Modelling of buildings and solar systems with EnergyPlus
Part CC: Solar SYSTEMS - simulation of solar domestic hot water installation

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Content (75min)

- AA EnergyPlus (15 min)
- BB How to model Buildings by E+ (30 min)
- **CC How to model Solar systems by E+ (30 min)**

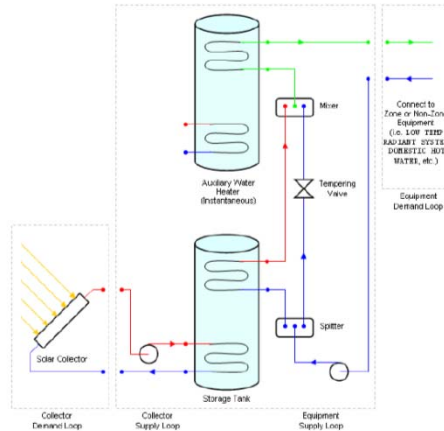COST is supported by
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Example: SolarCollectorFlatPlateWater.idf

CC SOLAR SYSTEMS - Simulation of a solar domestic hot water installation

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1 SOLAR DOMESTIC HOT WATER INSTALLATION

SDHWS serves to heat domestic hot water. The system heats the water by using solar energy and electric energy. The domestic hot water is used for heating of sink water, bath and shower water, and water for dish washing and cloth washing machines.

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1. SOLAR DOMESTIC HOT WATER INSTALLATION (CONTD)

The system consists of the solar collector, storage tank, instantaneous heating tank, and tempering valve. Solar energy heats water that flows through the collector. Furthermore, the water from collector heats water in the storage tank to some temperature that may be higher or lower than the needed (hot-water set-up) temperature. If this temperature is higher than the needed temperature, then this temperature is lowered by using cold water through the tempering valve. If this temperature is lower than the needed temperature, this water is heated by electric energy in the instantaneous water heater.

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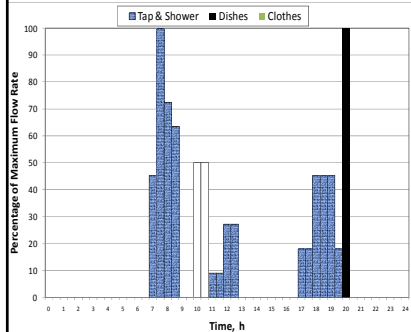
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2. Hot Water Consumption:

Fig. 2 Schedule of hot water use for (a) tap and shower (0.0000945 m³/s maximum with 43.3⁰C) (b) dish and clothes washer (0.000063 m³/s maximum with 50⁰C). Dish-washer operates daily, while cloth washer on Sundays).

This installation generates four different types of hot water: that of tap, shower, dish-washer, and cloth-washer. Fig.2 provide hot water characteristics: temperatures, maximum flow rates and daily schedules that may be valid for family of four in Serbia For water with lower temperature and for water with higher temperature used in dish washer, the daily schedule is the same for each day throughout entire summer. For water with higher temperature used in the cloth washer, the daily schedule is the same for each Sunday throughout the entire summer.

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2.1 WaterUse description by E+

WaterUse:Connections,

WaterUse:Equipment

(sinks, shower, clotheswasher, dishwasher)

Flow rate fraction schedule name (sinks, showers, chlotswasher, dishwasher)

Targets Temperature Schedule: Compact, (sinks and showers temp schedule, washers temp schedule)

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2.2 WaterUse:Connections,

```
WaterUse:Connections,
   Domestic Hot Water,      !- Name
   Domestic Hot Water Inlet Node,  !- Inlet Node Name
   Domestic Hot Water Outlet Node,  !- Outlet Node Name
   ,               !- Supply Water Storage Tank Name
   ,               !- Reclamation Water Storage Tank Name…
NONE,             !- Drain Water Heat Exchanger Type…
   Sinks,            !- Water Use Equipment 1 Name
   Showers,            !- Water Use Equipment 2 Name
   Clotheswasher,         !- Water Use Equipment 3 Name
   Dishwasher;          !- Water Use Equipment 4 Name
```

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2.3 WaterUse:Equipment,

Sinks,   **!- Name**

Sinks,   **!- End-Use Subcategory**

0.0000945,   **!- Peak Flow Rate{m3/s}**

Sinks,   **!- Flow Rate Fraction Schedule Name**

Sinks and Showers Temp Schedule; !- Target Temperature Schedule Name

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2.4 Schedule: Flow Rate Fraction

Schedule:Compact,		Until: 12:00,	!- Field 11
Sinks,	!- Name	0.1,	!- Field 12
Fraction, !- Schedule Type Name		Until: 13:00,	!- Field 13
Through: 12/31,	!- Field 1	0.3,	!- Field 14
For: AllDays,	!- Field 2	Until: 17:00,	!- Field 15
Until: 7:00,	!- Field 3	0.0,	!- Field 16
0.0,	!- Field 4	Until: 18:00,	!- Field 17
Until: 8:00,	!- Field 5	0.2,	!- Field 18
0.3,	!- Field 6	Until: 19:00,	!- Field 19
Until: 9:00,	!- Field 7	0.5,	!- Field 20
0.7,	!- Field 8	Until: 20:00,	!- Field 21
Until: 11:00,	!- Field 9	0.2,	!- Field 22
0.0,	!- Field 10	Until: 24:00,	!- Field 23
		0.0;	!- Field 24

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2.5 Schedule: Target Temperature

Schedule:Compact,

Washers Temp Schedule,   !- Name

Any Number,   !- Schedule Type Limits Name

THROUGH: 12/31,   !- Field 1

FOR: AllDays,   !- Field 2

UNTIL: 24:00,50.0;   !- Field 3

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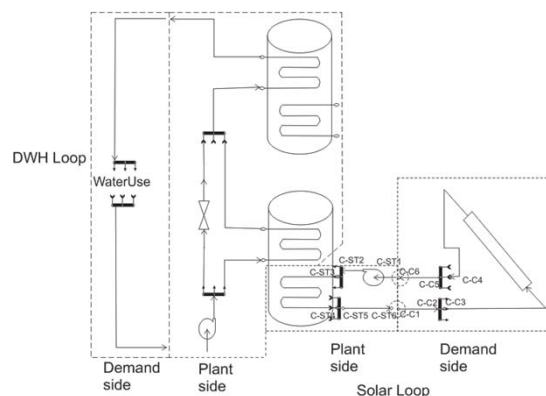through an EC contract

