Chapter 14
Hot Water System

Hot water supply plays an important role in domestic, Hospitality, Hospitals and in Industries. It Provides Continues 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)

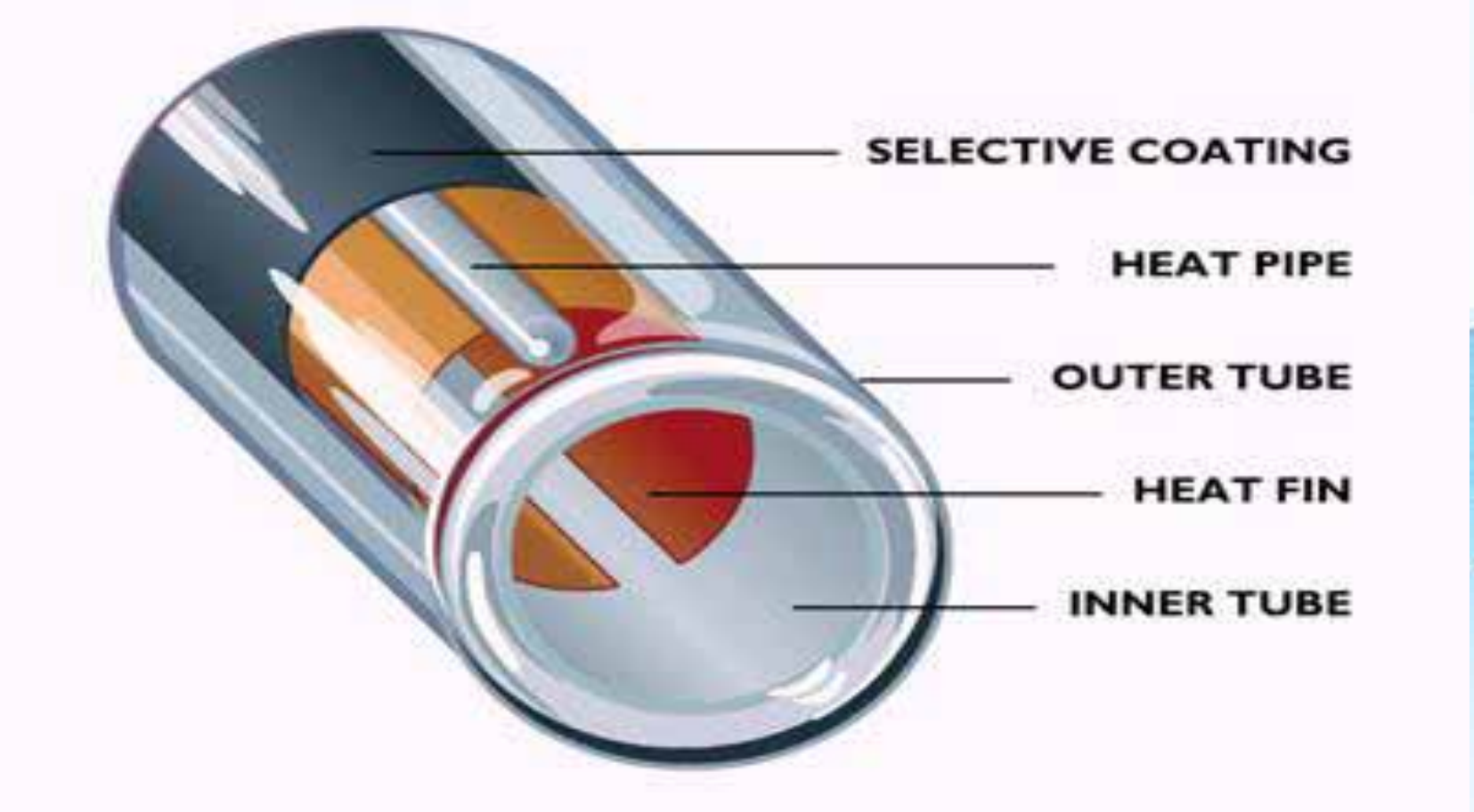
1. Solar Systems

i. Flat Plate Collectors

1. Solar Systems

ii. Evacuated Tube Collectors

Details of Evacuated Tube

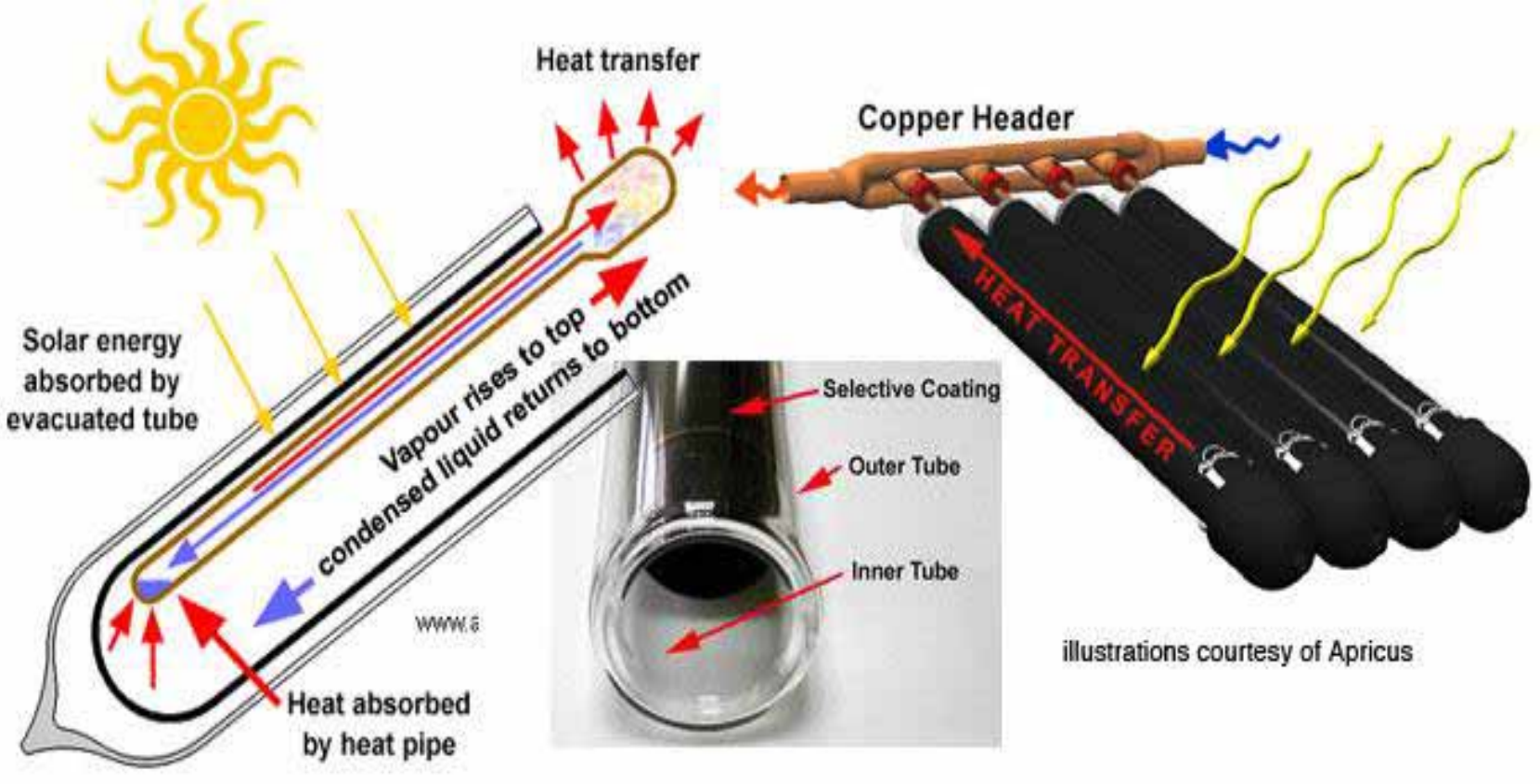


