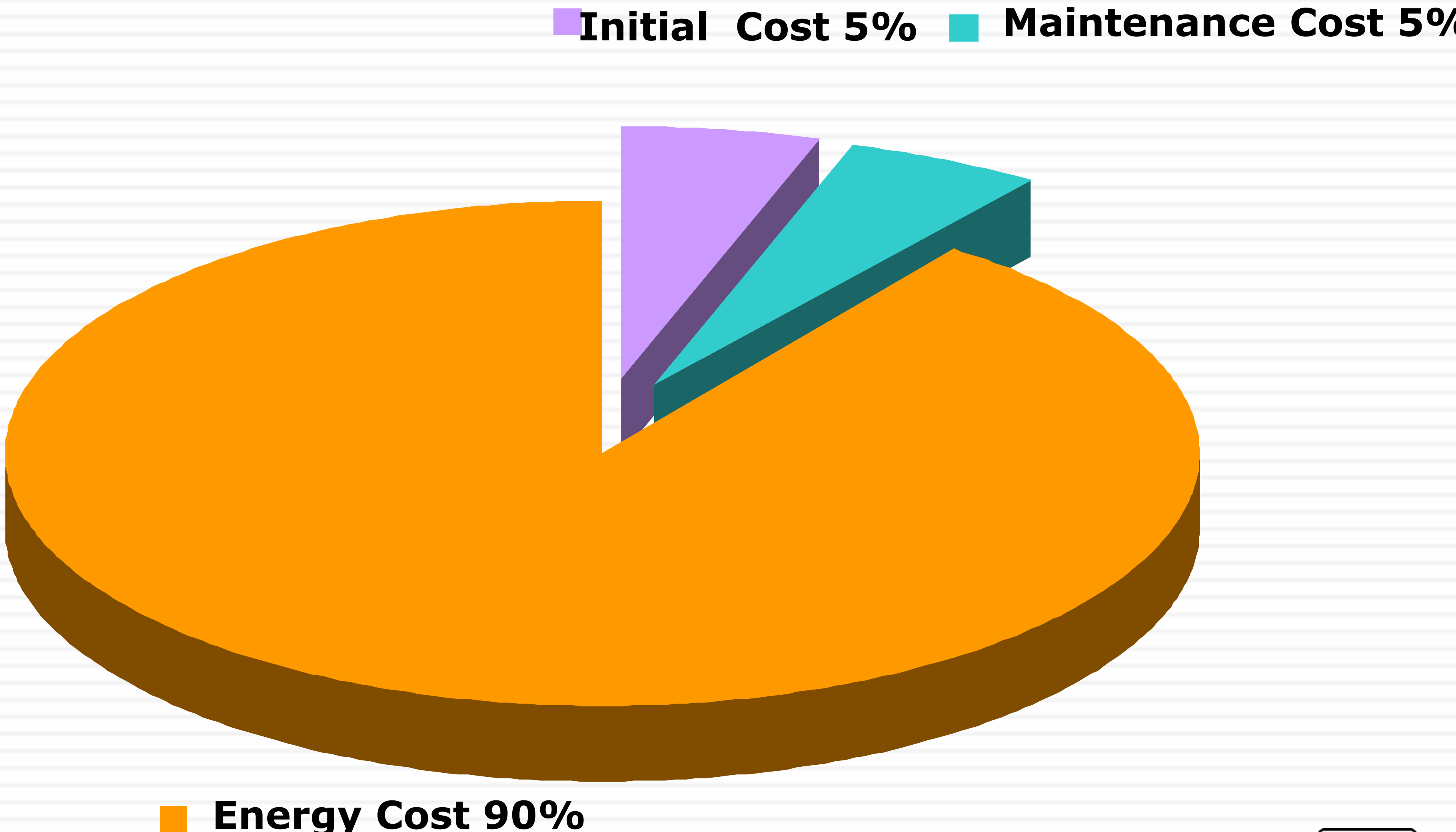
UTILITY SYSTEM – COMPRESSORS AND PUMPS

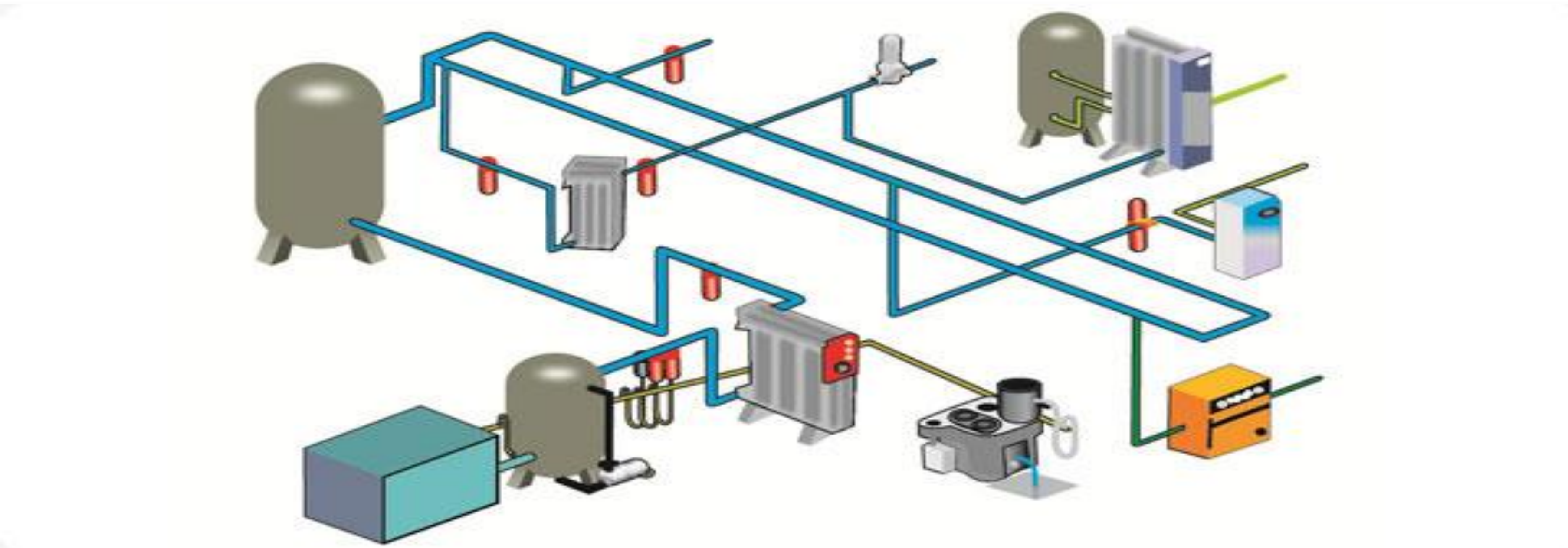
ENERGY IS LIFE BEE CONSERVE IT

Confederation of Indian Industry

Life Cycle Cost



COMPRESSED AIR SYSTEM



gef

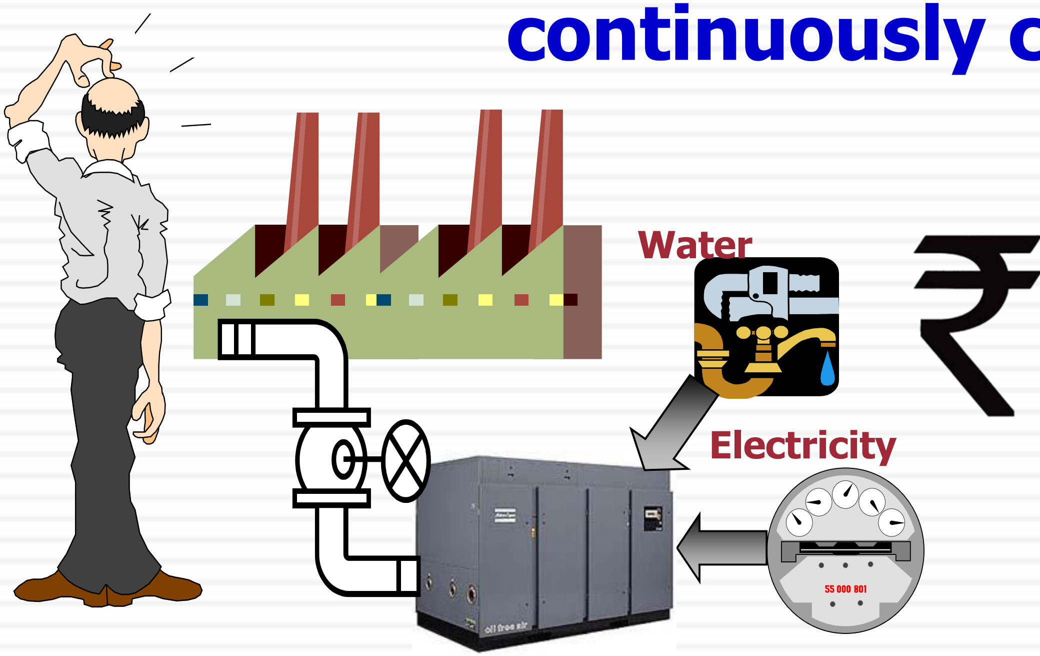
ENERGY IS LIFE
BEE
CONSERVE IT

UNIDO

CII
Confederation of Indian Industry

Energy Cost of Running Air Compressor

90 kW Compressor running continuously consumes ~ 600,000 kWh annually

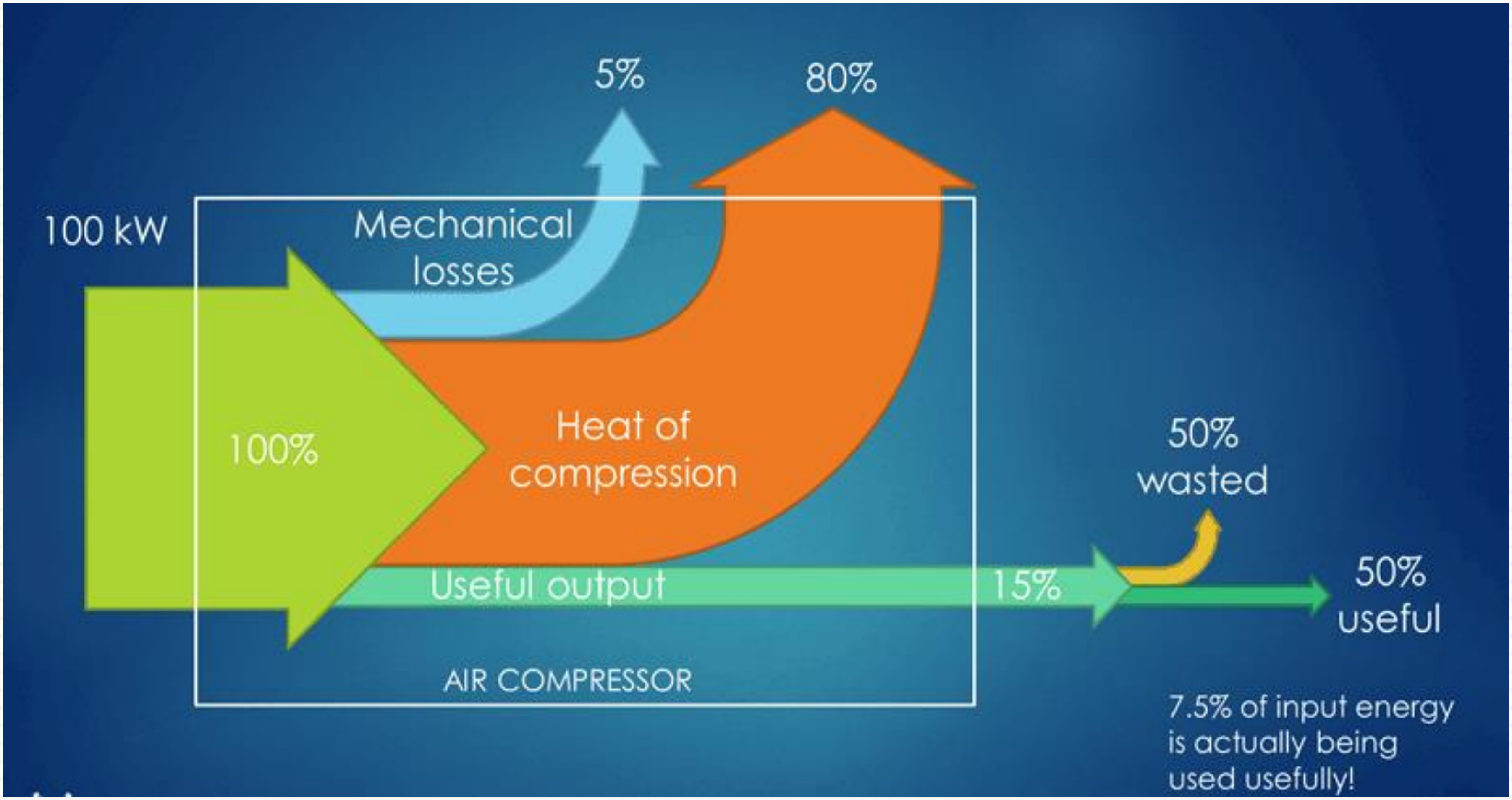


@ rate of Rs. 6/kWh,

Costs Rs. 36 Lacs/year

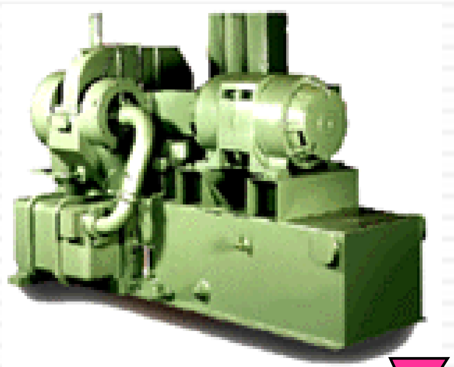
Which is 4 times the cost of Compressor itself !!

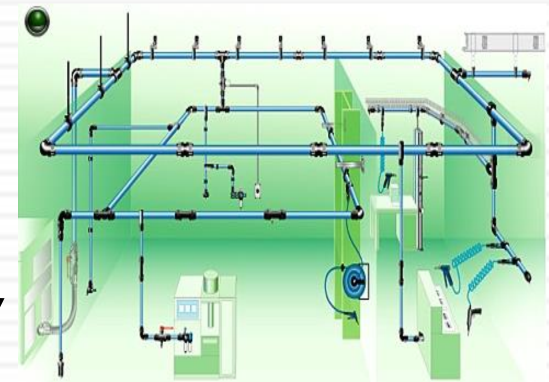
Sankey Diagram of Compressed Air System



CII

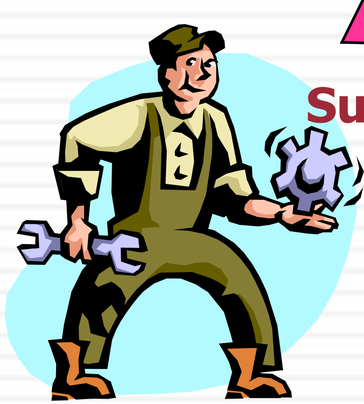
Compressed Air: Most Expensive Form of Energy!





