ANNAMALAI UNIVERSITY

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NATIONAL CONFERENCE ON ENVIRONMENTAL POLLUTION AND CONTROL TECHNOLOGIES - 2019

30 & 31 August, 2019

EPACT - 2019

Stoping Pollution is the Best Solution

Organized by

DEPARTMENT OF CHEMICAL ENGINEERING

Faculty of Engineering and Technology

Annamalai University, Annamalai Nagar - 608 002

Tamil Nadu, India.

Funded by

TAMIL NADU STATE COUNCIL FOR HIGHER EDUCATION

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PROCEEDINGS

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Organized by
Department of Chemical Engineering
Faculty of Engineering and Technology
Annamalai University

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Tamil Nadu State Council for Higher Education
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PLENARY SESSION

OPTIMISATION OF ENERGY CONSUMPTION IN INDUSTRIAL UTILITY SYSTEMS SUSTAINABLE DEVELOPMENT APPROACH

Dr. L. VENKATA SUDHEER
Managing Director
VSL Prayag Energy Systems & Services
Chennai - 600092, Tamil Nadu, India
Sudhir.energy@vslprayag.com www.vslprayag.com

Date: 30.08.2019
Time: 11.00 AM
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FEAT
Annamalai University
Chidambaram

ABSTRACT

In general, climate changes prior to the Industrial Revolution in the 1700s can be explained by natural causes (such as changes in solar energy, volcanic eruptions & natural changes in greenhouse gas (GHG) concentrations). Research indicates that human activities (Anthropogenic Emissions) have been the dominant cause of recent climate changes, resulting in global warming. India has signed the Paris agreement in 2016 and proactively committed to reduce its emission levels by 2030. Since then, Indian Government has implemented aggressive policy decisions such as “National Smart Grid Mission” to reduce the transmission & distribution losses; “Strategic Plan for New and Renewable Energy” & “National Solar Mission” to enhance the renewable energy share; Elimination of IC engines before 2030 in transport sector. In addition to that PAT schemes (BEE) is being enforced to reduce the Specific Energy Consumption levels in the industrial sector. The aim of this paper is to highlight the importance of enhancing the Energy Efficiency of various Thermal & electrical Industrial utility systems. Wasteful practices and reliance on fossil fuels always come with a severe cost. Therefore, access to sustainable modern energy services is the need of the hour as it helps in sustainable development. With increasing importance of monitoring improved industrial energy efficiency, Specific Energy Consumption (SEC) has become an energy key performance indicator (e-KPI). Certain critical design aspects and SEC of Conventional & High efficiency Utility systems have been discussed in detail to achieve the benchmarking levels. With raising energy costs, optimising the energy consumption levels will not only enhance the profit margins of the industries, it also serves as emission saving projects.

Keywords: Green House Gas; Climate Change; Renewable Energy; Solar Energy, Specific Energy Consumption; Energy Efficiency

ENVIRONMENT& ANTHROPOGENIC EMISSIONS

Environmental Pollution occurs when the natural environment cannot destroy an element without creating harm or damage to itself. In other words, pollution takes place when an element has been brought in an unnatural way into the natural environment that cause adverse change. Generally, decomposition of such elements can vary from a few days to thousands of years (radioactive pollutants, plastics etc.,). We can identify several types of pollution on Earth such as Air Pollution, Soil Pollution, Water Pollution and radioactive contamination. Before we go deeper into our subject, let us understand the constituents of our Earth’s Environment in which we are living. Environment comprises the following

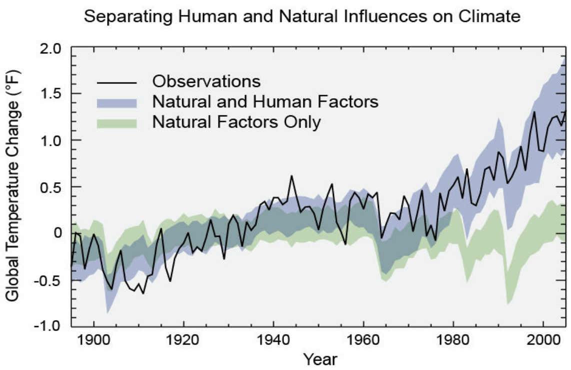
(i) Atmosphere – explained separately below
(ii) Hydrosphere - 75% of earth (Sea, Oceans, rivers, lakes & ponds etc.,)
(iii) Lithosphere – solid component of earth consisting of soil, rocks, mountains etc., of which upper crest containing weathered rocks as well as organic, is the soil containing minerals & other ores.
(iv) Biosphere - where living organisms interact with water (in Hydrosphere) &Soil (in Lithosphere) and live together.

