GGGI

ASIA LOW CARBON BUILDINGS TRANSITION PROJECT

Life Cycle Assessment for Transitioning to a Low-Carbon Economy | PROJECT

2.7 Building Energy Audits

November 2024

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IKI INTERNATIONAL CLIMATE INITIATIVE

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WHAT WILL YOU LEARN?

01 Objectives of energy audit

02 Building energy audits: Scope and methodology

03 Instruments required for site measurements

04 Holistic systems approach to energy audit

05 Energy saving opportunities in pumps and water chillers

06 Major energy consuming equipment in buildings

07 Buildings: Areas demanding detailed site study and analyses

ENERGY AUDIT

A diagnostic tool for energy management

- The most commonly-practiced energy performance assessment tool
- Walk-through energy audits
- Detailed energy audits

Energy Auditor

Portable Gadgets

Data Analysis

Energy audit is NOT a fault-finding exercise, but an approach to identify energy saving opportunities and scope for performance improvement

ENERGY AUDIT

A diagnostic tool for energy management

An *energy audit* can be defined as a systematic exercise for collection and analyses of information on energy consumption and energy costs at macro and micro levels with the following objectives:

- Understand energy consumption and associated costs
- Quantify energy in: per unit of building floor area, per bed in a hospital, per room in a hotel, per employee in a commercial building, per unit of delivery service, per unit of production in an industry, etc.
- Quantify operating energy efficiencies in processes and equipment, supplementing gaps in comparison with best practices
- Identify opportunities to reduce energy consumption and costs through operational changes, retrofits and energy efficient alternatives
- Explore opportunities for substitution of conventional fossil fuel-based energy sources with renewable energy sources
- Explore energy supply side opportunities to reduce energy costs

Image source: https://comelectrical.com/energy-audit-importance-and-why-you-should-be-prioritizing-it/

ENERGY AUDIT (EA)

Types based on objectives, time and resources employed

Preliminary walk-through EA

A walk-through study usually takes one or two days, depending on the size of the facility, for a quick review of energy consumption and costs, and physical observations of operations without any measurements, to identify areas with potential for energy savings (without detailed measurements or quantification)

Detailed EA

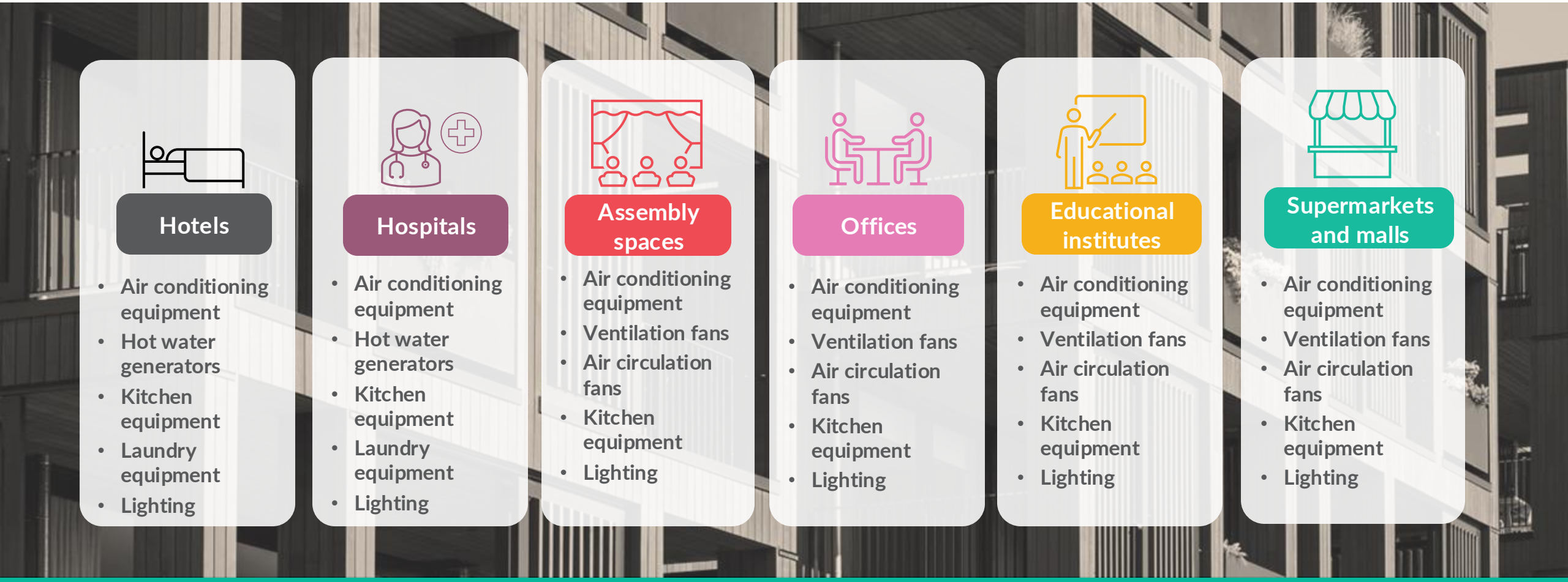
A detailed study is conducted over a few days or weeks, depending on the size of the facility, involving detailed observations, measurements and analyses for quantification of process and equipment efficiencies, identification of energy and cost saving opportunities, and detailing of recommended measures, with cost-benefit analyses