Compressor η & Installation

Compressed Air System
Installation
Comp Acc + Piping + Design

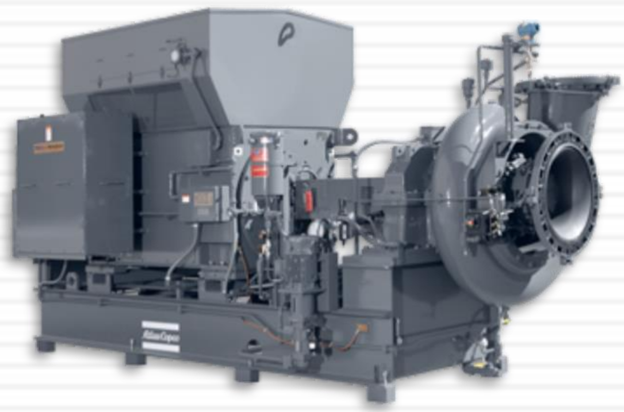


Sustenance

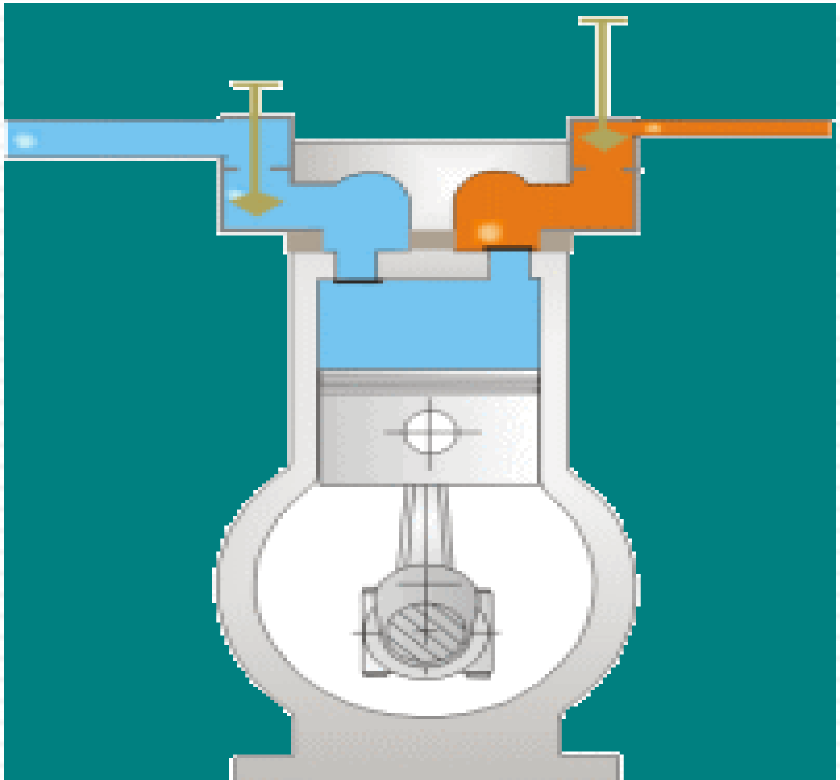
Efficiency in Air Utilisation

Air Compressors

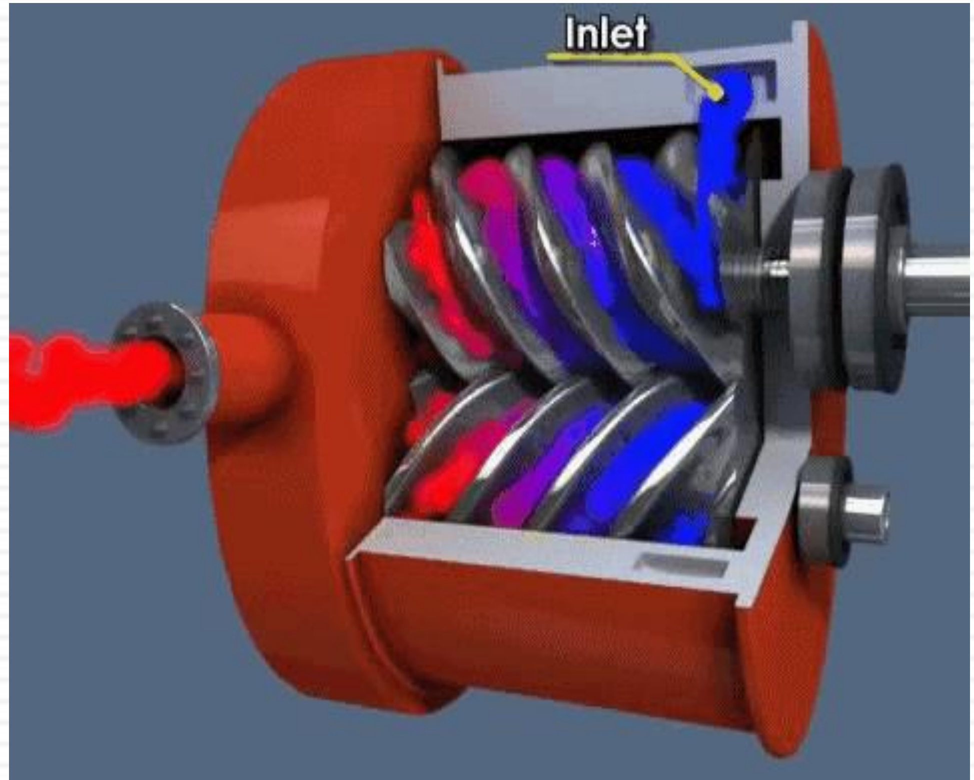
- Compressors
  - Positive Displacement
    - Reciprocating Type
    - Rotary Screw Type
  - Centrifugal Type
    - Radial Flow
    - Axial Flow



Reciprocating and Screw Compressor

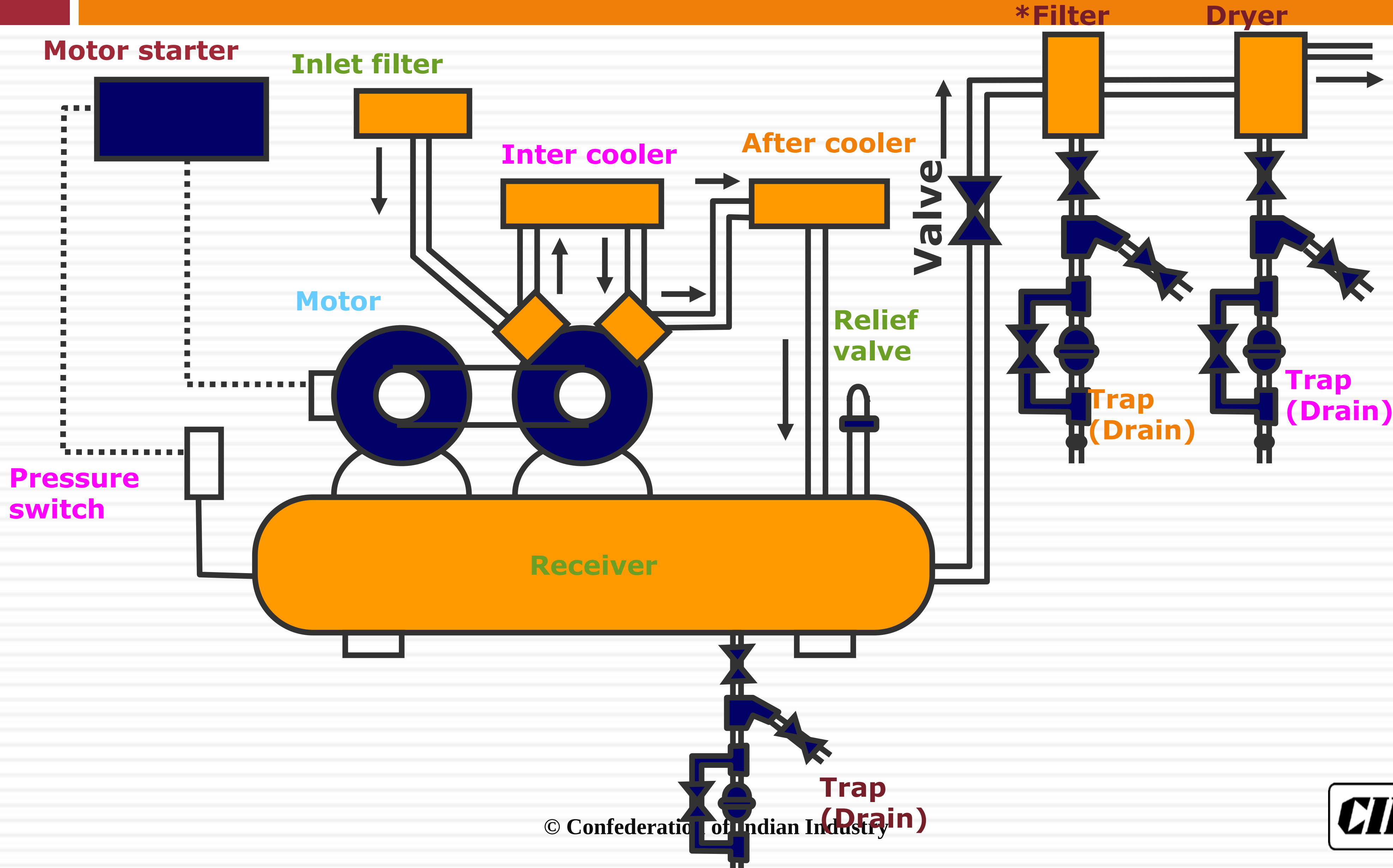


Reciprocating Compressor



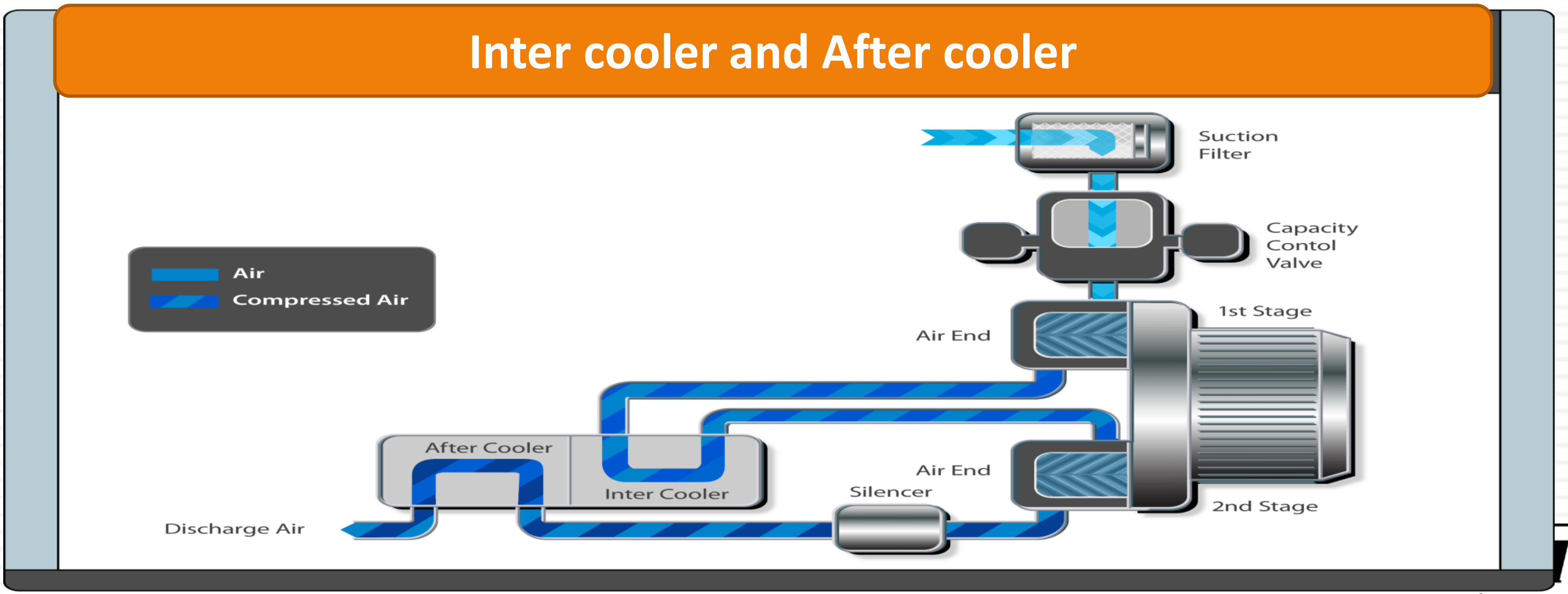
Rotary Screw Compressor

Two Stage Reciprocating Compressor

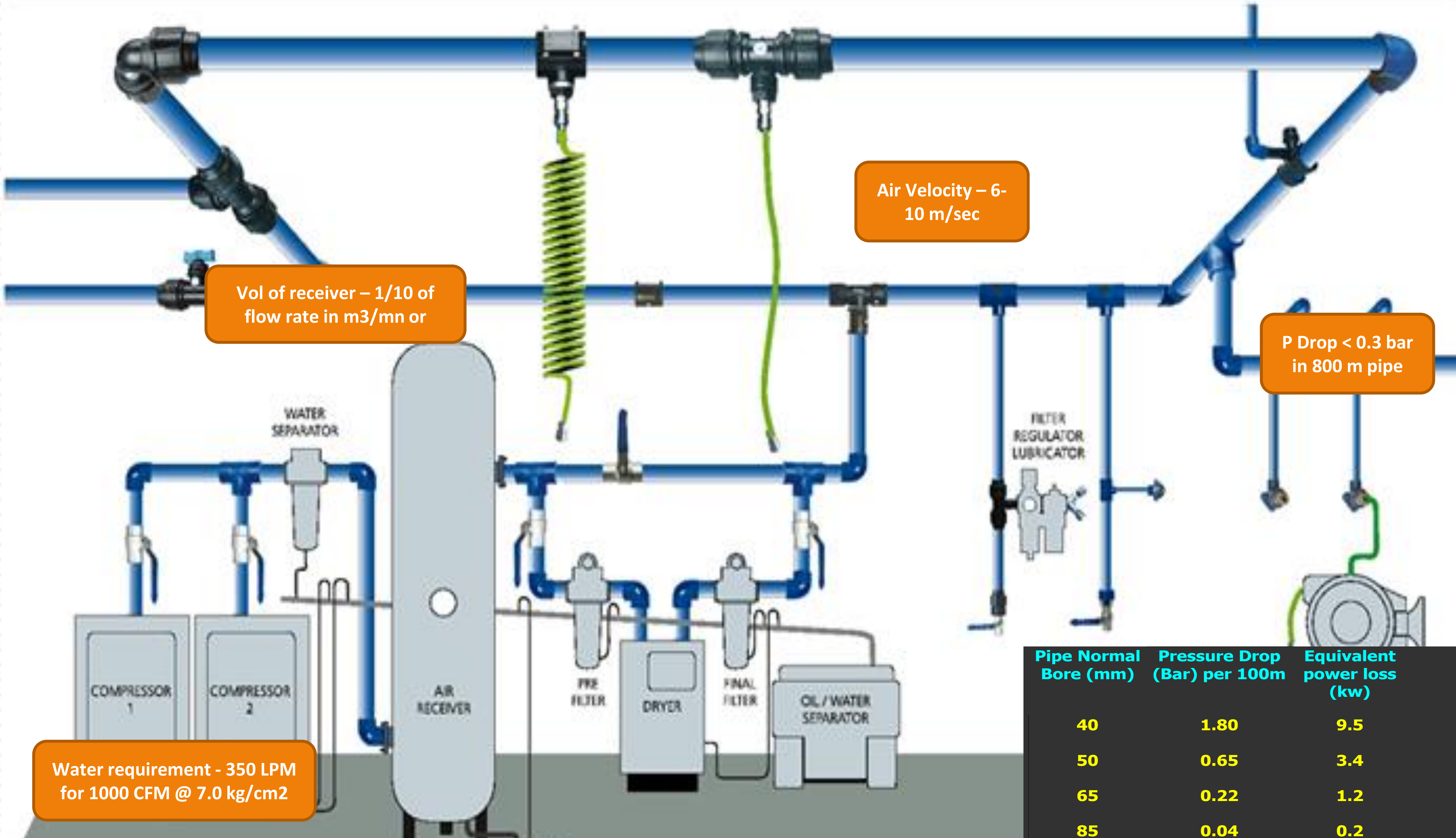


Inter-cooler & After cooler

- **Inter cooling reduces temperature & volume**
- **After cooler reduces the moisture**



Recommended Installation



Air Velocity – 6-10 m/sec

Vol of receiver – 1/10 of flow rate in m3/mn or

P Drop < 0.3 bar in 800 m pipe

Water requirement - 350 LPM for 1000 CFM @ 7.0 kg/cm2

Pipe Normal Bore (mm)	Pressure Drop (Bar) per 100m	Equivalent power loss (kw)
40	1.80	9.5
50	0.65	3.4
65	0.22	1.2
85	0.04	0.2

Capacity Test (Pumping Method)

$$\text{Average Compressor Delivery} = \frac{P_2 - P_1}{P} \cdot V_R \cdot \frac{1}{\Delta t}$$

P_1	=	Initial pressure in receiver
P_2	=	Final pressure in receiver
P	=	Atmospheric pressure
V_R	=	Volume of air receiver
Δt	=	Time taken for charging the receiver from P_1 to P_2

