUNCTION)
*TRACE 60,61

UNIT 3 TYPE 3 PUMP
PARAMETERS 4
* mMAX    Cp    Pmax(KJ/HR)   fpar
  325.    4.19     100.        0.
INPUTS 3
*  Ti    mi   GAMMA
  60,6  60,4   2,1
   TI    0.0    0.0
```

```
*OUTPUTS: 1,To 2,mo 3,Pfan

UNIT 60 TYPE 60 SOLAR STORAGE TANK
PARAMETERS 43
*NODES  MODE  VOL   H    PER  H1IN  H1OUT  H2IN  H2OUT CP
 NODES   1  TSIZE  HGHT  -1   0.00  HGHT   HGHT  0   4.19
*RHO   Ut     K  KDELTA  TBOIL  AUXMODE   HAUX1  HSTAT1  TSET1
 1000  ULOSS 2.0988 0.   100      2        1.155  1.155   TSET
*Udb1  Ldb1  Qaux1  Haux2  HSTAT2  TSET2  Udb2  Ldb2  QAUX2
  2     2   0.0   0.495  0.495   TSET    2     2    0.00
*UAflue  Tflue  HMODE  Umode  Hhx  HXFLUID  %GLY   ID  OD
  0.0     TENV   0      0    -0.1      1    0.60   0.1 0.3
*HXAo  FINFRAC  FINEFF  HX_L  HX_K  NOWARN
  0.86   0.73   0.8      4.9  1444    1
INPUTS 12
*M1IN M1OUT M2IN M2OUT TMAINS  T2IN TENV GMA1 GMA2 HXIN MHX
C_HX
MLOAD MLOAD 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
*29,1 29,1 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
0.0   0.0   0.0  -2    6.9     TI  TENV  1.  1.  71.  -300 0.513
DERIVATIVES NODES
TI TI TI TI TI
*OUTPUTS: 1,MLOAD 2,MLOAD 3,Mcoll 4,Mcoll 5,Tload 6,Tcoll 7,Qenv
* 8,Qin1 9,Qout1 10,Qin2 11,Qout2 12,Qaux2 13,Qaux1 14,Qaux2 15,Qflue
* 16,deltaU 17,Tave 18,dPRESS 19,dPRESS 20,dPRESS 21,dPRESS 22,Qhx
* 23,EB 24,TOUThx 25,LMTDhx 26,UAhx 27=>27+NODES=TNODES
*TRACE 0,24

*UNIT 4 OUTPUTS:
*OUTPUTS: 1,Trtn 2,m_rtnCOLL 3,Tload 4,m_load 5,Qenv,loss 6,Qs
*        7,dEtank 8,Qaux1

UNIT 6 TYPE 6 BACK-UP HEATER FOR SOLAR
PARAMETERS 5
* Qmax(KJ/HR) Tset(C) Cp(KJ/KG-C) UAloss(kJ/hr-C) EFFhtr
   9999999.    TSET       4.19       0            1
INPUTS 4
* Ti(C) mi(KG/HR) GAMMA    Tenv
  60,5    60,1       0,0     0,0
   TI    0.0        1.       21.0
*OUTPUTS: 1,To 2,mo 3,Qaux(KJ/HR) 4,Qloss 5,Qfluid(kJ/hr)

* THIS HEATER IS THE MODEL FOR THE ELECTRIC ONLY TANK
* MAINS IS HEATED WITH NO STORAGE, LOSSES ARE ACCOUNTED FOR
WITH THE
```

```
* STANDBY LOSS TERM
UNIT 61 TYPE 6 HEATER
PARAMETERS 5
* Qmax(KJ/HR) Tset(C) Cp(KJ/KG-C) UAloss(kJ/hr-C) EFFhtr
   9999999.   TSET      4.19      0          1
INPUTS 4
* Ti(C) mi(KG/HR)   GAMMA   Tenv
  39,1   29,1      0,0    0,0
   8.0   0.0        1.     18.0
*OUTPUTS: 1,To 2,mo 3,Qaux(KJ/HR) 4,Qloss 5,Qfluid(kJ/hr)

EQUATIONS 14
*CONVERTING KJ/HR TO KW FOR DEMAND & KG/HR TO GPM WATER DRAW
*FOR FIRST 2 TRIPLE DAYS (0-144) USE FACTOR 3.7853, FOR SINGLE STAT
DRAW=[29,1]/SCALE
PFAN=[3,3]/3600
GAMPUMP=[2,1]
DmdSOL=([6,3]+STBYLOSS)/3600
DmdELC=([61,3]+STBYLOSS)/3600
dTANKLOSS=STBYLOSS/3600
QauxSOL=([6,3]+STBYLOSS)
QauxELC=([61,3]+STBYLOSS)
SF=((QauxELC-QauxSOL)/(QauxELC+0.00000001))*100
*Qaux1=[60,13]/3600
QenvLOSS=[60,7]/3600
QsTANK=([60,10]-[60,11])/3600
Qsolar=[16,4]/3600
Qgain=[1,3]/3600
DRAWS=[29,1]/3.7853
*PRINTS GALLONS/HOUR