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3. Loops: (1)Collector & (2)DHW
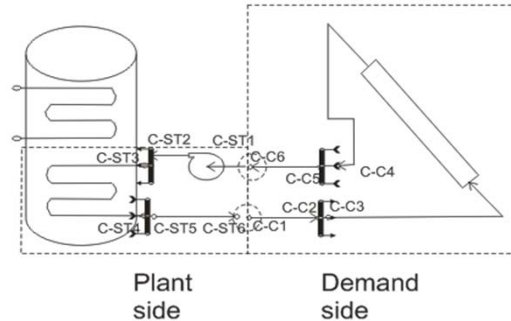
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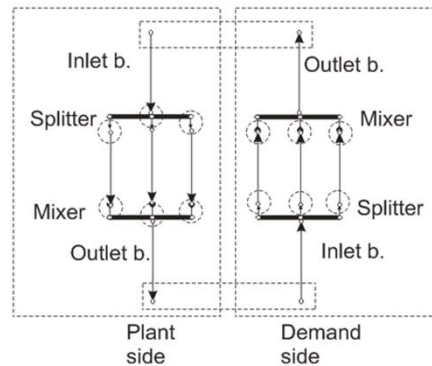
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4. Collector Loop: (a)Plant side and (b) Demand side

Plant side   Demand side

---

4. Collector loop

```
PlantLoop,
    Collector Loop,        !- Name
    WATER,                 !- Fluid Type
    Collector Loop Operation,!- Plant Equipment Operation Scheme Name
    Storage Tank Source Loop Outlet Node, !- Loop Temperature Setpoint Node Name
    100,                   !- Maximum Loop Temperature {C}
    3,                     !- Minimum Loop Temperature {C}
    AUTOSIZE,              !- Maximum Loop Flow Rate {m3/s}
    0.0,                   !- Minimum Loop Flow Rate {m3/s}
    autocalculate,         !- Plant Loop Volume {m3}
    Storage Tank Source Loop Inlet Node, !- Plant Side Inlet Node Name
    Storage Tank Source Loop Outlet Node, !- Plant Side Outlet Node Name
    Storage Tank Source Branches, !- Plant Side Branch List Name
    Storage Tank Source Connectors, !- Plant Side Connector List Name
    Collector Loop Inlet Node, !- Demand Side Inlet Node Name
    Collector Loop Outlet Node, !- Demand Side Outlet Node Name
    Collector Branches,    !- Demand Side Branch List Name
    Collector Connectors,  !- Demand Side Connector List Name
    OPTIMAL,               !- Load Distribution Scheme
    Collector Loop Availability Manager List; !- Availability Manager List Name
```

4. Loop - General schematic

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5.1 Branch list: Demand side of Collector Loop

```
BranchList,
    Collector Branches,      !- Name
    Collector Inlet Branch, !- Branch 1 Name
    Collector 1 Branch,     !- Branch 2 Name
    Collector Outlet Branch; !- Branch 3 Name
ConnectorList,
    Collector Connectors,       !- Name
    Connector:Splitter,         !- Connector 1 Object Type
    Collector Splitter,         !- Connector 1 Name
    Connector:Mixer,            !- Connector 2 Object Type
    Collector Mixer;            !- Connector 2 Name

Connector:Splitter,
    Collector Splitter,         !- Name
    Collector Inlet Branch,     !- Inlet Branch Name
    Collector 1 Branch;         !- Outlet Branch 1 Name
Connector:Mixer,
    Collector Mixer,            !- Name
    Collector Outlet Branch,    !- Outlet Branch Name
    Collector 1 Branch;         !- Inlet Branch 1 Name
```

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5.2 Branches: Demand side of Collector Loop

```
Branch,
   Collector Inlet Branch,   !- Name
   0,                        !- Maximum Flow Rate {m3/s}
   ,                         !- Pressure Drop Curve Name
   Pipe:Adiabatic,           !- Component 1 Object Type
   Collector Inlet Pipe,     !- Component 1 Name
   Collector Loop Inlet Node,  !- Component 1 Inlet Node Name
   Collector Pipe-Collector Node,  !- Component 1 Outlet Node Name
   PASSIVE;                  !- Component 1 Branch Control Type
```

```
Branch,
   Collector 1 Branch,    !- Name
   ,                      !- Maximum Flow Rate {m3/s}
   SolarCollector:FlatPlate:Water,  !- Component 1 Object Type
   Collector 1,           !- Component 1 Name
   Collector 1 Inlet Node, !- Component 1 Inlet Node Name
   Collector 1 Outlet Node, !- Component 1 Outlet Node Name
   ACTIVE;                !- Component 1 Branch Control Type
```

```
Branch,
   Collector Outlet Branch, !- Name
   0,                       !- Maximum Flow Rate {m3/s}
   ,                        !- Pressure Drop Curve Name
   Pipe:Adiabatic,          !- Component 1 Object Type
   Collector Outlet Pipe,   !- Component 1 Name
   Collector Collector-Pipe Node,  !- Component 1 Inlet Node Name
   Collector Loop Outlet Node,  !- Component 1 Outlet Node Name
   PASSIVE;                 !- Component 1 Branch Control Type
```

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5.3 Components

- Collector Inlet Pipe (Pipe: Adiabatic)
- Collector 1(SolarCollector:FlatPlate:Water)
- Collector Outlet Pipe (Pipe: Adiabatic)

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5.4 Collector Inlet Pipe (Pipe: Adiabatic)

```
Pipe:Adiabatic,
   Collector Inlet Pipe,      !- Name
   Collector Loop Inlet Node,  !- Inlet Node Name
   Collector Pipe-Collector Node;  !- Outlet Node Name
```

5.5 Collector Object
Table 1: SolarCollectorPerformance: FlatPlate, Alternate Energy Technologies AE-32 (from SolarCollectors.idf)

	Quantity	Unit	Value
1	Collector area (A)	m^2	8.89
2	Collector width	m	2.43
3	Collector length	m	3.66
4	Collector angle (α)	Deg.	45
5	Maximum Flow Rate	m3/s	0.00006
5	Test fluid		WATER
6	Test flow rate	m3/s	0.000233
7	Test correlation type		INLET
8	Coefficient 2 of EE	W/m2-K	3.396
9	Coefficient 1 of EE	-	0.691
10	Coefficient 2 of EE	W/m^2-K^2	0.00193
11	Coefficient 2 of IAM	-	-0.1939
12	Coefficient 3 of IAM	-	-0.0055