Investment grade EA

A very detailed study for preparation of a bankable project report for selected processes and equipment with accurate quantification of energy and cost saving potential, detailing of required project hardware and software, with accurate cost estimates (supported with budgetary quotes from solution providers), and financial analyses

BUILDINGS

High-energy-consuming equipment



Hotels

- Air conditioning equipment
- Hot water generators
- Kitchen equipment
- Laundry equipment
- Lighting

Hospitals

- Air conditioning equipment
- Hot water generators
- Kitchen equipment
- Laundry equipment
- Lighting

Assembly spaces

- Air conditioning equipment
- Ventilation fans
- Air circulation fans
- Kitchen equipment
- Lighting

Offices

- Air conditioning equipment
- Ventilation fans
- Air circulation fans
- Kitchen equipment
- Lighting

Educational institutes

- Air conditioning equipment
- Ventilation fans
- Air circulation fans
- Kitchen equipment
- Lighting

Supermarkets and malls

- Air conditioning equipment
- Ventilation fans
- Air circulation fans
- Kitchen equipment
- Lighting

BUILDING ENERGY AUDITS

Typical scope of work

- Energy usage pattern (billing and inventory)
- Transformer (loading and operation)
- DG set (loading and specific fuel consumption)
- Lighting system (inventory, lighting index and illumination survey)
- Air conditioning system (energy efficiency ratio and operation)
- Boiler (efficiency and operation)
- Water pumping system (specific water consumption, pump operation and pump efficiency)
- Hot water generating system (specific energy consumption and efficiency)
- General observation (laundry and kitchen)

Critical aspects of energy audits

- **Scope of audit**
- **Quality auditor**
- **Quality data**
- **Gadgets and instrument**
- **Participative**

BUILDING ENERGY AUDITS

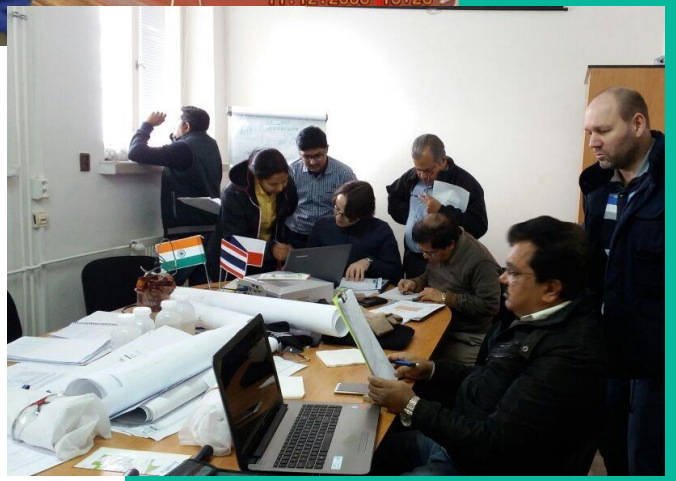
Important equipment

- Electric motors
- Central water chillers
- Unitary air conditioners
- Precision air conditioners
- Steam and hot water generators
- Heat pumps
- Air handling units
- Cooling towers
- Pumps
- Fans and blowers
- Kitchen and pantry equipment
- Laundry equipment
- Office equipment
- Lighting

BUILDING ENERGY AUDITS

Objectives

- Correlate monthly energy consumption and cost with service delivered, floor area, occupancy, weather parameters, etc. for establishing Energy Performance Indexes (EPIs) with appropriate metrics and benchmarking
- Understand energy sources and accounting of energy consumption in significant end uses. Typical energy guzzlers are building air conditioning, hot water generation, kitchen equipment, laundry equipment and lighting
- Establish energy efficiencies or alternative figures of merit for energy-intensive equipment and systems
- Identify gaps and opportunities for energy optimization by improving energy efficiencies, reduction of losses and other innovative measures
- In buildings with both heating and cooling applications, explore possibilities for heat integration, including waste heat and cold recovery, to reduce the demand for cooling and heating
- Explore scope for using renewable energy for electricity generation and heating and cooling applications
- Suggest improvements in the energy monitoring and control system



BUILDING ENERGY AUDITS

Approach and methodology

- Walk through building and utility areas to understand energy sources, energy-intensive end-use equipment and systems, building utilization, occupancy patterns, etc.
- Collect monthly energy consumption data (overall and area-wise), energy costs, inventory of electrical and fuel-fired equipment, and weather data
- Critically review information from building management system or energy management system (if available)
- Holistically study energy-intensive equipment and systems. In most buildings, high energy consumption can be expected in air conditioning, water heating, water pumping and lighting
- Perform spot measurements and prolonged data logging (if required) of operating parameters of relevant equipment and systems
- Confirm segregation and utilization of air-conditioned and naturally-ventilated building spaces. This includes quantification of building cooling and heating load (sensible and latent heat loads) and contribution of heat ingress from building envelope (roof, walls, glass and air ingress)

BUILDING ENERGY AUDITS

Approach and methodology (continued)

- Quantify equipment and system energy efficiencies or appropriate figures of merit
- Quantify energy consumption in lighting during daytime and nighttime, with the objective of reducing daytime electric lighting
- Understand the energy consumption of energy-intensive appliances, such as unitary air conditioners, hot water generators, laundry equipment, kitchen equipment, etc.
- Identify unused roof area and other open areas for possible installation of solar photovoltaic systems or solar heating systems
- Critically analyze data to identify energy saving opportunities from operational changes, retrofits or replacements with more efficient equipment
- Firm up energy saving recommendations, along with quantification of energy saving potential, estimates of investment required, projected returns on investment, and contacts of relevant vendors and solution providers
- Draft the energy audit report, followed by presentation and discussion with clients
- Finalize the energy audit report, incorporating clients' concerns and modifications in recommendations