**************HOURLY RESULTS**************
UNIT 42 TYPE 24 INTEGRATOR FOR HOURLY ENERGY AND DEMAND
SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*             Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
        1.0
INPUTS 2
*  QauxSOL     QauxELC  DRAWS
  QauxSOL     QauxELC  DRAW    TEST
   0.0        0.0     0.0     0.0
*OUTPUTS: 1,QauxSOLhourly 2,QauxELChourly
```

```
EQUATIONS 4
* HOURLY DEMAND OF SOLAR & ELECTRIC BACKUP
SOLdmd=([42,1]/3600)
ELCdmd=([42,2]/3600)
SOLsvgs=(SOLdmd-ELCdmd)
SFRACTION=((([24,2]-[24,1])/([24,2]+0.00000001))*100

UNIT 28 TYPE 25 HOURLY RESULTS PRINTER
*PRINT RUNNING TOTALS DEMAND EVERY HOURS
PARAMETERS 4
* dtp  tON  tOFF Lunit UNITS
  1   START  STOP   13
INPUTS 3
SOLdmd     ELCdmd     SOLsvgs
SOLdmd(kW) ELCdmd(kW) SOLsvgs(kW)

**********DAILY RESULTS****************
 UNIT 24 TYPE 24 INTEGRATOR FOR DAILY ENERGY SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
          24.0
INPUTS 3
*  QauxSOL     QauxELC  DRAWS
   QauxSOL     QauxELC  DRAWS
   0.0        0.0     0.0
*OUTPUTS: 1,QauxSOLdaily 2,QauxELCdaily
*TRACE 0,24

UNIT 25 TYPE 25 DAILY RESULTS PRINTER
*PRINT RUNNING TOTALS OF INTEGRATION RESULTS EVERY 24 HOURS
PARAMETERS 4
* dtp    tON  tOFF    LU  UNITS
  24    START   STOP    17
INPUTS 4
* QauxSOLDAILY QauxELCDAILY      SFRACTION  DRAWS
  24,1            24,2          SFRACTION  24,3
 QauxSOL(kJ/DAY) QauxELC(kJ/DAY)    SF(%)    DRAWS(GAL/DAY)

******MONTHLY RESULTS***********
UNIT 22 TYPE 24 INTEGRATOR FOR MONTHLY ENERGY SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
```

```
*  TIME PERIOD TO INTEGRATE OVER
           -1
INPUTS 3
*  QauxSOL     QauxELC
   QauxSOL     QauxELC   DRAWS
    0.0         0.0      0.0
*OUTPUTS: 1,QauxSOLmonthly 2,QauxELCmonthly

EQUATIONS 1
SFMONTHLY=100*([22,2]-[22,1])/([22,2]+0.000000001)

UNIT 52 TYPE 25 MONTHLY RESULTS PRINTER
*PRINT RUNNING TOTALS OF INTEGRATION RESULTS EVERY MONTH
PARAMETERS 4
* dtp    tON  tOFF   LU  UNITS
  -1    START  STOP   18
INPUTS 4
* QauxSOL      QauxELCD         SFRACTION  DRAWS
  22,1            22,2          SFMONTHLY  22,3
 QauxSOL(kJ/DAY) QauxELC(kJ/DAY)    SF(%)   DRAWS(GPH)

END
UNIT 65 TYPE 65 ON-LINE GRAPHICS
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   3    2  0    5000    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3    365   4    0      2      0
INPUTS 5
19,5, 16,6   1,3      DmdELC    DmdSOL
WEATHRAD PROCCED Qgain(KJ/HR)   Delec(kW)  Dsol(kW)

end

UNIT 65 TYPE 65 ON-LINE GRAPHICS
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   2      3  0    100    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3    365   4    0      2      0
INPUTS 5
39,1      60,17      Qgain       DmdELC    DmdSOL
TMAINS(C) TsAVE(C)   Qgain(KW)   Delec(kW)  Dsol(kW)

END
```

TRNSYS Deck of System Size #2 With Single Tank Configuration (w/ PV pump)