A number of natural cyclic processes like oxygen, water, nitrogen etc. are taking place in the environment to keep a balance of different materials present in the environment. The term “Atmosphere” is explained as follows:

(a) **TROPOSPHERE** – varies from 7 to 20 KM above sea level depending upon latitude & season. It constitutes 79% N, 21% O2 and very small volumes of Argon, CO2 etc., Weather occurs in this layer of which water vapor helps to form clouds. 70 ~ 80% of mass of atmosphere is available in this layer. Top layer is colder. (b) **STRATOSPHERE** or **OZONOSPHERE** – from 20 km to 50 km. Bottom layer is cooler & temperature raises with height. Ozone is abundantly available between 19 to 30 km. Ozone is formed when solar radiation splits O2 it into two atoms apart and the freed atoms conjoin with the oxygen through the process of photolysis which helps in life on earth as this absorbs UV radiation. No water vapor in this region. Ozone is also broken down by a chemical reaction with compounds containing nitrogen, hydrogen and chlorine. The Ozone depleting substances like CFCs could stay here and react with ozone, resulting in depletion in the amount of ozone. (c) **MESOSPHERE** – 50 to 85 km – bottom portion is hotter & temperature reduces as the height increases; with upper most recording – 900° C. (d) **THERMOSPHERE**– 85 to 500 km and extends up to 1000 km. The space begins with thermosphere at an altitude of 100 km, as the air is too thin, in this region. The space shuttles and space stations are orbiting around the earth in this region only. Temperature reaches 5000° C to 20000° C. (e) **EXOSPHERE**: It is the fifth layer having a very thin layer of air containing atoms and molecules only. These particles escape into the space from this region only.

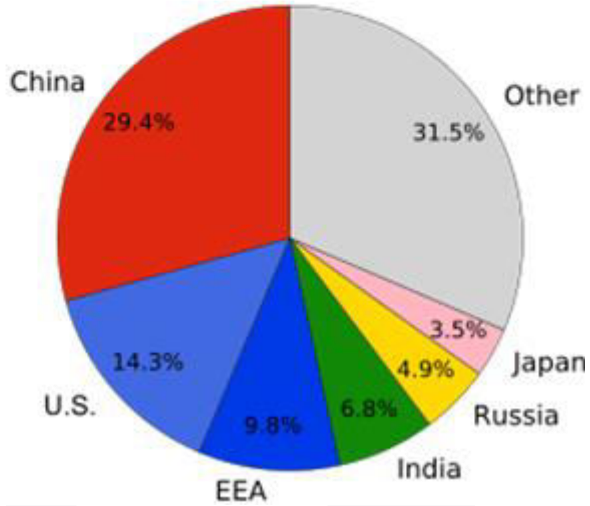
REASONS OF CLIMATE CHANGE – NATURAL& HUMAN ACTIVITIES

Earth's temperature depends on the balance between energy entering and leaving the planet's system. When incoming energy from the sun is absorbed by the Earth system, Earth warms. When the sun's energy is reflected back into space, Earth avoids warming. When absorbed energy is released back into space, Earth cools. When sunlight reaches Earth's surface, it can either be reflected back into space or absorbed by Earth. Once absorbed, the planet releases some of the energy back into the atmosphere as heat (also called infrared radiation). Greenhouse gases like water vapor (H_2O), carbon dioxide (CO_2), and methane (CH_4) absorb energy, slowing or preventing the loss of heat to space. In this way, GHGs act like a blanket, making Earth warmer than it would otherwise be. Many factors, both natural and human, can cause changes in Earth's energy balance. These factors have caused Earth's climate to change many times. In general, climate changes prior to the Industrial Revolution in the 1700s can be explained by natural causes, such as changes in solar energy, volcanic eruptions, and natural changes in greenhouse gas (GHG) concentrations. Recent climate changes, however, cannot be explained by natural causes alone. Research indicates that natural causes do not explain most observed warming, especially warming since the mid-20thcentury. Rather, it is extremely likely that human activities (Anthropogenic Emission) have been the dominant cause of that warming. In the first half of 2016 average temperatures were about 1.3 °C (2.3 degrees Fahrenheit) above the average in 1880, when global record-keeping began.