1. Solar Systems

ETC – HP Systems

1. Solar Systems

Evacuated Tube – Heat Pipe



TYPES OF SOLAR SYSTEMS

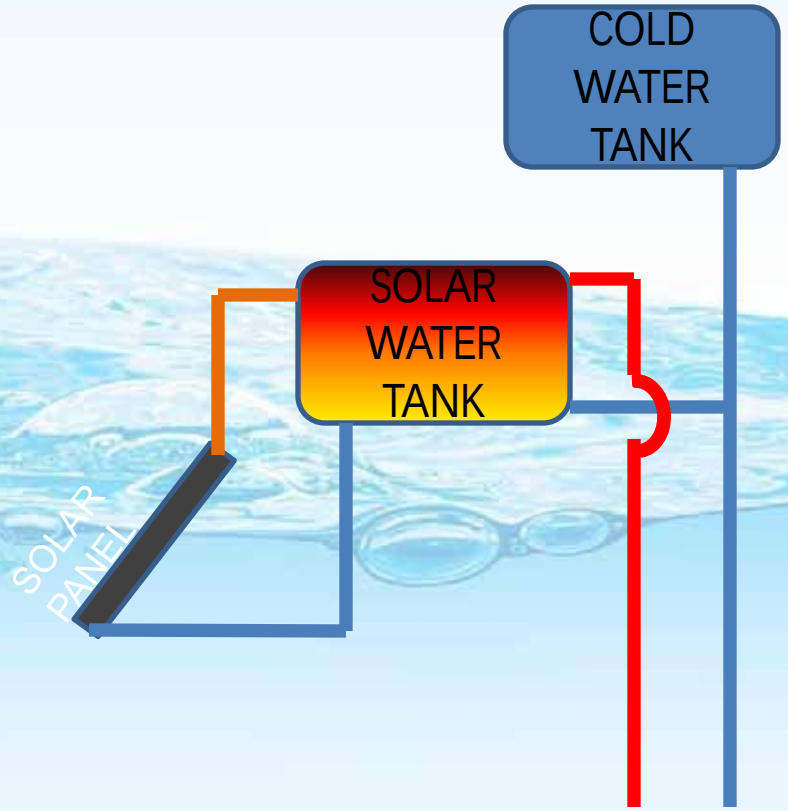
1) Thermosyphon System

- 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

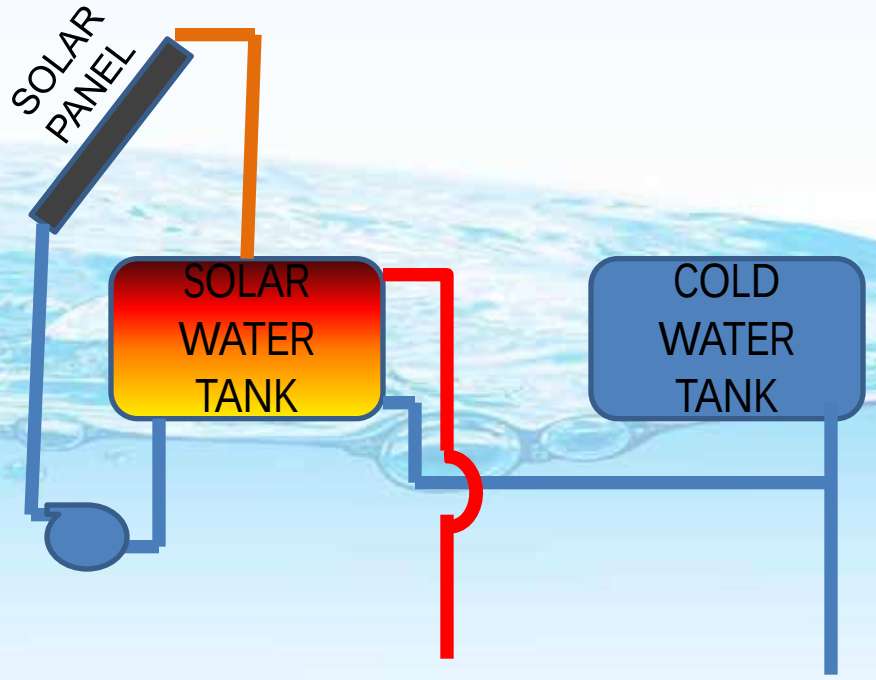


. Hot water being lighter than cold water, rises to the top of the collector and into the hot water tank.