Efficiency Equation = EE;
Incident Angle Modifier =IAM

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5.6 Solar collector

```
SolarCollector:FlatPlate:Water,
   Collector 1,              !- Name
   Alternate Energy Technologies AE-32,  !- SolarCollectorPerformance Name
   Collector Surface 1,      !- Surface Name
   Collector 1 Inlet Node,   !- Inlet Node Name
   Collector 1 Outlet Node,  !- Outlet Node Name
   0.00006;                  !- Maximum Flow Rate {m3/s}
```

```
SolarCollectorPerformance:FlatPlate,
   Alternate Energy Technologies AE-32,  !- Name
   8.892,          !- Gross Area {m2}
   WATER,          !- Test Fluid
   0.0002328,      !- Test Flow Rate {m3/s}
   INLET,          !- Test Correlation Type
   0.691,          !- Coefficient 1 of Efficiency Equation {dimensionless}
   -3.396,         !- Coefficient 2 of Efficiency Equation {W/m2-K}
   -0.00193,       !- Coefficient 3 of Efficiency Equation {W/m2-K2}
   -0.1939,        !- Coefficient 2 of Incident Angle Modifier
   -0.0055;        !- Coefficient 3 of Incident Angle Modifier
```

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5.7 Collector Outlet Pipe (Pipe: Adiabatic)

```
Pipe:Adiabatic,
   Collector Outlet Pipe,    !- Name
   Collector Collector-Pipe Node,  !- Inlet Node Name
   Collector Loop Outlet Node;  !- Outlet Node Name
```

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6.1 Branch list: Plant side of Collector Loop

```
BranchList,
    Storage Tank Source Branches,  !- Name
    Storage Tank Source Inlet Branch,  !- Branch 1 Name
    Storage Tank Source Branch,  !- Branch 2 Name
    Storage Tank Source Outlet Branch;  !- Branch 3 Name

ConnectorList,
    Storage Tank Use Connectors,  !- Name
    Connector:Splitter,        !- Connector 1 Object Type
    Storage Tank Use Splitter,  !- Connector 1 Name
    Connector:Mixer,           !- Connector 2 Object Type
    Storage Tank Use Mixer;  !- Connector 2 Name

Connector:Splitter,
    Storage Tank Source Splitter,  !- Name
    Storage Tank Source Inlet Branch,  !- Inlet Branch Name
    Storage Tank Source Branch;  !- Outlet Branch 1 Name

Connector:Mixer,
    Storage Tank Source Mixer,  !- Name
    Storage Tank Source Outlet Branch,  !- Outlet Branch Name
    Storage Tank Source Branch;  !- Inlet Branch 1 Name
```

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6.2 Branches: Plant side of Collector Loop

```
Branch,
    Storage Tank Source Inlet Branch,  !- Name
    0,                          !- Maximum Flow Rate {m3/s}
    ,                           !- Pressure Drop Curve Name
    Pump:VariableSpeed,         !- Component 1 Object Type
    Collector Loop Pump,        !- Component 1 Name
    Storage Tank Source Loop Inlet Node,  !- Component 1 Inlet Node Name
    Storage Tank Source Pump-Water Heater Node,  !- Component 1 Outlet Node Name
    ACTIVE;                     !- Component 1 Branch Control Type

Branch,
    Storage Tank Source Branch,  !- Name
    0,                          !- Maximum Flow Rate {m3/s}
    ,                           !- Pressure Drop Curve Name
    WaterHeater:Mixed,          !- Component 1 Object Type
    Storage Tank,               !- Component 1 Name
    Storage Tank Source Inlet Node,  !- Component 1 Inlet Node Name
    Storage Tank Source Outlet Node,  !- Component 1 Outlet Node Name
    PASSIVE;                    !- Component 1 Branch Control Type

Branch,
    Storage Tank Source Outlet Branch,  !- Name
    0,                          !- Maximum Flow Rate {m3/s}
    ,                           !- Pressure Drop Curve Name
    Pipe:Adiabatic,             !- Component 1 Object Type
    Storage Tank Source Outlet Pipe,  !- Component 1 Name
    Storage Tank Source Water Heater-Pipe Node,  !- Component 1 Inlet Node Name
    Storage Tank Source Loop Outlet Node,  !- Component 1 Outlet Node Name
    PASSIVE;                    !- Component 1 Branch Control Type
```

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6.3 Components

- Collector Loop Pump (Pump:VariableSpeed),
- Storage Tank (WaterHeater:Mixed)
- Storage Tank Source Outlet Pipe (Pipe: Adiabatic)

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6.4 Objects –pipe: adiabatic

```
Pipe:Adiabatic,
    Storage Tank Source Outlet Pipe,  !- Name
    Storage Tank Source Water Heater-Pipe Node,  !- Inlet Node Name
    Storage Tank Source Loop Outlet Node;  !- Outlet Node Name
```

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6.5 Collector Loop Pump (Pump:VariableSpeed)

```
Pump:VariableSpeed,
    Collector Loop Pump,       !- Name
    Storage Tank Source Loop Inlet Node,   !- Inlet Node Name
    Storage Tank Source Pump-Water Heater Node,   !- Outlet Node Name
    AUTOSIZE,                   !- Rated Flow Rate {m3/s}
    300000,                     !- Rated Pump Head {Pa}
    AUTOSIZE,                   !- Rated Power Consumption {W}
    0.87,                       !- Motor Efficiency
    0.0,                        !- Fraction of Motor Inefficiencies to Fluid Stream
    0,                          !- Coefficient 1 of the Part Load Performance Curve
    1,                          !- Coefficient 2 of the Part Load Performance Curve
    0,                          !- Coefficient 3 of the Part Load Performance Curve
    0,                          !- Coefficient 4 of the Part Load Performance Curve
    0.0,                        !- Minimum Flow Rate {m3/s}
    INTERMITTENT;               !- Pump Control Type
```

