

**JUBILANT INGREVIA LIMITED**

**Summer Internship Report**

Project Title:

***Cooling Water Requirement Calculation***

***and Power Saving in Unit 2***

Submitted by:

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*Under the guidance of*

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Internship Duration:

June – July 2025

Location:

Jubilant Ingrevia, Bharuch

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# CERTIFICATE

This is to certify that **Mr. Manish Kumar**, a student of B.Tech in Chemical Engineering at NIT Jalandhar, has successfully completed his summer internship at **Jubilant Ingrevia Limited,** Bharuch during June–July 2025.

He undertook a project titled

**“Cooling Water Requirement Calculation and Power Saving in Unit 2”**

under the guidance of **Mr. Aresh Bhatnagar, Senior Manager – Business Excellence.**

This report is the result of his original work carried out with sincerity and discipline.

Date: \_\_\_\_\_\_\_\_\_\_\_\_\_

Signature:

(**Mr. Aresh Bhatnagar**)

# ACKNOWLEDGEMENT

I would like to express my sincere gratitude to **Jubilant Ingrevia Limited, Bharuch**, for providing me the opportunity to carry out my summer internship in an industrial environment that fosters learning and technical growth.

I am especially thankful to **my mentor at Unit 2**, whose valuable guidance, support, and encouragement helped me understand the technical aspects of the cooling water system and stay focused throughout the project.

I also extend my thanks to the **operations, maintenance, and instrumentation teams at Unit 2** for their practical insights, coordination, and help during equipment visits and data collection.

I am grateful to my **faculty members at NIT Jalandhar** for providing me with the academic background and motivation that enabled me to contribute effectively during this internship.

Manish Kumar

(22112047)

# ABSTRACT

This internship report presents an in-depth technical study on the “**Cooling Water Requirement Calculation and Power Saving in Unit 2**” conducted at **Jubilant Ingrevia** Limited, Bharuch during the summer internship program (June–July 2025).

The project primarily focused on evaluating the existing cooling water distribution network in Unit 2, identifying the actual cooling demand for individual equipment, and comparing it with the current system configuration. It involved meticulous data collection, equipment-wise flowrate estimation, hydraulic calculations, and analysis of pump performance and pipe design.

The findings revealed a considerable mismatch between the actual cooling water requirement and the volume being circulated through the system. Oversizing of pumps and piping, coupled with lack of flow regulation, were observed to be leading causes of inefficiency. These discrepancies not only contribute to excess energy consumption but also result in unstable cooling conditions across multiple units.

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# INTRODUCTION TO COMPANY & DEPARTMENT

**Overview of Jubilant Ingrevia Limited**

Jubilant Ingrevia Limited is a global integrated life science ingredients and specialty chemicals company headquartered in India. It is part of the Jubilant Bhartia Group and operates with a vision to deliver value through innovation, quality, and sustainability.

The company serves over 1,400 customers in more than 60 countries, providing high-quality and performance-based solutions across diverse industries such as:

* **Pharmaceuticals and Life Sciences**
* **Food and Nutrition**
* **Agrochemicals**
* **Industrial Chemicals**
* **Personal Care**

Jubilant Ingrevia operates across three strategic segments:

1. **Specialty Chemicals** – Includes Pyridine & Picolines, Value-added Pyridine Derivatives, and other fine chemicals.
2. **Nutrition & Health Solutions** – Covers nutrition-based APIs, animal nutrition, and vitamins.
3. **Acetyls** – Core chemicals such as Acetic Acid, Acetic Anhydride, Ethyl Acetate, etc.

The organization is committed to operational excellence, innovation, and environmental responsibility. It holds several ISO certifications and complies with stringent global standards such as REACH, FDA, and cGMP.

**Bharuch Manufacturing Facility – Unit 2**

The Bharuch facility of Jubilant Ingrevia is located in Gujarat, one of India’s leading industrial zones. The plant operates round the clock with multiple production units, utility systems, and support functions. The site is known for:

* **High-capacity manufacturing lines**
* **Advanced process automation**
* **Sustainable energy and water management systems**
* **Robust safety and environmental protocols**

Unit 2 is one of the core units on the site and is involved in the manufacturing of specialty intermediates. It hosts critical equipment such as:

* **Reactors**
* **Heat Exchangers**
* **Condensers**
* **Glass Columns**
* **Distillation Trains**

Due to the exothermic nature of many reactions, efficient heat removal through cooling water systems is crucial to ensure product stability and safety.

**Utility Systems at Jubilant Ingrevia**

The utility section at Bharuch plant comprises:

* **Cooling Water System**
* **Boilers (Steam Generation)**
* **Chilled Water Units**
* **Compressed Air Systems**
* **Power Distribution Panels**
* **Effluent Treatment Plants**

Among these, the cooling water system is one of the most power-intensive systems, involving:

* High-capacity centrifugal pumps to circulate water (2000+ m³/hr)
* Cooling towers to reject heat absorbed from equipment
* Piping network laid across all production zones
* Flow control devices such as valves, orifice plates, and balancing tanks

**Introduction to the Process Engineering / Business Excellence Department**

During the internship, I worked under the Business Excellence and Process Optimization Department. This team is responsible for improving plant performance by:

* Auditing utility and process efficiency
* Identifying energy saving opportunities
* Standardizing best operating practices
* Supporting plant digitalization and automation projects
* Ensuring sustainability compliance (GHG, Water, Waste, Energy)

The department collaborates with operations, maintenance, and engineering to bring measurable improvements through data-driven decision-making and technical projects like the one I undertook.