```
ASSIGN C:\KEARY\ANNUAL\SYS2B.LST            6
ASSIGN C:\KEARY\ANNUAL\Hsys2PVB.out         13
ASSIGN C:\KEARY\ANNUAL\WTHR91.DAT           14
ASSIGN C:\KEARY\ANNUAL\91DRAWS.dat          15
ASSIGN C:\KEARY\ANNUAL\MLKMAIN.DAT          16
ASSIGN C:\KEARY\ANNUAL\Dsys2PVB.OUT         17
ASSIGN C:\KEARY\ANNUAL\Msys2PVB.OUT         18
* SINGLE TANK for System #2B W/PV
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                     *
*              Analysis of Average Water Loads                        *
*                 An Annual 1991 Analysis                             *
*            for Demand Reduction of SDHW Systems                     *
*               Milwaukee, WI WEPCo Utility                           *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
EQUATIONS 26
START=0.00
STOP=8760
STEP=1./6
TENV=18.0
TSET=60.0
*Solar TANK SIZE IN ACTUAL 80 GALLONS=>(3.7854*10^-3 m^3/1 gal)
OTSIZE=0.302832
*MODELLED SIZE IS 2/3 THE ORIGINAL DUE TO THE HEATING ELEMENT IN
*THE UPPER ONE THIRD OF TANK.
TSIZE=(2/3)*(OTSIZE)
OHGHT=1.2192
*SAME GOES FOR HEIGHT
HGHT=(2/3)*OHGHT
NODES=5
AREA=6.00
TI=6.9
*uloss is needed for the tank evaluation in kJ/HR-M2-C SO DIVIDE
*BY THE SURFACE AREA OF THE SOLAR GALLON TANK @ SAME STANDBY
LOSS
* WHICH YIELDS %/HR*DENS*Cp/2*PI*R*H =>KJ/HR-M2-C
OULOSS=3
* COMPENSATE FOR THE 1/3 RELATIVELY CONSTANT STANDBY LOSS
TERMS
* THAT AREN'T ACCOUNTED FOR IN THE 2/3 SIZE TANK
ULOSS=1.5*(OULOSS)
DAY=1.0
RHOG=2.0000E-01
SLOPE=2.30000E+01
```

```
GAMMAI=0.0000E+0
SC=4871
SHIFT=0.0
LAT=3.85200E+01
*TEMPERING VALVE EQUATIONS FOLLOW: SO WATER NOT MORE THAN
TSET, IT
*IS MIXED WITH MAINS TEMPERATURE TO DELIVERY AT TSET ONLY.
* TMAINS IS FROM DATA READER 39 AND CHANGES MONTHLY
TDIFF=MAX(0.000001,([60,5]-[39,1]))
FLOWRATIO=MIN(1,((TSET-[39,1])/TDIFF))
MLOAD=[29,1]*FLOWRATIO
FACT=3.7853
SCALE=1.0*FACT
*SCALE IS WHAT THE WATER DRAW IS SCALED BY=>NORMALLY 69.3
GALLS
*FACT IS THE CONVERSION FROM GAL/HOUR TO KG/HR

SIMULATION START STOP STEP
Limits 25 25 25
TOLERANCES 0.001 0.001
WIDTH 72

UNIT 19 TYPE 9 DATA READER FOR MILKWAUKEE 1991 WEATHER
* 1/1/91 TO 12/31/91 WEATHER
PARAMETERS 20
* MODE  N  dT(HOURS)   DUMHOURS   Tdb(C) T_wb(C) Wind  I(kJ/M2-hr)
  -2    5     1         1 1 0    2 1 0  3 1 0   4 1 0  -5 1 0
*     LU FRMT
      14   0
*OUTPUTS: 2,Tdb 5,I
*TRACE 0,24

UNIT 29 TYPE 9 DATA READER FRO WATER DRAWS
*WATER DRAWS:  (GAL/HR) - CONVERT TO KG/HR
* USE FACTOR 3.7853
PARAMETERS 7
* MODE N   STEP   VAR   MULT   ADD   LU   FRMT
  2    1   STEP   -1    SCALE  0.    15    0
*OUTPUTS: 1,DRAW(KG/HR)
*TRACE 0,24

UNIT 39 TYPE 9 DATA READER FOR MILWAUKEE MAINS WATER
TEMPERATURE
* CHANGES MONTHLY BUT READ IN DAILY (24 HOURS) FROM F-CHART FILE
PARAMTERS 8
```

