Chapter 14
Hot Water System
Hot water supply plays an important role in domestic, Hospitality, Hospitals and in Industries. It provides continuous hot water to buildings to satisfy the users' need and forms an important element.

Hot Water Systems - Types

A. Individual Systems

(Localized System)

B. Centralized Systems

There are basically two types of sources

- Renewable Source
- Unrenewable Source
Individual Systems

1) Electrical Instant Geysers
2) Electrical Storage Geysers
3) Gas Heaters
4) Heat Pumps
1. Electrical Instant Geysers
2. Electrical Storage Geysers
3. Gas Heaters
4. Heat Pumps
Centralized Systems

1. Solar Systems:

   i. Flat Plate Collectors (FPC)

   ii. Evacuated Tube Collectors (ETC)

   iii. Evacuated Tube Collectors with Heat Pipes (ETC - HP)
1. Solar Systems

   i. Flat Plate Collectors
1. Solar Systems

ii. Evacuated Tube Collectors
Details of Evacuated Tube

- Selective Coating
- Heat Pipe
- Outer Tube
- Heat Fin
- Inner Tube
1. Solar Systems

ETC – HP Systems
1. Solar Systems

Evacuated Tube – Heat Pipe
TYPES OF SOLAR SYSTEMS

1) Thermosyphon System
   • Generally installed for one/fixed time usage.
   • These systems have fixed volume but varying temperatures.
   • These systems are closed loop system.

2) Forced Flow System
   • Generally installed for differed usage.
   • These systems have varying volumes but fixed temperatures.
   • These systems can be open loop systems or closed loop systems.
1. Thermosiphon System

. Hot water being lighter than cold water, rises to the top of the collector and into the hot water tank.

This cycle goes on during hours of sunshine (usually 10am to 4pm).

This phenomenon is called Thermosyphon. At end of the day the tank is full of hot water at designed temperature.
2. Forced Flow System

Cold water from the cold water tank is forced into the battery of collectors.

The solenoid valve/pump on/off operation is controlled by temperature sensor installed at the last collector at output side of the system.

The S.V / pump will remain On till all the hot water at specific temperature is replaced by cold water. This cycle goes on throughout the day.
3. Indirect Heating with Solar

In case if water quality is not good, this system can be installed.

Here indirect heating is done and treated water is used in circulation within the panel and coil.

This kind of a system can be used for thermo siphon as well as forced circulation methods.
## How much Space a Solar System occupy?

<table>
<thead>
<tr>
<th>System Capacity</th>
<th>Space Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 lpd</td>
<td>3 m²</td>
</tr>
<tr>
<td>500 lpd</td>
<td>12 m²</td>
</tr>
<tr>
<td>1000 lpd</td>
<td>24 m²</td>
</tr>
<tr>
<td>2000 lpd</td>
<td>48 m²</td>
</tr>
<tr>
<td>3000 lpd</td>
<td>72 m²</td>
</tr>
</tbody>
</table>
B. Centralized Systems

2. Hot Water Generation Systems:

a) Diesel Fired Systems
b) Gas Fired Systems
c) Heat Pump Systems
   1. Air Source Heat Pumps
   2. Water Source Heat Pumps
d) Combination Systems – Solar / Boilers / Heat Pumps
a) Diesel / Gas Boilers:

- Coil Type Boilers
- Shell Type Boilers
- Cast Iron Boilers
b) Gas Fired Boilers
WHAT IS A HEAT PUMP?

Heat pump is a machine which pumps (transports) heat energy from a source (an object with high heat potential) to a sink (an object with low heat potential).

- Tank filled with water at 30°C, volume 1000 L
- Heat pump
- Air at 10°C available abundantly
- High heat potential
- Low heat potential
The COMPRESSOR where the vapours are compressed and upgraded to a much higher temperature. The hot vapour now enters....

Hot Water Out

The CONDENSER where it is surrounded by water from the Hot Water Tank. The heat is given up to the cold water thus making it hot. Due to this the refrigerant comes to liquid state but still under high pressure. This pressure is released by passing the liquid through....

Cold Water In

The EVAPORATOR collects heat from the outside ambient air, pre-heated by the sun. This air is drawn into the unit by the fan and expelled through the evaporator fins, which has liquid refrigerant passing through it. The hot air gives up its heat to the refrigerant, which then vaporizes. This pre-heated vapour now travels to.......

Electricity

The EXPANSION DEVICE and from there, now at low pressure, it is returned to the evaporator and the cycle starts again....