**Scope of My Internship Project**

As an intern, I was assigned a project on:

**“Calculation of Cooling Water Requirement and Power Saving Potential in Unit 2”**

The objectives were:

* Calculate actual cooling water requirement for each equipment
* Compare it with existing system supply
* Identify oversized piping and pumping inefficiencies
* Recommend solutions for energy and cost saving

CHAPTER 1

# FUNDAMENTALS OF COOLING WATER SYSTEMS

* 1. **Introduction**

In every chemical and process industry, maintaining optimal temperatures in reactors, condensers, compressors, and other critical equipment is essential for smooth operation and process safety. Heat must be effectively removed from these systems to avoid equipment failure, side reactions, or unsafe operating conditions.

Cooling water systems play a pivotal role in performing this heat removal efficiently. They provide a continuous flow of water that absorbs heat from equipment and carries it away, either to a cooling tower or to another utility exchanger.

At Jubilant Ingrevia’s Bharuch Unit 2, the cooling water system is one of the largest utility consumers, both in terms of volume of water and the energy required to circulate it.

* 1. **Need for Cooling in Process Industry**

In chemical processes, heat is either generated (exothermic) or required (endothermic). If the excess heat generated is not removed:

* Product degradation may occur
* Catalyst deactivation could happen
* Pressure may rise uncontrollably
* Reactors or heat-sensitive equipment could fail
* Process control would become unstable

To maintain thermal balance, cooling is done through:

* **Jacketed Reactors**
* **Heat Exchangers**
* **Condensers**
* **Distillation Columns**
* **Utility Stations**

The medium used is cooling water due to its high heat capacity, availability, and ease of circulation.

* 1. **Types of Cooling Water Systems**

There are generally two types of cooling water systems used in industries:

* + 1. **Once-through Cooling System**
* Water is drawn from a source (e.g., river), passed through equipment, and then discharged.
* Economical in terms of capital cost.
* Not suitable for areas with water scarcity.
* Environmental concerns due to hot water discharge.

**1.3.2 Recirculating Cooling System (Closed Loop)**

* Water is continuously circulated through a loop.
* Heat is rejected to the atmosphere using cooling towers.
* Higher initial cost but more sustainable and efficient.
* This is the system followed at Jubilant Ingrevia.
  1. **Major Components of a Cooling Water System**

Let’s explore each key part of a typical industrial cooling water system like the one at Jubilant Bharuch:

**1.4.1 Cooling Water Pumps**

* Centrifugal pumps are used to maintain constant water circulation.
* Located at the utility block.
* Must be designed for required flowrate and head.
* In Unit 2, the pump currently handles ~2000 m³/hr.

**1.4.2 Cooling Tower**

* A heat rejection device that extracts waste heat to the atmosphere via evaporation.
* Typically uses induced draft fans and fill packs to increase efficiency.
* The cooling range (difference between inlet and outlet water temperatures) is usually 5–10°C.

**1.4.3 Distribution Headers and Piping**

* Carry water from the pump to different plant units.
* Use carbon steel or PVC-lined pipes.
* Require proper sizing to avoid high pressure drop or velocity erosion.

**1.4.4 Heat Exchange Equipment**

* Include shell & tube heat exchangers, plate heat exchangers, and condensers.
* Designed based on log mean temperature difference (LMTD) and required heat load.
* Must ensure turbulent flow (Reynolds number > 4000) for efficient heat transfer.

**1.4.5 Return Headers**

* After absorbing heat, water is returned to the cooling tower.
* Some systems include a balancing tank to maintain pressure head.

**1.5 Design Considerations for Cooling Water Systems**

Designing a cooling system involves:

* Calculating heat load (Q = m × Cp × ΔT)
* Selecting flow rate based on ΔT (usually 5°C in industry)
* Choosing pipe sizes for 1.5–3 m/s velocity
* Ensuring Net Positive Suction Head (NPSH) for pumps
* Monitoring water quality to prevent scaling and corrosion

**1.6 Challenges in Cooling Water System Operation**

Even a properly designed system faces issues during continuous operation:

| Challenge | Effect |
| --- | --- |
| Fouling | Reduces heat transfer efficiency, increases pressure drop |
| Scaling | Blocks tubes, lowers flow area, leads to overheating |
| Corrosion | Damages equipment and piping |
| Microbial Growth | Algae/bacteria reduce efficiency, safety concern |
| Over-pumping | Higher power use, pump wear, flow imbalance |
| Undersized piping | Leads to cavitation and inadequate cooling |
| Water wastage | Costly and environmentally unsustainable |

Regular maintenance and optimization audits help prevent these issues.

**1.7 Cooling Water System at Jubilant Ingrevia – Key Stats**

| Parameter | Value |
| --- | --- |
| Cooling Water Flowrate (Actual) | ~2000 m³/hr |
| Calculated Requirement | ~1100–1200 m³/hr |
| Cooling Tower Type | Induced Draft |
| ΔT (Temperature Drop) | ~5–6°C |
| Pump Type | Horizontal Centrifugal Pump |
| Pipe Material | MS + Internal Coating |
| Flow Distribution | Through headers to 25+ users |

This project specifically focused on optimizing this system by comparing actual flowrate vs equipment need and analyzing pump power and pipe sizing.

**1.8 Role of Cooling Water in Sustainability**

Water is a scarce resource, and so is energy. Excess use of cooling water and over-pumping leads to:

* Higher carbon emissions (more electricity used)
* Thermal pollution
* Excess load on pumps (more maintenance cost)
* Greater operational inefficiencies

By right-sizing the system and ensuring flow regulation through valves or VFDs, industries like Jubilant can achieve both cost savings and meet sustainability goals.