Check list for efficient operation of Compressor

Dry Air Intake

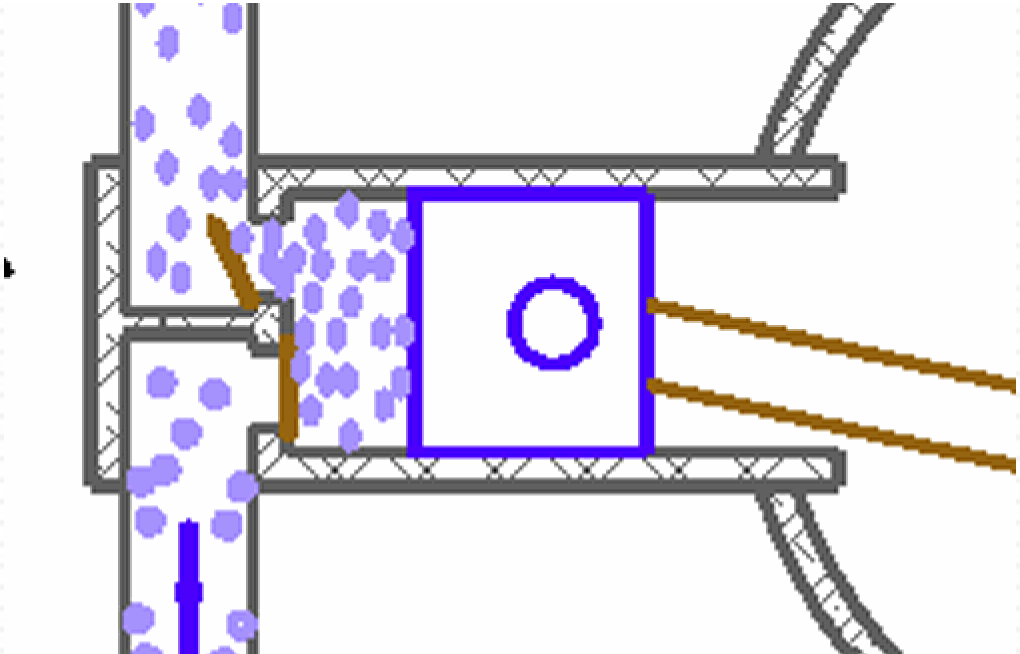
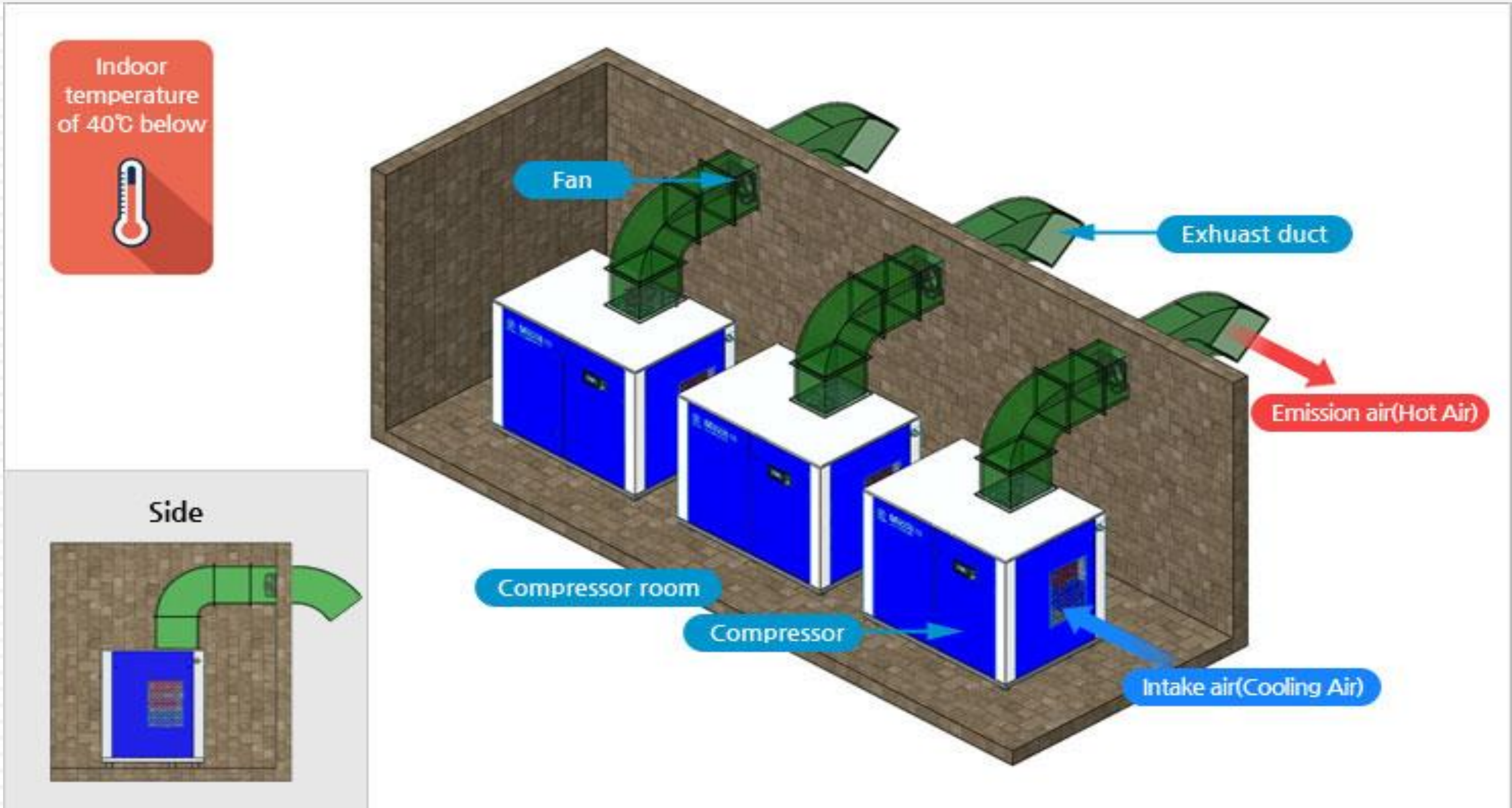


TABLE 3.2 EFFECT OF INTAKE AIR TEMPERATURE ON POWER CONSUMPTION		
Inlet Temperature (°C)	Relative Air Delivery (%)	Power Saved (%)
10.0	102.0	+ 1.4
15.5	100.0	Nil
21.1	98.1	– 1.3
26.6	96.3	– 2.5
32.2	94.1	– 4.0
37.7	92.8	– 5.0
43.3	91.2	– 5.8

Every 4°C rise in inlet air temperature results in a higher energy consumption by 1 % to achieve equivalent output

CII

Compressor Room



Pressure settings

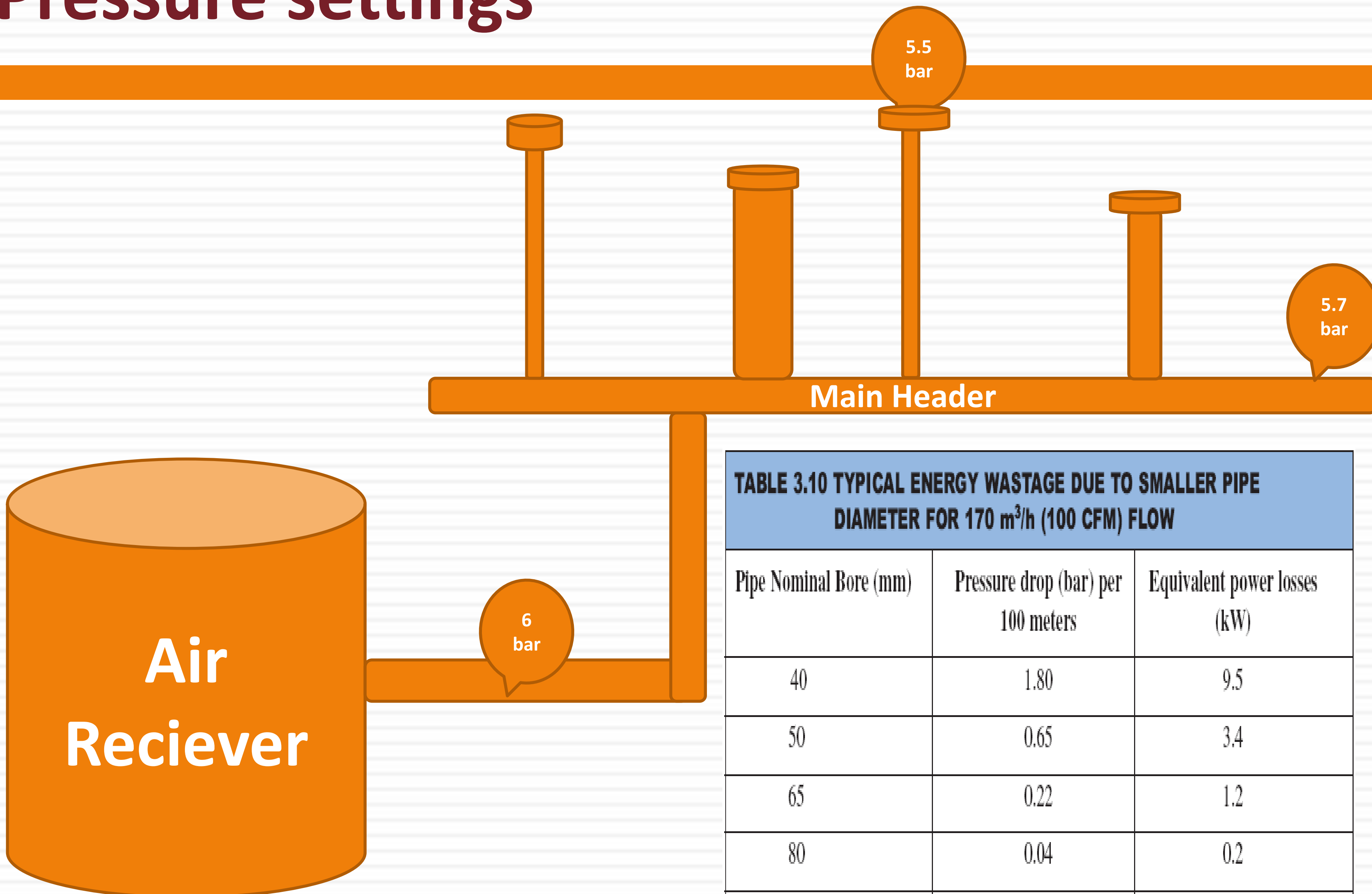


TABLE 3.10 TYPICAL ENERGY WASTAGE DUE TO SMALLER PIPE DIAMETER FOR 170 m^3/h (100 CFM) FLOW		
Pipe Nominal Bore (mm)	Pressure drop (bar) per 100 meters	Equivalent power losses (kW)
40	1.80	9.5
50	0.65	3.4
65	0.22	1.2
80	0.04	0.2
100	0.02	0.1

Operation of compressors

- 5 compressors available
  - 660 CFM, 7.5 bar, 110 kW
- 3 compressors are required to be operated

Operation of Compressors

No
CP1
CP2
CP3
CP4
CP5

Operation of Compressors

No	kW
CP1	110
CP2	90
CP3	100
CP4	105
CP5	95

Operation of Compressors

No	kW	FAD
CP1	110	660
CP2	90	500
CP3	100	600
CP4	105	645
CP5	95	470

Operation of Compressors

No	kW	FAD	kW / CFM
CP1	110	660	0.17
CP2	90	500	0.18
CP3	100	600	0.17
CP4	105	645	0.16
CP5	95	470	0.20

Always select compressor based on SEC (kW/CFM) not on kW and CFM separately

Comparison of Specific Power Consumption

	Reciprocating	Centrifugal	Screw (Single stage)	Screw (Multi stage)
FAD	3950 CFM at 7kg/cm^2			
kW	549	515	632	510
Specific Power (kW/CFM)	0.139	0.130	0.162	0.129

CII

Replacement of Inefficient Compressor

SEC – 0.21 kW/CFM
Power Consumption – 21 kW

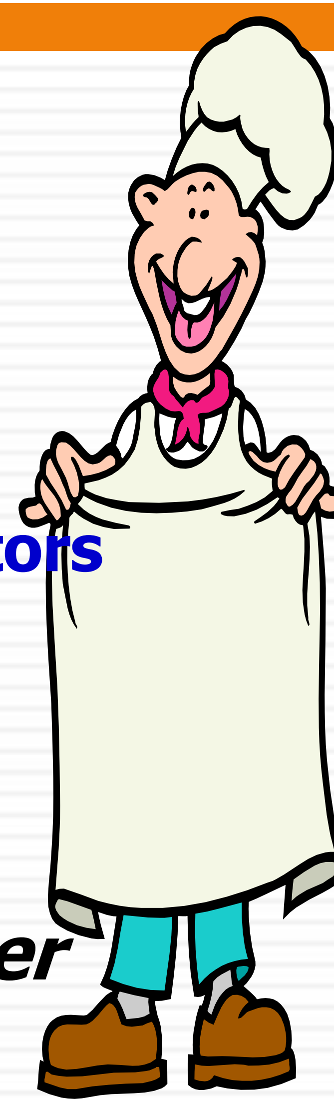
New Screw Compressor
SEC – 0.16 kW/CFM
Power Consumption – 16 kW

Power Savings 25 %

Energy Losses

System Losses waste 20%!!

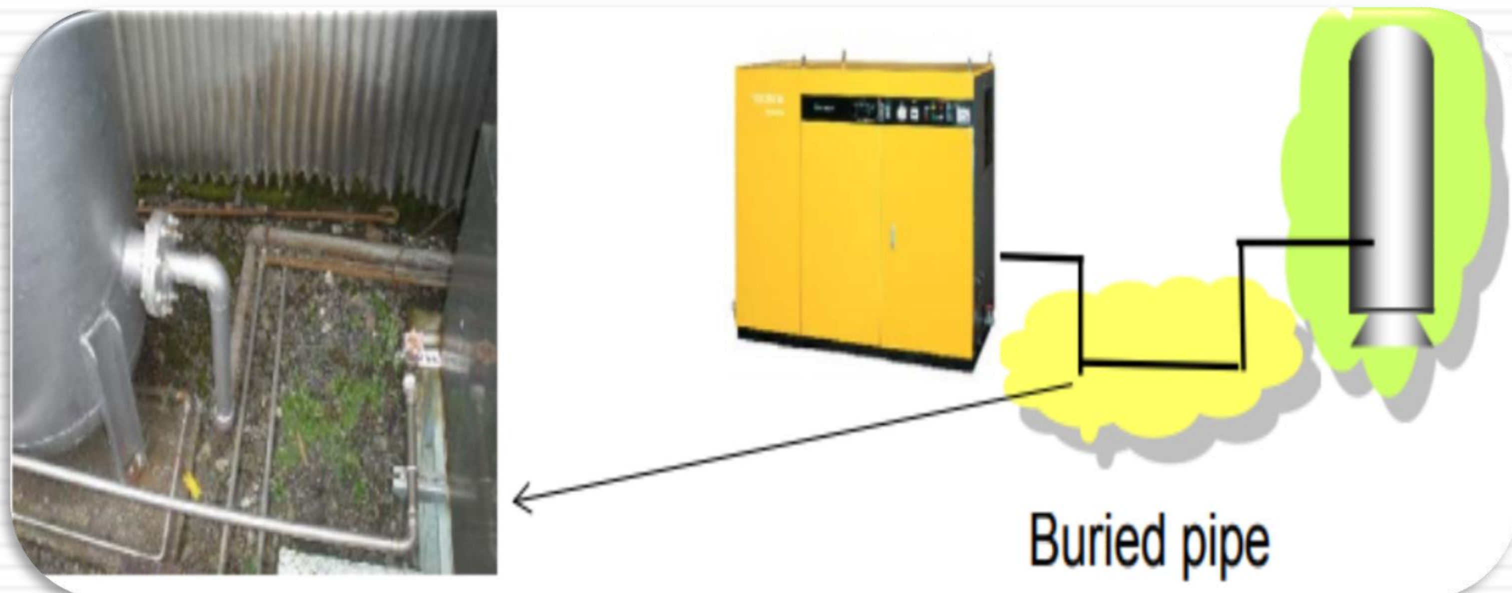
- **Pressure Loss in Pipelines, Bends & Valves**
- **Air Leakages from Corroded Pipe**
- **Pressure Loss in After Coolers, Moisture Separators**
- **Air leakages in joints & end connections**
- **Pressure Loss across Filters & Dryers**



Leading to Compressor operation at Higher Pressure to overcome these losses!