ENERGY AUDIT

Instruments used in site studies

Power analyzer with clamp-on current transformers

Image source: Krykard

Ultrasonic flow meters

Image source: Acorn Controls

Anemometer

Image source: UNI-T

Flue gas analyzer

Image source: Testo

Thermometers

Image source: Artech

ENERGY AUDIT

Instruments used in site studies (continued)

Sling psychometer

Image source: BHI

Manometer with pitot tube

Image source: Sunflow Technologies

Pressure gauges

Image source: Nishka Instruments

Lux meter

Image source: Lutron

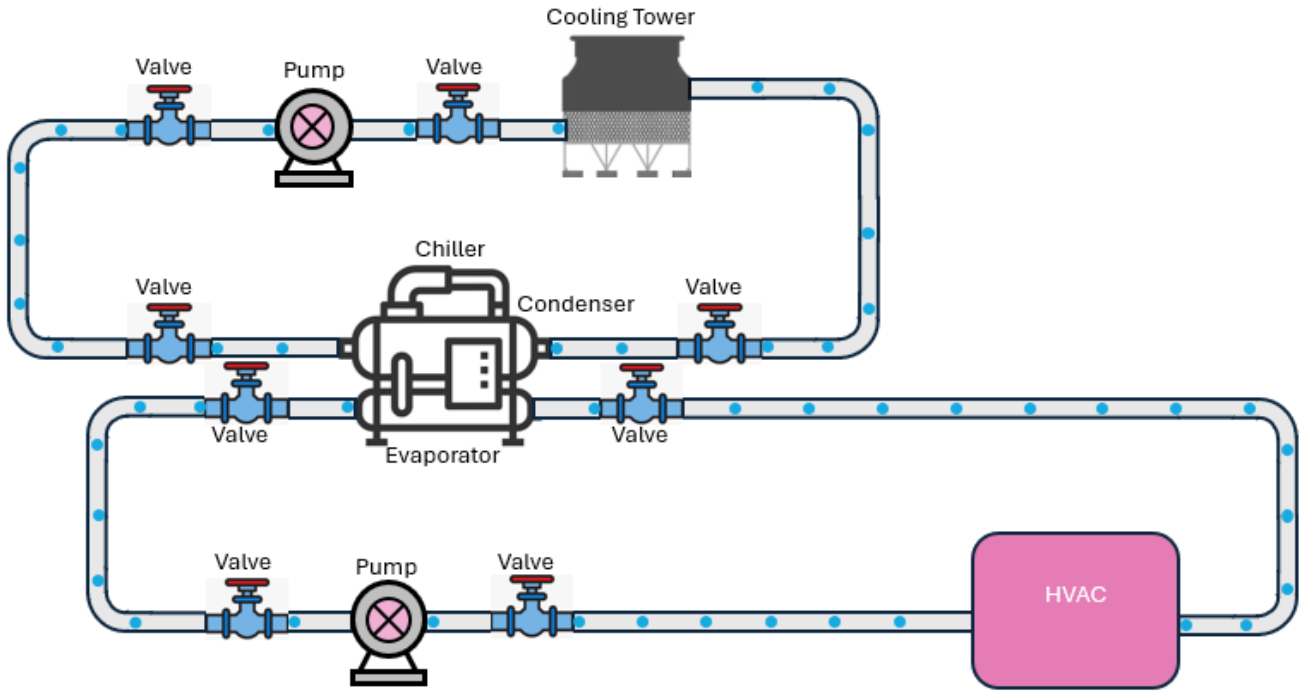
Thermal imager

Image source: Testo

ENERGY AUDIT

HVAC system: A holistic approach is recommended

- To achieve significant energy savings, it is recommended that each energy-intensive equipment is not studied in isolation, but as part of the larger system in which it operates
- For example, a pump operates in a system involving piping, valves, heat exchangers, etc. Even when the pump efficiency is good, the overall pumping system efficiency may be poor due to excess flow or avoidable pressure losses in the system
- Similarly, a water chiller may be efficient, but the heat of load on the chiller may comprise of some spurious, avoidable heat loads
- In the case of lighting, the priority should be to maximize the use of natural lighting before focusing on energy efficient lamps, gears and controls



