



# Energy Conservation Guidelines for **Industrial Sector**

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## Energy Efficiency Guidelines for Industrial Sector

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## Preface

Bahrain's electricity and water industry is being transformed at a time countries globally commit to decarbonization targets. Bahrain is committed to achieving net-zero by 2060 and the Electricity and Water Authority (EWA) has an important role to play in this process. Consequently, EWA developed its Energy Transition Plan and has set a target to depend on renewable sources for 5% of the Kingdom's entire electricity production by 2025, and 20% by 2035.

The industrial sector is an essential element in the Energy Transition Plan and an important pillar of the economy. In the Kingdom of Bahrain, the industrial sector consumes about 16% of the overall electricity supplied by the EWA.

With the continuous growth in Bahrain's economic development, it is inevitable that energy consumption in this sector will also increase. However, energy conservation can be implemented to reduce the energy consumption and improve energy efficiency.

Therefore, EWA has prepared Energy Conservation Guidelines for the Industrial Sector. By implementing these Guidelines, industries can reduce their billings, make a significant contribution to reduce energy consumption and improve sustainability in the Kingdom of Bahrain.

## INTRODUCTION

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## 1. Introduction

The Energy Conservation Guidelines for Industrial Sector have been prepared by the Electricity & Water Authority, Kingdom of Bahrain to enable Industrial consumers to reduce electricity consumption.

The guidelines provided in this booklet concentrate on the common equipment found in most industries. Common equipment provide support for the production process and account for only a low share of total energy consumption in the industry. Common equipment covered in this booklet are as in the following Table.

No.	Equipment
1	Air Compressors & Compressed Air System
2	Pumps & Pumping System
3	Fans & Blowers
4	Electric Motors
5	Lighting
6	HVAC

**Guidelines for each equipment is grouped under:**

- a. Operation & Management
- b. Necessary measures when installing new facilities
- c. Target components

## AIR COMPRESSORS

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## 2. Air Compressors

### 2.1 Operation & Management

- Ensure that the quality of suction air to the compressor is clean, cool, and dry air for optimum performance.
- Pre-set a minimum generation pressure of compressed air based on plant requirements to optimize the performance.
- Maintain optimum pressure setting of slightly more than maximum requirement for the plant to compensate envisaged pressure losses in distribution line.
- Install receiver tanks of sufficient capacities for compressed air storage to cater to load demands and process fluctuations without any trouble irrespective of compressor operational status.
- Use suitable size of air compressor to meet compressed air demands.
- The industry shall use dedicated air compressors to meet exclusive high or low pressure demands.
- Install intelligent flow controller for effective compressed air demand management involving multiple compressor operation.
- Use the most energy efficient compressors to meet base load in case of multi compressor operation.
- Isolate compressed air distribution lines wherein compressed air is not required for a prolonged time.
- Install suitable pressure gauges on discharge side of air compressor pipeline, air receivers, and end-use points to monitor the pressure of the compressed air for estimating pressure losses in distribution lines.
- Use air blowers or air gun, wherever feasible, to reduce compressed air usage and leakage levels.



## 2.2 Necessary measures when installing new facilities

- Install Energy efficient systems such as Built in VFD or Inverter driven compressor.
- Install compressor with lowest Specific Power Consumption (SPC)
- Avoid installing oversized compressors.
- Install air compressor closer to point of use.
- Consider ring main loop header for minimizing pressure losses.
- Use seamless metallic pipes or fiber reinforced plastic (FRP) pipe.
- Install optimum size piping and increase diameter of pipes whenever a new compressor is added to the system.
- Avoid unnecessary bends and turns in distribution network to reduce pressure losses.
- Take tapings from branches from top of the main line.
- Install separate high pressure and low-pressure lines.
- Use moisture separators to remove moisture before entering pneumatic equipment. The separator is not required if the industry has installed air dryer.
- Install dedicated air receiver close to the location wherein intermittent high volume compressed air is required.
- Install pressure reduction valves for low pressure applications and boosters for high pressure applications.
- Meet fluctuations in compressed air demands using VFD-enabled screw air compressors. While using multiple air compressors system, the industry shall use one-inverter type air compressor with a suitable pressure setting to meet the variable load conditions while the other air compressors shall be used in continuous operation to cater to the base load. Use reciprocating compressor for part-load applications.
- Use centrifugal compressors for meeting high volume air with low pressure applications, wherever feasible.

- Install air dryers in the distribution line which supplies to dry air usage points only, for example, instrumentation air.
- Ensure the proper location of air compressors and the quality of suction air as per the recommendation of OEM.
- Avoid exposure of compressor to direct sunlight or other heat producing units, while ensuring adequate ventilation of air compressor room.

### 2.3 Target components

- Ensure compressed air leakage is within 3% to 10%.
- Maintain operating Specific Power Consumption (SPC) within the design range as provided by the
- Original Equipment Manufacturers.