CII

Inefficient Piping Layout



Minimise Leakages

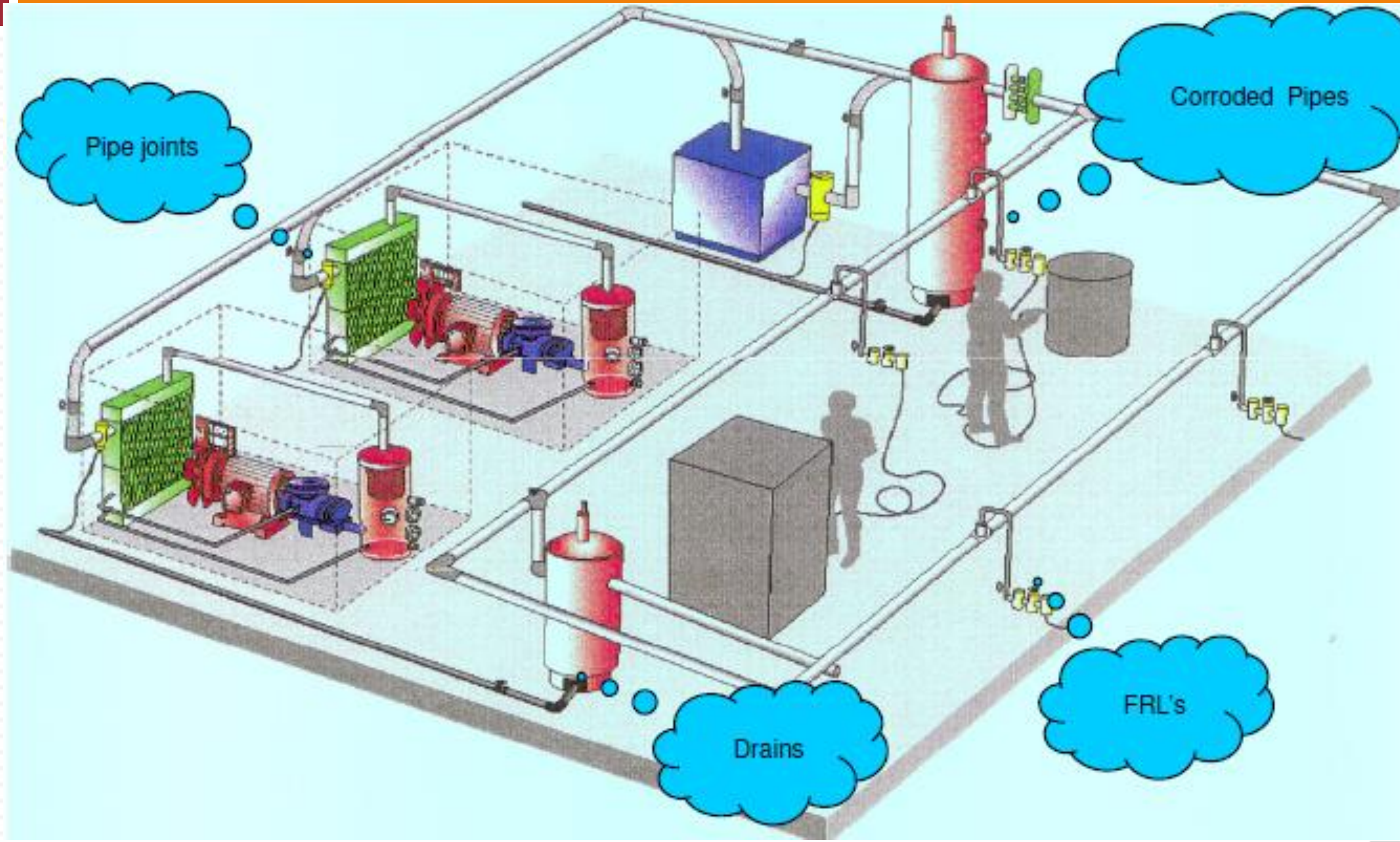
- Common in all industries
- Tricky
- Quantification

God has given abundant air, which is free!!

But … compressed air is not free!!

CII

Common Leak Locations



Common Leak Locations

Valves

Air Gun

Regulator

Hose Joint

Coupler

Hoses

Leakage Test

- Close all user points
- Charge the lines
- Note: On-load time of compressor (T)
  Off-load time of compressor (t)
- Q : Capacity of compressor

$$\text{Air leakage : L} = \left(\frac{T}{T + t}\right) \cdot Q$$

$$\%\ \text{air leakage} = \frac{\text{Air leakage}}{\text{Compressor capacity}} \times 100$$

CII

Cost Of Leakage At 7kg/cm^2

Orifice (mm)	Air Leakage (CFM)	Power Wasted (kW)	Annual Savings @ Rs 5/kWh
1.6	6.5	1.26	Rs 0.60 Lakhs
3.2	26	5.04	Rs 2.40 Lakhs
6.4	104	20.19	Rs 7.25 Lakhs

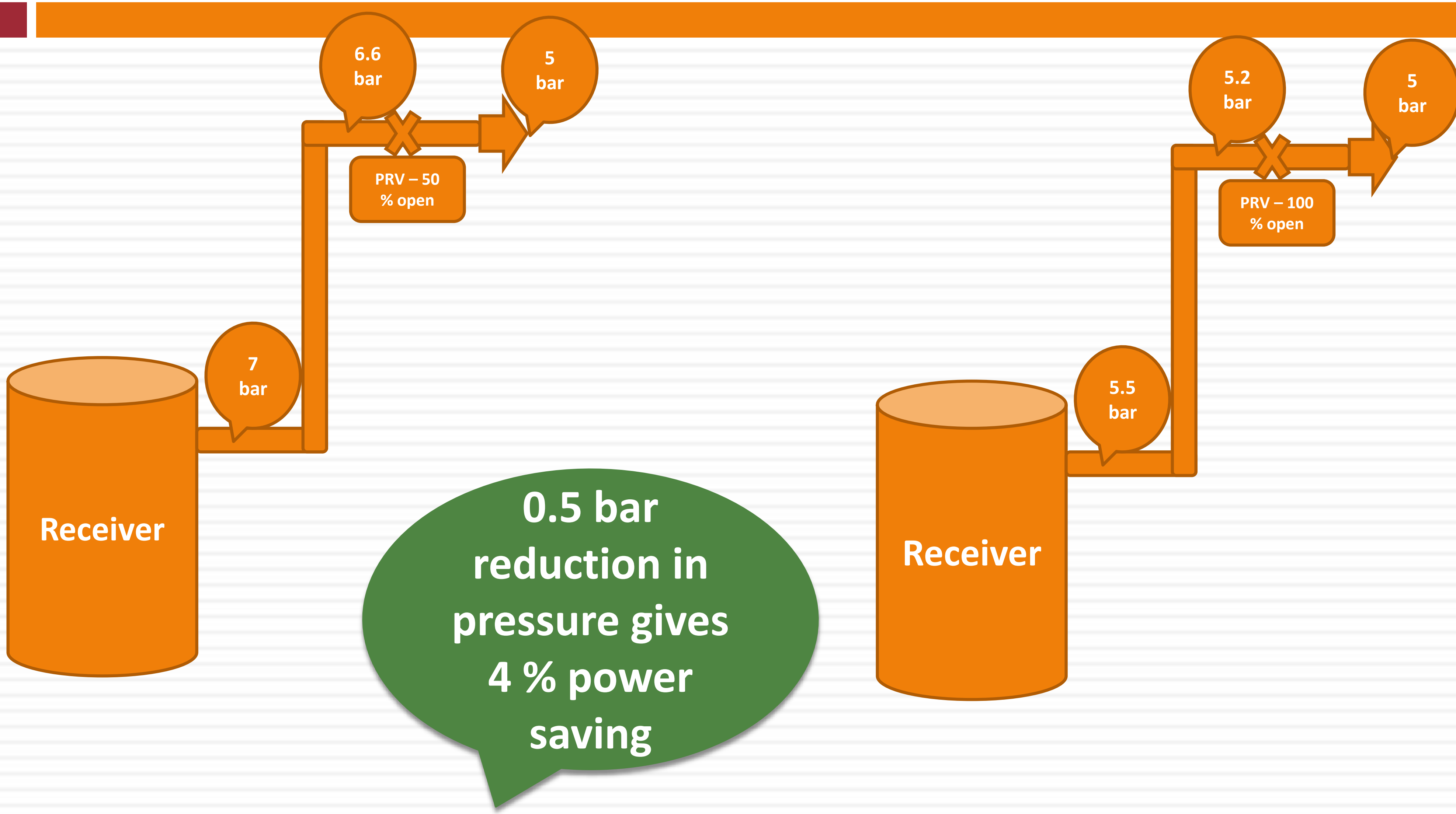
Optimal Utilisation of Compressors

37 kW Compressor
Loading – 30 % (27 kW)
Unloading – 70 % (9 kW)

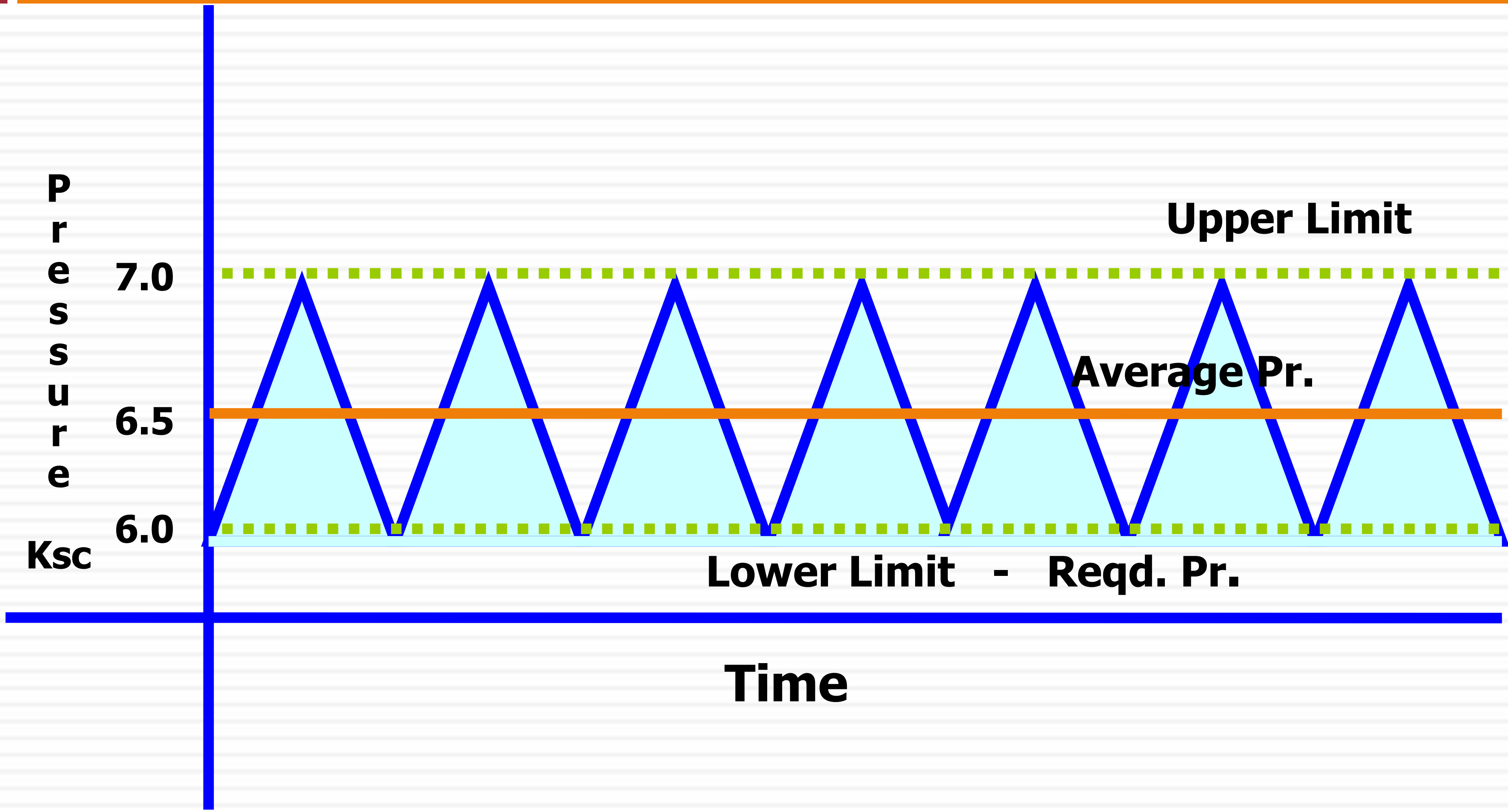
Install new 15 kW Compressor
Use existing compressor as standby