6.6 Storage Tank (WaterHeater:Mixed)

```
WaterHeater:Mixed,
    Storage Tank,              !- Name
    0.75,                      !- Tank Volume {m3}
    Hot Water Setpoint Temp Schedule,  !- Setpoint Temperature Schedule Name
    5.0,                       !- Deadband Temperature Difference {deltaC}
    82.2222,                   !- Maximum Temperature Limit {C}
    CYCLE,                     !- Heater Control Type
    0.0,                       !- Heater Maximum Capacity {W}
    ELECTRICITY,               !- Heater Fuel Type
    0.90,                      !- Heater Thermal Efficiency
    SCHEDULE,                  !- Ambient Temperature Indicator
    Ambient Temp Schedule,     !- Ambient Temperature Schedule Name
    5.0,                       !- Off Cycle Loss Coefficient to Ambient Temperature {W/K}
    5.0,                       !- On Cycle Loss Coefficient to Ambient Temperature {W/K}
    Storage Tank Use Inlet Node,   !- Use Side Inlet Node Name
    Storage Tank Use Outlet Node,  !- Use Side Outlet Node Name
    1.0,                       !- Use Side Effectiveness
    Storage Tank Source Inlet Node,   !- Source Side Inlet Node Name
    Storage Tank Source Outlet Node,  !- Source Side Outlet Node Name
    1.0,                       !- Source Side Effectiveness
    autosize,                  !- Use Side Design Flow Rate {m3/s}
    autosize;                  !- Source Side Design Flow Rate {m3/s}
```

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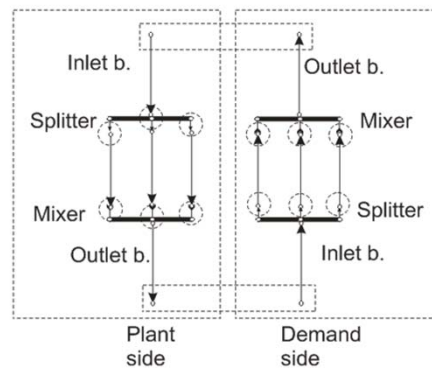
7. DHW Loop (a)Plant side and (b) Demand side
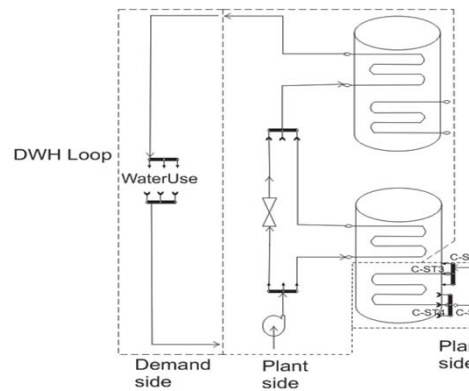
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7. Loop - General schematic

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7.1 DHW Loop

```
PlantLoop,
    DHW Loop,              !- Name
    WATER,                 !- Fluid Type
    DHW Loop Operation,    !- Plant Equipment Operation Scheme Name
    Instantaneous Water Heater Outlet Node, !- Loop Temperature Setpoint Node Name
    100,                   !- Maximum Loop Temperature {C}
    3,                     !- Minimum Loop Temperature {C}
    AUTOSIZE,              !- Maximum Loop Flow Rate {m3/s}
    0,                     !- Minimum Loop Flow Rate {m3/s}
    autocalculate,         !- Plant Loop Volume {m3}
    Storage Tank Use Loop Inlet Node, !- Plant Side Inlet Node Name
    Instantaneous Water Heater Outlet Node, !- Plant Side Outlet Node Name
    Storage Tank Use Branches, !- Plant Side Branch List Name
    Storage Tank Use Connectors, !- Plant Side Connector List Name
    Demand Inlet Node,     !- Demand Side Inlet Node Name
    Demand Outlet Node,    !- Demand Side Outlet Node Name
    Demand Branches,       !- Demand Side Branch List Name
    Demand Connectors,     !- Demand Side Connector List Name
    OPTIMAL;               !- Load Distribution Scheme
DHW Loop
```

8.1 Branches and connectors:
demand part of the loop

```
BranchList,
    Demand Branches,          !- Name
    Demand Inlet Branch,      !- Branch 1 Name
    Domestic Hot Water Branch, !- Branch 2 Name
    Demand Outlet Branch;     !- Branch 3 Name
ConnectorList,
    Demand Connectors,        !- Name
    Connector:Splitter,       !- Connector 1 Object Type
    Demand Splitter,          !- Connector 1 Name
    Connector:Mixer,          !- Connector 2 Object Type
    Demand Mixer;             !- Connector 2 Name

Connector:Splitter,
    Demand Splitter,          !- Name
    Demand Inlet Branch,      !- Inlet Branch Name
    Domestic Hot Water Branch; !- Outlet Branch 1 Name

Connector:Mixer,
    Demand Mixer,             !- Name
    Demand Outlet Branch,     !- Outlet Branch Name
    Domestic Hot Water Branch; !- Inlet Branch 1 Name
```

8.2 Branches and connectors: demand part of the loop

```
Branch,
    Demand Inlet Branch,       !- Name
    0,                         !- Maximum Flow Rate {m3/s}
    ,                          !- Pressure Drop Curve Name
    Pipe:Adiabatic,            !- Component 1 Object Type
    Demand Inlet Pipe,         !- Component 1 Name
    Demand Inlet Node,         !- Component 1 Inlet Node Name
    Demand Pipe-DHW Node,      !- Component 1 Outlet Node Name
    PASSIVE;                   !- Component 1 Branch Control Type

Branch,
    Domestic Hot Water Branch,  !- Name
    0,                          !- Maximum Flow Rate {m3/s}
    ,                           !- Pressure Drop Curve Name
    WaterUse:Connections,       !- Component 1 Object Type
    Domestic Hot Water,         !- Component 1 Name
    Domestic Hot Water Inlet Node,   !- Component 1 Inlet Node Name
    Domestic Hot Water Outlet Node,  !- Component 1 Outlet Node Name
    ACTIVE;                     !- Component 1 Branch Control Type

Branch,
    Demand Outlet Branch,      !- Name
    0,                         !- Maximum Flow Rate {m3/s}
    ,                          !- Pressure Drop Curve Name
    Pipe:Adiabatic,            !- Component 1 Object Type
    Demand Outlet Pipe,        !- Component 1 Name
    Demand DHW-Pipe Node,      !- Component 1 Inlet Node Name
    Demand Outlet Node,        !- Component 1 Outlet Node Name
    PASSIVE;                   !- Component 1 Branch Control Type
```