THE PARIS AGREEMENT& ITS OBJECTIVE

At Paris, on 12 December 2015, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. The Paris deal is the world's first comprehensive climate agreement



Global carbon dioxide emissions by jurisdiction

The aim of the agreement is to decrease global warming described in its Article 2, "enhancing the implementation" through:

a. Holding the increase in the global average temperature to well below 2°C above pre-industrial revolution levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial revolution levels. As the 2°C scenarios lead to a projected level of 55 giga tonnes in 2030, and to hold the increase in the global average temperature to 1.5°C by reducing emissions to 40 giga tonnes.

b. Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production.

c. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

d. This strategy involved energy and climate policy including the so called 20/20/20 targets, namely reduction of greenhouse gas emissions (by 20 %), the increase of RES(renewables) share (to 20 % on the basis of consumption)and the increase of energy efficiency, thus, saving up to 20 % in the energy consumption.

Countries furthermore aim to reach "global peaking of greenhouse gas emissions as soon as possible". The agreement has been described as an incentive for and driver of fossil fuel divestment. Contributions each individual country should make to achieve the worldwide goal are called Nationally Determined Contributions (NDC).

KYOTO PROTOCOL Vs PARIS AGREEMENT

The Paris Agreement has a 'bottom up' structure in contrast to most international environmental law treaties, which are 'top down', characterised by standards and targets set internationally, for states to implement. Unlike its predecessor, the Kyoto Protocol, which sets commitment targets that have legal force, the Paris Agreement, with its emphasis on consensus-building, allows for voluntary and nationally determined targets. The specific climate goals are thus politically encouraged, rather than legally bound. Only the processes governing the reporting and review of these goals are mandated under international law. Another key difference between the Paris Agreement and the Kyoto Protocol is their scopes. While the Kyoto Protocol differentiated between Annex-1 and non-Annex-1 countries, this bifurcation is blurred in the Paris Agreement, as all parties will be required to submit emissions reductions plans. Also, it does not provide a specific division between developed and developing nations. The Sustainable Development Mechanism (SDM) lays the framework for the future of the Clean Development Mechanism post-Kyoto (in 2020).The SDM is considered to be the successor to the Clean Development Mechanism (CDM), a flexible mechanism under the Kyoto Protocol, by which parties could collaboratively pursue emissions reductions for their Intended NDC. Since the Kyoto Protocol went into force, the CDM has been criticized for failing to produce either meaningful emissions reductions or sustainable development benefits in most instances. It has also suffered from the low price of Certified Emissions Reductions (CERs), creating less demand for projects.

LULUCF (LAND USE, LAND-USE CHANGE AND FORESTRY)

Any process, activity or mechanism which removes a greenhouse gas from the atmosphere is referred to as a "sink". Human activities impact terrestrial sinks, through land use, land-use change and forestry (LULUCF) activities, consequently, the exchange of CO2 (carbon cycle) between the terrestrial biosphere system and the atmosphere is altered. Mitigation can be achieved through activities in the LULUCF sector that increase the removals of greenhouse gases (GHGs) from the atmosphere or decrease emissions by sources leading to an accumulation of carbon stocks. Forests present a significant global carbon stock accumulated through growth of trees and an increase in soil carbon. While sustainable management, planting and rehabilitation of forests can conserve or increase forest carbon stocks, deforestation, degradation and poor forest management do reduce carbon stocks. For the world as a whole, carbon stocks in forest biomass decreased by an estimated 0.22 Gt CO_2e annually during the period 2011-2015. This was mainly because of a reduction in the global forest area.