EFFICIENCY RE-DEFINED
1 KW POWER
= 860 KILO CALORIES

ENERGY IN
(3024 KCAL + 860 KCAL)

ENERGY OUT
(3884 KCAL)

1 TR REFRIGERATION
= 3024 KILO CALORIES
What is COP and Why is it 4??

COEFFICIENT OF PERFORMANCE
RATIO OF ENERGY OUTPUT TO WORK DONE

COP = \frac{\text{ENERGY OUTPUT}}{\text{WORK DONE}}

COP = \frac{3884 \text{ KCAL}}{860 \text{ KCAL}} = 4.51

Practically COP is in the range 3.6 – 4.0
Heat Pump Testing Setup

Heat Pump Installation

Indian Plumbing Association
Solar & Heat Pump Hybrid System Installation
Swimming Pool Heating:

Indian Plumbing Association
WATER TO WATER HEAT PUMP

• Water to Water heat pump utilizes heat from the chiller return line as a source

• In turn water from chiller return line is cooled from 12°C to 7°C and sent to chiller

• This reduces the load on chiller and savings on operating costs of the chiller

• As a result the COP of Water to Water heat pumps is usually higher i.e. 4.5 to 5

• Usually these are very high capacity heat pumps
Combination systems

Typical consumption pattern of hot water across the year
### Sizing of Hot Water Systems

#### Consumption Patterns:

<table>
<thead>
<tr>
<th>Type of Bath</th>
<th>HW Req.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bucket Bath</td>
<td>15 – 25 Liters/Person</td>
</tr>
<tr>
<td>Shower Bath</td>
<td>40 – 50 Liters/Person</td>
</tr>
<tr>
<td>Tub Bath</td>
<td>100 – 120 Liters/Person</td>
</tr>
<tr>
<td>Shower Panels</td>
<td>100 – 120 Liters/Person</td>
</tr>
<tr>
<td>Rain Showers</td>
<td>150 – 170 Liters/Person</td>
</tr>
</tbody>
</table>

NOTE: Above figures are for consumption at 38°C - 40°C
Sizing of Hot Water Systems

Points to be considered during selection of Hot Water Systems:

1. Total HW requirement
2. Time Factor of Usage
3. Arrive the Capacity of Equipments & Hot Water Tanks
4. Location of Boilers from point of Exhaust Duct
5. Calculate operating costs
6. Arrive at a System Configuration
Effect of Mixing of Cold Water

When we draw Hot Water from Tank cold water enters in the tank. So average temp of tank reduces. Below are theoretical calculations for the same.
# Effect of Mixing of Cold Water

<table>
<thead>
<tr>
<th>TEMP</th>
<th>QUANTITY OF WATER</th>
<th>USE OF WATER</th>
<th>TEMP OF WATER TO MIXED</th>
<th>QUANTITY OF COLD WATER TO BE ADDED TO GET 42 CET.</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.59</td>
</tr>
<tr>
<td>59.7</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.58</td>
</tr>
<tr>
<td>59.4</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.57</td>
</tr>
<tr>
<td>59.1</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.56</td>
</tr>
<tr>
<td>58.8</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.55</td>
</tr>
<tr>
<td>58.5</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.54</td>
</tr>
<tr>
<td>58.2</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.53</td>
</tr>
<tr>
<td>57.9</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.52</td>
</tr>
<tr>
<td>57.6</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.51</td>
</tr>
<tr>
<td>57.3</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.5</td>
</tr>
<tr>
<td>57</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.49</td>
</tr>
<tr>
<td>54</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.39</td>
</tr>
<tr>
<td>53.7</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.38</td>
</tr>
<tr>
<td>47.1</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.16</td>
</tr>
<tr>
<td>46.8</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.15</td>
</tr>
<tr>
<td>45</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.09</td>
</tr>
<tr>
<td>44.7</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.08</td>
</tr>
<tr>
<td>42.9</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.02</td>
</tr>
<tr>
<td>42.6</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0.01</td>
</tr>
<tr>
<td>42.3</td>
<td>100</td>
<td>1</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>42</td>
<td>61</td>
<td></td>
<td></td>
<td>18.3</td>
</tr>
</tbody>
</table>
Effect of Mixing of Cold Water

TOTAL WATER CONSUMED = 61 HW + 18.3 COLD WATER

= 79.3 SAY 80 LITERS

THIS SHOWS US THAT WHEN WE CONSUME 80 LITERS
OF TOTAL WATER @ 42 DEC.C THEN 61 LITERS OF HOT
WATER GETS CONSUMED.

WE SHOULD SIZE THE SYSTEM FOR
20 % MORE THAN THE CONSUMED QUANTITY. IF PARALLEL HEATING IS NOT
AVAILABLE.