Rs 0.5 Lakhs Savings
<12 Months Payback

Pressure Reduction

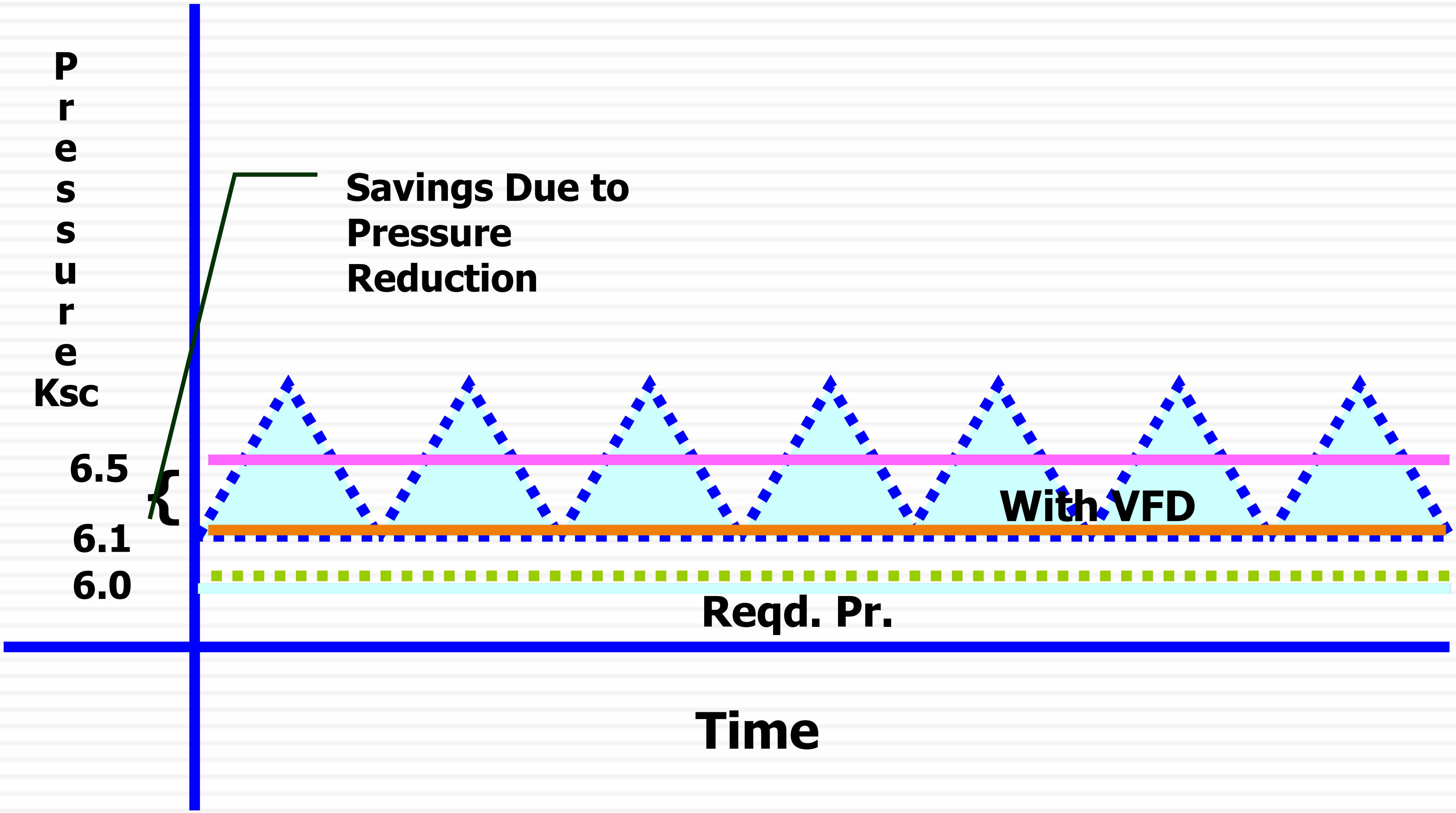


Concept - Conventional Control

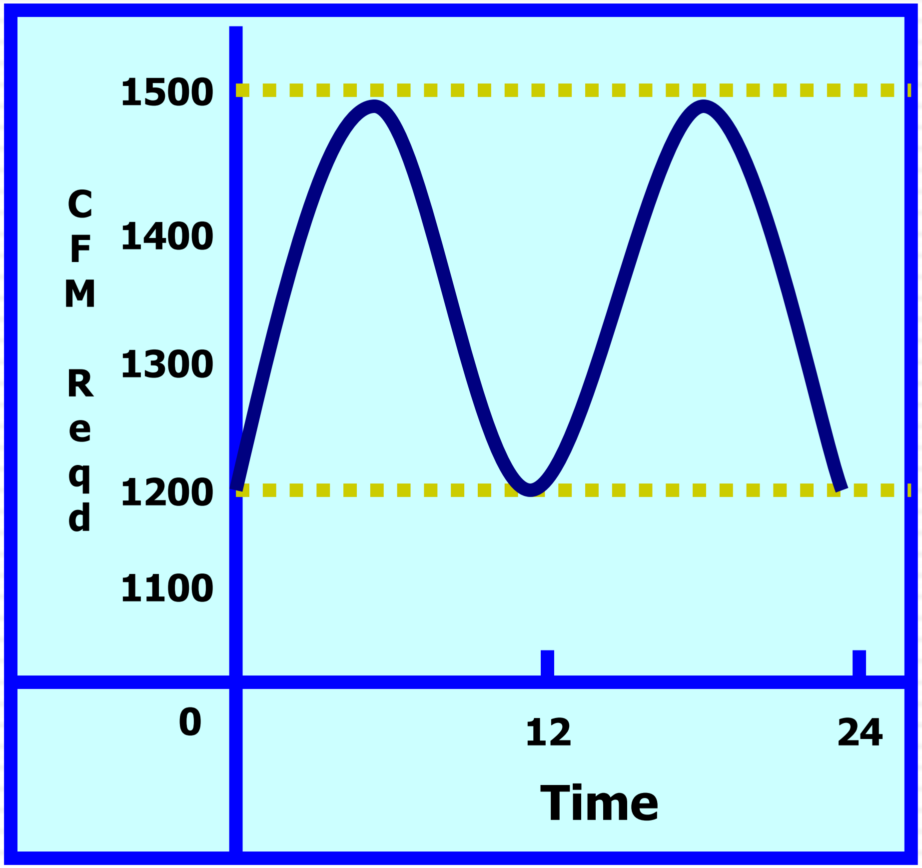


CII

Concept - VFD Control

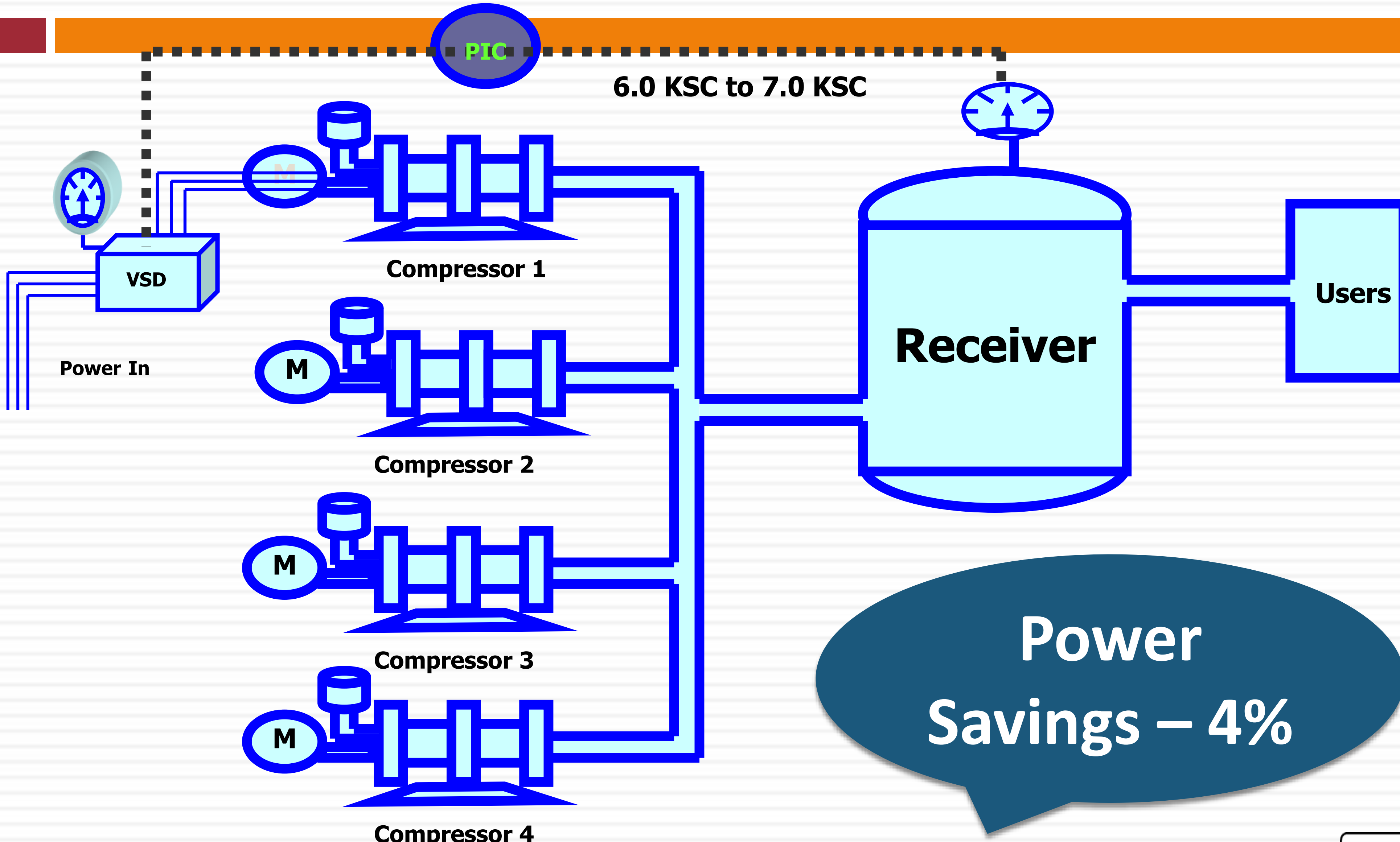


Savings in Unload Power

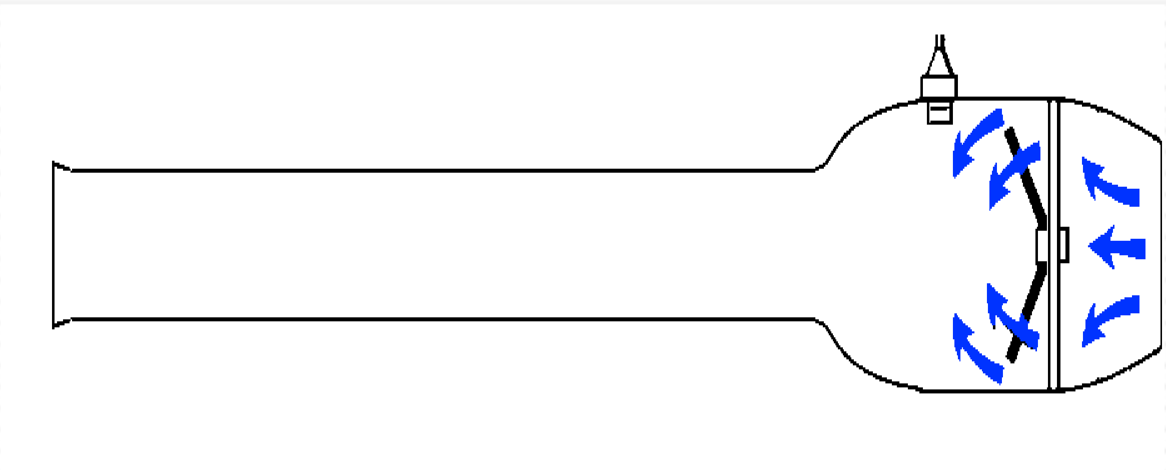


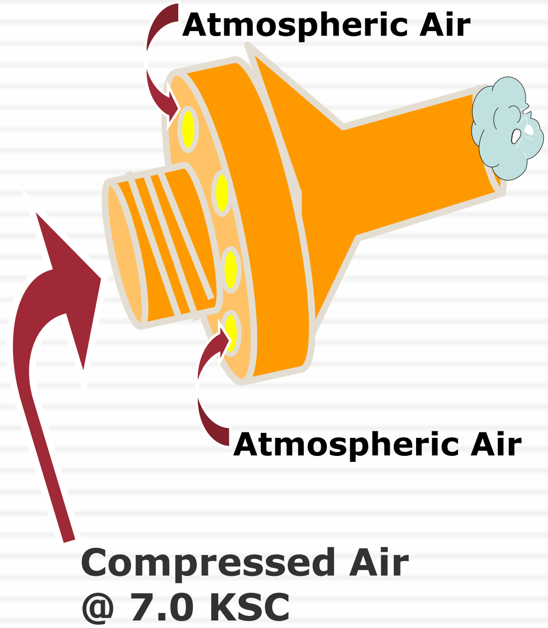
- Compressors Designed to meet Fluctuating Load
- Fluctuating Load Leads to Load / Unload
- Lean Time - Unload
- Unload power 15 - 40%
- No useful work
- VSD Avoids Unloading of Compressors

Install VFD for One Compressor



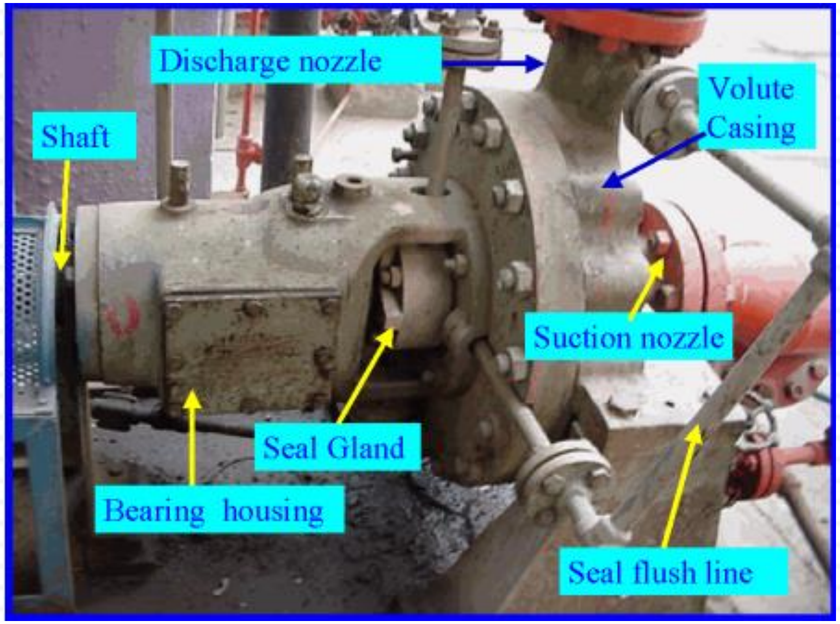
Use Transvector Nozzle In Air Hose

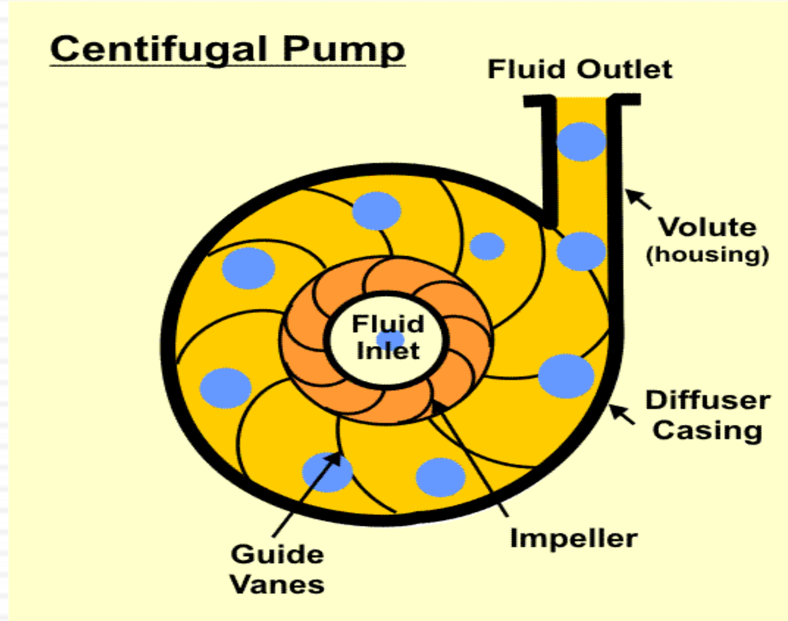




PUMPING SYSTEM

Centrifugal Pumps

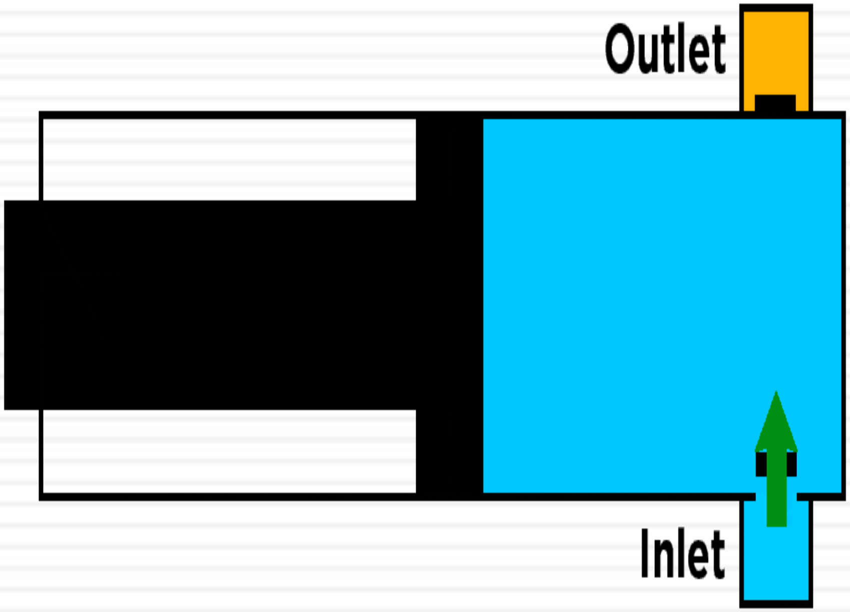


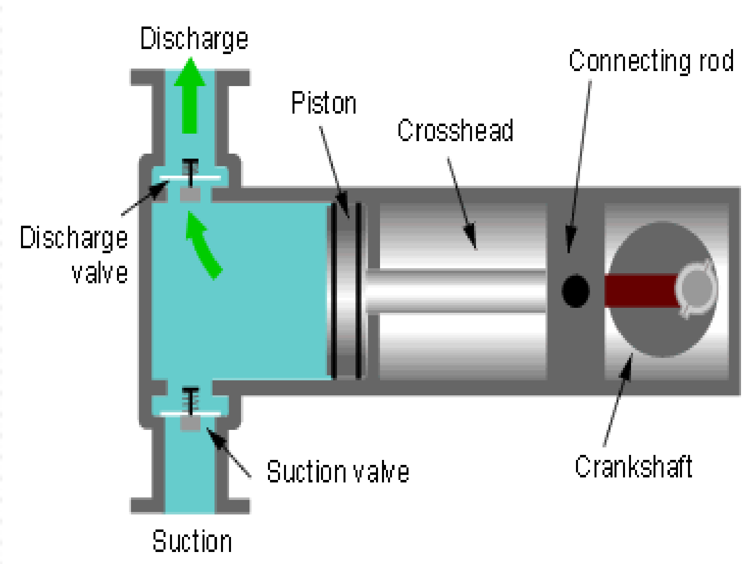


Centrifugal

- Moderate pressure (upto 6000 m WC)
- Moderate capacity (upto 10,000 m^3/h)
- General applications