CHAPTER 2

# EQUIPMENT-WISE COOLING WATER REQUIREMENTS

**2.1 Introduction**

In an integrated chemical plant like Jubilant Ingrevia Unit 2, cooling water is distributed to **multiple types of equipment** including:

* Batch and continuous **reactors**
* **Glass columns**
* **Heat exchangers**
* **Condensers**
* **Utility storage vessels**

Each of these systems requires a **specific flowrate of cooling water**, determined by its heat load, outlet temperature requirements, and fluid characteristics.

This chapter presents the **calculated cooling water requirements** for major equipment and compares them with **existing system flow distribution**.

**2.2** Methodology for Calculation

The general formula used to estimate cooling water requirement for a piece of equipment is:

**Q = (ṁ × Cp × ΔT) / 3600**

Where:

* Q = Cooling water requirement (m³/hr)
* ṁ = Mass flow rate of process stream (kg/hr)
* Cp = Specific heat capacity of fluid (kcal/kg°C or kJ/kg°C)
* ΔT = Temperature difference to be removed (°C)

For simplification and when using water as the primary coolant:

**Q = Heat Duty / (Cp × ΔT × ρ)**

Where ρ = Density of water (≈ 1 kg/L), Cp ≈ 4.18 kJ/kg°C, and ΔT is typically 5°C.

In this project, heat load estimation was done based on:

* Field operator logs
* Equipment heat balance
* Reaction temperature requirements
* Cooling tower performance assumptions

2.3 Actual Data Collection

To carry out this study, actual plant data was collected from:

* Utility flow distribution diagrams
* Process data sheets (PDS) of equipment
* Cooling water header return flow logs
* Operator interviews and instrumentation panel records

This data was compiled into a tabular format and analyzed in MS Excel to obtain the final cooling water requirement per equipment.

2.4 Sample Equipment Cooling Data Table

| **Equipment** | **Cooling Water Req. (m³/hr)** | **Theoretical Pipe Dia. (inch)** | **Actual Pipe Dia. (inch)** |
| --- | --- | --- | --- |
| Glass Column | 30.0 | 3 | 3 |
| Reactor 102 A | 11.3 | 2 | 3 |
| Reactor 102 B | 11.3 | 2 | 3 |
| Reactor 104 B | 7.7 | 1.5 | 3 |
| Reactor 104 B Heat Exchanger | 7.7 | 1.5 | 3 |
| Reactor 104 C | 7.7 | 1.5 | 3 |
| Reactor 305 A | 24.5 | 3 | 3 |
| Reactor 305 B | 24.5 | 3 | 3 |
| Column Condenser 1 | 18.0 | 2.5 | 3 |
| Product Cooler (PHE) | 21.0 | 2.5 | 3 |

**Total Cooling Water Requirement** (calculated from over 25 major equipment):  
**~ 1200 m³/hr**

2.6 Analysis of Flow Distribution

Upon reviewing the data, it was observed that:

* Many pipe sizes are **oversized** compared to theoretical need
* The flow is **not regulated** via orifice plates or balancing valves
* A few lines have **continuous flow**, even when equipment is idle
* **Top 5 equipment** consume nearly **50%** of total flow

This uneven distribution results in **overcooling** in some areas and **energy waste** through unnecessary circulation.

2.7 Implications

The impact of this over-distribution is:

* Increased pump load
* Higher friction losses
* Pump wear and energy cost
* Water usage beyond sustainable levels
* Inefficient cooling leading to control issues in some cases

By reducing flow to match real need, we can save **energy**, **cost**, and **water**.

2.8 Key Learnings from This Section

* Equipment cooling demand must be calculated and verified with actual system supply
* Pipe diameter plays a vital role in flow rate control
* Control valves or flow restrictors should be used at high-flow points
* Cooling towers also benefit from flow reduction due to lower heat load

CHAPTER 3

# PUMP SIZING AND FLOWRATE COMPARISON

3.1 Overview of Pumping in Utility Systems

In industrial utility systems, pumps play a central role in transporting fluids—such as water, chemicals, and steam—between units. Within cooling systems, centrifugal pumps are most commonly employed due to their capability to handle large flow rates at relatively low heads with continuous operation.

A pump’s performance depends on parameters such as flow rate (Q), head (H), power input, and efficiency. Selecting the right pump size is essential for ensuring stable operation, avoiding energy wastage, and minimizing mechanical stress.

3.2 Importance of Proper Pump Sizing

Proper pump sizing involves matching the pump’s operating point with the actual system requirement. An **undersized pump** will fail to deliver the necessary cooling water to equipment, potentially leading to overheating, process instability, or equipment damage. Conversely, an **oversized pump** results in excessive flow, high energy consumption, and the need for throttling through control valves, which reduces overall efficiency.

Industrial systems often lean towards overdesign as a precaution, but this approach leads to long-term inefficiencies if not optimized based on real-time data.

3.3 Observations from the Existing Setup

During the internship, it was observed that the existing pump setup in Unit 2 was designed to handle a significantly higher flow rate than what is currently required by the equipment. This mismatch between pump capacity and demand can lead to several issues:

* Increased electrical power consumption
* Higher operating pressures and risk of pipe erosion
* Uneven distribution of cooling water among connected units
* Difficulty in achieving flow control at the user level
* Continuous throttling at discharge, which reduces pump life

Field interactions and informal discussions with maintenance personnel confirmed that the same pump model has been in use for multiple years without re-evaluation of its sizing against actual plant load changes.

3.4 Role of System Curve and Pump Curve

The concept of **system curve** versus **pump curve** is essential in understanding pump performance.

* The **system curve** represents the head requirement of the piping system as a function of flow rate.
* The **pump curve** represents the capability of the pump across different flow rates and heads.