INDIA'S PARIS AGREEMENT TARGETS:

India ratified the Paris Agreement exactly one year after the submission of its Intended Nationally Determined Contribution (INDC), on 2 October 2016. Since India did not submit an NDC prior to ratification, the INDC became its first NDC. It includes the following main elements:

i. To reduce the emissions intensity of GDP by 33%–35% by 2030 below 2005 levels. Under the assumption of a 7.2% annual GDP growth rate (IEA, 2016), the emissions level resulting from this target would be 5.9–6 Gt CO_2e (excluding LULUCF) by 2030.

ii. To increase the share of non-fossil-based energy resources to 40% of installed electric power capacity by 2030, with help of transfer of technology and low-cost international finance including from Green Climate Fund (GCF). By additional capacity of renewable energy sources (Solar, Wind, Biomass Gasification etc.,), nuclear power, or a combination of both, it is estimated that reaching this target would result in an emissions level of 5.2–5.3 Gt CO_2e (excluding LULUCF) by 2030.

iii. To create an additional (cumulative) carbon sink of 2.5 to 3 Gt CO_2e through additional forest and tree cover by 2030 with an average annual carbon sink of 167–200 Mt CO_2e over the period 2016–2020. Over half of this target could be achieved by the Green India Mission, which is expected to enhance annual carbon sequestration by about 100 Mt CO_2e.

SECTOR SPECIFIC POLICIES IMPLEMENTED IN INDIA

A. ENERGY SUPPLY & POLICY

The power sector accounted for 38% of India's total emissions (excluding LULUCF) in 2014. Given that the fuel mix is dominated by coal-fired generation which is 75% in 2014 (IEA, 2016c), the emissions intensity of electricity supply in India is relatively high (812 g CO_2/kWh in 2014). In June 2014, the Government of India announced its commitment to achieving a reliable electricity supply for all by 2019. Population growth, increased access to electricity and economic development are expected to result in a rapid growth of electricity demand in India.

B. RENEWABLE ENERGY SECTOR & POLICY

India has implemented two major renewable energy-related policies. The 'Strategic Plan for New and Renewable Energy' and the 'National Solar Mission', launched in 2010, contains capacity targets for solar energy. As of March 2017, India has installed 12.2 GW of utility scale solar PV capacity. In the first half of 2015, targets for other renewable energy sources were also increased. India currently targets a cumulative installed capacity of 175 GW by 2022. This target consists of 100 GW solar, 60 GW wind, 10 GW biomass and 5 GW small-scale hydro (MNRE, 2015b). The Ministry of Power announced in April 2015 that every new coal-fired power plant would have to be accompanied by the installation of renewable power plants with a total capacity of at least 10% of the capacity of the new coal-fired power plant (IEEFA, 2015).

C. CONVENTIONAL ENERGY SECTOR & POLICIES

In 2010 the Indian Government introduced a coal tax of 50 rupees (0.8 USD) per metric tonne of coal produced and imported to acknowledge the externalities related to coal use and to encourage a shift away from coal-fired power. Since then, the government has doubled this tax, now called the Clean Environment Cess, three times, reaching 400 rupees per tonne in the 2016–2017 budget. The revenues from the coal tax feed into the National Clean Environment Fund, which provides finance to renewable energy projects. Part of the revenue has been earmarked for the implementation of 'Ultra Mega Solar Power' projects. Another major challenge India faces is its high electricity transmission and distribution system losses, estimated at 26%. In May 2015 the "National Smart Grid Mission" was approved to bring efficiency in power supply and facilitate the reduction in grid losses and outages. The Draft National Energy Policy published in June 2017 by a government think tank, the National Institute for Transforming India (NITI) Aayogal so developed projections for the electricity sector. It forecasts the share of renewable energy capacity to move above 60% by 2040. The three-year Action Agenda (2017-18 to 2019-20) published by NITI Aayog in August 2017 also advocates for:

a. reduced reliance on imports of coal, oil and gas (NITI Aayog, 2017b).
b. It mentions measures to achieve the 2022 renewable energy targets,
c. reaffirms various energy efficiency measures, such as the Perform Achieve Trade (PAT) I and II industrial energy efficiency programmes as well as the National Mission for Enhanced Energy Efficiency (NMEEE).
d. It also sets short term targets to increase the efficiency of fossil fuel generation, e.g. through renovation and modernisation of existing thermal plants and by setting a requirement for new coal power projects to be based on ultra-super critical technology.