Typical Specific Power Consumption (SPC) levels of different types of air compressors used in the industry are provided in the following Table.

Type	FAD range (cfm)	Pressure range (bar)	SPC range (kW/cfm)
Reciprocating	20–7000	0.8–12	0.20–0.35
Screw (Single stage)	50–1500	0.8–13	0.14–0.25
Screw (Multistage)	50–1500	0.8–24	0.18–0.35

Effect of pressure drop across air inlet filter on power consumption

Pressure drop across air filter (mm WC)	Increase in power consumption (%)
0	0
200	1.6
400	3.2
600	4.7
800	7.0

# Pumps and Pumping Systems

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## 3. Pumps and pumping systems

### 3.1 Operation & Management

- Operate pumps close to the best operating point as specified by the OEMs. It shall ensure optimum loading of the pumps.
- Use pumps with highest efficiency to meet the base load when multiple pumps are in operation.
- Install variable frequency drive (VFD) for fluctuating loads instead of throttling.
- Use on-line monitoring for centralized large system and periodical measurement for decentralized smaller pumps.
- Use a number of smaller pumps in parallel operation in place of single pump of higher capacity.
- Manage and control the loading of pumps near the best operating point of respective characteristic curve in case of multiple pumps in meet process requirements.
- Replace worn-out pumps with energy efficient pumps.
- Maintain a minimum Net Positive Suction Head (NPSH) of pumps as prescribed by the manufacturer.

### 3.2 Necessary measures when installing new facilities

- Undertake demand assessment of air to select suitable fan or blower as applicable, while considering the dust type, its concentration, etc., while handling dust-laden gases.
- Select and install correct capacity of fan/ blower with highest efficiency as provided in Table 5.6, considering existing requirements, immediate expansion plans, plant layout, and routing of pipes.
- Avoid unnecessary bends and turns while installing air ducts.

- Install direct coupled motor drives wherever possible.
- Provide sufficient straight length of duct (at least 3 times the duct diameter) and shall avoid bends close to fan inlet to avoid uneven air flow and vibrations.
- Undertake demand assessment of air to select suitable fan or blower as applicable, while considering the dust type, its concentration, etc., while handling dust-laden gases.
- Select and install correct capacity of fan/ blower with highest efficiency as provided in Table 5.6, considering existing requirements, immediate expansion plans, plant layout, and routing of pipes.
- Avoid unnecessary bends and turns while installing air ducts.

### **3.3 Target components**

- Ensure operating efficiency of fan/ blower close to the design values provided by the OEMs.
- Replace rewound motors in pumps with energy efficiency motors.

## Fans and Blowers

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## 4. Fans and blowers

### 4.1 Operation & Management

- Ensure that the quality of suction air to fan or blower is clean for optimum performance.
- Ensure no blockage or restrictions at inlet or suction of fan or blower.
- Manage and operate fans and blowers close to best operating point of the characteristic curve, as provided by the manufacturer.
- Use blowers in series for high resistance, and in parallel connection for low resistance system in case of multiple blower operation.
- Use multiple blowers in parallel to generate higher volume in place of a single, large pumping system.
- Undertake pressure holding test to detect and plug-off for leakages in distribution system.
- Replace over-sized fans/ blowers with optimum size system to meet the process requirements for high-load conditions.
- Retrofit existing fan or blower with a VFD in case of fluctuating load conditions in place of damper control.
- Use on-line monitoring for centralized large system and periodical measurement for decentralized smaller blowers.

### 4.2 Necessary measures when installing new facilities

- Undertake demand assessment of air to select suitable fan or blower as applicable, while considering the dust type, its concentration, etc., while handling dust-laden gases.



- Select and install correct capacity of fan/ blower with highest efficiency as provided in Table 5.6, considering existing requirements, immediate expansion plans, plant layout, and routing of pipes.
- Avoid unnecessary bends and turns while installing air ducts.
- Install direct coupled motor drives wherever possible.
- Provide sufficient straight length of duct (at least 3 times the duct diameter) and shall avoid bends close to fan inlet to avoid uneven air flow and vibrations.
- Undertake demand assessment of air to select suitable fan or blower as applicable, while considering the dust type, its concentration, etc., while handling dust-laden gases.
- Select and install correct capacity of fan/ blower with highest efficiency as provided in Table 5.6, considering existing requirements, immediate expansion plans, plant layout, and routing of pipes.
- Avoid unnecessary bends and turns while installing air ducts.

#### **4.3 Target components**

- Ensure operating efficiency of fan/ blower close to the design values provided by the OEMs.
- Replace rewound motors in pumps with energy efficiency motors.