```
* MODE  N  dT(HOURS) TMAINS   LU  FRMT
  2   1     24     -1 1 0   16   0
*OUTPUTS: 1, TMAINS

UNIT 16 TYPE 16 RADIATION PROCESSOR
PARAMETERS 8
* RADMODE TRACKMODE TILTMODE DAY LAT SC SHIFT SMOOTH
   3        1        1     DAY LAT SC SHIFT   2
INPUTS 6
* I(kJ/m2-hr)  td1    td2    RHOG    BETA1    GAMMAI  INext 19,5 0.0
 19,5          19,19  19,20  RHOG    SLOPE    GAMMAI  19,25
 0.0           0.0    0.0    RHOG    SLOPE    GAMMAI  0.0
*OUTPUTS: 1,Io 2,THETAz 3,GAMMAs 4,I 5,Id 6,IT1 7,IbT1 8,IdT1 9,THETA1
*        10,BETA1 11,IT1
*TRACE 60,61

UNIT 1 TYPE 1 COLLECTOR
PARAMETERS 14
* MODE N AREA Cp  EFFMODE G   ao  a1  a2  EFF CpHX OPTMODE bo b1
  1   1 AREA  4.19  1    50 .7 15. 0.0 -1  4.19   1    0.1 0.0
INPUTS 10
* Ti  mCOLL(KG/HR) mHX  Tamb   It    I    Id    RHOG  THETA BETA(SLOPE)
 3,1  3,2          3,2  19,2  16,6 16,4  16,5   0,0    16,9   16,10
 TI   0.0          0.0  20.0   0.0  0.0   0.0    0.7    0.0    40.0
*OUPUTS: 1, To 2,mo 3,Qgain(KJ/HR) 4,Tco
*TRACE 60,61

UNIT 2 TYPE 2 PUMP CONTROLLER
PARAMETERS 4
* NSTK dThigh dTlow Tmax
  11  1.0  1.0    100
INPUTS 4
* Th   Tl    TIN  GAMMAI
  1,1  60,6  0,0  0,0
  15.  TI    TI  0.
*OUTPUTS: 1,GAMMAo (CONTROL FUNCTION)
*TRACE 60,61

UNIT 3 TYPE 3 PUMP
PARAMETERS 4
* mMAX    Cp    Pmax(KJ/HR)   fpar
  325.    4.19     100.        0.
INPUTS 3
*  Ti    mi   GAMMA
  60,6  60,4   2,1
```

```
  TI    0.0    0.0
*OUTPUTS: 1,To 2,mo 3,Pfan

UNIT 60 TYPE 60 SOLAR STORAGE TANK
PARAMETERS 43
*NODES  MODE  VOL   H    PER  H1IN  H1OUT  H2IN  H2OUT CP
 NODES   1  TSIZE  HGHT  -1   0.00  HGHT   HGHT  0   4.19
*RHO   Ut    K  KDELTA  TBOIL  AUXMODE   HAUX1  HSTAT1  TSET1
 1000  ULOSS 2.0988 0.   100      2        0.75  0.75  TSET
*Udb1  Ldb1  Qaux1  Haux2  HSTAT2  TSET2  Udb2  Ldb2  QAUX2
  2      2   0.0   0.495  0.495   TSET    2     2    0.00
*UAflue  Tflue  HMODE  Umode  Hhx  HXFLUID  %GLY   ID  OD
  0.0     TENV   0      0    -0.1      1    0.60   0.1 0.3
*HXAo  FINFRAC  FINEFF  HX_L  HX_K  NOWARN
  0.86   0.73   0.8      4.9  1444    1
INPUTS 12
*M1IN M1OUT M2IN M2OUT TMAINS  T2IN TENV GMA1 GMA2 HXIN MHX
C_HX
MLOAD MLOAD 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
*29,1 29,1 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
0.0   0.0   0.0  -2    6.9    TI  TENV  1.  1.  71.  -300 0.513
DERIVATIVES NODES
TI TI TI TI TI
*OUTPUTS: 1,MLOAD 2,MLOAD 3,Mcoll 4,Mcoll 5,Tload 6,Tcoll 7,Qenv
* 8,Qin1 9,Qout1 10,Qin2 11,Qout2 12,Qaux2 13,Qaux1 14,Qaux2 15,Qflue
* 16,deltaU 17,Tave 18,dPRESS 19,dPRESS 20,dPRESS 21,dPRESS 22,Qhx
* 23,EB 24,TOUThx 25,LMTDhx 26,UAhx 27=>27+NODES=TNODES
*TRACE 0,24

*UNIT 4 OUTPUTS:
*OUTPUTS: 1,Trtn 2,m_rtnCOLL 3,Tload 4,m_load 5,Qenv,loss 6,Qs
*        7,dEtank 8,Qaux1