D. INDUSTRY SECTOR& POLICY

The main instrument to increase energy efficiency in industry is the Perform, Achieve and Trade (PAT) Mechanism, which is implemented under the 'National Mission on Enhanced Energy Efficiency. PAT resembles an emissions trading scheme (ETS).

The first phase of the PAT scheme ran from 2012 to 2015. The target is to achieve, on average, energy savings of 6.7 Million toe of the participating facilities in 2015 below the 2007–2010 baseline level. These targets are calculated for each installation separately; more efficient plants have lower SEC targets compared to more inefficient plants.

Currently the scheme is in its second phase (2016–2019). PAT differs from traditional cap-and-trade systems as it sets intensity-based energy targets. The scheme covers 60% of India’s 2007 GHG emissions. In the second phase, PAT scheme has incorporated more units from the existing sectors as well as including additional sectors like railways, electricity distribution and refineries as stated in its NDC. The second phase target is to achieve on average energy savings of 8.9 Million toe from the participating facilities in 2019 below the 2014–15 baseline level.

E. TRANSPORT SECTOR& POLICY

India finalised its first light vehicle fuel-efficiency standards in 2014. The standards came into force in April 2017, setting efficiency targets for new vehicles that weigh under 3,500 kg with no more than 9 seats. The efficiency targets start at the equivalent of 130 gCO_2/km in 2017 and fall to 113 gCO_2/km in 2022. The Ministry of Road Transport and Highways (MORTH) is responsible for implementing the standards under the regulations of Bureau of Energy Efficiency (BEE). India’s vision for electrification of vehicles was also reflected in a recent statement by Indian Power Minister Piyush Goyal who said: “by 2030, not a single petrol or diesel car should be sold in the country.” (The Times of India, 2017).

SUSTAINABILITY AND SUSTAINABLE DEVELOPMENT?

The definition of sustainability is not nearly as simple as it might seem, likewise with the definition of sustainable development. This is best illustrated by the fact that there are over 200 different definitions to what is sustainable development.

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This implies that we need to look after our planet, our resources and our people to ensure that we can live in a sustainable manner and that we can hand down our planet to our children and our grandchildren to live in true sustainability. But what is sustainability? The definition of sustainability may be taken further and it is widely accepted that true Sustainability can be achieved only through balancing Environmental, Economic & Social aspects and therefore a truly circular economy. To live in true **ENVIRONMENTAL SUSTAINABILITY,** we need to ensure that we are consuming our natural resources, such as materials, energy fuels, land, water...etc, at a sustainable rate and the resource are kept within Circular Economy principles. **ECONOMIC SUSTAINABILITY,** requires that a business or country uses its resources efficiently and responsibly so that it can operate in a sustainable manner to consistently produce an operational profit. Without acting responsibly and using its resources efficiently a company will not be able to sustain its activities in the long term. Achieving **SOCIAL SUSTAINABILITY** ensures that the social wellbeing of a country, an organisation, or a community can be maintained in the long term.

THE ROLE OF ENERGY IN 21stCENTURY LIFE

Electricity, heat and fuel are engines that drive economic growth, efficient food production and a higher standard of living. As the U.N.’s report from the 2012 Rio+20 Earth Summit states, “Access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health and helps provide basic human needs.” Note the emphasis on sustainable services. Wasteful practices and a reliance on fossil fuels have come with a severe cost. For example,

- Fossil fuel use accounts for 57 percent of total global greenhouse gas emissions, according to the Environmental Protection Agency.
- A little over a half-trillion metric tons of carbon have been burned since the beginning of the Industrial Revolution in 18th century (1760 – 1840), according to calculations by University of Oxford scientist Myles R. Allen. At the current growth rate of energy consumption, the trillionth ton will be burned around 2040.