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

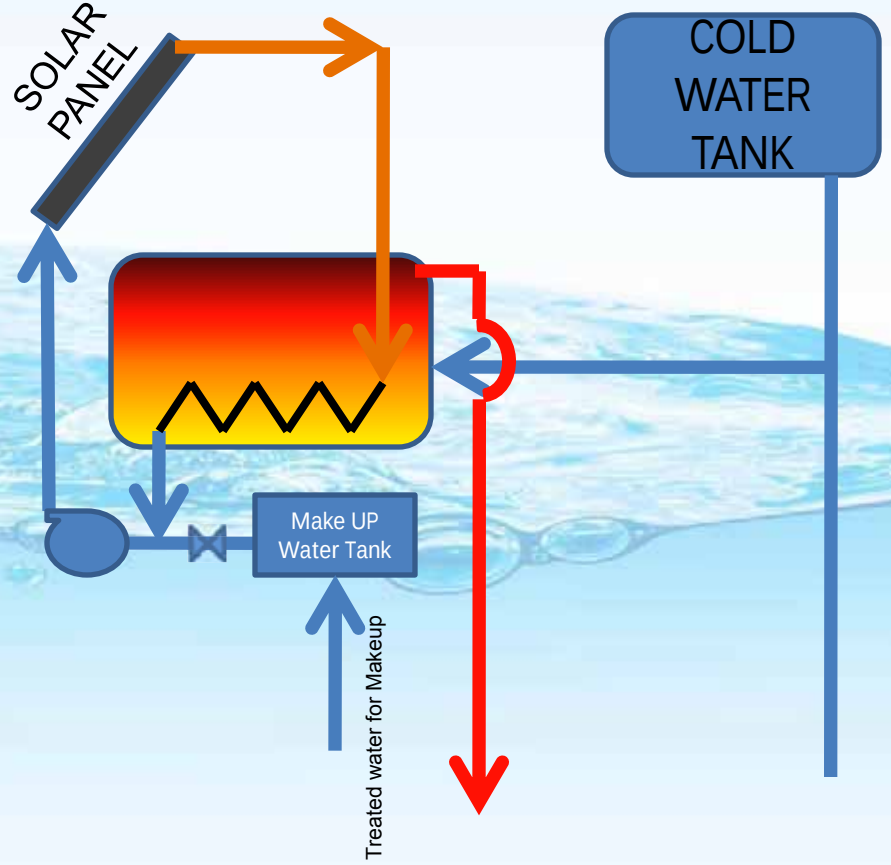


Cold water from the cold water tank is forced into the battery of collectors.

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?

System Capacity	Space Required
125 lpd	3 m^2
500 lpd	12 m^2
1000 lpd	24 m^2
2000 lpd	48 m^2
3000 lpd	72 m^2

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

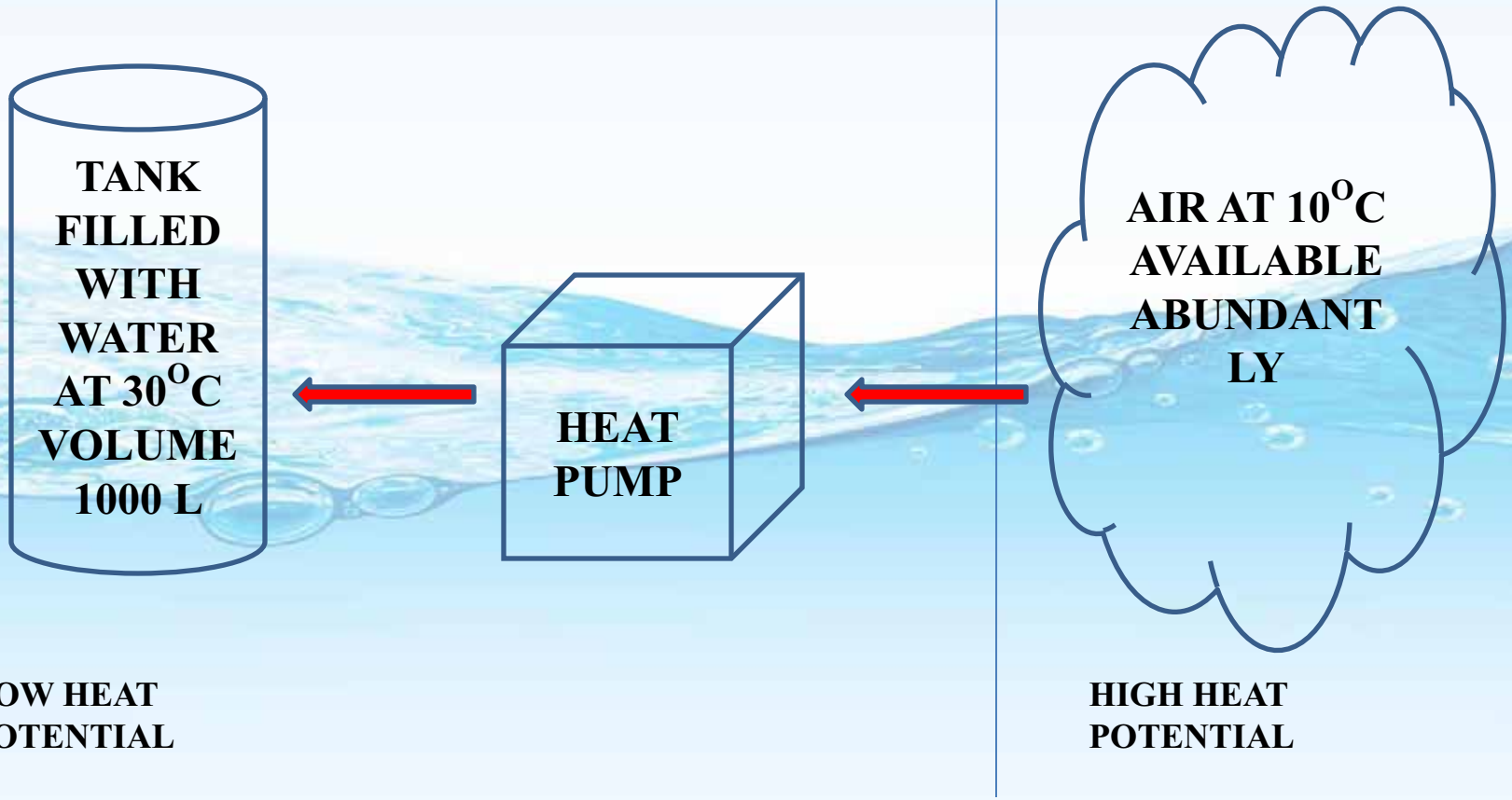
a) Diesel / Gas Boilers :