Typical chilled water system

Image source: Devki Energy Consultancy Pvt. Ltd., India

HVAC PUMPING SYSTEM

Energy losses in HVAC system circulation pumps

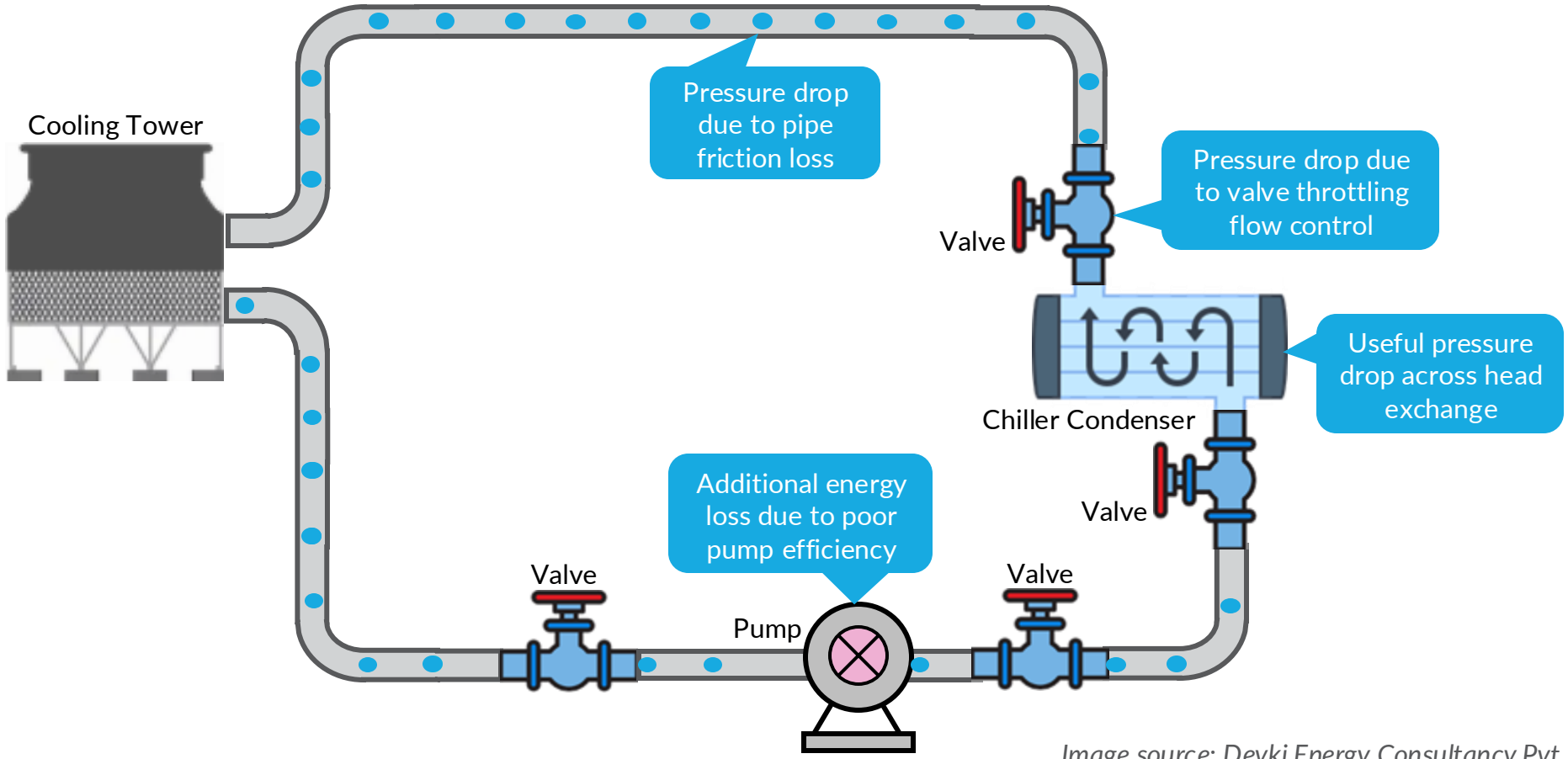
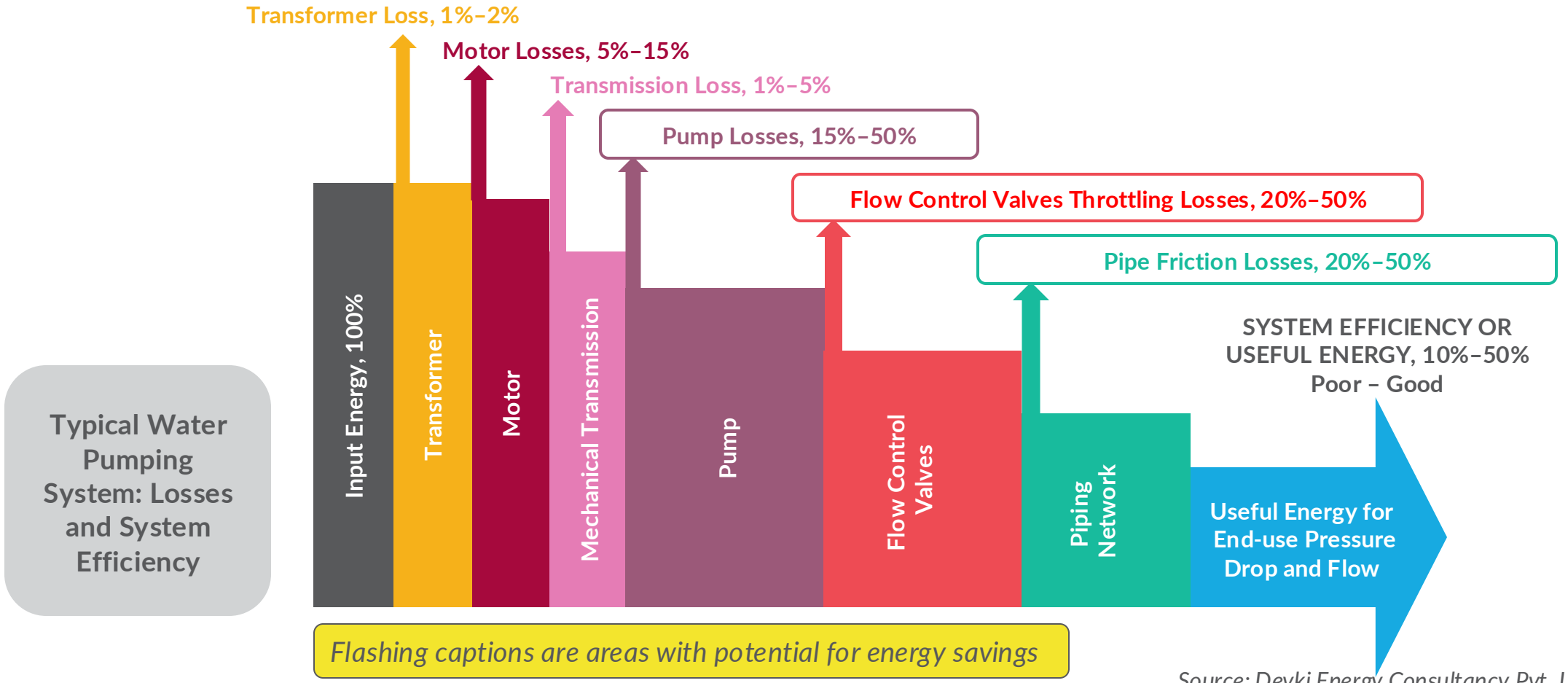