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8.3 Components

- Demand Inlet Pipe (Pipe: Adiabatic)
- Domestic hot water (Water Use: Conecctions)
- Demand Outlet Pipe (Pipe: Adiabatic)

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8.4 Objects –pipe: adiabatic

```
Pipe:Adiabatic,
    Demand Inlet Pipe,      !- Name
    Demand Inlet Node,      !- Inlet Node Name
    Demand Pipe-DHW Node;   !- Outlet Node Name

Pipe:Adiabatic,
    Demand Outlet Pipe,     !- Name
    Demand DHW-Pipe Node,   !- Inlet Node Name
    Demand Outlet Node;     !- Outlet Node Name
```

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9.1 Branches and connectors of storage tank part: plant part of the loop

```
BranchList,
    Storage Tank Use Branches, !- Name
    Storage Tank Use Inlet Branch, !- Branch 1 Name
    Storage Tank Use Branch, !- Branch 2 Name
    Storage Tank Tempering Branch, !- Branch 3 Name
    Storage Tank Use Outlet Branch; !- Branch 4 Name

Water heater side of DHW loop: Storage Tank Use Branches
```

```
ConnectorList,
    Storage Tank Use Connectors, !- Name
    Connector:Splitter,     !- Connector 1 Object Type
    Storage Tank Use Splitter, !- Connector 1 Name
    Connector:Mixer,        !- Connector 2 Object Type
    Storage Tank Use Mixer; !- Connector 2 Name

Water heater side of DHW loop: Storage Tank Use Connectors
```

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9.2 Connectors

```
Connector:Splitter,
    Storage Tank Use Splitter,  !- Name
    Storage Tank Use Inlet Branch,  !- Inlet Branch Name
    Storage Tank Use Branch,  !- Outlet Branch 1 Name
    Storage Tank Tempering Branch;  !- Outlet Branch 2 Name
Connector:Mixer,
    Storage Tank Use Mixer,  !- Name
    Storage Tank Use Outlet Branch,  !- Outlet Branch Name
    Storage Tank Use Branch,  !- Inlet Branch 1 Name
    Storage Tank Tempering Branch;  !- Inlet Branch 2 Name


Water heater side of DHW loop: Storage Tank Use Splitter and Storage Tank
Use Mixer
```

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9.3 Branches

```
Branch,
    Storage Tank Use Inlet Branch,  !- Name
    ,                  !- Maximum Flow Rate {m3/s}
    Pump:VariableSpeed,      !- Component 1 Object Type
    DHW Loop Pump,          !- Component 1 Name
    Storage Tank Use Loop Inlet Node,  !- Component 1 Inlet Node Name
    DHW Use Side Pump Outlet,!- Component 1 Outlet Node Name
    ACTIVE;              !- Component 1 Branch Control Type

Branch,
    Storage Tank Tempering Branch,  !- Name
    ,                  !- Maximum Flow Rate {m3/s}
    TemperingValve,        !- Component 1 Object Type
    DHW Anti-Scald Diverter,  !- Component 1 Name
    DHW Anti-Scald Inlet Node,  !- Component 1 Inlet Node Name
    DHW Anti-Scald Outlet Node,  !- Component 1 Outlet Node Name
    ACTIVE;              !- Component 1 Branch Control Type
```

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9.4 Branches (contd)

```
Branch,
    Storage Tank Use Branch, !- Name
    ,              !- Maximum Flow Rate {m3/s}
    WaterHeater:Mixed,      !- Component 1 Object Type
    Storage Tank,        !- Component 1 Name
    Storage Tank Use Inlet Node,  !- Component 1 Inlet Node Name
    Storage Tank Use Outlet Node, !- Component 1 Outlet Node Name
    PASSIVE;           !- Component 1 Branch Control Type

Branch,
    Storage Tank Use Outlet Branch, !- Name
    ,              !- Maximum Flow Rate {m3/s}
    WaterHeater:Mixed,      !- Component 1 Object Type
    Instantaneous Water Heater, !- Component 1 Name
    Instantaneous Water Heater Inlet Node, !- Component 1 Inlet Node Name
    Instantaneous Water Heater Outlet Node, !- Component 1 Outlet Node
Name
    PASSIVE;           !- Component 1 Branch Control Type

Water heater side of DHW loop: Information on branches
```

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9.5 Components

- DHW Loop Pump (Pump:VariableSpeed),
- DHW Anti-Scald Diverter (TemperingValve),
- Storage Tank (WaterHeater:Mixed)
- Instantaneous Water Heater, (WaterHeater: Mixed)

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9.6 DHW Loop Pump (Pump:VariableSpeed)

```
Pump:VariableSpeed,
    DHW Loop Pump,          !- Name
    Storage Tank Use Loop Inlet Node, !- Inlet Node Name
    DHW Use Side Pump Outlet,!- Outlet Node Name
    AUTOSIZE,               !- Rated Flow Rate {m3/s}
    300000,                 !- Rated Pump Head {Pa}
    AUTOSIZE,               !- Rated Power Consumption {W}
    0.87,                   !- Motor Efficiency
    0.0,                    !- Fraction of Motor Inefficiencies to Fluid Stream
    0,                      !- Coefficient 1 of the Part Load Performance Curve
    1,                      !- Coefficient 2 of the Part Load Performance Curve
    0,                      !- Coefficient 3 of the Part Load Performance Curve
    0,                      !- Coefficient 4 of the Part Load Performance Curve
    0,                      !- Minimum Flow Rate {m3/s}
    INTERMITTENT;           !- Pump Control Type

Variable speed pump of DHW loop
```

9.7 Object –tempering valve
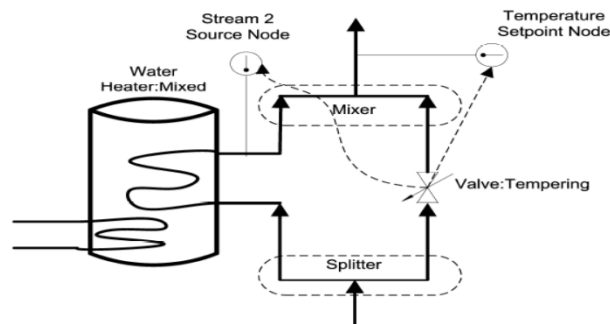

```
TemperingValve,
    DHW Anti-Scald Diverter, !- Name
    DHW Anti-Scald Inlet Node,  !- Inlet Node Name
    DHW Anti-Scald Outlet Node,  !- Outlet Node Name
    Storage Tank Use Outlet Node,  !- Stream 2 Source Node Name
    Instantaneous Water Heater Outlet Node,  !- Temperature Setpoint Node Name
    DHW Use Side Pump Outlet;!- Pump Outlet Node Name
```