UNIT 6 TYPE 6 BACK-UP HEATER FOR SOLAR
PARAMETERS 5
* Qmax(KJ/HR) Tset(C) Cp(KJ/KG-C) UAloss(kJ/hr-C) EFFhtr
   9999999.    TSET       4.19        0            1
INPUTS 4
* Ti(C) mi(KG/HR) GAMMA    Tenv
  60,5    60,1       0,0     0,0
   TI    0.0        1.       21.0
*OUTPUTS: 1,To 2,mo 3,Qaux(KJ/HR) 4,Qloss 5,Qfluid(kJ/hr)


EQUATIONS 10
```

```
*CONVERTING KJ/HR TO KW FOR DEMAND & KG/HR TO GPM WATER DRAW
*FOR FIRST 2 TRIPLE DAYS (0-144) USE FACTOR 3.7853, FOR SINGLE STAT
DRAW=[29,1]/SCALE
PFAN=[3,3]/3600
GAMPUMP=[2,1]
DmdSOL=([6,3])/3600
QauxSOL=([6,3])
QenvLOSS=[60,7]/3600
QsTANK=([60,10]-[60,11])/3600
Qsolar=[16,4]/3600
Qgain=[1,3]/3600
DRAWS=[29,1]/3.7853
*PRINTS GALLONS/HOUR

**************HOURLY RESULTS**************
UNIT 42 TYPE 24 INTEGRATOR FOR HOURLY ENERGY AND DEMAND
SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
        1.0
INPUTS 2
*  QauxSOL    DRAWS
  QauxSOL    DRAW
   0.0       0.0
*OUTPUTS: 1,QauxSOLhourly 2,QauxELChourly

EQUATIONS 1
* HOURLY DEMAND OF SOLAR & ELECTRIC BACKUP
SOLdmd=([42,1]/3600)

UNIT 28 TYPE 25 HOURLY RESULTS PRINTER
*PRINT RUNNING TOTALS DEMAND EVERY HOURS
PARAMETERS 4
* dtp  tON  tOFF Lunit UNITS
  1   START  STOP   13
INPUTS 1
SOLdmd
SOLdmd(kW)

*********DAILY RESULTS****************
 UNIT 24 TYPE 24 INTEGRATOR FOR DAILY ENERGY SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
```

```
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
         24.0
INPUTS 2
*  QauxSOL      DRAWS
  QauxSOL      DRAWS
   0.0          0.0
*OUTPUTS: 1,QauxSOLdaily 2,QauxELCdaily
*TRACE 0,24

UNIT 25 TYPE 25 DAILY RESULTS PRINTER
*PRINT RUNNING TOTALS OF INTEGRATION RESULTS EVERY 24 HOURS
PARAMETERS 4
* dtp    tON  tOFF    LU  UNITS
  24    START   STOP    17
INPUTS 2
* QauxSOLDAILY    DRAWS
  24,1           24,3
 QauxSOL(kJ/DAY)  DRAWS(GAL/DAY)

******MONTHLY RESULTS***********
UNIT 22 TYPE 24 INTEGRATOR FOR MONTHLY ENERGY SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
         -1
INPUTS 2
*  QauxSOL
  QauxSOL    DRAWS
   0.0       0.0
*OUTPUTS: 1,QauxSOLmonthly 2,QauxELCmonthly

UNIT 52 TYPE 25 MONTHLY RESULTS PRINTER
*PRINT RUNNING TOTALS OF INTEGRATION RESULTS EVERY MONTH
PARAMETERS 4
* dtp    tON  tOFF    LU  UNITS
  -1    START  STOP   18
INPUTS 2
* QauxSOLDAILY    DRAWS
  22,1           22,3
 QauxSOL(kJ/DAY)  DRAWS(GPH)
END

UNIT 65 TYPE 65 ON-LINE GRAPHICS
```

```
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   3     2  0    5000    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3     365   4    0      2      0
INPUTS 5
19,5, 16,1   1,3      DmdELC    DmdSOL
WEATHRAD PROCCED Qgain(KJ/HR)   Delec(kW)  Dsol(kW)

end

UNIT 65 TYPE 65 ON-LINE GRAPHICS
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   2      3  0    100    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3     365   4    0      2      0
INPUTS 5
39,1      60,17      Qgain       DmdELC    DmdSOL
TMAINS(C) TsAVE(C)   Qgain(KW)   Delec(kW)  Dsol(kW)