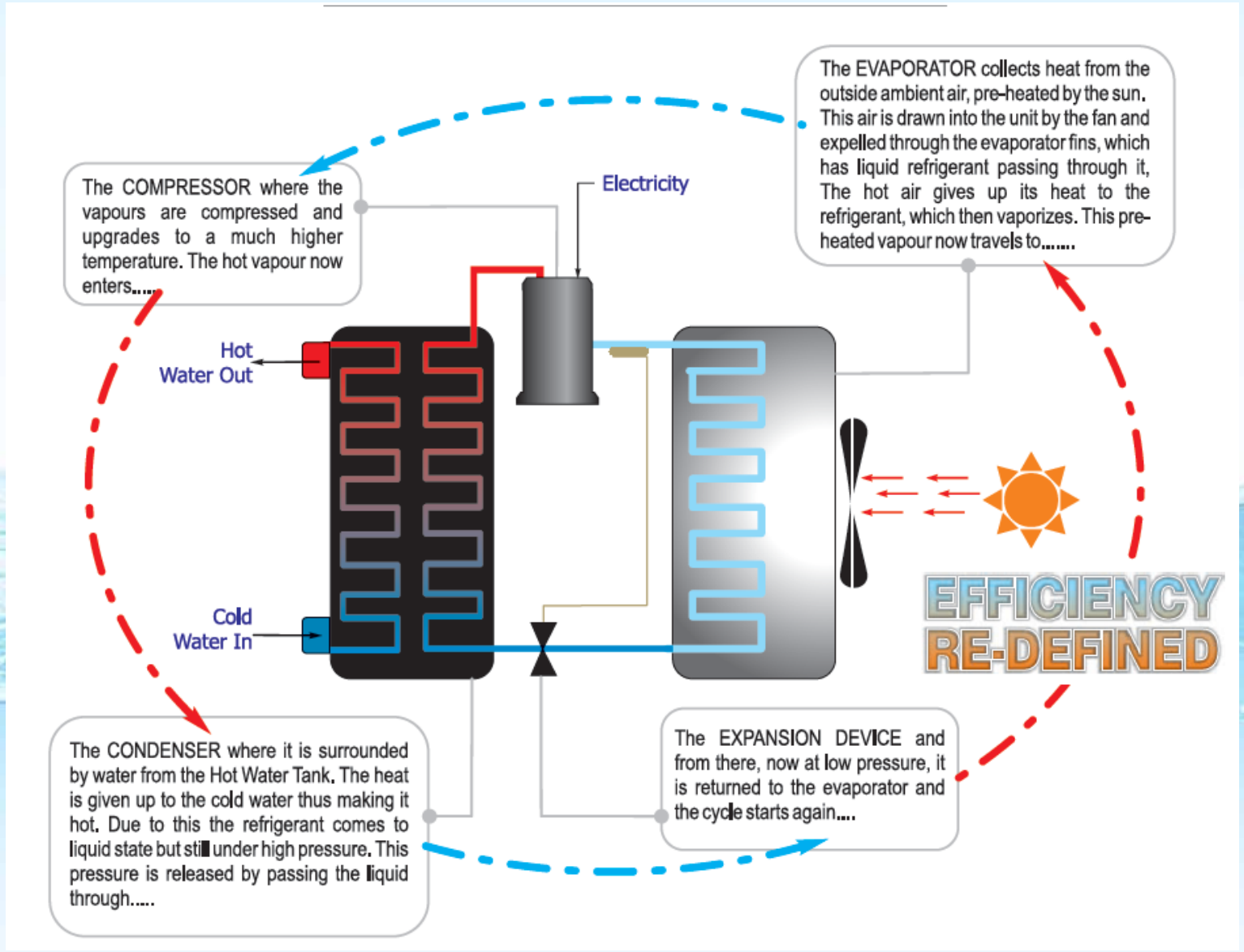
- Coil Type Boilers
- Shell Type Boilers
- Cast Iron Boilers

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)




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.....
The COMPRESSOR where the vapours are compressed and upgrades to a much higher temperature. The hot vapour now enters.....
Electricity
Hot Water Out
Cold Water In
EFFICIENCY RE-DEFINED
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.....
The EXPANSION DEVICE and from there, now at low pressure, it is returned to the evaporator and the cycle starts again.....