9.8 Instantaneous Water Heater, (WaterHeater: Mixed)

```
WaterHeater:Mixed,
  Instantaneous Water Heater,  !- Name
  0.00568,          !- Tank Volume {m3}
  Hot Water Setpoint Temp Schedule,  !- Setpoint Temperature Schedule Name
  82.2222,          !- Maximum Temperature Limit {C}
  MODULATE,          !- Heater Control Type
  80000,          !- Heater Maximum Capacity {W}
  ELECTRICITY,          !- Heater Fuel Type
  0.90,          !- Heater Thermal Efficiency
  SCHEDULE,          !- Ambient Temperature Indicator
  Ambient Temp Schedule,  !- Ambient Temperature Schedule Name
  1.0,          !- Off Cycle Loss Coefficient to Ambient Temperature {W/K}
  1,          !- Off Cycle Loss Fraction to Zone
  1.0,          !- On Cycle Loss Coefficient to Ambient Temperature {W/K}
  1,          !- On Cycle Loss Fraction to Zone
  Instantaneous Water Heater Inlet Node,  !- Use Side Inlet Node Name
  Instantaneous Water Heater Outlet Node,  !- Use Side Outlet Node Name
  1.0,          !- Use Side Effectiveness
  autosize;          !- Use Side Design Flow Rate {m3/s}
Instantaneous Water Heater of DWH loop
```

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10.1 Operation Schemes (Collector Loop)

```
PlantEquipmentOperationSchemes,
  Collector Loop Operation,!- Name
  PlantEquipmentOperation:HeatingLoad,  !- Control Scheme 1 Object Type
  Collector Control Scheme,!- Control Scheme 1 Name
  AlwaysOnSchedule;    !- Control Scheme 1 Schedule Name
PlantEquipmentOperation:HeatingLoad,
  Collector Control Scheme,!- Name
  0,          !- Load Range 1 Lower Limit {W}
  10000000,          !- Load Range 1 Upper Limit {W}
  Collector Plant Equipment;  !- Priority Control 1 Equipment List Name
PlantEquipmentList,
  Collector Plant Equipment,  !- Name
  WaterHeater:Mixed,    !- Equipment 1 Object Type
  Storage Tank;        !- Equipment 1 Name
```

```
Schedule:Compact,
  AlwaysOnSchedule,        !- Name
  Fraction,          !- Schedule Type Limits Name
  THROUGH: 12/31,        !- Field 1
  FOR: AllDays,          !- Field 2
  UNTIL: 24:00,          !- Field 3
  1.0;          !- Field 4
```

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10.1 Operation Schemes (DHW Loop)

```
PlantEquipmentOperationSchemes,
  DHW Loop Operation,        !- Name
  PlantEquipmentOperation:HeatingLoad,  !- Control Scheme 1 Object Type
  DHW Control Scheme,        !- Control Scheme 1 Name
  AlwaysOnSchedule;          !- Control Scheme 1 Schedule Name
```

```
PlantEquipmentOperation:HeatingLoad,
  DHW Control Scheme,        !- Name
  0,                         !- Load Range 1 Lower Limit {W}
  10000000,                  !- Load Range 1 Upper Limit {W}
  DHW Plant Equipment;       !- Range 1 Equipment List Name
```

```
Schedule:Compact,
  AlwaysOnSchedule,        !- Name
  Fraction,                !- Schedule Type Limits Name
  THROUGH: 12/31,          !- Field 1
  FOR: AllDays,            !- Field 2
  UNTIL: 24:00,            !- Field 3
  1.0;                     !- Field 4
```

```
PlantEquipmentList,
  DHW Plant Equipment,        !- Name
  TemperingValve,             !- Equipment 1 Object Type
  DHW Anti-Scald Diverter,    !- Equipment 1 Name
  WaterHeater:Mixed,          !- Equipment 2 Object Type
  Storage Tank,               !- Equipment 2 Name
  WaterHeater:Mixed,          !- Equipment 3 Object Type
  Instantaneous Water Heater; !- Equipment 3 Name
```

10.2 Availability Manager Assignment List for the collector loop

```
AvailabilityManagerAssignmentList,
  Collector Loop Availability Manager List, !- Name
  AvailabilityManager:HighTemperatureTurnOff,  !- Availability Manager 1 Object Type
  High Temperature Turn Off Availability Manager,  !- Availability Manager 1 Name
  AvailabilityManager:LowTemperatureTurnOn,  !- Availability Manager 2 Object Type
  Low Temperature Turn On Availability Manager,  !- Availability Manager 2 Name
  AvailabilityManager:DifferentialThermostat,  !- Availability Manager 3 Object Type
  Differential Thermostat Availability Manager;  !- Availability Manager 3 Name
```

10.2 Table 2 Main parameters of solar heating installation (solar loop = loop through the solar collector)

	Quantity	Unit	Value
2	High temperature turn off in solar loop.	^0C	60
3	High temperature turn on in solar loop	^0C	0
4	Temperature difference on limit (differential thermostat)	^0C	10
5	Temperature difference off limit (differential thermostat)	^0C	2

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10.2 System Availability Managers.

```
AvailabilityManager:HighTemperatureTurnOff,
   High Temperature Turn Off Availability Manager,  !- Name
   Storage Tank Use Outlet Node,  !- Sensor Node Name
   60;              !- Temperature  {C}
```

```
AvailabilityManager:LowTemperatureTurnOn,
   Low Temperature Turn On Availability Manager,  !- Name
   Collector 1 Outlet Node, !- Sensor Node Name
   0.0;              !- Temperature  {C}
```

```
AvailabilityManager:DifferentialThermostat,
   Differential Thermostat Availability Manager,  !- Name
   Collector 1 Outlet Node, !- Hot Node Name
   Storage Tank Source Outlet Node,  !- Cold Node Name
   10.0,             !- Temperature Difference On Limit {deltaC}
   2.0;              !- Temperature Difference Off Limit {deltaC}
```