Image source: Devki Energy Consultancy Pvt. Ltd., India

HVAC PUMPING SYSTEM

A holistic understanding of energy losses and system efficiency



Source: Devki Energy Consultancy Pvt. Ltd., India

HVAC PUMPING SYSTEM

Typical energy saving opportunities

- Optimization of chilled and cooling water circulation rates and operating head
- Elimination of valve throttling losses by incorporating variable speed drives for flow control
- Optimization of the number of parallel pumps in a system for achieving good operating efficiency and reliability
- Ensuring optimal sizing of pipes to reduce pressure losses due to pipe friction
- Selection of appropriately-sized high efficiency pumps
- Regular pump maintenance, monitoring and control to ensure optimal operation

Pumping system efficiencies (including all system losses) can be improved from usually prevailing levels of 10%–20% to 40%–50% by minimizing or eliminating valve throttling losses and ensuring selection of pumps with optimal head and flow, with the highest available pump efficiency

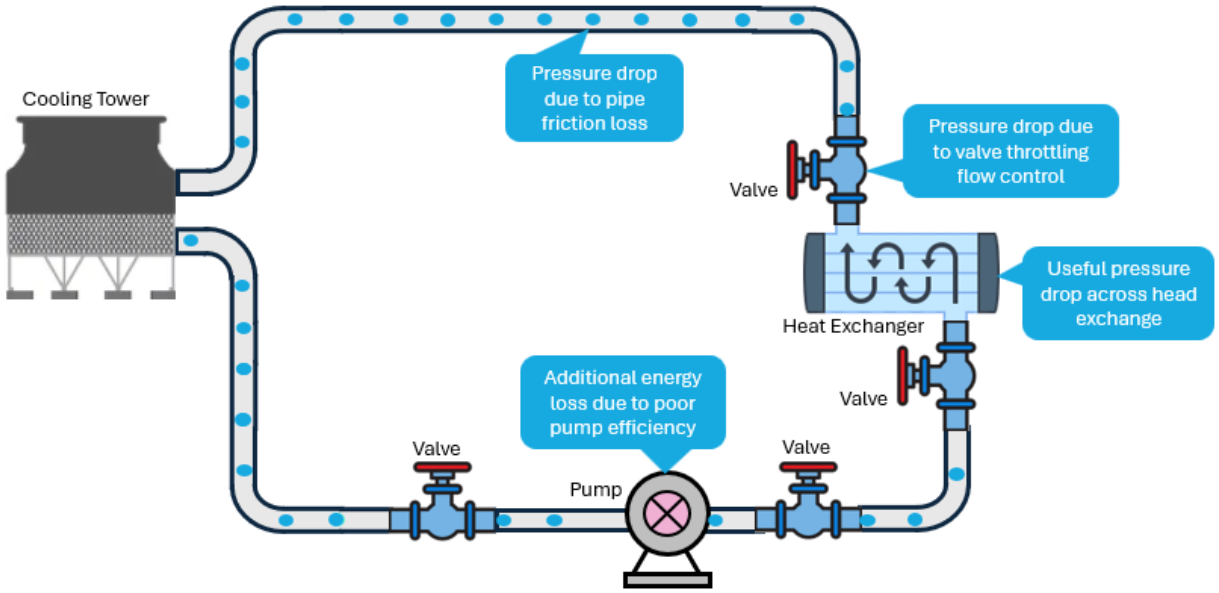


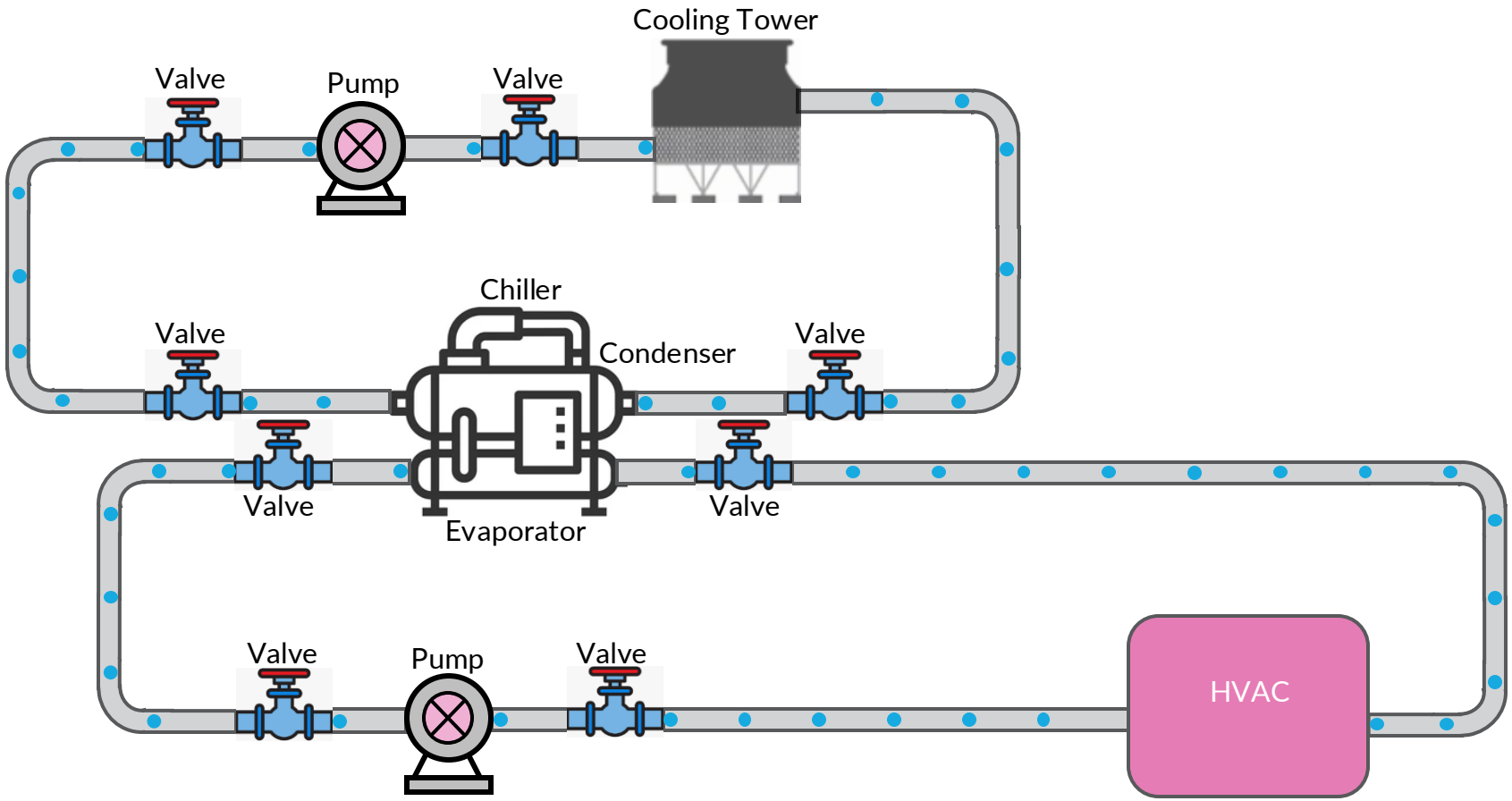
Image source: Devki Energy Consultancy Pvt. Ltd., India

HVAC WATER CHILLERS

Energy losses in HVAC water chilling systems

Likely reasons for poor chiller performance

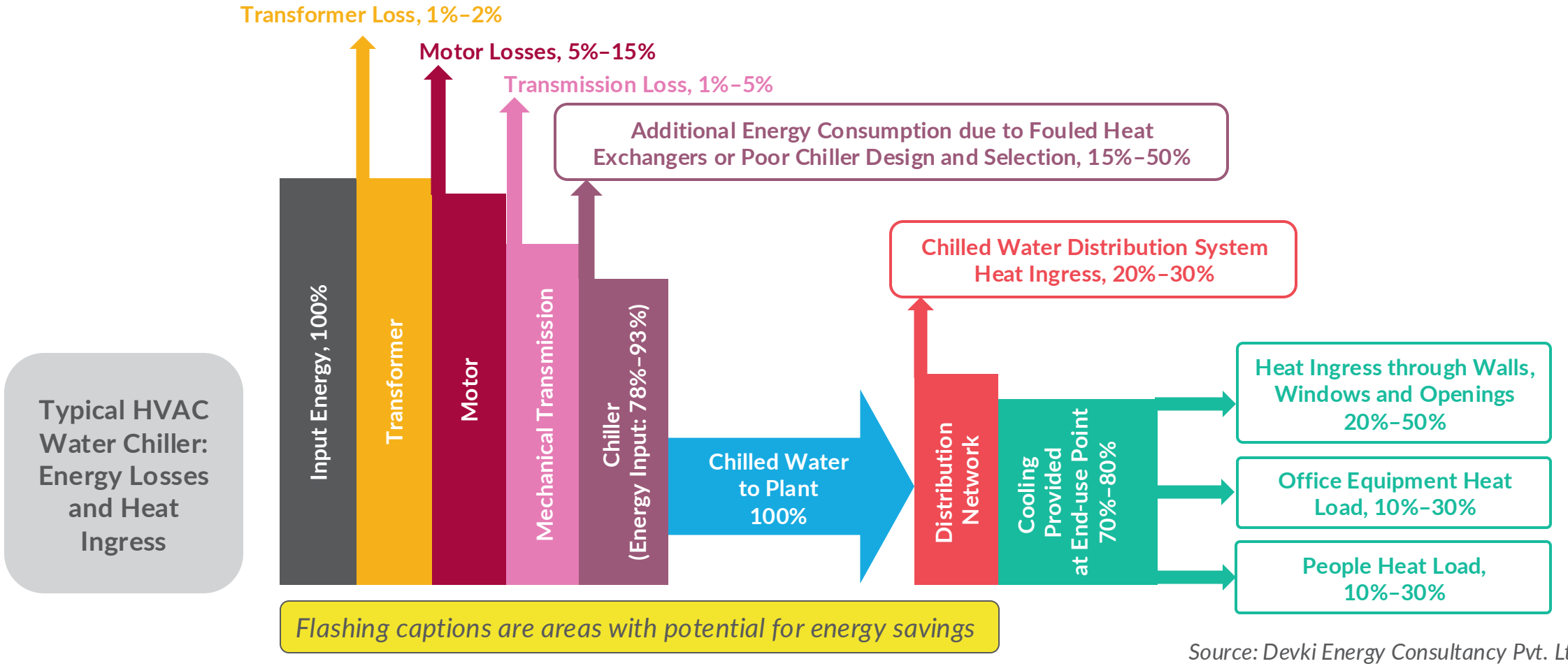
1. Poor chilled water temperature control
2. Prolonged chiller operation at partial load
3. Inadequate chilled water and/or cooling water flows
4. Fouling of evaporator and/or condenser
5. Poor cooling tower or air-cooled condenser performance
6. Inadequate heat transfer area in evaporator or condenser