For efficient operation, the intersection point of these curves—called the **duty point**—should lie close to the **Best Efficiency Point (BEP)** of the pump. Operating far from this point increases energy loss, causes mechanical vibrations, and shortens pump life.

3.5 Flowrate Management Challenges

Due to the oversized pump and absence of advanced control systems like variable frequency drives (VFDs), operators rely on manual valve throttling to regulate flow. While this helps in reducing flow downstream, it doesn’t address the fundamental energy waste occurring at the pump. Additionally, lack of flow meters at individual equipment inlets makes it difficult to monitor and balance water supply across the plant.

3.6 Need for Re-evaluation of Pumping Strategy

Based on these findings, it is clear that there is a need to re-evaluate the current pumping configuration. This should include:

* Periodic audits of equipment-wise cooling water requirement
* Review of pump specifications against updated load profiles
* Consideration of installing flow regulation devices and automation systems
* Assessment of operating points relative to system curve

These actions will help in reducing overdesign, conserving energy, and improving the overall stability and reliability of the cooling system.

3.7 Conclusion

The pump sizing strategy used in Unit 2, while effective during initial commissioning, has not adapted to changing plant demands. Continuous operation under off-design conditions results in unnecessary energy losses and long-term reliability issues. A systematic reassessment of the pump’s suitability, supported by actual demand analysis, is a necessary step toward a more efficient and optimized utility system.

CHAPTER 4

# PIPE SIZING METHODOLOGY AND ACTUAL VS THEORETICAL COMPARISON

4.1 Introduction

Pipes are the arteries of any utility system. They transport fluids such as cooling water, steam, and compressed air across different sections of a chemical plant. For cooling water systems in particular, **pipe sizing plays a critical role** in:

* Ensuring uniform flow distribution
* Avoiding high pressure drops
* Preventing erosion or cavitation
* Minimizing pump energy consumption

At Jubilant Ingrevia Unit 2, it was observed that while the cooling water supply is well distributed, many pipes were **oversized** compared to actual cooling requirements. This leads to **excessive flow**, **increased pump load**, and inefficient use of resources.

4.2 Basics of Pipe Sizing

Pipe diameter is selected based on the **volumetric flow rate** and **recommended flow velocity**. The standard formula used is derived from the **continuity equation**:

Q=A×v=πD24×vQ = A \times v = \frac{\pi D^2}{4} \times vQ=A×v=4πD2​×v

Where:

* **Q** = Flow rate (m³/s)
* **A** = Cross-sectional area (m²)
* **v** = Flow velocity (m/s)
* **D** = Pipe internal diameter (m)

Rearranged to find diameter:

D=4QπvD = \sqrt{\frac{4Q}{\pi v}}D=πv4Q​​

This formula allows us to compute the ideal pipe diameter based on:

* Desired flow (Q)
* Acceptable velocity (v)

4.3 Recommended Flow Velocities

The choice of flow velocity depends on the fluid and application. For **cooling water**, standard guidelines recommend:

| **Pipe Type** | **Recommended Velocity Range** |
| --- | --- |
| Branch Lines | 1.0 – 2.0 m/s |
| Main Headers | 2.0 – 3.0 m/s |
| Return Lines | 1.0 – 2.5 m/s |

These velocities help ensure:

* Efficient turbulence for heat transfer
* No erosion of pipe walls
* Low noise and vibration
* Minimal pressure drop

4.4 Example Calculation: Pipe Diameter for Reactor 104 B

Let’s consider an equipment needing **7.7 m³/hr** cooling water.

* Flow, Q = 7.7 / 3600 = **0.00214 m³/s**
* Assume velocity, v = 1.5 m/s

D=4×0.00214π×1.5≈0.0426 m=42.6 mm≈1.67 inchD = \sqrt{\frac{4 \times 0.00214}{\pi \times 1.5}} \approx 0.0426 \text{ m} = 42.6 \text{ mm} \approx 1.67 \text{ inch}D=π×1.54×0.00214​​≈0.0426 m=42.6 mm≈1.67 inch

**Result:** A **1.5" diameter pipe** is sufficient, but **3" is actually used** in the plant. This results in **over-supply**, reduced control, and flow imbalance.

4.5 Theoretical vs Actual Pipe Size Table

Below is a summary of real plant data compared to calculated values:

| **Equipment** | **Cooling Water (m³/hr)** | **Theoretical Dia (inch)** | **Actual Dia (inch)** |
| --- | --- | --- | --- |
| Glass Column | 30.0 | 3.0 | 3.0 |
| Reactor 102 A | 11.3 | 2.0 | 3.0 |
| Reactor 104 B | 7.7 | 1.5 | 3.0 |
| Heat Exchanger 104 B | 7.7 | 1.5 | 3.0 |
| Reactor 305 A | 24.5 | 3.0 | 3.0 |
| Product Cooler (PHE) | 21.0 | 2.5 | 3.0 |
| Reactor 305 B | 24.5 | 3.0 | 3.0 |
| Condenser - Column 1 | 18.0 | 2.5 | 3.0 |

**Key Observation:** Actual pipe diameters are often **1 size larger** than necessary, which leads to **excessive flow and poor balancing**.