STATE: GAS
TEMP: 90^{O}C
PRESS: 28 bar

Compressor

Hot Water Out

STATE: GAS
TEMP: 12-18^{O}C
PRESS: 6 bar

Condenser

Evaporator with Fan

Cold Water In

STATE: LIQUID
TEMP: 60^{O}C
PRESS28 bar

Expansion Valve

STATE: LIQUID
TEMP: 5-8^{O}C
PRESS: 6 bar

INDIAN PLUMBING PROFESSIONALS LEAGUE

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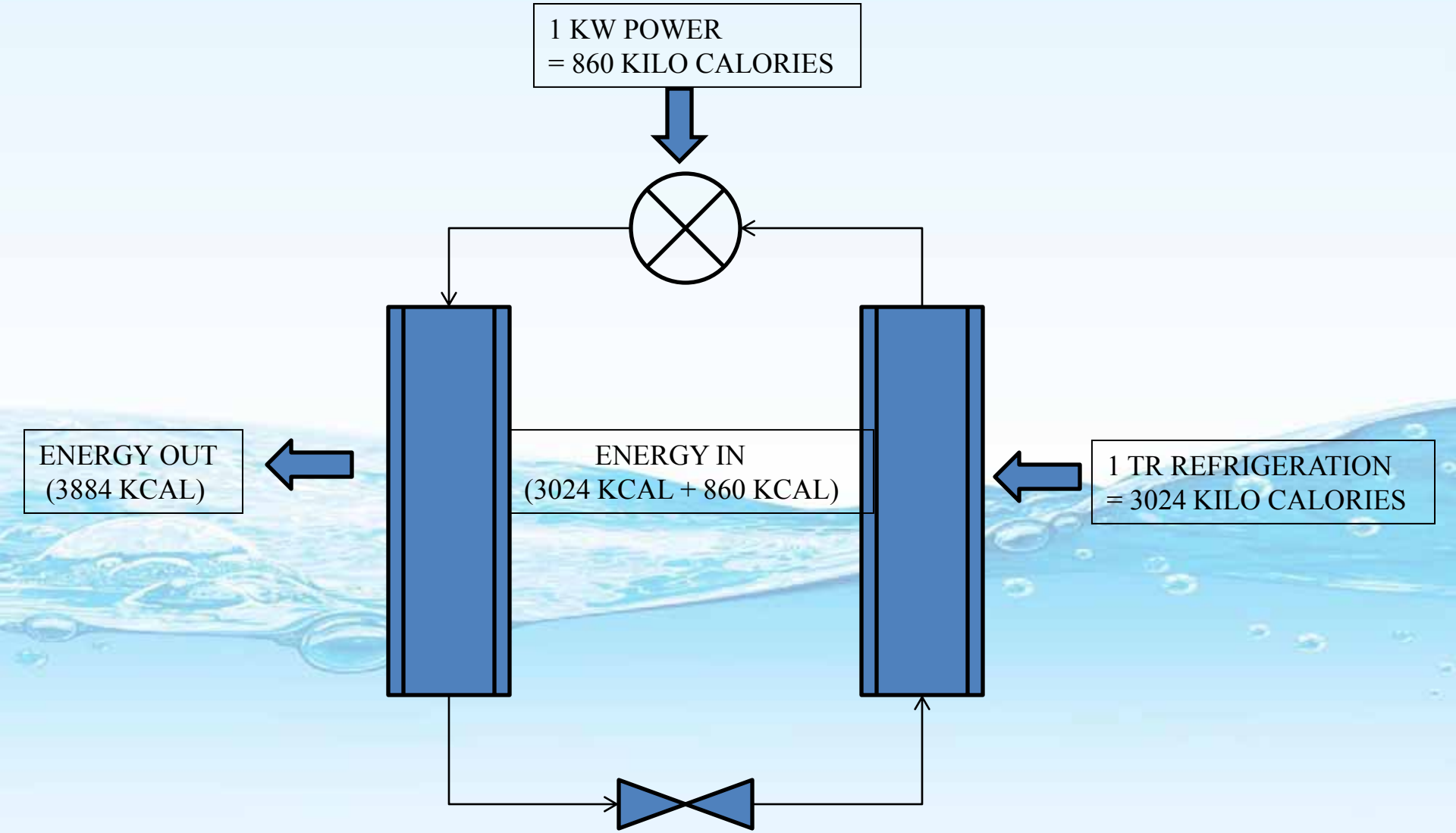
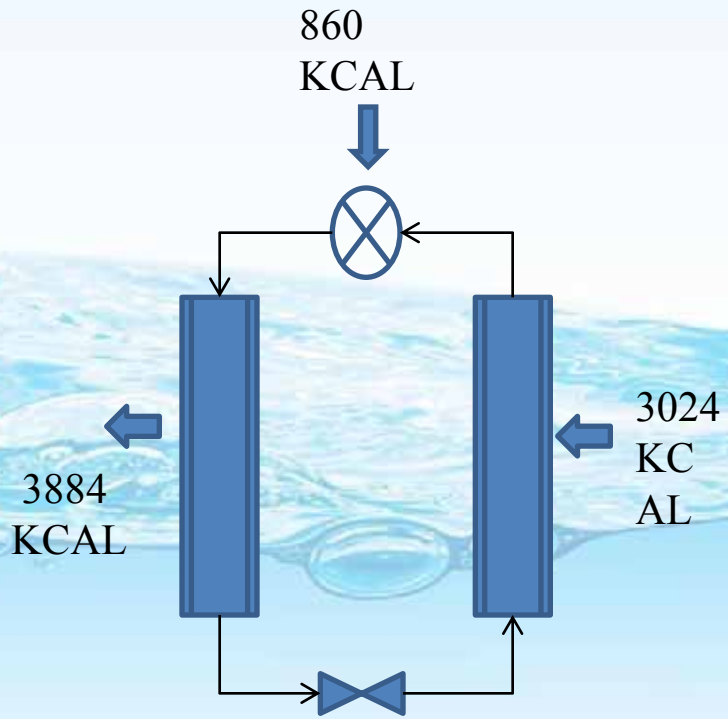

1 KW POWER
= 860 KILO CALORIES
ENERGY OUT
(3884 KCAL)
ENERGY IN
(3024 KCAL + 860 KCAL)
1 TR REFRIGERATION
= 3024 KILO CALORIES

What is COP and Why is it 4??



COEFFICIENT OF PERFORMANCE

RATIO OF ENERGY OUTPUT TO WORK DONE

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

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

$$COP = 4.51$$

Practically COP is in the range 3.6 – 4.0

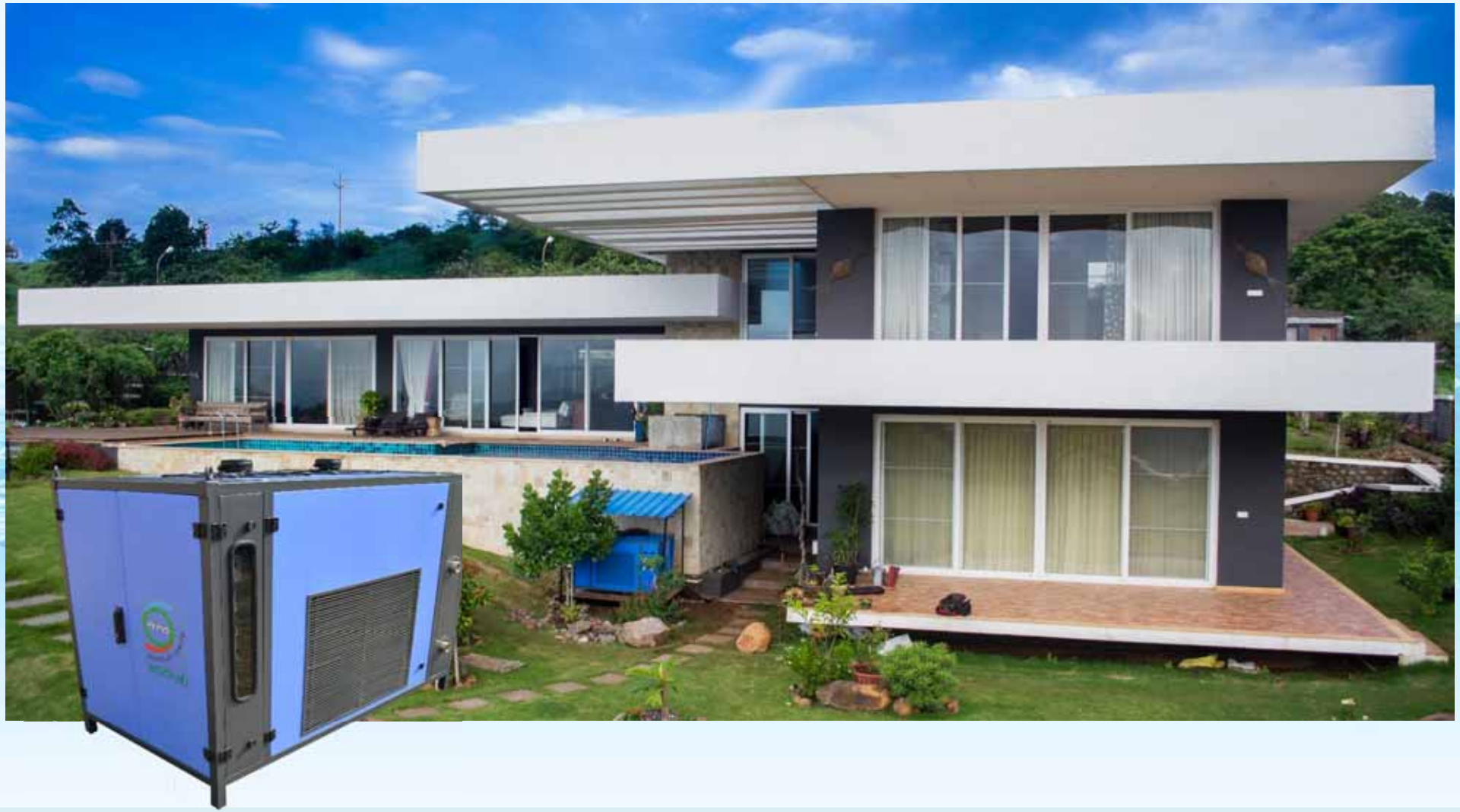
Heat Pump Testing Setup

Heat Pump Installation

Heat Pump Internal View

Solar & Heat Pump Hybrid System Installation

Swimming Pool Heating :