END
```

TRNSYS Deck of System Size #2 With 60 Gallon GAS Two-Tank Configuration

```
ASSIGN C:\KEARY\ANNUAL\SYS2GAS.LST                6
ASSIGN C:\KEARY\ANNUAL\WTHR91.DAT                 14
ASSIGN C:\KEARY\ANNUAL\91DRAWS.dat                15
ASSIGN C:\KEARY\ANNUAL\MLKMAIN.DAT                16
ASSIGN C:\KEARY\ANNUAL\Msys2GAS.OUT               18
* 60 GALLON GAS TANK B.U. for System #2 W/PV
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                                       *
*                Analysis of Average Water Loads                        *
*                   An Annual 1991 Analysis                             *
*               for Demand Reduction of SDHW Systems                    *
*                  Milwaukee, WI WEPCo Utility                          *
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
EQUATIONS 26
START=0.00
STOP=8760
STEP=1./6
TENV=18.0
TSET=60.0
*Solar TANK SIZE IN ACTUAL 80 GALLONS=>(3.7854*10^-3 m^3/1 gal)
TSIZE=0.302832
HGHT=1.2192
NODES=5
AREA=6.00
TI=6.9
*uloss is needed for the tank evaluation in kJ/HR-M2-C SO DIVIDE
*BY THE SURFACE AREA OF THE SOLAR GALLON TANK @ SAME STANDBY
LOSS
* WHICH YIELDS %/HR*DENS*Cp/2*PI*R*H =>KJ/HR-M2-C
ULOSS=3
*fractional loss is the (%/hour) rating for different dhw's
FRCTLOSS=3.5
*STANDBYLOSS=FRCLOSS(%/HR)/100%*VOL(GAL)*8.34(LB/GAL)*T(F)*1(BTU/
LB-F)
*STNDBY=KJ/HOUR =>(%/HR)/(%)*VOL(M3)*DENS(KG/M3)*T(C)*Cp(KJ/KG-C)
*THE bACK-UP TANK SIZE IS 60 GALLONS, WITH ITS ASSOCIATED LOSSES
BUTSIZE=0.227124
STBYLOSS=(FRCTLOSS/100)*(BUTSIZE)*1000*(TSET-TENV)*4.19
DAY=1.0
RHOG=2.0000E-01
SLOPE=2.30000E+01
GAMMAI=0.0000E+0
SC=4871
```

```
SHIFT=0.0
LAT=3.85200E+01
*TEMPERING VALVE EQUATIONS FOLLOW: SO WATER NOT MORE THAN
TSET, IT
*IS MIXED WITH MAINS TEMPERATURE TO DELIVERY AT TSET ONLY.
* TMAINS IS FROM DATA READER 39 AND CHANGES MONTHLY
TDIFF=MAX(0.000001,([60,5]-[39,1]))
FLOWRATIO=MIN(1,((TSET-[39,1])/TDIFF))
MLOAD=[29,1]*FLOWRATIO
FACT=3.7853
SCALE=1.0*FACT
*SCALE IS WHAT THE WATER DRAW IS SCALED BY=>NORMALLY 69.3
GALLS
*FACT IS THE CONVERSION FROM GAL/HOUR TO KG/HR

SIMULATION START STOP STEP
Limits 25 25 25
TOLERANCES 0.001 0.001
WIDTH 72

UNIT 19 TYPE 9 DATA READER FOR MILKWAUKEE 1991 WEATHER
* 1/1/91 TO 12/31/91 WEATHER
PARAMETERS 20
* MODE  N  dT(HOURS)   DUMHOURS   Tdb(C) T_wb(C) Wind  I(kJ/M2-hr)
  -2    5    1          1 1 0    2 1 0  3 1 0   4 1 0  -5 1 0
*      LU FRMT
      14   0
*OUTPUTS: 2,Tdb 5,I
*TRACE 0,24

UNIT 29 TYPE 9 DATA READER FRO WATER DRAWS
*WATER DRAWS:  (GAL/HR) - CONVERT TO KG/HR
* USE FACTOR 3.7853
PARAMETERS 7
* MODE N   STEP   VAR   MULT   ADD   LU   FRMT
  2    1   STEP   -1    SCALE  0.    15    0
*OUTPUTS: 1,DRAW(KG/HR)
*TRACE 0,24

UNIT 39 TYPE 9 DATA READER FOR MILWAUKEE MAINS WATER
TEMPERATURE
* CHANGES MONTHLY BUT READ IN DAILY (24 HOURS) FROM F-CHART FILE
PARAMTERS 8
* MODE  N  dT(HOURS) TMAINS   LU  FRMT
   2    1    24     -1 1 0   16   0
```