4.6 Consequences of Oversized Piping

Using oversized pipes can result in:

| **Issue** | **Description** |
| --- | --- |
| Flow Imbalance | Excess flow to some equipment, low to others |
| Pressure Drop | Higher due to sudden contractions or fittings |
| Pump Overload | Larger pipes draw more flow, increase energy use |
| Reduced Control | Harder to regulate flow with valves |
| Noise and Vibration | Can occur at high velocities in narrow branches |
| Cost Overruns | Larger pipes cost more to install and maintain |

4.7 Practical Implications at Jubilant

* **Reactors** that only need 2" piping are operating on 3" lines
* Water is not reused in secondary cooling loops
* There is **no regulation at the outlet** of several exchangers
* Even during **idle equipment operation**, water flows continuously

4.8 Recommendations

The following actions are suggested:

1. **Install Flow Restriction Orifice Plates**
   * Low-cost, non-moving solution to control flow per line
2. **Use Control Valves with Feedback Loops**
   * Adjust flow automatically based on process requirement
3. **Replace Oversized Pipes During Shutdowns**
   * Target lines with >30% over-sizing
4. **Add Ultrasonic Flow Meters**
   * For real-time monitoring of flow rate in each section
5. **Create Pressure Balancing Loops**
   * Reduce flow surges, especially during batch operations

4.9 Summary

| **Aspect** | **Existing Observation** | **Suggested Change** |
| --- | --- | --- |
| Pipe Sizes | Mostly 3" (even for small users) | Match with design velocity |
| Flow Control | Manual, or non-existent | Add orifice/control valves |
| Energy Impact | Pump runs harder, more power needed | Reduce flow → reduce energy |
| Balance Issues | Some equipment overcooled | Regulate based on demand |

4.10 Conclusion

Pipe sizing in a cooling water system must be based on **scientific flow calculations**, not just standard sizes or legacy designs. The findings in Unit 2 at Jubilant Ingrevia show that:

* **Over 70%** of lines are oversized
* No dynamic control exists for flow balancing
* Energy, water, and maintenance costs are affected

Corrective action can result in improved system stability, **lower energy bills**, and increased **equipment life**.

CHAPTER 5

# ENERGY SAVING AND COST REDUCTION ESTIMATION

5.1 Introduction

Energy efficiency is a core pillar of sustainable manufacturing. In chemical process industries, **cooling water systems** are among the most power-intensive utilities due to the continuous operation of **large centrifugal pumps**, especially in multi-shift plants like Jubilant Ingrevia’s Unit 2.

Previous chapters identified two key inefficiencies:

1. **Over-pumping**: Flow rate of ~2000 m³/hr vs actual demand of ~1200 m³/hr
2. **Oversized piping**: Causing higher flow velocities, unregulated supply, and energy waste

In this chapter, we quantify the **cumulative energy loss**, **cost impact**, and **savings potential** through detailed calculations and case analysis.

5.2 Power Consumption by Pumping

Let us revisit the power formula for pump energy consumption:

Power (kW)=Q×H×γη×1000\text{Power (kW)} = \frac{Q \times H \times \gamma}{\eta \times 1000}Power (kW)=η×1000Q×H×γ​

Where:

* Q = Flow rate in m³/s
* H = Head in meters (assumed 30 m)
* γ = Specific weight of water (9810 N/m³)
* η = Pump efficiency (0.75 assumed)

5.3 Calculated Power Values

**Case 1: Current Condition**

* Flow rate (Q₁) = 2000 m³/hr = 0.5556 m³/s

P1=0.5556×30×98100.75×1000≈218.3 kWP\_1 = \frac{0.5556 \times 30 \times 9810}{0.75 \times 1000} \approx 218.3 \text{ kW}P1​=0.75×10000.5556×30×9810​≈218.3 kW

**Case 2: Optimized Condition**

* Flow rate (Q₂) = 1200 m³/hr = 0.3333 m³/s

P2=0.3333×30×98100.75×1000≈130.9 kWP\_2 = \frac{0.3333 \times 30 \times 9810}{0.75 \times 1000} \approx 130.9 \text{ kW}P2​=0.75×10000.3333×30×9810​≈130.9 kW

5.4 Energy Saved

Power Saved=P1−P2=218.3−130.9=87.4 kW\text{Power Saved} = P\_1 - P\_2 = 218.3 - 130.9 = \boxed{87.4 \text{ kW}}Power Saved=P1​−P2​=218.3−130.9=87.4 kW​

This is the amount of electrical power that can be saved **continuously** if flow is reduced to the calculated requirement.

5.5 Monthly & Annual Energy Savings

Now, let’s convert this power saving into energy and financial terms:

| **Metric** | **Value** |
| --- | --- |
| Hours per day | 24 |
| Days per month | 30 |
| Days per year | 365 |
| Electricity cost per unit | ₹7 per kWh (average in Gujarat) |

**Daily Energy Saved:**

87.4 kW×24 hrs=2097.6 kWh/day87.4 \text{ kW} \times 24 \text{ hrs} = 2097.6 \text{ kWh/day}87.4 kW×24 hrs=2097.6 kWh/day

**Monthly Energy Saved:**

2097.6×30=62,928 kWh/month2097.6 \times 30 = 62,928 \text{ kWh/month}2097.6×30=62,928 kWh/month

**Annual Energy Saved:**

2097.6×365=765,594 kWh/year2097.6 \times 365 = 765,594 \text{ kWh/year}2097.6×365=765,594 kWh/year

**Annual Cost Saving:**

765,594×₹7=₹53,59,158≈₹53.6 lakhs/year765,594 \times ₹7 = \boxed{₹53,59,158 ≈ ₹53.6 \text{ lakhs/year}}765,594×₹7=₹53,59,158≈₹53.6 lakhs/year​

5.6 5-Year Cumulative Savings

If no action is taken, over the next 5 years:

₹53.6 lakhs/year×5=₹2.68 crores₹53.6 \text{ lakhs/year} \times 5 = \boxed{₹2.68 \text{ crores}}₹53.6 lakhs/year×5=₹2.68 crores​

This excludes **maintenance savings**, **cooling tower load reduction**, and **lower carbon taxes** — all of which further increase the benefit.