Positive Displacement Pumps





Reciprocating

- **High pressure - upto 10,000 m WC**
- **Low capacity - upto 1000 m^3/h**
- **Lubrication oil pumps**

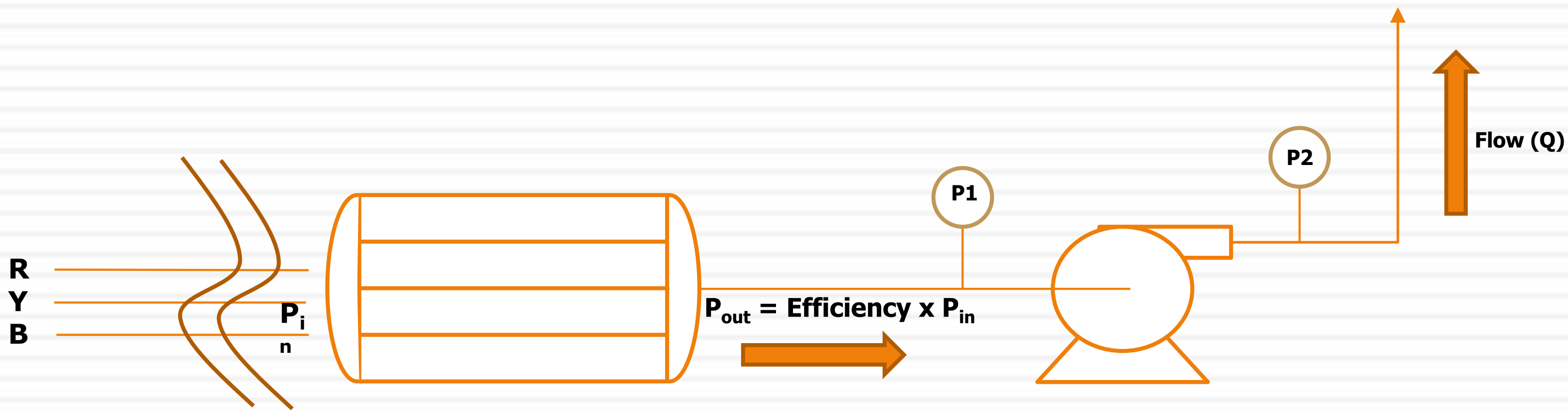
Energy Parameters

Capacit
y or
Flow

Head or
Pressur
e

Efficiency

Efficiency of Pump



$$\text{Pump } \eta\ (\%) = \frac{\text{Flow (lps)} \times \text{(h2-h1) (m)} \times \text{Sp. Gr.}}{102 \times P_{out}}$$

Pumps Formulae

- **Capacity** α **(RPM)**
- **Head** α **$(RPM)^2$**
- **Power** α **(Capacity x Head)**

  α **$(RPM)^3$**

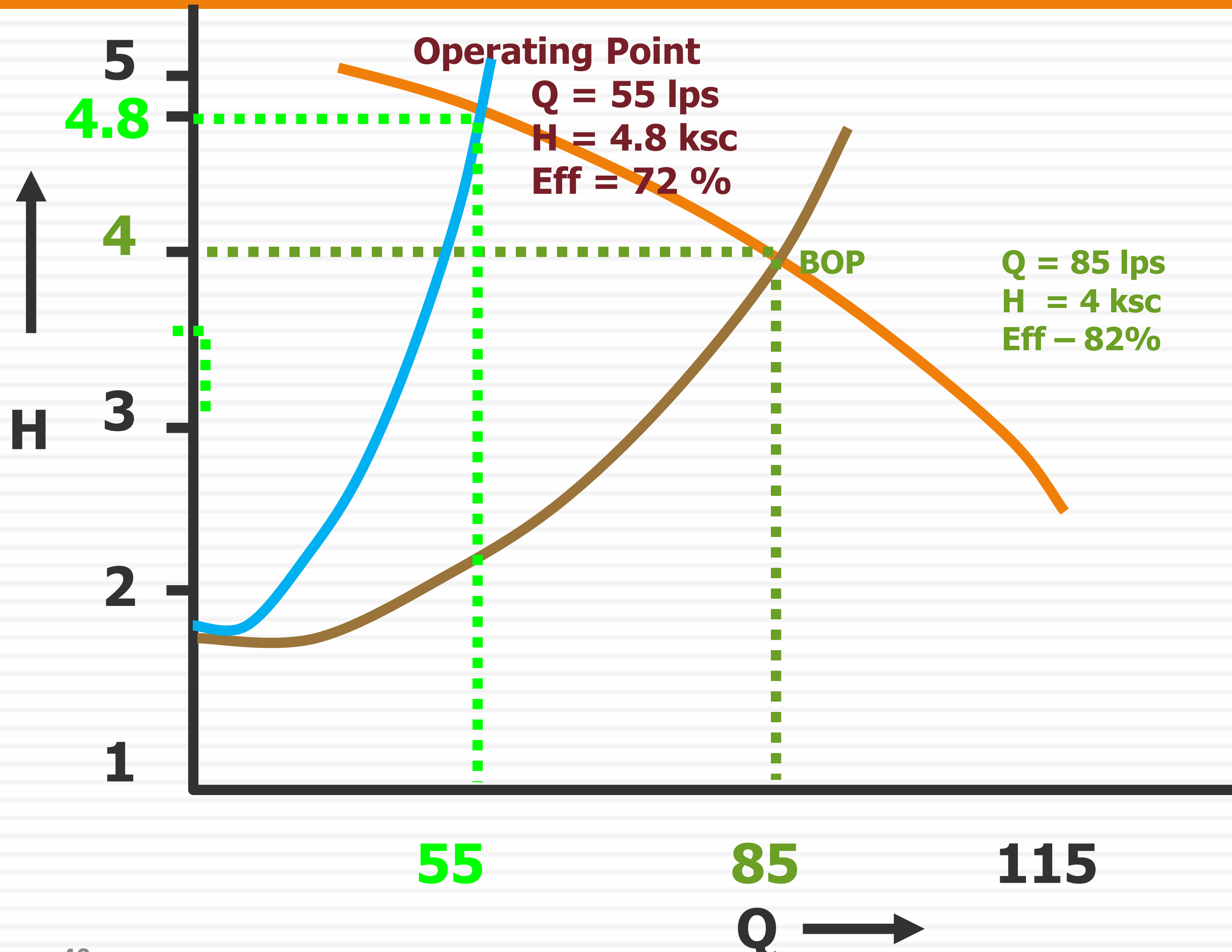
CII

Pumps Formulae

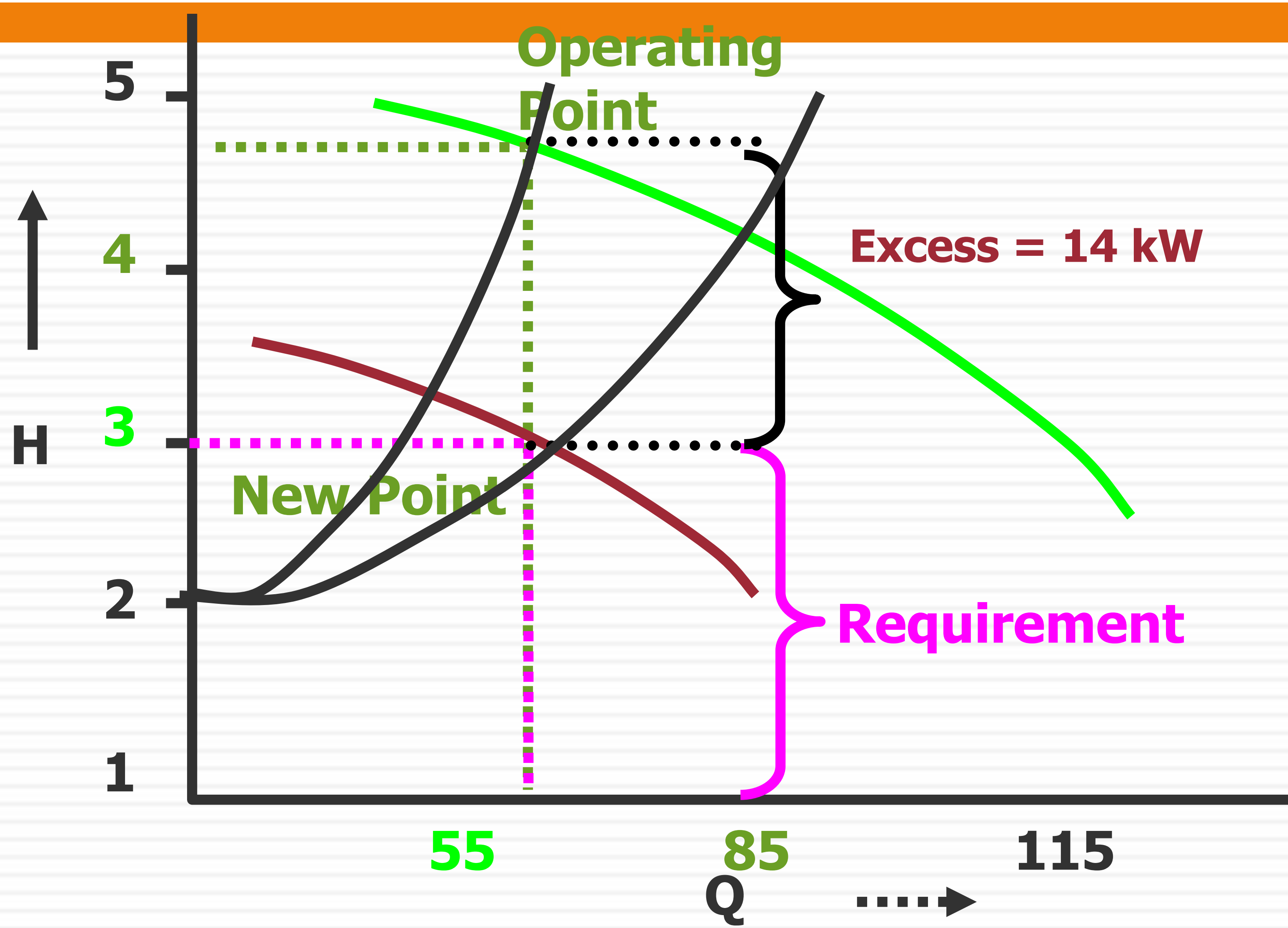
If the RPM is reduced by say 10%, what will happen to the

- **Capacity : reduces by 10%**
- **Head : reduces by 19%**
- **Power : reduces by 27%**