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10.2. Nodes for Availablility Mangers for the Solar Loop

Collector 1 Outlet Node

Storage Tank Use Outlet Node

Storage Tank Source Outlet Node

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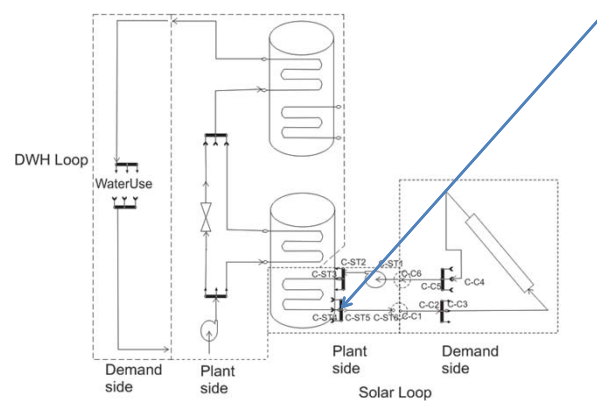through an EC contract

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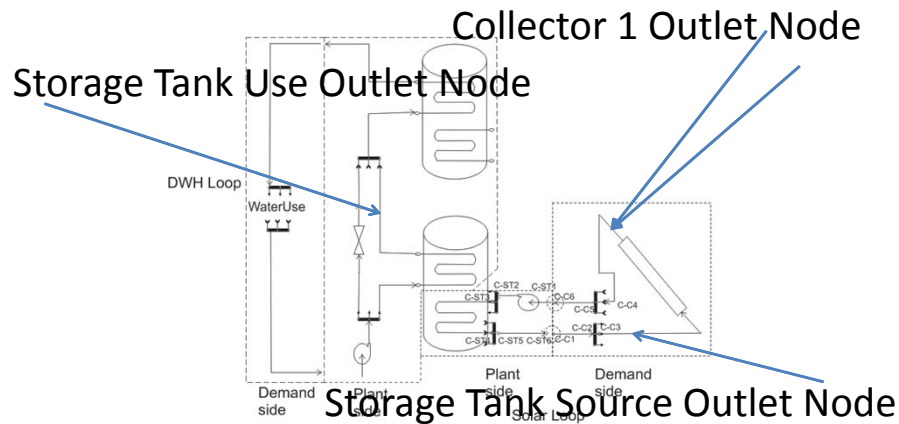
10.3 Setpoint Managers: DHW Loop

```
SetpointManager:Scheduled,
   DHW Loop Setpoint Manager,  !- Name
   Temperature,          !- Control Variable
   Hot Water Setpoint Temp Schedule,  !- Schedule Name
   DHW Loop Setpoint Node List;  !- Setpoint Node or NodeList Name

Schedule:Compact,
   Hot Water Setpoint Temp Schedule,  !- Name
   Any Number,           !- Schedule Type Limits Name
   THROUGH: 12/31,        !- Field 1
   FOR: AllDays,         !- Field 2
   UNTIL: 24:00,         !- Field 3
   50;                !- Field 4

NodeList,
   DHW Loop Setpoint Node List,  !- Name
   Instantaneous Water Heater Outlet Node,  !- Node 1 Name
   Instantaneous Water Heater Inlet Node;  !- Node 2 Name
```

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10.3 Instantanous Water Heater Outlet and Inlet Nodes

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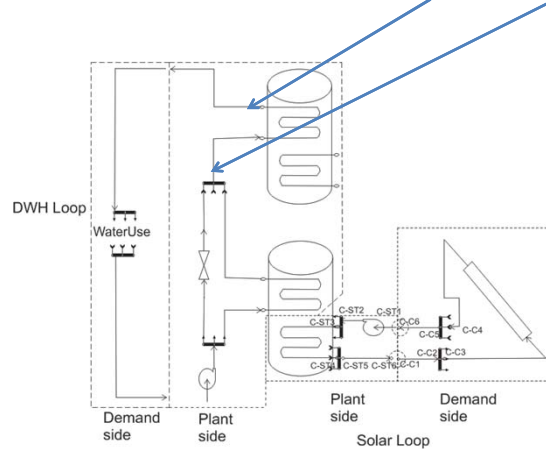
10.3 Setpoint Managers: solar loop

```
SetpointManager:Scheduled,
    Collector Loop Setpoint Manager,  !- Name
    Temperature,            !- Control Variable
    Loop Temperature Schedule, !- Schedule Name
    Collector Loop Setpoint Node List;  !- Setpoint Node or NodeList Name

Schedule:Compact,
    Loop Temperature Schedule,  !- Name
    Any Number,             !- Schedule Type Limits Name
    THROUGH: 12/31,         !- Field 1
    FOR: AllDays,           !- Field 2
    UNTIL: 24:00,           !- Field 3
    60;                     !- Field 4

NodeList,
    Collector Loop Setpoint Node List,  !- Name
    Storage Tank Source Loop Outlet Node;  !- Node 1 Name
```

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10.3 Storage Tank Source Loop Outlet Node

11. Final setting of E+ model of the installation

```
!-  ==========  ALL OBJECTS IN CLASS: RUNPERIOD  ===

RunPeriod,
    6,                !- Begin Month
    21,               !- Begin Day of Month
    9,                !- End Month
    21,               !- End Day of Month
    UseWeatherFile,   !- Day of Week for Start Day
    Yes,              !- Use Weather File Holidays and Special Days
    Yes,              !- Use Weather File Daylight Saving Period
    No,               !- Apply Weekend Holiday Rule
    Yes,              !- Use Weather File Rain Indicators
    Yes,              !- Use Weather File Snow Indicators
    1;                !- Number of Times Runperiod to be Repeated
```

11.1 SIMULATION PARAMETERS -VERSION

```
Version,
   8.1;              !- Version Identifier
```

```
SimulationControl,
   No,               !- Do Zone Sizing Calculation
   No,               !- Do System Sizing Calculation
   No,               !- Do Plant Sizing Calculation
   Yes,              !- Run Simulation for Sizing Periods
   Yes;              !- Run Simulation for Weather File Run Periods
```