Source: Devki Energy Consultancy Pvt. Ltd., India

HVAC SYSTEMS

Holistic system approach to identify efficiency gaps and energy losses



Source: Devki Energy Consultancy Pvt. Ltd., India

HVAC SYSTEMS

Energy saving opportunities

- Maintenance of optimal temperature and humidity levels with effective feedback controls and optimal AHU fan flows using variable frequency drives
- Minimization of demand for energy-intensive room air conditioning by using natural ventilation to the extent possible and other innovative, less energy-intensive solutions, such as evaporative cooling
- In warm and humid climatic zones, use of *treated fresh air (TFA) units* to reduce humidity of fresh air enables operation of air conditioning system at higher temperatures without causing discomfort
- Reduction of heat ingress into buildings by optimizing glass-to-wall ratio, ensuring proper thermal insulation and integrating ventilation air heat recovery
- Use of *precision air conditioners with e*nergy recovery technologies for *low relative humidity* air conditioning

Image source: https://www.rsi.edu/blog/hvacr/introduction-to-energy-efficient-hvac-what-hvac-students-need-to-know/

HVAC SYSTEMS

Energy saving opportunities (continued)

- In chillers, ensure adequate evaporator and condenser heat transfer areas with optimal fluid flows to improve the coefficient of performance (COP)
- Maintenance of cleanliness of heat transfer surfaces with special coatings and automatic cleaning systems
- Use of variable speed drives on chiller compressors that operate at variable load to achieve significantly higher COP (compared to design values) at partial loads
- Use of appropriately-sized higher efficiency pumps
- Use of high efficiency fans with BLDC motors in AHUs

Image source: https://www.rsi.edu/blog/hvacr/introduction-to-energy-efficient-hvac-what-hvac-students-need-to-know/

ENERGY OPTIMIZATION

HVAC systems: Typical issues

- Excessive heat load through building envelope, especially due to high glass-to-wall ratio
- External air ingress and poor control over ventilation
- Operation at lower temperatures to overcome end-use temperature issues due to improper air distribution
- Excessive air recirculation flows in rooms
- Absence of control over chillers and air conditioners during low room occupancy hours
- Low operating COP of chillers due to operation at multiple loads
- Low operating COP due to issues in condenser cooling, such as low coolant flow, fouling of heat transfer surfaces, poor performance of cooling towers, etc.
- Low operating COP of unitary air conditioners due to poor maintenance or selection of less efficient air conditioners
- Inadequacy of refrigerant charge in the system
- Poor efficiencies of pumps due to inappropriate selection
- Significant valve throttling losses in pumps
- Poor efficiencies of AHU fans
- High *time of day (TOD)* charges due to absence of thermal storage system