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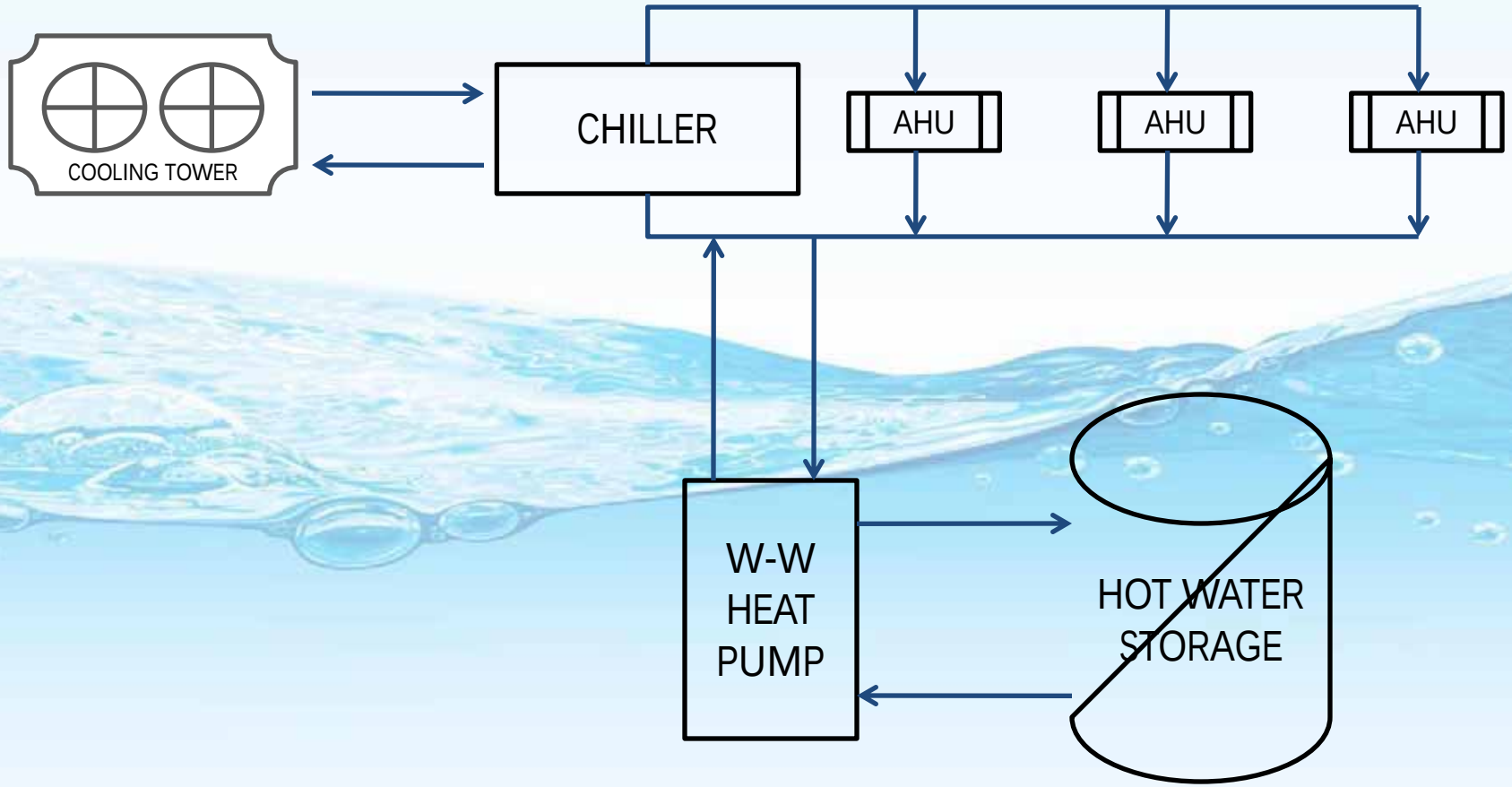
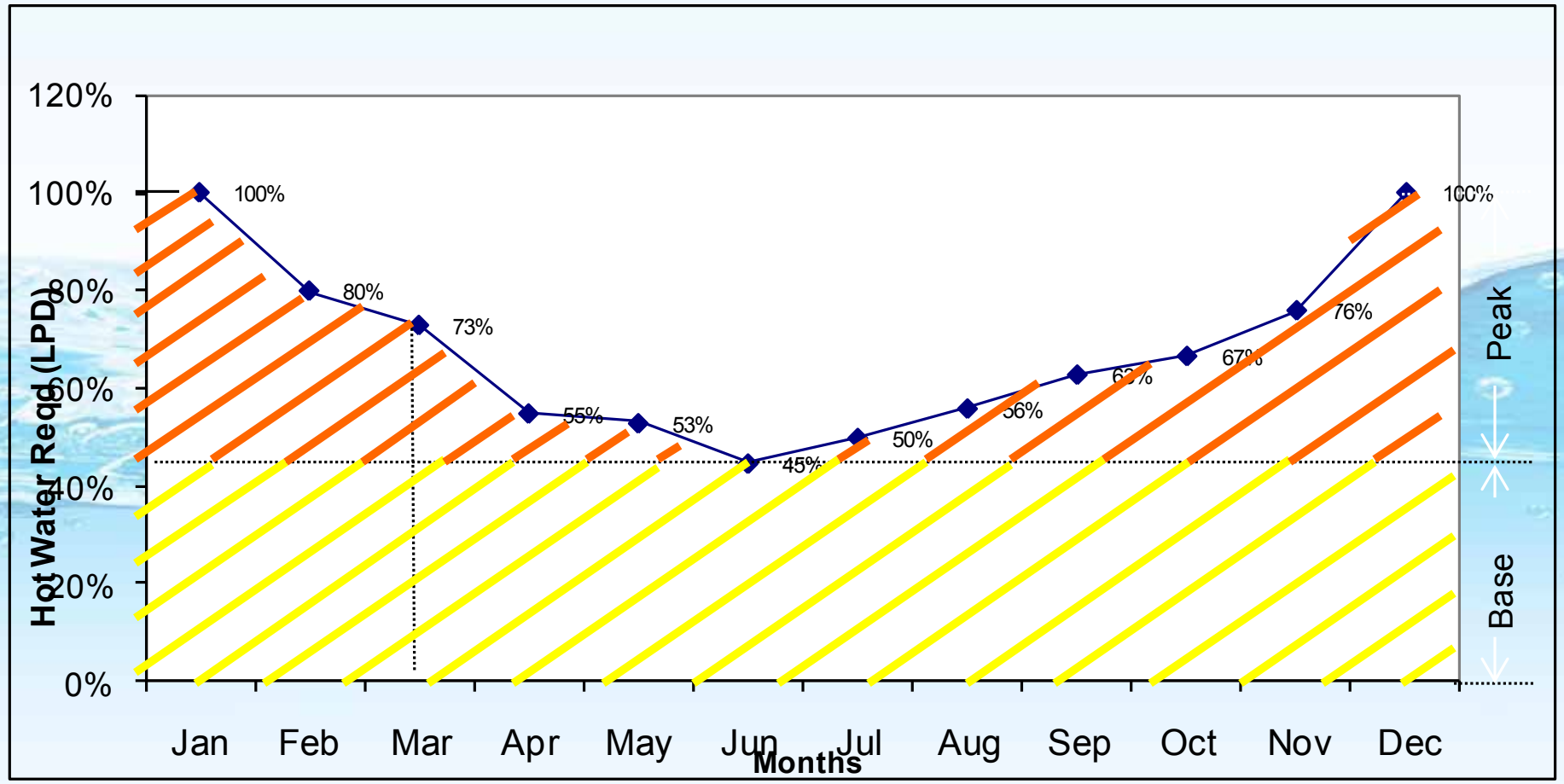
WATER TO WATER HEAT PUMP