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11.3 SIMULATION PARAMETERS - Building

```
Building,
   Simple One Zone (Wireframe DXF),  !- Name
   0,                !- North Axis {deg}
   Suburbs,          !- Terrain
   0.04,             !- Loads Convergence Tolerance Value
   0.004,            !- Temperature Convergence Tolerance Value {deltaC}
   MinimalShadowing, !- Solar Distribution
   30;               !- Maximum Number of Warmup Days
   6;                !- Minimum Number of Warmup Days
```

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11.4 SIMULATION PARAMETERS-Algorithms

```
SURFACECONVECTIONALGORITHM:INSIDE

SurfaceConvectionAlgorithm:Inside,TARP;
```

SurfaceConvectionAlgorithm:Outside,
DOE-2;   !- Algorithm

HeatBalanceAlgorithm,
    ConductionTransferFunction;   !- Algorithm

Timestep,
    4;   !– Number of Timesteps per Hour

11.5 LOCATION

```
Site:Location,
    DENVER_STAPLETON_CO_USA_WMO_724690, !- Name
    39.77,              !- Latitude {deg}
    -104.87,            !- Longitude {deg}
    -7.00,              !- Time Zone {hr}
    1611.00;            !- Elevation {m}
```

11.6 DESCRIPTION OF BUILDING

- Rectangular single story building – 15.24mx15.24mx4.57m
- 1 Zone, No windows,
- Lightweightconstruction
- Surfaces made of concrete 0.1m thick.
- **Internal Load:** no.

- **Space Conditioning: no**
- **Environment:** Location: Denver, Colorado, USA

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11.6 SURFACE CONSTRUCTION AND BUILDING GEOMETRY (SEE model Buildings by E+)

Collector is located at the building roof
1. WALL & ROOF MATERIAL
2. WALL & ROOF CONSTRUCTION
3. GLOBAL GEOMETRY RULES
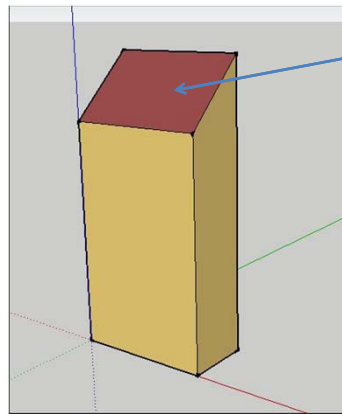4. ZONE DEFINITION
5. BUILDING SURFACE: DETAILED

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11.7 Example BUILDING with Solar Collector

Solar Collector

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12. Final setting of E+ model of the installation: output

```
Output:Meter:MeterFileOnly,
   Electricity:Facility,   !- Name
   monthly;               !- Reporting Frequency

Output:Meter:MeterFileOnly,
   DistrictHeating:Facility ,  !- Name
   Monthly;               !- Reporting Frequency
```

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12.2 Do postprocessing:

- Calculation of energy consumption during the whole summer gives two electrical energies *E* and *R* consumed for DHW production. The energy *E* is consumed by the electric heater when the solar collector is present and operating, and energy *R* is consumed when no solar collector is employed. The performance of the installation is evaluated by calculating the solar fraction (*f*) by:

$f = 100\ (R\text{-}E)/R$ \qquad\qquad (1)

13.1 RESULTS
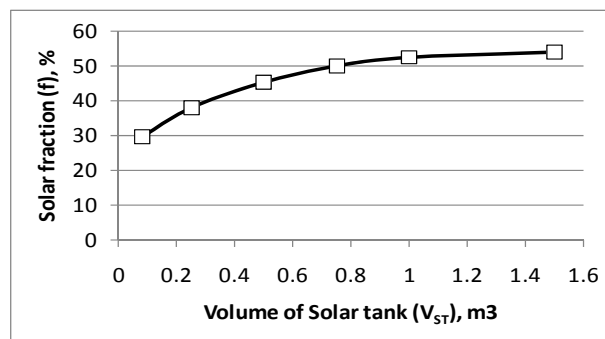
Fig. 3 Solar fraction vs. storage-tank volume. Here, $T_L=60^0C$; $T_H=50^0C$; A= 8.89 m^2; α =45^0.

13.2 RESULTS

Fig.4 Solar fraction vs. solar-collector area. Here, $T_L=60^0C$; $T_H=50^0C$; $V_{ST}=0.75m^3$; $\alpha =21.25^0$.

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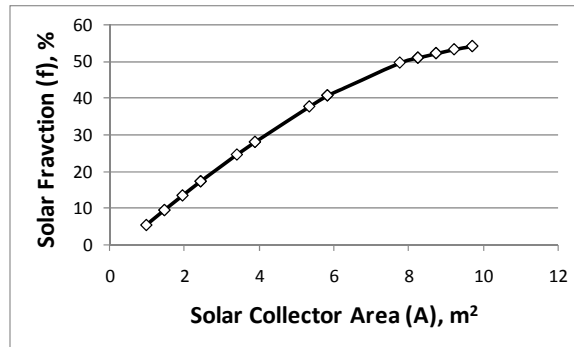
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13.3 RESULTS
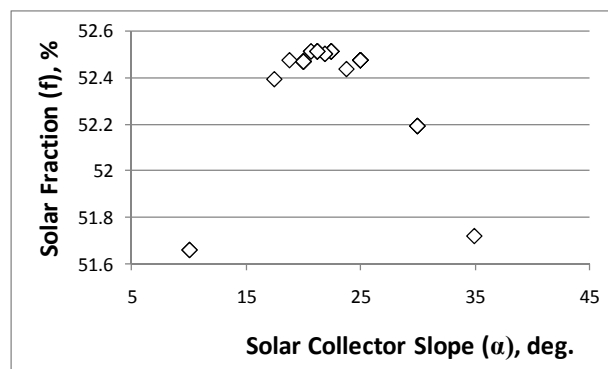
Fig.5 Solar fraction vs. solar-collector slope angle.

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14. CONCLUSION

- This lecture presents simulation of operation of solar domestic hot water installation.

Other examples are presented in the files

1. HP_wICS**SolarCollector**.idf
2. HPAirToAir_w**SolarCollector**HWCoil.idf
3. *S*hopWithPVandBattery.idf- PVT collectors
4. ShopWithPVandStorage.idf- PVT collectors
5. TranspiredCollectors.idf

If there are any problem related to this topic please contact E+ suport group and/or author of this presentation at milorad.bojic@gmail.com