```
*OUTPUTS: 1, TMAINS

UNIT 16 TYPE 16 RADIATION PROCESSOR
PARAMETERS 8
* RADMODE TRACKMODE TILTMODE DAY LAT SC SHIFT SMOOTH
   3        1        1     DAY LAT SC SHIFT   2
INPUTS 6
* I(kJ/m2-hr)  td1    td2    RHOG    BETA1    GAMMAI  INext 19,5 0.0
 19,5          19,19  19,20  RHOG    SLOPE    GAMMAI  19,25
 0.0           0.0    0.0    RHOG    SLOPE    GAMMAI  0.0
*OUTPUTS: 1,Io 2,THETAz 3,GAMMAs 4,I 5,Id 6,IT1 7,IbT1 8,IdT1 9,THETA1
*        10,BETA1 11,IT1
*TRACE 60,61

UNIT 1 TYPE 1 COLLECTOR
PARAMETERS 14
* MODE N AREA Cp  EFFMODE G   ao  a1  a2  EFF CpHX OPTMODE bo b1
   1   1 AREA  4.19  1    50 .7 15. 0.0 -1  4.19   1    0.1 0.0
INPUTS 10
* Ti  mCOLL(KG/HR) mHX  Tamb   It    I    Id    RHOG  THETA BETA(SLOPE)
 3,1  3,2          3,2  19,2  16,6 16,4  16,5   0,0    16,9   16,10
 TI   0.0          0.0  20.0   0.0  0.0   0.0    0.7    0.0    40.0
*OUPUTS: 1, To 2,mo 3,Qgain(KJ/HR) 4,Tco
*TRACE 60,61

UNIT 2 TYPE 2 PUMP CONTROLLER
PARAMETERS 4
* NSTK dThigh dTlow Tmax
   11  1.0  1.0    100
INPUTS 4
* Th   Tl    TIN  GAMMAI
  1,1  60,6  0,0  0,0
  15.  TI    TI  0.
*OUTPUTS: 1,GAMMAo (CONTROL FUNCTION)
*TRACE 60,61

UNIT 3 TYPE 3 PUMP
PARAMETERS 4
* mMAX    Cp    Pmax(KJ/HR)   fpar
  325.    4.19     100.        0.
INPUTS 3
*  Ti    mi   GAMMA
  60,6  60,4   2,1
   TI    0.0    0.0
*OUTPUTS: 1,To 2,mo 3,Pfan
```

```
UNIT 60 TYPE 60 SOLAR STORAGE TANK
PARAMETERS 43
*NODES  MODE  VOL   H    PER  H1IN  H1OUT  H2IN  H2OUT CP
 NODES   1  TSIZE  HGHT  -1   0.00  HGHT   HGHT  0   4.19
*RHO   Ut     K  KDELTA  TBOIL  AUXMODE   HAUX1  HSTAT1  TSET1
 1000  ULOSS 2.0988 0.   100      2       1.155  1.155   TSET
*Udb1  Ldb1  Qaux1  Haux2  HSTAT2  TSET2  Udb2  Ldb2  QAUX2
  2      2   0.0   0.495  0.495   TSET    2     2    0.00
*UAflue  Tflue  HMODE  Umode  Hhx  HXFLUID  %GLY   ID  OD
  0.0     TENV   0      0    -0.1      1    0.60   0.1 0.3
*HXAo  FINFRAC  FINEFF  HX_L  HX_K  NOWARN
  0.86   0.73   0.8      4.9  1444    1
INPUTS 12
*M1IN M1OUT M2IN M2OUT TMAINS  T2IN TENV GMA1 GMA2 HXIN MHX
C_HX
MLOAD MLOAD 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
*29,1 29,1 1,2  0,0   39,1    1,1  0,0  0,0  0,0  0,0  0,0  0,0
0.0   0.0   0.0  -2    6.9     TI  TENV  1.  1.  71.  -300 0.513
DERIVATIVES NODES
TI TI TI TI TI
*OUTPUTS: 1,MLOAD 2,MLOAD 3,Mcoll 4,Mcoll 5,Tload 6,Tcoll 7,Qenv
* 8,Qin1 9,Qout1 10,Qin2 11,Qout2 12,Qaux2 13,Qaux1 14,Qaux2 15,Qflue
* 16,deltaU 17,Tave 18,dPRESS 19,dPRESS 20,dPRESS 21,dPRESS 22,Qhx
* 23,EB 24,TOUThx 25,LMTDhx 26,UAhx 27=>27+NODES=TNODES
*TRACE 0,24

*UNIT 4 OUTPUTS:
*OUTPUTS: 1,Trtn 2,m_rtnCOLL 3,Tload 4,m_load 5,Qenv,loss 6,Qs
*        7,dEtank 8,Qaux1