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^{O}C to 7^{O}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:

Type of Bath	HW Req.
Bucket Bath	15 – 25 Liters/Person
Shower Bath	40 – 50 Liters/Person
Tub Bath	100 –120 Liters/Person
Shower Panels	100 –120 Liters/Person
Rain Showers	150 – 170 Liters/Person

NOTE: Above figures are for consumption at 38^{O}C - 40^{O}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

	QUANTITY OF WATER	USE OF WATER	TEMP OF WATER TO MIXED	QUANTITY OF COLD WATER TO BE ADDED TO GET 42 CET.
TEMP	100	1	30	0.6
60	100	1	30	0.59
59.7	100	1	30	0.58
59.4	100	1	30	0.57
59.1	100	1	30	0.56
58.8	100	1	30	0.55
58.5	100	1	30	0.54
58.2	100	1	30	0.53
57.9	100	1	30	0.52
57.6	100	1	30	0.51
57.3	100	1	30	0.5
57	100	1	30	0.49
54	100	1	30	0.39
53.7	100	1	30	0.38
47.1	100	1	30	0.16
46.8	100	1	30	0.15
45	100	1	30	0.09
44.7	100	1	30	0.08
42.9	100	1	30	0.02
42.6	100	1	30	0.01
42.3	100	1	30	0
42		61		18.3

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.

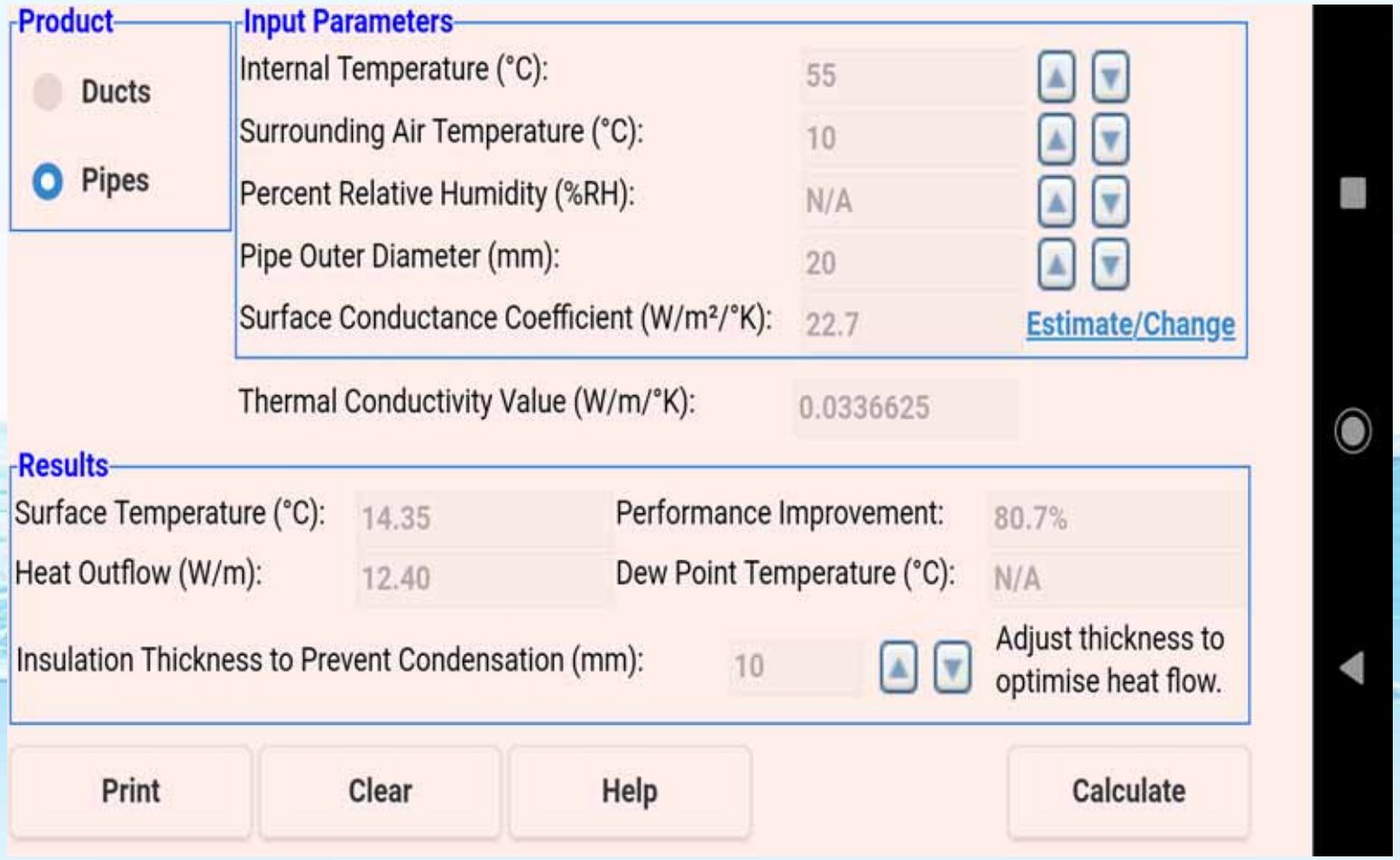
OR IN OTHER WORDS WE GET 80% OF TANK CAPACITY