OR IN OTHER WORDS WE GET 80% OF TANK CAPACITY
HOT WATER AT 42 DEG. C IN ACTUAL
Effect of Insulation

Un insulated Line
# Effect of Insulation

## Insulated Line – 10 mm

<table>
<thead>
<tr>
<th>Product</th>
<th>Ducts</th>
<th>Pipes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Input Parameters</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Internal Temperature (°C):</td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Surrounding Air Temperature (°C):</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Percent Relative Humidity (%RH):</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Pipe Outer Diameter (mm):</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Surface Conductance Coefficient (W/m²/°K):</td>
<td></td>
<td>22.7</td>
</tr>
<tr>
<td>Thermal Conductivity Value (W/m/°K):</td>
<td></td>
<td>0.0336625</td>
</tr>
</tbody>
</table>

| **Results** | | |
| Surface Temperature (°C): | 14.35 | Performance Improvement: | 80.7% |
| Heat Outflow (W/m): | 12.40 | Dew Point Temperature (°C): | N/A |
| Insulation Thickness to Prevent Condensation (mm): | 10 | Adjust thickness to optimise heat flow. |

[Indian Plumbing Association](https://www.indianplumbingassociation.org)
## Effect of Insulation

### Insulated Line – 19 mm

<table>
<thead>
<tr>
<th>Product</th>
<th>Input Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ducts</td>
<td>Internal Temperature (°C):</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Surrounding Air Temperature (°C):</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Percent Relative Humidity (%RH):</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Pipe Outer Diameter (mm):</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Surface Conductance Coefficient (W/m²/°K):</td>
<td>22.7</td>
</tr>
</tbody>
</table>

**Estimate/Change**

<table>
<thead>
<tr>
<th>Resulting Value</th>
<th>Performance Improvement</th>
<th>Dew Point Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Temperature (°C):</td>
<td>14.35</td>
<td>80.7%</td>
</tr>
<tr>
<td>Heat Outflow (W/m):</td>
<td>12.40</td>
<td>N/A</td>
</tr>
<tr>
<td>Insulation Thickness to Prevent Condensation (mm):</td>
<td>10</td>
<td>Adjust thickness to optimise heat flow.</td>
</tr>
</tbody>
</table>

**Print**  **Clear**  **Help**  **Calculate**
## Effect of Insulation

<table>
<thead>
<tr>
<th>Insulation thickness (mm)</th>
<th>Heat Loss (w/m)</th>
<th>Performance improvement in Stopping the heat loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 mm</td>
<td>64.18</td>
<td>0%</td>
</tr>
<tr>
<td>10 mm</td>
<td>12.4</td>
<td>80.7%</td>
</tr>
<tr>
<td>13 mm</td>
<td>10.61</td>
<td>83.5%</td>
</tr>
<tr>
<td>16 mm</td>
<td>9.40</td>
<td>85.4%</td>
</tr>
<tr>
<td>19 mm</td>
<td>8.53</td>
<td>86.7%</td>
</tr>
</tbody>
</table>
Sizing of Hot Water Systems

- A Case study:
  - Let us look at a case study in detail
Sizing of Hot Water Systems

Hotel of 100 Rooms case Study

Basis Of Design:

No of Rooms: 100 Nos.
No of People: 100 X 2 = 200 Nos.
Hot Water per person: 50 Liters
Total Hot Water req.: = 200 X 50 = 10000 Liters

Heat Load: 
\[ Q = m \cdot C_p \cdot \Delta T \]
\[ = 10000 \times 1 \times (55-25) \text{ Deg C} \]
\[ = 3,00,000 \text{ Kcal} \]

Running Costs

Electrical Heating: 
\[ = \frac{3,00,000}{(860 \times 0.8)} \]
\[ = 436 \text{ kW} \]
Sizing of Hot Water Systems

Hotel of 100 Rooms case Study

Running Costs

Diesel Boiler = 3,00,000 / (10500 * 0.9)
= 31.74 Kgs = 37.34 Liters

Solar with Electrical Back up – (If we consider 90 Non Solar Days in a year)
= 436 kW X 90 = 39240 kW/Year

Heat Pumps = 3,00,000 / (860 / 0.38)
= 92 kW

(Considering COP of Heat Pump is 3.80)
Sizing of Hot Water Systems
Hotel of 100 Rooms case Study

Yearly Running Costs for 300 Days

1. Electrical Heating = 436 kW X Rs. 8.00 X 300 Days
   = Rs. 10,46,400.00

2. Diesel Heating = 37 Liters X Rs.60.00 X 300
   = Rs. 6,66,000.00

3. Solar with Electrical = 39240 kW X Rs.8.00
   = Rs. 3,13,920.00

4. Heat Pumps = 92 kW X Rs. 8.00 X 300 Days
   = Rs. 2,20,800.00
Sizing of Hot Water Systems

Issues regarding selection of Systems

• Solar System:
   It is LPD System. Sun Direction very Important. Sizing needs to be done carefully.