Operating Conditions of Pump



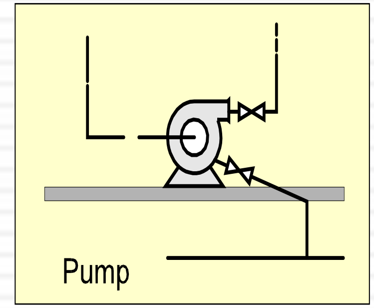
Operating Conditions of Pump



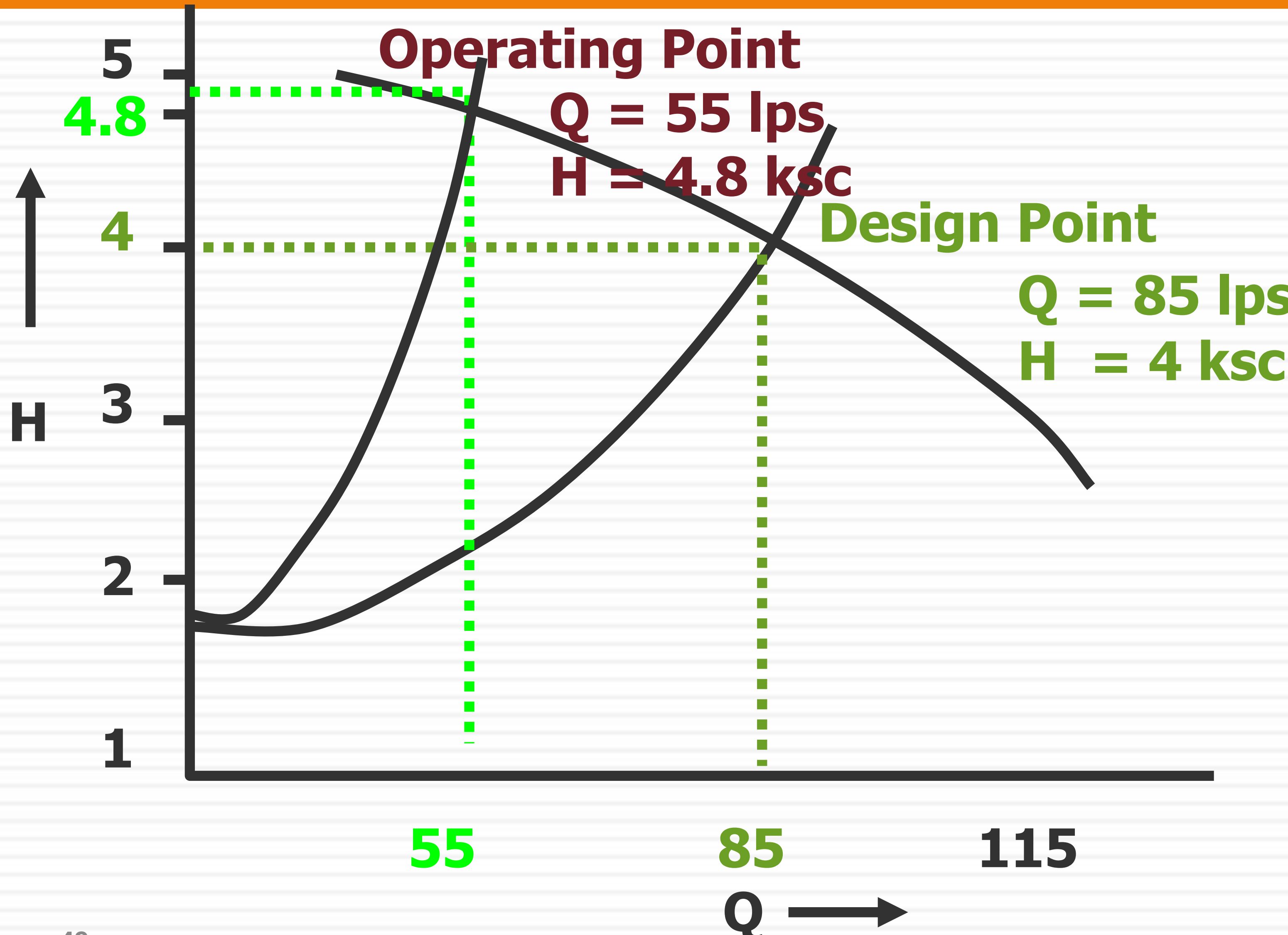
CII

Reasons for excess power consumption

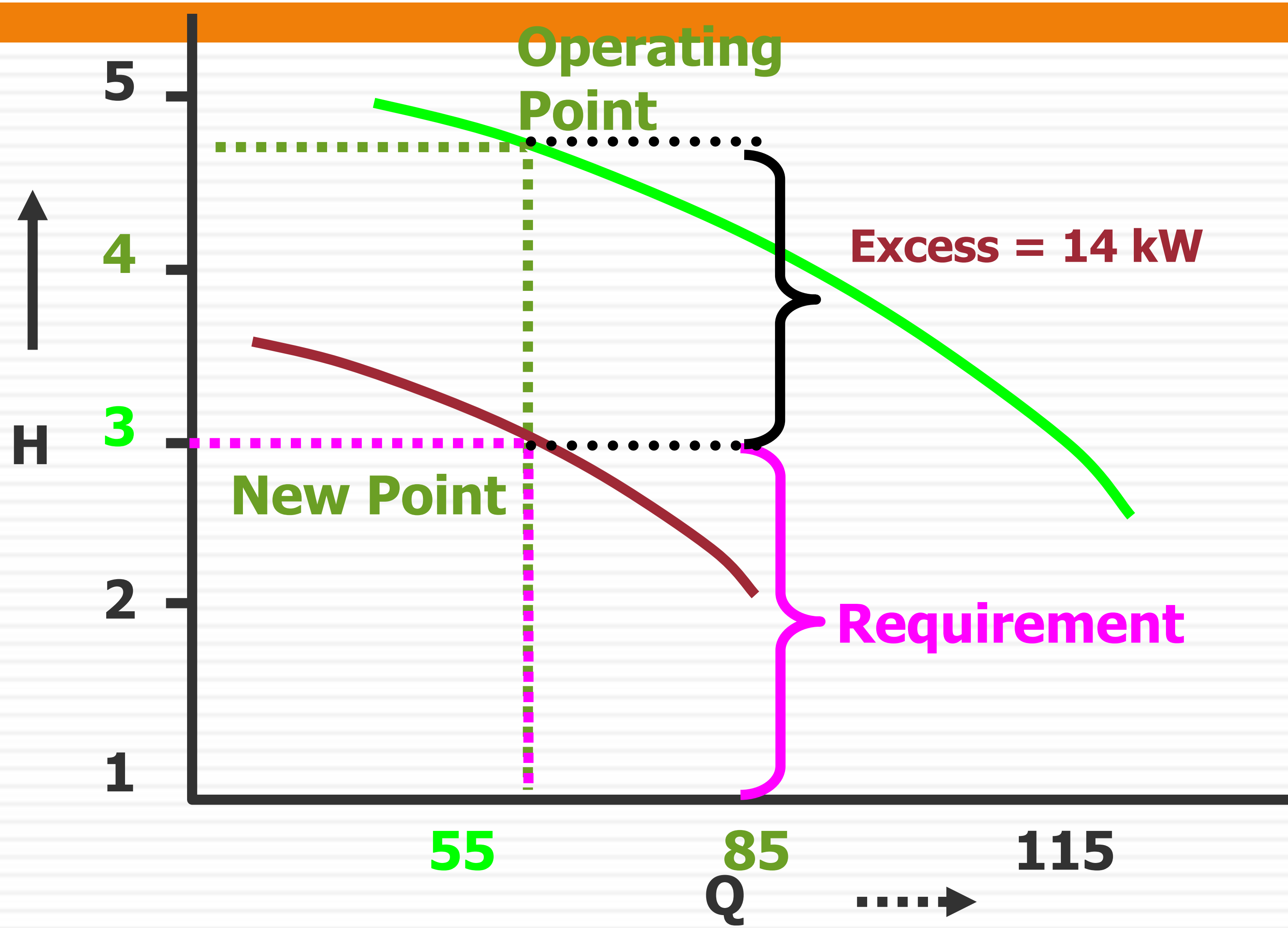
- Wrong Selection
- Over Design
- Improper Layout
- Old inefficient pumps
- Multiple smaller size pumps



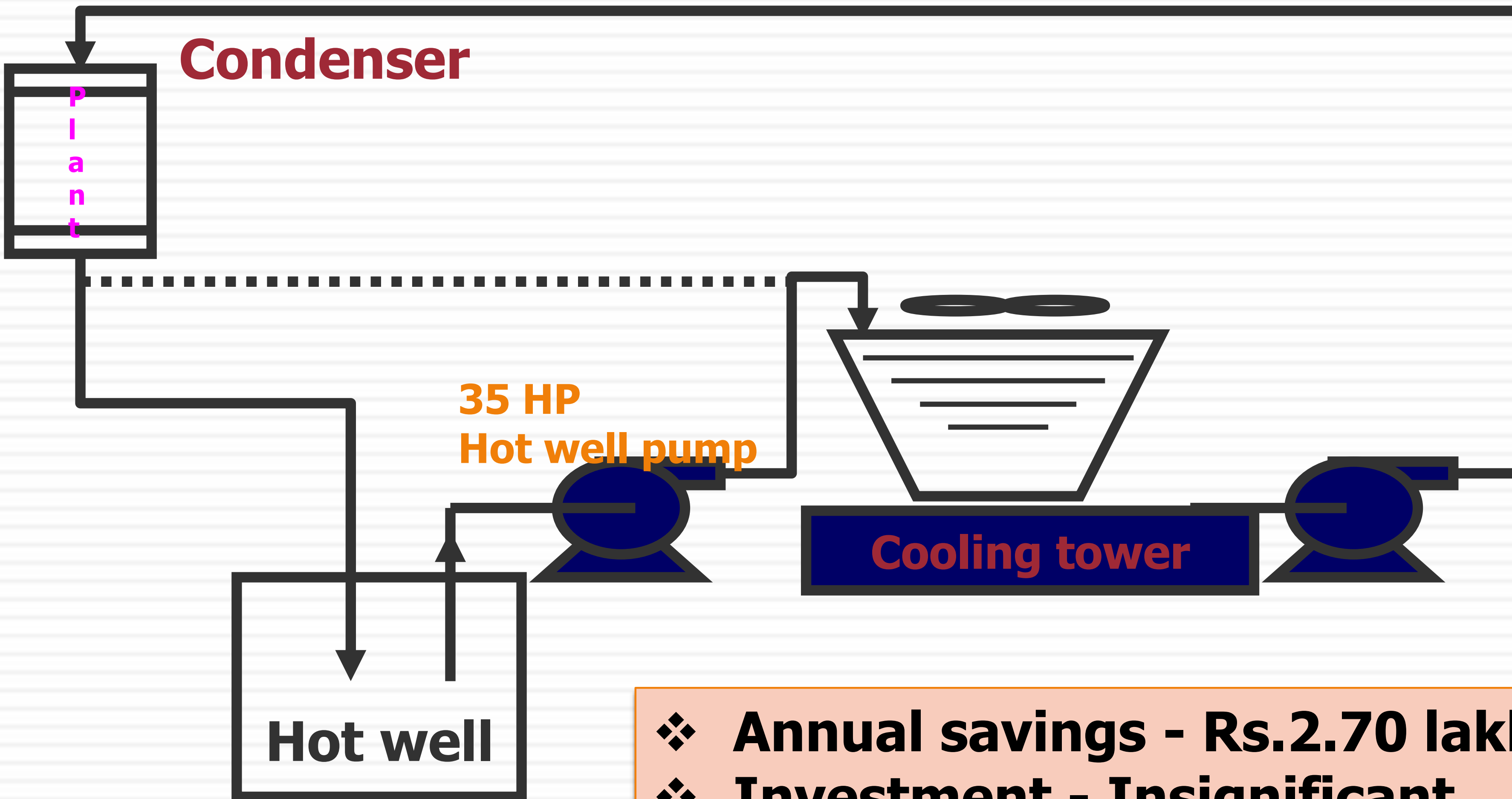
Operating Conditions of Pump



Operating Conditions of Pump



Use Gravity Flow as Much as Possible



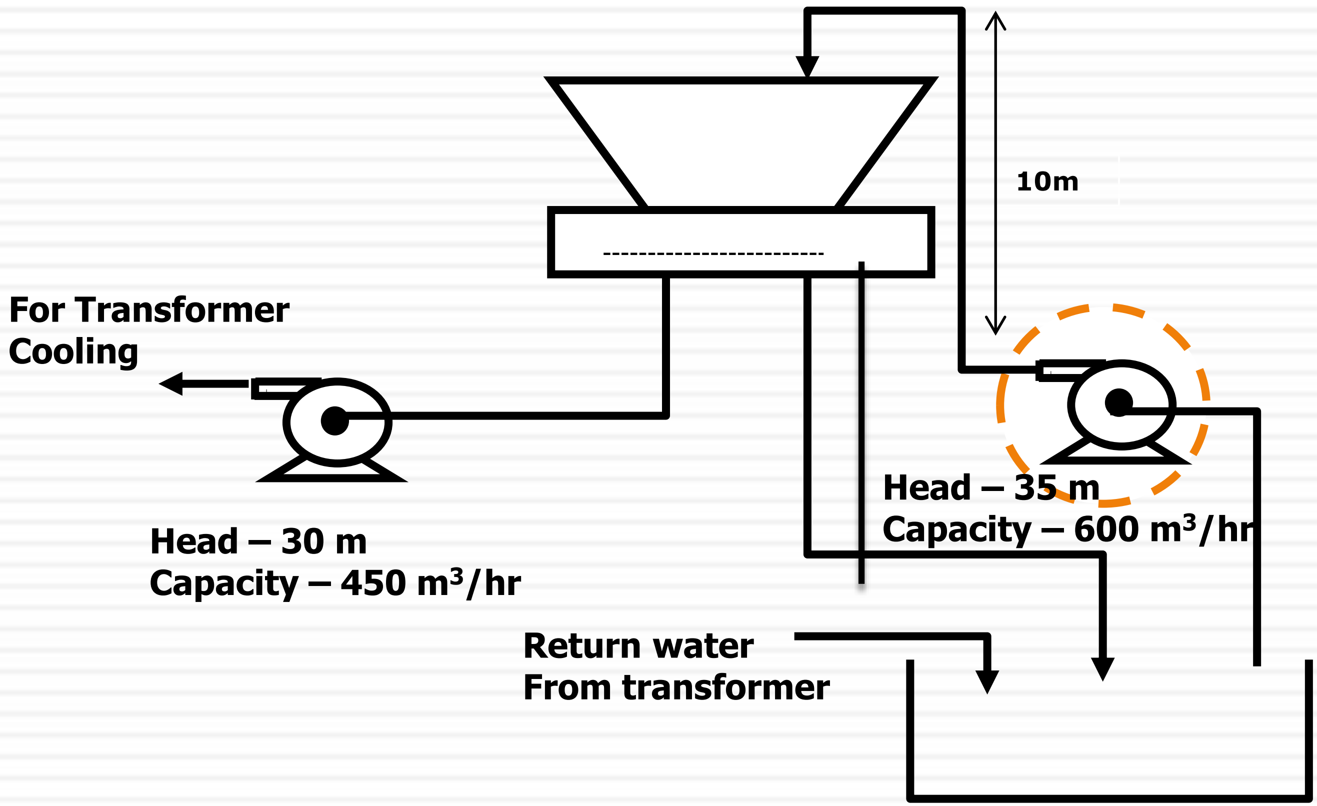
- Annual savings - Rs.2.70 lakhs
- Investment - Insignificant

Methodology of Pump Survey

- ❖ **Is the pump correctly Sized ?**
  - ➢ **Excess capacity due to uncertainty**
- ❖ **Leads to operation with valve throttling**
  - ➢ **Energy inefficient practice**

- ❖ **Impeller reduction**
- ❖ **Low capacity/head pump**
- ❖ **Installation of variable speed drive**

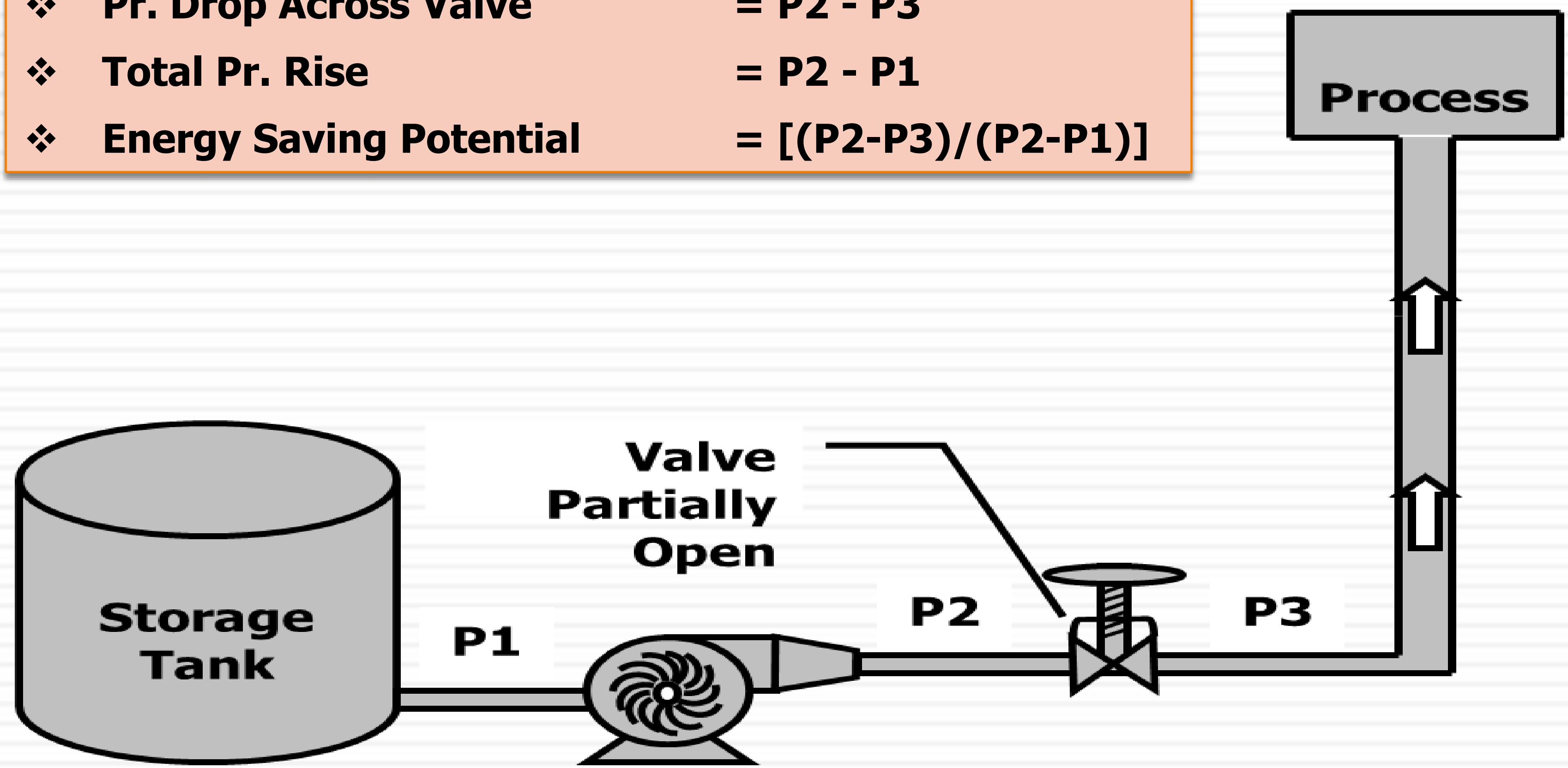
Installation of correct size pump



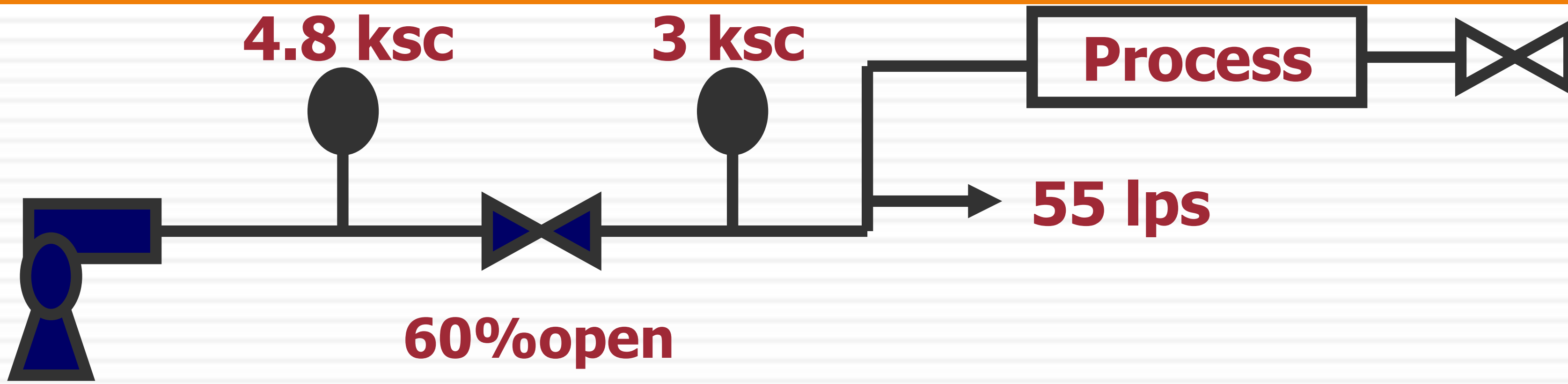
Annual savings	-	Rs 7.29 Lakhs
Investment	-	Rs 3.00 Lakhs
Payback period	-	5 months