HOT WATER AT 42 DEG. C IN ACTUAL

Effect of Insulation

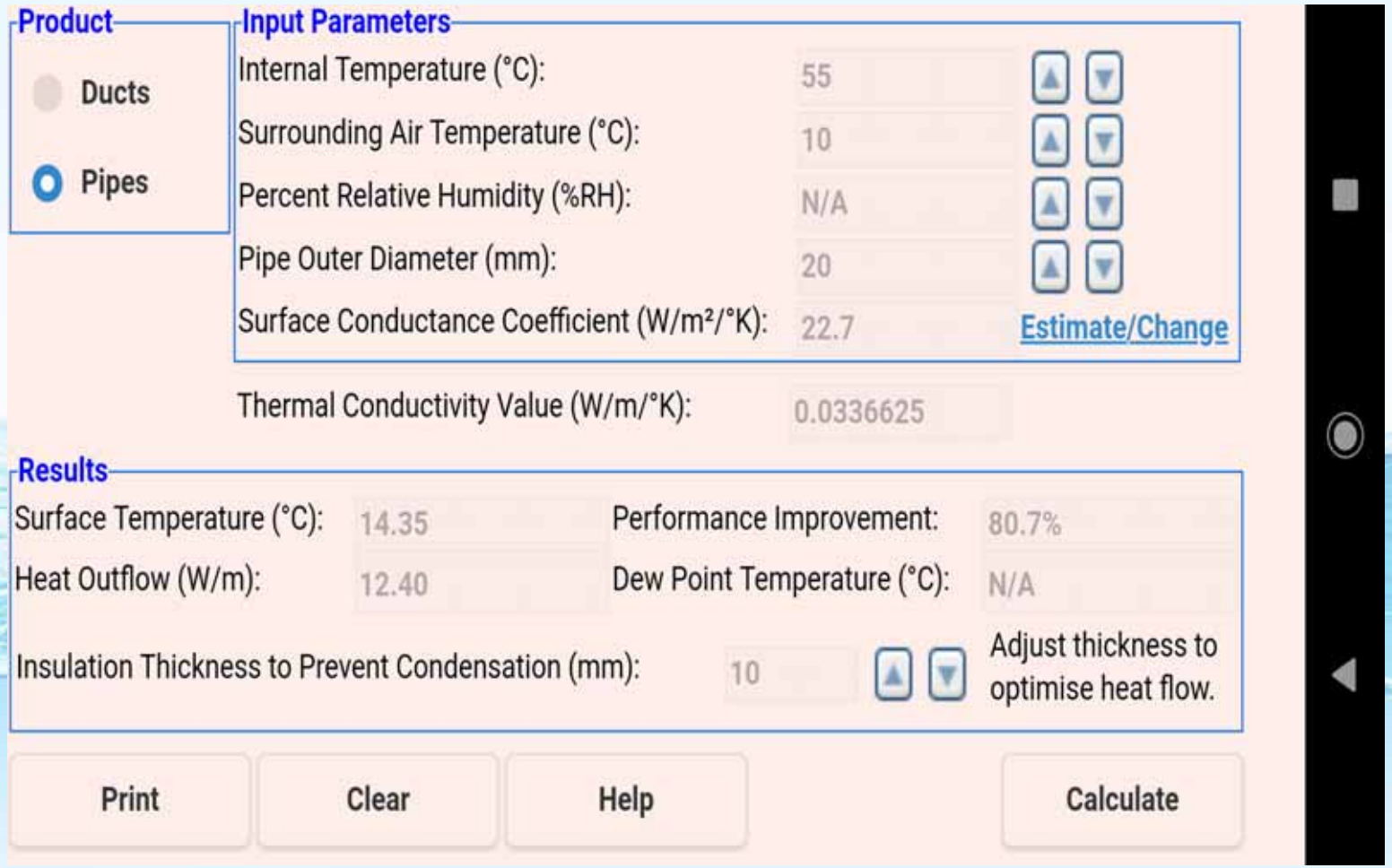
Un insulated Line

Effect of Insulation



Insulated Line – 10 mm

Effect of Insulation



Insulated Line – 19 mm

Effect of Insulation

Insulation thickness (mm)	Heat Loss (w/m)	Performance improvement in Stopping the heat loss (%)
0 mm	64.18	0%
10 mm	12.4	80.7%
13 mm	10.61	83.5%
16 mm	9.40	85.4%
19 mm	8.53	86.7%

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 Cp Delta T

= 10000 X 1 X (55-25) Deg C

= 3,00,000 Kcal

Running Costs

Electrical Heating

= 3,00,000 /(860*0.8)

= 436 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 :

1. High Requirement of Power & Availability of same.

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

HEATER TYPE	BOILER	BOILER	BOILER	BOILER	SOLAR	HEAT PUMPS
ENERGY SOURCE	WOOD	DIESEL	GAS	ELECTRICITY	SOLAR + ELECTRICITY	AIR + ELECTRICITY
POLLUTION	VERY HIGH	HIGH	HIGH	NONE	NONE	NONE
LIFE SPAN	8 YEARS	10 YEARS	10 YEARS	5 YEARS	5 YEARS	20 YEARS
FLAMMABILITY	HIGH	VERY HIGH	VERY HIGH	NONE	NONE	NONE
SAFETY	HAZARDOUS	HAZARDOUS	HAZARDOUS	SAFE	SAFE	VERY SAFE
SPACE REQD	LARGE	LARGE	LARGE	SMALL	VERY HIGH	SMALL
OPERATING COST	MODERATE	HIGH	HIGH	VERY HIGH	VERY LOW	VERY LOW
INITIAL INVESTMENT	MODERATE	HIGH	HIGH	MODERATE	VERY HIGH	MODERATE
ROI	NIL	NIL	NIL	NIL	4-5 YEARS	1 YEAR

HOT WATER SYSTEMS

Formula's for Hot Water System

- Q = m * Cp * Delta T
- 1 kW = 860 Kcal
- 1 TR = 3024 Kcal

Thank you

Any Questions?

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