UNIT 6 TYPE 6 BACK-UP HEATER FOR SOLAR
PARAMETERS 5
* Qmax(KJ/HR) Tset(C) Cp(KJ/KG-C) UAloss(kJ/hr-C) EFFhtr
   9999999.    TSET       4.19        0            0.7
INPUTS 4
* Ti(C) mi(KG/HR) GAMMA    Tenv
  60,5    60,1       0,0     0,0
   TI    0.0        1.       21.0
*OUTPUTS: 1,To 2,mo 3,Qaux(KJ/HR) 4,Qloss 5,Qfluid(kJ/hr)

* THIS HEATER IS THE MODEL FOR THE ELECTRIC ONLY TANK
* MAINS IS HEATED WITH NO STORAGE, LOSSES ARE ACCOUNTED FOR
WITH THE
* STANDBY LOSS TERM
```

```
UNIT 61 TYPE 6 HEATER
PARAMETERS 5
* Qmax(KJ/HR) Tset(C) Cp(KJ/KG-C) UAloss(kJ/hr-C) EFFhtr
   9999999.    TSET      4.19       0           0.7
INPUTS 4
* Ti(C) mi(KG/HR)    GAMMA    Tenv
  39,1    29,1       0,0     0,0
   8.0    0.0         1.     18.0
*OUTPUTS: 1,To 2,mo 3,Qaux(KJ/HR) 4,Qloss 5,Qfluid(kJ/hr)

EQUATIONS 16
*CONVERTING KJ/HR TO KW FOR DEMAND & KG/HR TO GPM WATER DRAW
*FOR FIRST 2 TRIPLE DAYS (0-144) USE FACTOR 3.7853, FOR SINGLE STAT
DRAW=[29,1]/SCALE
PFAN=[3,3]/3600
GAMPUMP=[2,1]
DmdSOL=([6,3]+STBYLOSS)/3600
DmdELC=([61,3]+STBYLOSS)/3600
dTANKLOSS=STBYLOSS/3600
QauxSOL=([6,3]+STBYLOSS)
QauxELC=([61,3]+STBYLOSS)
QTHERM=QauxELC*(0.9478/100000)
QSGAS=QauxELC*(0.9478/100000)
SF=((QauxELC-QauxSOL)/(QauxELC+0.00000001))*100
*Qaux1=[60,13]/3600
QenvLOSS=[60,7]/3600
QsTANK=([60,10]-[60,11])/3600
Qsolar=[16,4]/3600
Qgain=[1,3]/3600
DRAWS=[29,1]/3.7853
*PRINTS GALLONS/HOUR

******MONTHLY RESULTS***********
UNIT 22 TYPE 24 INTEGRATOR FOR MONTHLY ENERGY SAVINGS
* PARAMETERS 1: dtR=>TIME INTERVAL FOR Xi'S TO BE INTEGRATED
*              Yi's ARE RESET TO 0 AFTER EACH TIME INTERVAL
PARAMETERS 1
*  TIME PERIOD TO INTEGRATE OVER
          -1
INPUTS 5
*  QauxSOL     QauxELC
   QauxSOL     QauxELC   DRAWS    QTHERM  QSGAS
    0.0         0.0      0.0      0.0   0.0
*OUTPUTS: 1,QauxSOLmonthly 2,QauxELCmonthly
```

```
EQUATIONS 1
SFMONTHLY=100*([22,2]-[22,1])/([22,2]+0.000000001)

UNIT 52 TYPE 25 MONTHLY RESULTS PRINTER
*PRINT RUNNING TOTALS OF INTEGRATION RESULTS EVERY MONTH
PARAMETERS 4
* dtp    tON  tOFF   LU  UNITS
  -1    START  STOP   18
INPUTS 6
* QauxSOL      QauxELCD        SFRACTION  DRAWS
  22,1            22,2          SFMONTHLY  22,3   22,4  22,5
 QauxSOLkJ QauxELCkJ    SF(%)   DRAWS  QTHERM  QSGAS

END
UNIT 65 TYPE 65 ON-LINE GRAPHICS
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   3    2  0    5000    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3    365   4    0      2      0
INPUTS 5
19,5, 16,6   1,3      DmdELC    DmdSOL
WEATHRAD PROCCED Qgain(KJ/HR)   Delec(kW)  Dsol(kW)

end

UNIT 65 TYPE 65 ON-LINE GRAPHICS
PARAMETERS 14
* Ntop  Nbot Ymin1 Ymax1 Ymin2 Ymax2 Irefrsh Iupd
   2     3  0    100    0    1.5    1      1
* UNITS  Npic Grid Stop SYMBOLS  OUT
   3    365   4    0      2      0
INPUTS 5
39,1      60,17      Qgain      DmdELC    DmdSOL
TMAINS(C) TsAVE(C)   Qgain(KW)   Delec(kW)  Dsol(kW)

END
```