5.7 Environmental Benefits

Reducing energy consumption also lowers **greenhouse gas (GHG) emissions**. The emission factor for Indian electricity grid is approximately:

0.82 kg CO₂/kWh0.82 \text{ kg CO₂/kWh}0.82 kg CO₂/kWh

So, annual CO₂ reduction:

765,594×0.82= 627,788 kg CO₂/year765,594 \times 0.82 = \boxed{~627,788 \text{ kg CO₂/year}}765,594×0.82= 627,788 kg CO₂/year​

That’s equivalent to:

* CO₂ absorbed by 28,500 mature trees per year
* Taking 150+ cars off the road annually

5.8 Savings from Pipe Optimization

Apart from pumping savings, additional savings can be expected from:

| **Source of Saving** | **Description** | **Estimate** |
| --- | --- | --- |
| Reduced Pump Maintenance | Less vibration and overload | ₹2–3 lakhs/year |
| Water Treatment Chemical Reduction | Less volume to treat | ₹1–1.5 lakhs/year |
| Lower Tower Fan Load | Less water → less heat to reject | ₹50k–₹1 lakh/year |
| Reduced Flow Imbalance Downtime | Better control → fewer line failures | ₹1 lakh/year approx. |

📌 **Total Additional Savings** ≈ ₹5–6 lakhs/year

5.9 Combined Financial Impact

| **Category** | **Annual Savings** |
| --- | --- |
| Pump Energy Saving | ₹53.6 lakhs |
| Piping & Control Optimization | ₹5–6 lakhs |
| **Total Annual Saving** | ₹58–60 lakhs |

🌱 **ROI for Automation Investment (e.g., VFDs, flow meters)** can be achieved within **6–8 months**

5.10 Suggested Investment Plan

| **Item** | **Estimated Cost** | **Payback Period** |
| --- | --- | --- |
| VFD Installation | ₹10–12 lakhs | < 6 months |
| Flow Meters + Orifice Plates | ₹2–3 lakhs | < 1 year |
| Training + SOP Development | ₹50,000 | — |

5.11 Conclusion

This chapter clearly demonstrates that **simple changes in system design**, like resizing pumps and balancing pipe flows, can lead to:

* **Huge energy savings** (~87.4 kW continuously)
* **Cost reductions** (₹58+ lakhs annually)
* **Environmental benefits** (627 tonnes CO₂/year)
* **Operational stability** (less equipment wear, smoother cooling)

It is **technically and financially feasible** for Jubilant Ingrevia to implement these measures immediately with minimal capital investment and fast returns.

CHAPTER 6

# ENVIRONMENTAL AND SAFETY ASPECTS

6.1 Introduction

Environmental sustainability and workplace safety are now integral components of every chemical industry’s operational strategy. Companies like **Jubilant Ingrevia Limited**, with a strong commitment to **ESG (Environmental, Social, and Governance)** compliance, strive to minimize environmental impact while ensuring high safety standards for both equipment and personnel.

This chapter outlines how optimizing the cooling water system in Unit 2 not only offers energy savings but also aligns with the plant’s **environmental protection goals**, **resource efficiency mandates**, and **safety management systems**.

6.2 Cooling Water System and Environmental Footprint

Cooling water systems have a **direct and indirect impact** on the environment through:

1. **Electricity Consumption**
   * Pumping large volumes 24x7 contributes significantly to plant’s total energy usage.
   * Most electricity is grid-supplied, which in India is **fossil-fuel dominated**, causing high carbon emissions.
2. **Freshwater Withdrawal**
   * Large volumes of water are drawn from rivers, borewells, or treated sources.
   * Overuse stresses local ecosystems and reduces water availability for nearby communities.
3. **Discharge to Environment**
   * Blowdown and drift from cooling towers may carry **TDS, chlorides, and biocides**.
   * Poor quality discharge can lead to soil and water body contamination.

6.3 Carbon Emission Impact

Electricity saved through pump optimization leads to reduced **CO₂ emissions**, calculated using India’s average emission factor (0.82 kg CO₂/kWh).

**Annual energy saved = 765,594 kWh**  
**CO₂ emissions avoided = 765,594 × 0.82 = 627,788 kg = 627.8 tonnes CO₂/year**

This is equivalent to:

* Annual CO₂ absorption by **28,500 mature trees**
* Taking **150 cars off the road**
* Saving emissions from **700 average households**

This makes a **strong case for carbon credit eligibility** or green certification under ISO 14001.

6.4 Water Conservation Benefits

By reducing flow from ~2000 m³/hr to ~1200 m³/hr, the plant can:

* Save **800 m³/hr** of unnecessary circulation
* Reduce total daily withdrawal by **~19,200 m³/day**
* Reduce blowdown volume and treatment chemical use
* Improve cooling tower performance (less load → higher cycles of concentration)

💧 This aligns with **Zero Liquid Discharge (ZLD)** and **water-positive site goals** that Jubilant aims to achieve.

6.5 Reduced Chemical Use in Water Treatment

Cooling water is typically treated with:

* Anti-scalants
* Biocides
* Corrosion inhibitors
* Alkalinity and hardness adjusters

These chemicals are **consumed in proportion to the volume of water** circulating. With reduced flow, chemical usage drops significantly, leading to:

* **Lower procurement cost**
* **Less chemical handling risk**
* **Reduced load on effluent treatment plants (ETP)**

Example: A 40% drop in circulating water can reduce chemical dosing by **30–50%** depending on control strategy.

6.6 Impact on Safety and Equipment Life

Safety is not limited to personal protection equipment (PPE) or fire drills—it is deeply tied to **system design and operational stability**.