CONCEPT OF ENERGY HIERARCHY

As humans have become aware of their impact on the environment, the definition of conservation has expanded to address the effects of human consumption. We are now encouraged to “reduce, reuse, recycle,” buy local and reduce our carbon footprint. The ultimate aim of these measures is to conserve the resources (such as water and energy) required for the human race to survive.

The Energy Hierarchy, proposed by the Institution of Mechanical Engineers, is a prime example. This system arranges energy options in an inverted pyramid of priorities. The most favoured options are at the top; the least favoured are on the bottom:

- **ENERGY CONSERVATION**: The elimination or reduction of energy use. Technological developments have a large role to play.
- **ENERGY EFFICIENCY**: Better-designed power stations, as well as Industrial utilities & systems, cut down on needless energy losses.
- **SUSTAINABLE / RENEWABLE ENERGY PRODUCTION**: This includes energy production from sources such as the sun, wind and tides, as well as biofuels. The ultimate goal is to improve energy accessibility and affordability while reducing environmental harm.

- **LOW-IMPACT ENERGY PRODUCTION**: Low-impact energy solutions make the use of non-renewable natural resources more efficient and less damaging in the long term.
- **HIGH-IMPACT ENERGY PRODUCTION**: This is the current norm: the exploitation of non-renewable natural resources (oil, gas and coal) for cheap and reliable sources of power.

PROMOTING ENERGY EFFICIENCY

Energy Efficiency is a critical tool to relieve pressure on energy supply. New pathways will be required to master the challenge of promoting energy efficiency.Energy efficiency represents around 40 percent of the greenhouse gas reduction potential that can be realized at a much lower cost.Energy efficiency offers an immense low-cost energy resource, only if innovative business models can be developed to unlock its entire potential. Energy efficiency is often still underestimated by public institutions and private businesses and a number of persistent barriers (listed below) need to be addressed to enable the large-scale implementation of energy efficiency initiatives

1. **Lack of expertise and information***:* The implementation of energy efficiency improvements is often prevented due to the lack of expertise and information.
2. **Low priority of energy efficiency projects***:* Energy efficiency almost always, sits outside the core competencies of most businesses. As a result, the company's core business activities are prioritized when determining annual budgets.
3. **Size of energy saving projects**: The size of energy saving projects is relatively small in comparison to other investments.
4. **Access to capital***:* Access to capital is cited as the most important barrier to the deployment of energy efficient technologies

SUSTAINABLE ENERGY POLICY &STRATEGY

Energy efficiency and renewable energy are said to be the "twin pillars" of a sustainable energypolicy. A sustainable energy economy thus requires major commitments to both efficiency and renewable energy.

Both strategies must be developed concurrently in order to stabilize and reduce carbon dioxide emissions. Efficient energy use is essential to slowing the energy demand growth so that rising clean energysupplies can make deep cuts in fossil fuel use.

- If energy use grows too rapidly, renewable energy development will chase a receding target.
- Likewise, unless clean energy supplies come online rapidly, slowing demand growth will only begin to reduce total carbon emissions; a reduction in the carbon content of energy sources is also needed.

ENERGY INTENSIVE INDUSTRIES & POTENTIAL FOR EMISSION SAVINGS

The global industrial sector accounted for ~42.8 EWh (~10^{12} Gwh) in 2014, of which Organization for Economic Co-operation and Development (OECD) countries accounted for 69% (~29.5 EWh) of the global industrial energy end-use. In this context, energy management is of great importance as it aims to reduce companies' energy use and associated energy costs continuously. Thirty five percent of the final energy consumption in India is attributed to the industrial sector; with the energy intensive industries—iron and steel, aluminium, cement, fertilizer, refining, and pulp and paper—accounting for 66 percent of this. The light industries—food processing, textiles, wood products, printing and publishing, and metal processing—account for the rest.