Pressure Drop Across Valve

❖	Pr. Drop Across Valve	= P2 - P3
❖	Total Pr. Rise	= P2 - P1
❖	Energy Saving Potential	= [(P2-P3)/(P2-P1)]



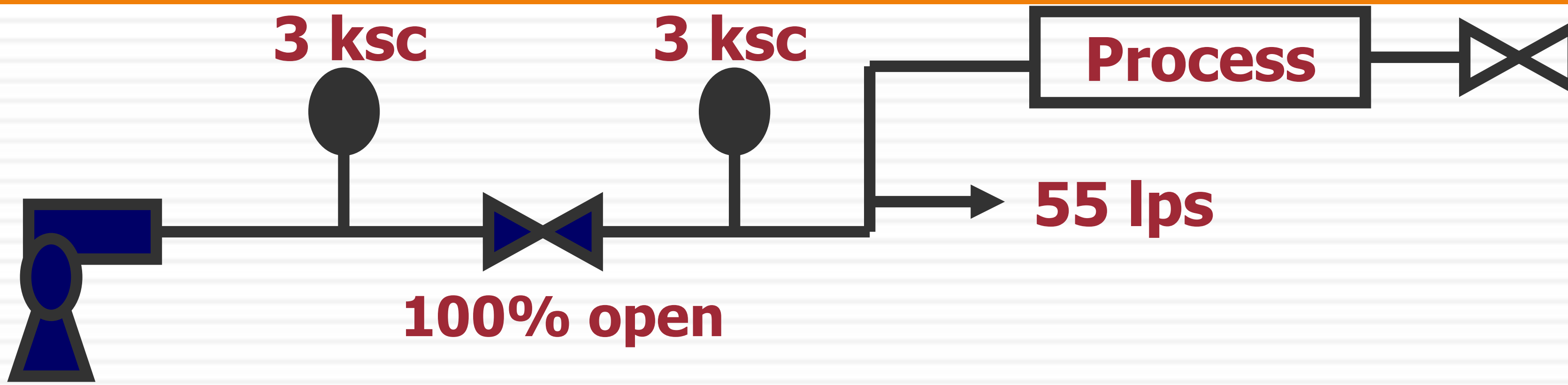
Effect of Valve Throttling



Design

Capacity	=	85 lps
Head	=	4 ksc
Existing	=	4.8 ksc
kW_{EX}	=	55 x 48/(102 x 0.7)
	=	37.0 kW

Effect of Valve Throttling



Modified

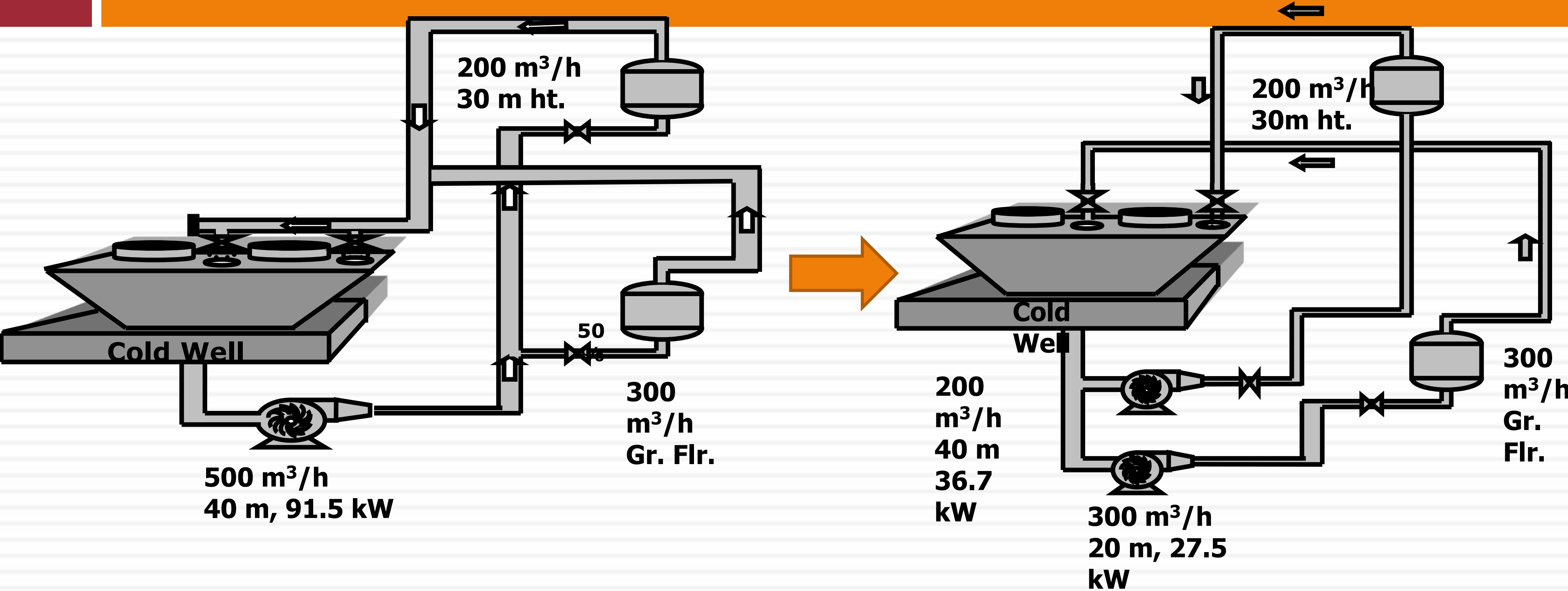
Proposed = 3.0 ksc

kW_P = 55 x 30/(102 x 0.7)

= 23.0 kW

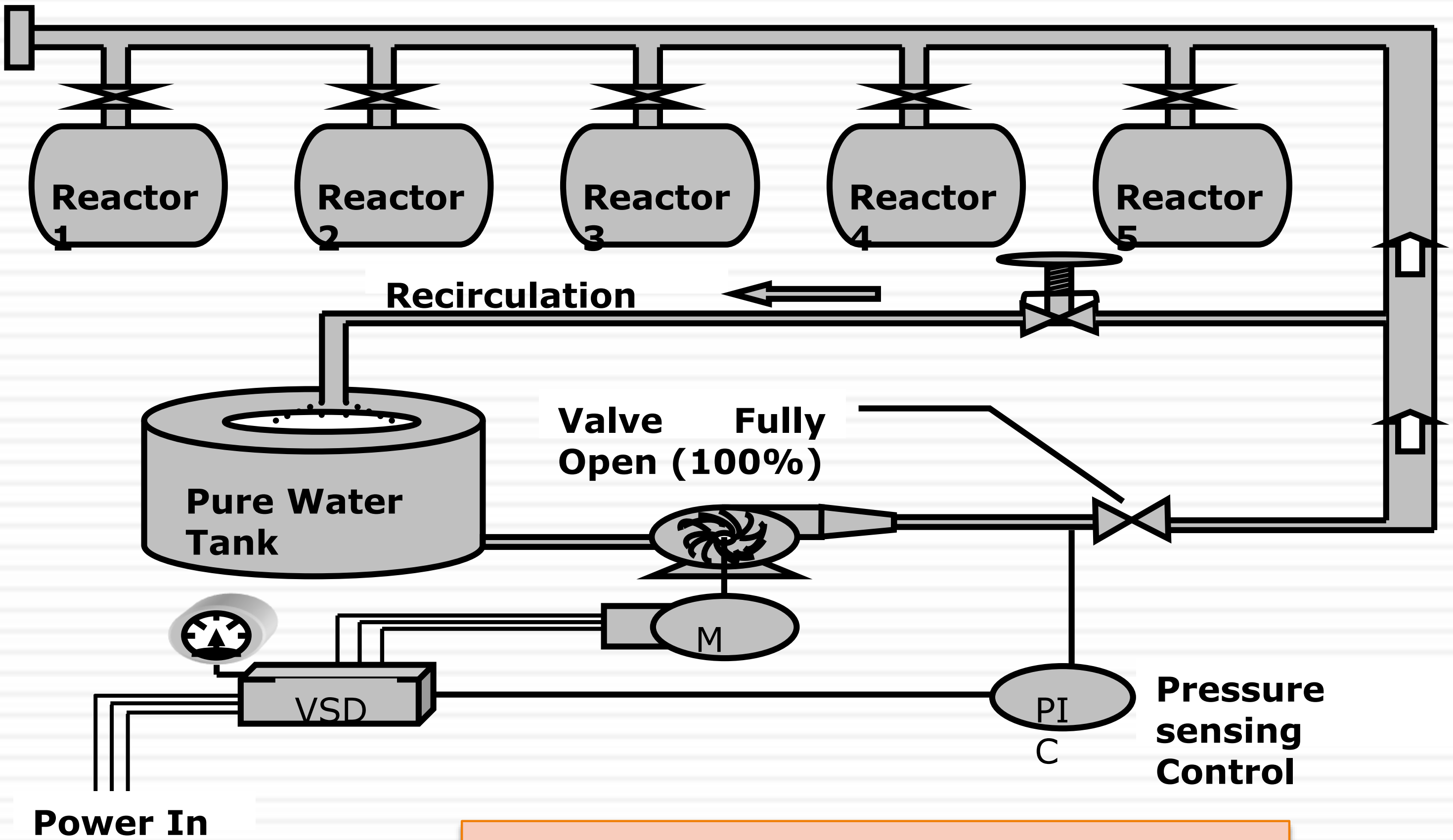
Savings = 14 kW

Segregate high and low head users



Annual Savings	= Rs. 4.80 Lakhs
Investment	= Rs. 6.00 Lakhs
Payback period	= 15 Months

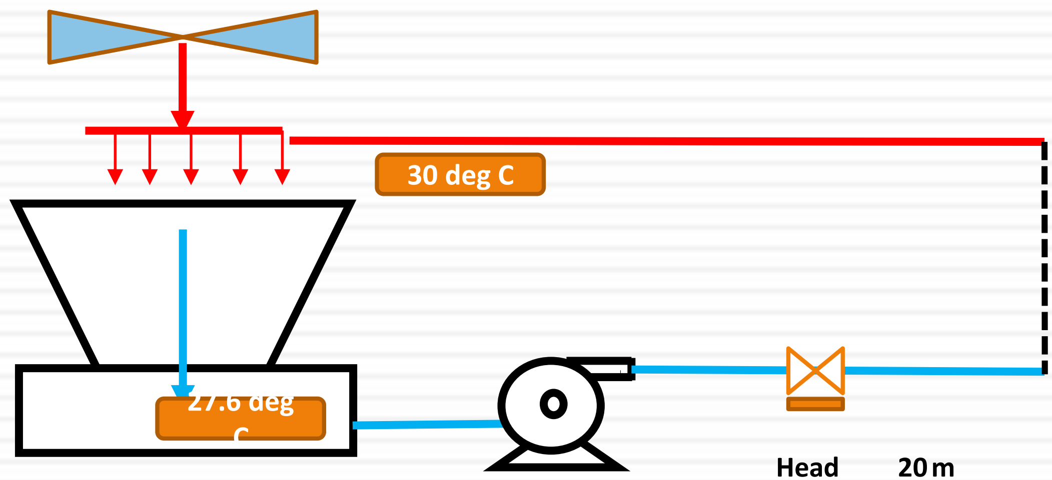
VFD for Pumping system



Annual savings	- Rs.3.00 Lakhs
Investment	- Rs.2.00 Lakhs
Payback period	- 8 Months

Install TIC for the cooling tower fan

- **Present system**
  - Two Pumps
    - One running and one standby
  - Cooling tower fan running continuously,
    - No control on the CT fan speed
  - DT = 2.4 degC



Head	20 m
Flow	30 m3/h
Efficiency	60 %
Power	3.03 kW

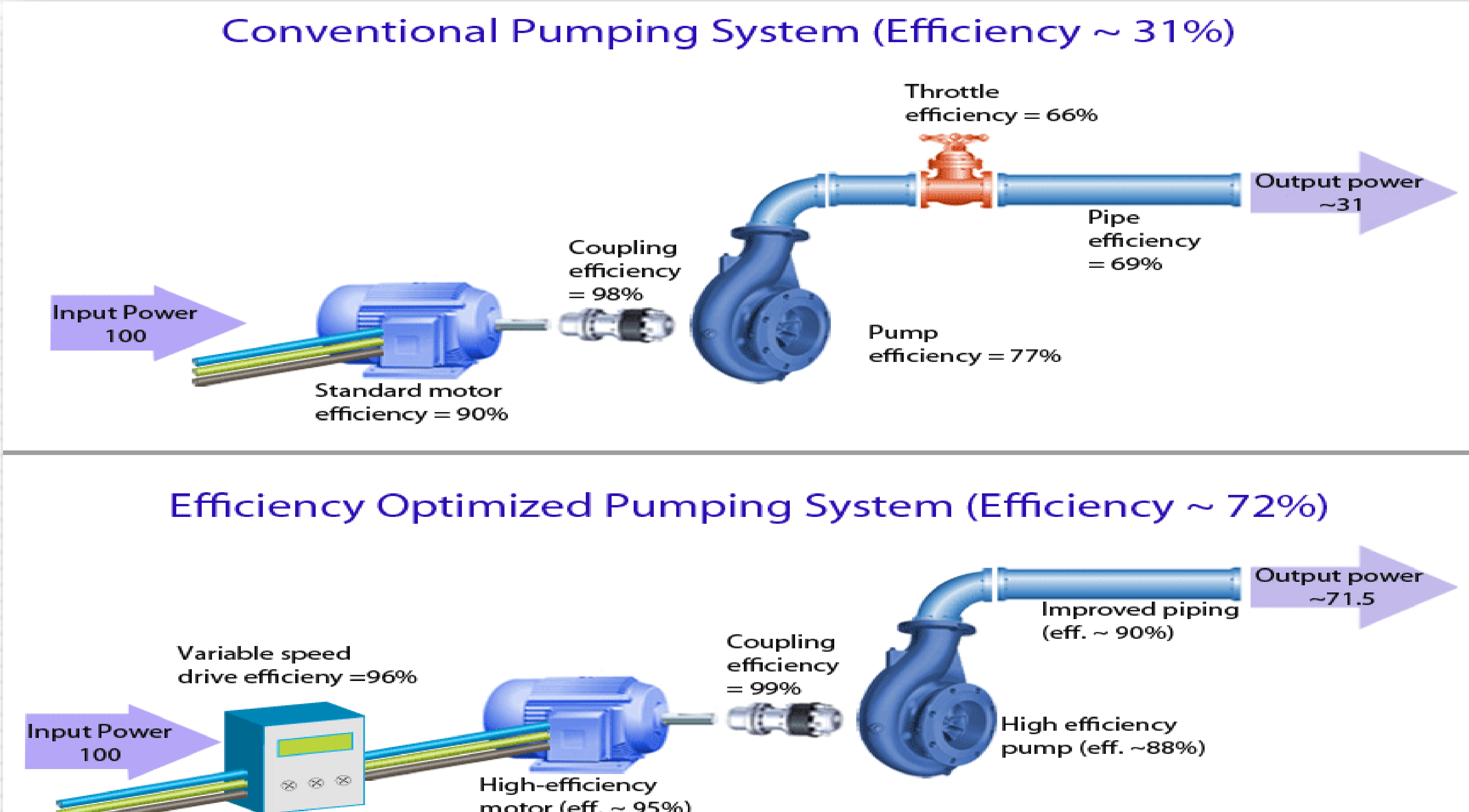
Install TIC for the cooling tower fan

- Recommendation
  - Install TIC and control fan operation
  - Automate CT fan operation based on the cold well temperature
    - CT fan switch OFF if cold well water temperature lesser than 24 ^{0}C
    - CT fan switch ON if cold well water temperature greater than 27 ^{0}C
  - Savings can be achieved during favorable conditions

Install TIC for the cooling tower fan

Annual Saving	-	Rs 3700
Investment	-	Rs 2000
Payback	-	6 months

Energy Efficient Pumping System



Thank You….