**How Cooling System Optimization Improves Safety:**

| **Area** | **Risk if Unoptimized** | **Benefit if Optimized** |
| --- | --- | --- |
| Pipe Stress and Erosion | High flow velocity can damage pipes and cause leaks | Stable flow prevents erosion and rupture |
| Pump Vibration and Failure | Overload shortens pump life and increases breakdowns | Pumps operate at Best Efficiency Point (BEP) |
| Overcooling of Reactors | Can affect product quality or freeze-sensitive systems | Controlled cooling ensures stability |
| Manual Flow Adjustments | Unsafe operator intervention during batch runs | Automated control minimizes risk |
| Chemical Exposure | More water → more treatment → higher chemical exposure | Reduced flow = less chemical dependency |

🛡️ Thus, **risk is lowered**, **reliability is improved**, and **worker safety is enhanced**.

6.7 Compliance with Global Environmental Norms

This project supports Jubilant Ingrevia’s alignment with:

* **ISO 14001: Environmental Management System**
* **ISO 50001: Energy Management System**
* **Responsible Care Certification**
* **Sustainable Development Goals (SDG 6, 7, 12, 13)**

| **Goal** | **Contribution from Project** |
| --- | --- |
| SDG 6 – Clean Water | Reduced consumption & discharge |
| SDG 7 – Clean Energy | Lower power demand, improved efficiency |
| SDG 12 – Responsible Use | Reduced raw material (water + chemicals) use |
| SDG 13 – Climate Action | Reduced CO₂ emissions and lower environmental footprint |

6.8 Opportunities for Green Innovation

* Install **flow meters** and link with **SCADA** for intelligent optimization
* Use **non-chemical treatment** (ozone/UV) in low-duty systems
* Implement **rainwater harvesting** for cooling tower make-up
* Develop **carbon offset projects** through energy audits

This project opens the door for Jubilant Bharuch to be a **model plant for green manufacturing** within the specialty chemical sector.

6.9 Summary

| **Environmental Area** | **Outcome of Optimization** |
| --- | --- |
| CO₂ Emissions | ~627 tonnes/year avoided |
| Water Withdrawal | ~19,000 m³/day saved |
| Chemical Usage | Up to 40–50% reduced |
| Discharge Load | Lower blowdown volume and pollutant load |
| Equipment Integrity | Better flow control = longer life and safety |

6.10 Conclusion

Through a purely engineering-driven initiative, this project shows how **energy and utility optimization** contributes significantly to:

* **Reducing environmental impact**
* **Improving safety for operations and personnel**
* **Supporting national and global sustainability mandates**

By continuing such efforts across other utility streams (steam, compressed air, etc.), Jubilant Ingrevia can lead the sector in **green process transformation**.

CHAPTER 7

# RECOMMENDATIONS AND OPTIMIZATION STRATEGIES

7.1 Introduction

The preceding chapters have highlighted a clear gap between the **existing performance** of the cooling water system and its **theoretical efficiency potential** at Jubilant Ingrevia, Unit 2.

This chapter presents **practical and data-backed recommendations** to bridge this gap, covering:

* Equipment upgrades
* Operational improvements
* Monitoring tools
* Investment considerations
* Long-term SOPs (Standard Operating Procedures)

These suggestions are tailored to **maximize energy savings, reduce resource wastage, and ensure sustainable long-term operation**.

7.2 Summary of Findings

Let’s revisit the key inefficiencies identified:

| **Area** | **Observation** |
| --- | --- |
| Pumping | Over-designed: 2000 m³/hr vs 1200 m³/hr demand |
| Power Consumption | 218.3 kW actual vs 130.9 kW required |
| Pipe Sizing | Most lines oversized (used 3” instead of 1.5–2”) |
| Flow Control | Manual valves or none; no feedback-based control |
| Energy Wastage | 87.4 kW continuously = ₹53+ lakhs/year |
| Flow Imbalance | Few equipment overcooled, some under-supplied |

7.3 Immediate Operational Recommendations

These are **low-cost**, **quick-win solutions** that can be implemented with minimum downtime:

**1. Install Flow Restriction Devices (Orifice Plates)**

* Helps reduce flow to over-supplied equipment
* Maintains turbulence for heat transfer
* Simple retrofit without full pipe replacement

*Estimated cost: ₹1,000–2,000 per line*

**2. Valve Adjustment SOP**

* Create a standard document specifying optimal valve positions
* Operators to follow these settings during each startup
* Prevents human error and trial-based opening

*Integrate into utility operations logbook*

**3. Monitor Idle Equipment Flow**

* Use temporary ultrasonic flow meters to detect unused lines with active flow
* Redirect this water using bypass valves

*Could save 5–10% of circulating water instantly*

7.4 Medium-Term Engineering Modifications

These involve hardware upgrades but offer **fast return on investment**:

**4. Install Variable Frequency Drive (VFD) on Cooling Pump**

* Regulates pump speed based on load
* Avoids throttling losses
* Improves motor lifespan and reduces vibration

*Estimated cost: ₹10–12 lakhs*  
 *Payback: < 6–8 months (based on ₹53 lakh/year saving)*

**5. Replace Oversized Pipes During Turnaround**

* Gradually replace oversized pipe sections during shutdown
* Focus on short runs connected to low-duty exchangers/reactors

*Target sections with >30% excess diameter*

**6. Segregate Header Networks**

* Separate cooling headers into:
  + High-demand equipment
  + Batch/on-demand users
* Install **automatic isolation valves**

*Reduces recirculation to idle areas*

7.5 Long-Term Digitalization & Automation

For sustainable utility optimization, adopt digital tools:

**7. Install Ultrasonic Flow Meters**

* Non-intrusive, easy to install
* Real-time monitoring of actual vs target flow
* Can be connected to DCS or SCADA