	COMPARISON OF SEC, MMKcal/Tonne			
COUNTRY	Steel	Cement	Pulp & Paper	Fertilizer
India	9.5	2	11.13	11.25
UK	6.07	1.3	7.62	12.23
USA	6.06	0.95	9.7	11.32
Japan	4.18	1.2		
Sweden	5.02	1.4	7.56	

India's nearly 3 million small and medium enterprises (SMEs) constitute more than 80 percent of the total number of industrial enterprises and approximately 60 percent of the country's GDP. Numerous sector-specific studies have confirmed that energy intensity in industry can be reduced with the widespread adoption of commercially available technologies, but SMEs have fallen behind larger Indian industry benchmarks in productivity, technology modernization, and energy efficiency. The SMEs are facing high and rising energy costs and increasing global competition. Industry has recorded greater energy efficiency improvements since the late 1980s than any other sector in India. All the principal industries have shown declining emissions intensity in recent decades. Between 1970 and 2001, the aluminium, cement, and fertilizer industries achieved the largest reduction in emissions intensity. Textiles, paper, and iron & Steel reduced emissions intensity less. With the introduction of the Energy Conservation Act in 2001 and the promotion of various energy efficiency improvement schemes by the Bureau of Energy Efficiency, there appears to be significant, potentially exploitable, energy and emission- saving opportunities in Indian industries, if barriers to energy efficiency improvements in India can be overcome.

Low Carbon Energy Sources: In addition to the development of solar power, nuclear power, and other lower carbon energy sources more stringent energy efficiency standards for appliances and buildings would also be needed.

Weighted average specific emissions for fossil fuel-fired stations in FY 2013-14

UNIT	LIGNITE	COAL	DIESEL	OIL	GAS
t CO_2/MWh	1.38	1.03	0.62	0.63	0.49

Energy Efficiency: There are possibilities in many sectors for significant improvements in energy efficiency, with low or potentially negligible costs. A well-known industry example is the tendency for a growing firm to choose production capacity expansion over energy efficiency improvement projects, even if both give positive as well as attractive rates of return.

SPECIFIC ENERGY CONSUMPTION Vs EQUIPMENT EFFICIENCY

Equipment efficiency, expressed as a ratio of Input energy to output energy, is very misleading. Generally, it expresses the inherent efficiency of an equipment – such as Centrifugal fan, Axial Fan, Reciprocating Compressor, Centrifugal pump, so on and so forth. Therefore, the energy performance of two systems employing similar fan or pump, cannot be compared because system losses are not accounted. Therefore, Energy Efficiency is widely accepted indicator to evaluate the performance of an utility system, be it Air Conditioning, Compressed Air or a drying system. Accordingly, the variable characterizing energy use per produced product and expressed as a ratio of thermodynamic units per physical unit is often referred to in literature as specific energy consumption. Given the increasing importance of monitoring improved industrial energy efficiency and the rising popularity of SEC as an energy key performance indicator (e-KPI).

POTENTIAL ENERGY (EMISSION) SAVING UTILITY SYSTEMS

There is substantial scope to improve the end-use energy efficiency of the Indian industry. Broadly, the energy consuming equipment in industries can be classified as Production Process Equipment & Utility Systems. The Production process equipment are basically technology-oriented equipment and are product specific. Potential to optimise the energy consumption (or rather emissions) exist in the Thermal & Electrical utilities as follows: are some of the generally found utility systems in all types of industries which offer energy saving potential.

THERMAL ENERGY UTILITIES

A. Boilers, Thermic Fluid Heaters & Heat Transfer systems
B. Electrical or Fuel fired Melting furnaces – All applications
C. Cogeneration or CHP systems – Steam / Gas Turbines
D. Waste Heat Recovery (Low / Medium / High Temperature)
E. Green Energy sources – e.g., Biomass Gasification etc.,

ELECTRICAL ENERGY UTILITIES

i. Air Compressors & Compressed Air systems
ii. Ventilation / Humidification / Pressurisation systems
iii. Chillers & Air Conditioning systems
iv. Cooling Tower systems
v. Waste Evacuation / fume extraction systems
vi. Water & Effluent treatment systems
vii. Lighting System
viii. Electrical Distribution system (including motors)

ENERGY OR EMISSION SAVING OPPORTUNITIES

It has been estimated that the total conservation potential of the Indian industry is around 25 to as high as 35% of the total energy used in these utility systems depending upon various factors. It is also estimated that over 5% to 10% saving is possible simply by better house-keeping and another 10-15% with small investments towards low-cost retrofitting, use of energy-efficient devices and controls, etc. The quantum of saving is much higher if high cost measures like major retrofitting, process modifications, etc., are considered.