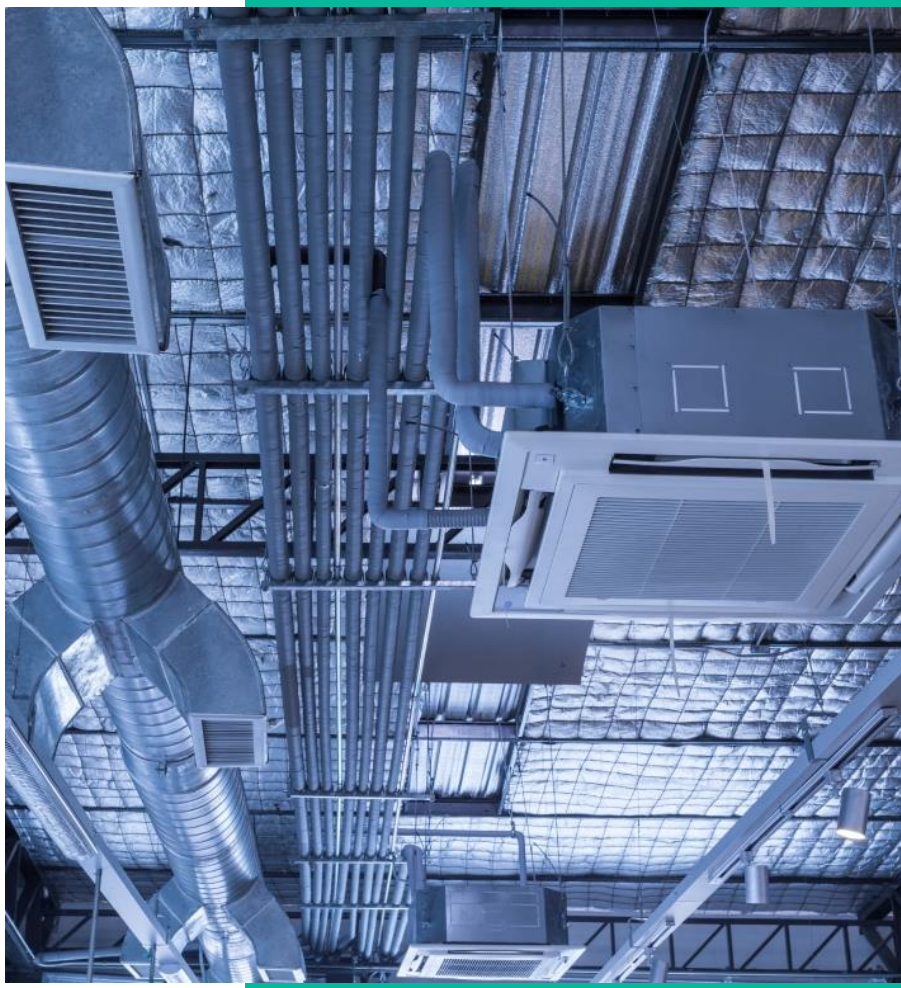


Image source: https://galooli.com/glossary/what-is-hvac/

ENERGY SAVING OPPORTUNTIES

Lighting: Typical issues

- Use of electric lighting during daytime
- Possibility of retrofitting of light shelves
- Possibility of retrofitting lamp dimming devices
- Possibility of use of low wattage lamps with improved luminaires
- Optimization of building façade lighting
- Control and optimization of outdoor lighting

Image source: Wipro Lighting

ENERGY AUDIT REPORT

Contents

- Summary of major recommendations
- Introduction to the facility
- Description of building and activities within
- Analyses of energy consumption and correlation using appropriate metrics
- Presentation of collected data, analyses and energy saving recommendations, with quantified savings
- Cost-benefit analyses for all recommendations
- Benchmarking of energy consumption
- Suggestions for improved energy monitoring and control
- A comprehensive list of good operating practices
- Annexures: Detailed compilation of measurements, references, etc.

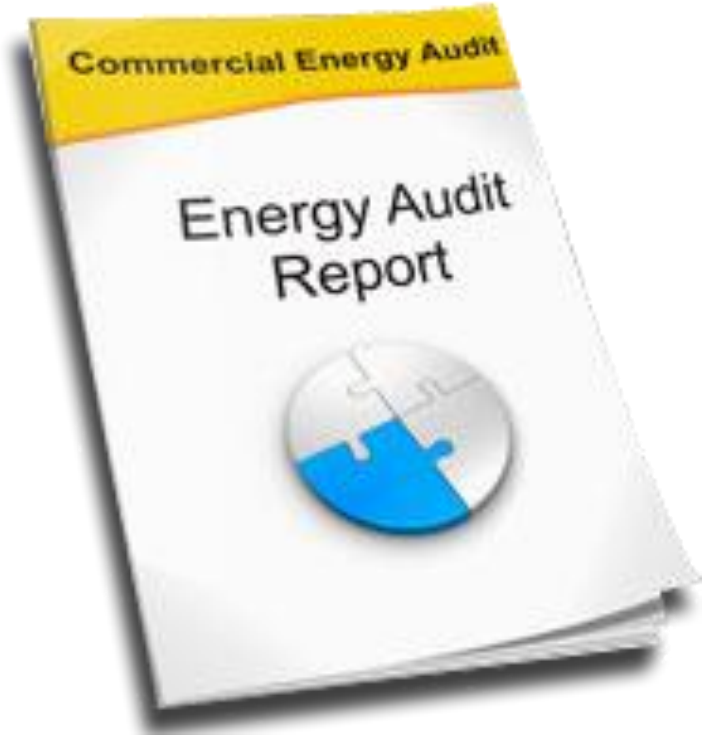


Image source: https://www.minzinc.com/products-20-6.html

Thank you!

For more information, visit us at https://ALCBT.GGGI.ORG or scan the QR code below

IKI Independent Complaint Mechanism

Any person who believes they may be harmed by an IKI project or who wish to report corruption or the misuse of funds, can lodge a complaint to the IKI Independent Complaint Mechanism at IKI-complaints@z-u-g.org. The IKI complaint mechanism has a panel of independent experts who will investigate the complaint. In the course of the investigation, we will consult with the complainant so as to avoid unnecessary risks for the complainant. More information can be found at https://www.international-climate-initiative.com/en/about-iki/values-responsibility/independent-complaint-mechanism/.

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