**8. Cooling System SCADA Integration**

* Use data to automatically adjust pump speed (via VFD)
* Set alarms for deviation beyond ±10% of expected flow
* Enables remote visibility and optimization

**9. Energy Dashboard for Utility Monitoring**

* Include:
  + Pump power consumption
  + Cooling water return temperature
  + Make-up water usage
* Use this dashboard to track real savings monthly

7.6 Suggested Investment Roadmap

| **Investment Item** | **Estimated Cost** | **Payback Period** |
| --- | --- | --- |
| VFD for Cooling Pump | ₹10–12 lakhs | 6–8 months |
| Flow Meters (10 units) | ₹4–5 lakhs | 1 year |
| Orifice Plates (20+ lines) | ₹0.5–1 lakh | Immediate impact |
| Header Resegregation | ₹2–3 lakhs | 1–2 years |
| SOP Development & Training | ₹25,000 | Ongoing benefit |

**Total Investment:** ~₹18–20 lakhs  
 **Payback Period (Full System):** < 1 year

7.7 Recommendations for Standard Operating Procedure (SOP)

Implement the following checklist-based SOPs:

**Cooling Startup Checklist**

* Open valves as per predefined positions
* Ensure flow matches equipment demand
* Confirm flow meter readings before initiating pump

**Weekly Monitoring**

* Log flow rates from installed meters
* Compare with ideal range per equipment
* Flag any high-deviation lines to maintenance

**Monthly Review**

* Validate savings with actual power bills
* Track KPIs:
  + Cooling water per unit production
  + Energy cost per kL water circulated
  + CO₂ footprint reduction (in tonnes)

7.8 Risk Mitigation Plan

| **Potential Risk** | **Mitigation Strategy** |
| --- | --- |
| Low flow during startup | Use bypass line to ramp-up gradually |
| Operator resistance to change | Training + digital displays for clarity |
| Flow restriction errors | Trial with temporary flow meters first |
| Pipe scaling with low velocity | Maintain minimum turbulence via design |

7.9 Conclusion

Implementing the above recommendations will help Jubilant Ingrevia achieve:

* 25–30% reduction in pumping energy
* 35–40% lower cooling water volume
* Improved equipment life
* Better process temperature control
* Stronger alignment with ESG and sustainability targets

The project is not only technically feasible but also **financially compelling**, with **high ROI** and **long-term strategic value** for the plant.

CHAPTER 8

# CONCLUSION

8.1 Project Summary

This internship project, titled **“Cooling Water Requirement Calculation and Power Saving in Unit 2”**, was conducted at **Jubilant Ingrevia Limited, Bharuch**, as part of an intensive summer training program.

The study focused on understanding and optimizing the cooling water utility system—a critical part of plant operations that directly affects:

* Energy consumption
* Equipment efficiency
* Process stability
* Environmental sustainability

Through detailed equipment-wise flow rate analysis, pump load calculations, pipe sizing checks, and system performance audits, the project identified multiple areas for technical and operational improvement.

8.2 Key Findings

| **Area Studied** | **Findings** |
| --- | --- |
| Cooling Water Requirement | Actual demand ~1200 m³/hr vs pump delivery 2000 m³/hr |
| Pumping Power | Excess consumption of ~87.4 kW continuously |
| Pipe Sizing | Most pipes oversized by 1–2 inches; leads to imbalance |
| Flow Control | Manual/no control at individual equipment level |
| Energy Wastage | ₹53.6 lakh/year in electrical losses |
| Environmental Impact | 627+ tonnes/year of CO₂ can be reduced |

8.3 Outcomes and Benefits

The project outcomes are **quantifiable** and **actionable**. If the recommendations are adopted, Jubilant Ingrevia Unit 2 can expect:

* **25–30% energy reduction** in utility pumping
* Over **₹58 lakhs annual cost saving**
* **Improved equipment life** and lower breakdown frequency
* **More balanced and efficient cooling distribution**
* Contribution toward **SDG and ESG targets**
* Stronger eligibility for **ISO 14001 and ISO 50001 audits**
* Lower **cooling water blowdown** and chemical treatment demand

8.4 Contribution to Organization

This report goes beyond theoretical recommendations—it serves as a **ready-to-implement action plan** for utility optimization. By:

* Performing realistic engineering calculations
* Using actual plant data from equipment in Unit 2
* Linking outcomes to sustainability and safety goals
* Proposing cost-effective retrofits (VFDs, orifice plates, flow meters)

…it provides the **groundwork for a full-scale cooling water optimization initiative.**

8.5 Learnings and Technical Exposure

During the course of this project, I (Manish Kumar) gained hands-on understanding of:

* Utility system operation in large-scale chemical plants
* Hydraulic calculations (flow rate, head, pressure drop)
* Real-world energy auditing and analysis
* Pipe sizing techniques and flow control hardware
* Excel-based data handling and industrial reporting
* Integration of environmental thinking into engineering design

These experiences have deeply enhanced my knowledge as a chemical engineering student and prepared me for future roles in process optimization, utilities, and energy management.

8.6 Scope for Future Work

This project focused specifically on **Unit 2** of Jubilant Ingrevia’s Bharuch facility. Further work may involve:

* Replicating similar audits for other plant units (Unit 1, Unit 3)
* Expanding to steam, compressed air, and chilled water systems
* Automating the entire utility performance tracking via SCADA
* Exploring carbon credit eligibility for energy savings
* Applying for **Green Building Certification** based on cumulative savings

8.7 Final Words

This internship project reinforces the idea that **small inefficiencies**, when multiplied across continuous operations, can lead to **huge hidden costs**. Fortunately, with the right data, tools, and approach, **most of these inefficiencies are avoidable**.

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