• Diesel System:
   1. Diesel Storage – We can have 990 liters storage without a License.
   2. Exhaust Duct – We need a Exhaust System

• Gas System:
   1. Sizing of No. of Cylinders is very important.
   2. Storage of Cylinders & Gas Piping.
B. Electrical System:


C. Heat Pump System:

1. Sizing very important issue.
Water & Energy Conservation

- **Water Conservation:**
  1. Return Line from Utility: Make a provision of return line.
  2. Use low flow fixtures.
  3. Use of Hot & Cold Mixer Valves.

- **Energy Conservation:**
  1. Sizing of Hot Water Lines.
  2. Proper Insulation of Hot Water Lines.
## Comparison of various Systems

<table>
<thead>
<tr>
<th>HEATER TYPE</th>
<th>BOILER</th>
<th>BOILER</th>
<th>BOILER</th>
<th>BOILER</th>
<th>SOLAR</th>
<th>HEAT PUMPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY SOURCE</td>
<td>WOOD</td>
<td>DIESEL</td>
<td>GAS</td>
<td>ELECTRICITY</td>
<td>SOLAR + ELECTRICITY</td>
<td>AIR + ELECTRICITY</td>
</tr>
<tr>
<td>POLLUTION</td>
<td>VERY HIGH</td>
<td>HIGH</td>
<td>HIGH</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>LIFE SPAN</td>
<td>8 YEARS</td>
<td>10 YEARS</td>
<td>10 YEARS</td>
<td>5 YEARS</td>
<td>5 YEARS</td>
<td>20 YEARS</td>
</tr>
<tr>
<td>FLAMMABILITY</td>
<td>HIGH</td>
<td>VERY HIGH</td>
<td>VERY HIGH</td>
<td>NONE</td>
<td>NONE</td>
<td>NONE</td>
</tr>
<tr>
<td>SAFETY</td>
<td>HAZARDOUS</td>
<td>HAZARDOUS</td>
<td>HAZARDOUS</td>
<td>SAFE</td>
<td>SAFE</td>
<td>VERY SAFE</td>
</tr>
<tr>
<td>SPACE REQ'D</td>
<td>LARGE</td>
<td>LARGE</td>
<td>LARGE</td>
<td>SMALL</td>
<td>VERY HIGH</td>
<td>SMALL</td>
</tr>
<tr>
<td>OPERATING COST</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>HIGH</td>
<td>VERY HIGH</td>
<td>VERY LOW</td>
<td>VERY LOW</td>
</tr>
<tr>
<td>INITIAL INVESTMENT</td>
<td>MODERATE</td>
<td>HIGH</td>
<td>HIGH</td>
<td>MODERATE</td>
<td>VERY HIGH</td>
<td>MODERATE</td>
</tr>
<tr>
<td>ROI</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>4-5 YEARS</td>
<td>1 YEAR</td>
</tr>
</tbody>
</table>
HOT WATER SYSTEMS

Formula’s for Hot Water System

• \( Q = m \times C_p \times \Delta T \)

• 1 kW = 860 Kcal

• 1 TR = 3024 Kcal
Thank you

Any Questions?

Compiled by Technical Committee - IPA

Disclaimer for IPPL Technical content prepared by IPA TC: The technical content of IPPL training presentation are developed by IPA Technical committee. The intent of the same is to impart code based technical knowledge to the participants of IPPL. These are set of recommendations to those who are involved in the design, engineering, construction or manufacturing of plumbing systems & products. In case of any conflict between any clause or recommendation in presentation and law of land such clause or recommendation shall not be adopted unless special waiver to that effect is given by Authority having jurisdiction. In case of any conflict between 2017 UIPC-I and NBC 2016 local applicable mandatory code need to be followed. IPA and its Technical committee disclaim liability for any personal injury, property or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, sue of or reliance on this document. By preparing and publishing this document, the IPA and its Technical committee individually or collectively do not volunteer to render professional or other services for or any person or entity. Any person using this document shall reply on his or her independent or as appropriate, seek the advice of the competent professional for the exercise of reasonable care in any given circumstances. The question and answers will be prepared by IPA and its Technical committee & Decision of Technical Committee on any technical matter will be considered as final.