## Electric Motors

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## 5. Electric Motors

### 5.1 Operation & Management

- Operate motors in the range of 75%–80% load for maximum efficiency.
- Avoid under-loading of the motors.
- Stop motor driven equipment when not in use or during idle operation.
- Ensure balancing of voltage in all three phases of motors for optimum performance.
- Ensure operating power factor close to unity.
- Ensure adequate ventilation of motors to avoid overheating.
- Use direct online (DOL) starters for motors up to 3.75 kW, star-delta type starters for 3.75 kW–15 kW motors, and soft starter for motor with more than 15 kW capacity.
- Avoid rewinding of motors more than two times. Replace rewound and standard motors with energy-efficient motors.

### 5.2 Necessary measures when installing new facilities

- Install energy saving measures, such as VFD, fluid couplings, etc., for variable load applications to minimize energy consumption.
- Use cogged v-belts instead of flat v-belts for belt driven motor applications.

### 5.3 Target components

- Install Energy Efficient motors for various applications.
- Maintain unbalanced voltage within 1%–3%.

Lighting

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## 6. Lighting

### 6.1 Operation & Management

- Maintain lighting systems in different areas based on standard illumination levels as provided in Table 5.1
- Install suitable control systems to auto switch off or dimming of lighting system. The control systems include motion sensors, timers, interlocking with security systems to avoid lighting when not required, etc.
- Manage dimming or turning-off the light in a way that eliminates excessive or unnecessary lighting.
- Eliminate unwanted lighting within the industrial premises.
- Use natural lighting wherever feasible.

### 6.2 Necessary measures when installing new facilities

- Replace inefficient lighting with energy-efficient lighting facilities, such as LEDs, induction lamps, etc.
- Maintain standard illumination with minimum lighting power density (LPD). The LPD range for a few application areas in industries is shown in Table 5.2.
- Select suitable lighting fixtures that can be easily maintained and allow easy cleaning and replacement of light source.
- Provide due consideration to factors affecting the total lighting efficiency while selecting lighting fixtures. The factors include illuminance efficiency of the light sources, efficiency of lighting circuits and lighting fixtures, etc.
- Ensure maximum use of natural day light and reduce electric lighting load, for example, use of translucent roof, large fibre glass skylight, high opening in the wall, etc.
- Use solar photo voltaic (SPV)-based lighting system wherever feasible.

### 6.3 Target components

Ensure illumination level as specified below.

*Table 6.1. Standard illumination for lighting*

Lighting	Average Illumination (Lux)	Limited Glare Index
Furnace rooms, bending, annealing lehrs	100	28
Mixing rooms, forming (blowing, drawing, pressing, rolling)	150	28
Cutting to size, grinding, polishing, toughening	200	25
Finishing (Beveling, decorating, etching, silvering)	300	22
Brilliant cutting	700	19
General inspection	200	19
Fine inspection	700	19
Storage areas	150	25
Maintenance workshop	150	28
Entrance, corridors, stairs	100	28
Outdoor areas	20	25

Ensure lighting power density (LPD), as specified below.

*Table 5.2. Lighting power density for industries*

Lighting	Average Illumination (Lux)	Lighting Power Density (w/m <sup>2</sup> )
Administrative building	50-400	5.0 – 9.5
Administrative corridor	100	2.3 – 7.1
Shop floor lighting (process)	150-300	6.0 – 12.0
Workshop	150-300	7.2 – 14.1
Warehouse – storage area	100-150	3.5 – 7.8

HVAC

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## 7. HVAC

### 7.1 Operation & Management

- Devise and follow a suitable energy management plan, which shall include periodical as well as preventive maintenance schedule.
- Keep HVAC system Off during unoccupied periods or increase the set temperature if need to be in operation.
- Replace or clean air filters and coils periodically as these are the two most critical elements in HVAC system.
- Reset chiller coil temperature as most of the time designed peak load may not be reached. It is possible to slightly increase the temperature saving chiller energy. Load decreases 3% by increasing the coil temperature by 1 deg C.
- In water cooled chillers, reduce the condenser water temperature to increase the efficiency of chillers.
- Ensure proper insulation is maintained for air ducts and chilled water pipes.

### 7.2 Necessary measures when installing new facilities

- Install energy efficient HVAC equipment with approved labelling showing higher number of stars.
- Use suitable size of HVAC equipment matching the end use application (Avoid installing oversized equipment)
- Install programmable thermostats.
- Install energy meters to monitor electricity consumption for HVAC system as well as for large equipment.
- Install Building Management System (BMS)
- Install variable speed drives for pumps and fans.
- Install air curtains



### 7.3 Target components

- Ensure HVAC equipment comply with minimum energy performance standards (approved label on the equipment with energy values and star rating)
- Ensure the room temperature set at 24 deg C in the relevant thermostats. It is recommended to install programmable thermostats.
- Ensure infiltration and leakages are arrested.



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