OUR EXPERIENCE IN ENERGY RE-ENGINEERING DESIGNING:

We give below some of the examples of marked difference between Conventionally designed industrial utility systems & High Energy efficient systems. These are implemented in Petrochemical, Manmade Fibre, Textile, Automobile, Pharmaceutical industries etc.,.

S NO	INDUSTRIAL EQUIPMENT / SYSTEM	CONVENTIONAL SYSTEM	ENERGY EFFICIENT SYSTEM
1	Humidification Plant	2500 to 3000 cfm/kW	6000 to 7500 cfm/kW
2	Air Handling Unit (Air Conditioning)	1750 to 2000 cfm/kW	6500 to 8000 cfm/kW
3	Chiller System	0.9 to 1.1 kW/TR	0.6 kW/TR
4	Compressed Air System Pressure Drop	1.5 to 2 kg/sq.cm	0.25 to 1 kg/sq.cm
5	Industrial Water Pumps	60 to 65% Efficiency	80 to 90% Efficiency

In our experience, we found that by employing latest technologies, best design practices & selection of high energy efficient driven equipment along with highly efficient motors will result in reducing the energy consumption by 35 to 40% levels. Indian industry must welcome technological developments and take responsibility to optimise the energy consumption levels. Most of the time, we found that they are economically viable prepositions with attractive payback periods of 9 to 18 months.

DESIGN FEATURES OF HIGH EFFICIENT AIRCONDITIONING SYSTEMS

Air Conditioning systems find vast application in Petrochemical, Manmade Fibre, Chemical, Pharmaceutical industries where Chilled water is either sprayed or circulated in the coils and centrifugal fans are used for circulating the conditioned air in the departments / process areas. However, in the case of Commercial office buildings, where the air conditioning load is lower, direct expansion type refrigeration systems find application along with VRF systems. In large systems, as in the case of Petrochemical & pharmaceutical industries, Fan energy contributesalmost30 to 40% of overall energy consumption. Fan energy is directly proportional to the pressure drop across the system. Thus, higher the pressure drop, higher would be the fan energy consumption. Low pressure drop designs are applicable to all fan systems from recirculation air handler systems to makeup air handlers. Other benefits of low pressure drop systems are less noise, more effective performance, better filter effectiveness, and in most cases lower total first cost (when avoided electrical and noise abatement equipment is included in the cost analysis). Conventional air handling units (consisting of Coil& filter) are mostly designed with a "rule of thumb" say, with 500 fpm of face velocity. We also come across the TR requirement, air flow evaluations (cfm/TR) are determined based on thumb rules or approximations. Similarly, ducting designs are considered with higher velocities. Such designs result in higher system resistances & higher-pressure fan systems.

⇒ Specific Energy Consumption of conventional high velocity design with higher system resistance (or pressure drops 76 to 116 mm wc) ranges from 1750 cfm/kw to 2500 cfm/kw.

⇒ Specific Energy Consumption of conventional medium velocity design with medium system resistance (or pressure drops 65 to 75 mm wc) ranges from 2600 cfm/kw to 3500 cfm/kw.

To achieve Optimum Specific Energy Consumption, it is necessary to:

⇒ Lower AHU Face Velocity with larger Coil cross sectional areas, larger (HEPA) filter area.

⇒ Higher duct size so as to achieve lower air velocity (& lower frictional losses) across the duct. Oversizing ducts rather than fan, provides a safety factor on the fan size that lowers operating costs

⇒ All the above steps results in lower fan energy (as overall pressure reduces from 3" to 4.68" wc (75 mm to 116 mm) to as low as 1" wc (25 mm).

⇒ In most cases, existing centrifugal fan (selected for 3" to 4.68" wcconsideration) will be replaced with Axial fans (preferably multiple fans) along with Variable Frequency Drives.

⇒ Optimum Specific Energy Consumption of such high efficiency design with ranges from 8000 cfm/kw to 10000 cfm/kw. These are proven results after effective implementation in various systems across the globe.

⇒ The above high efficiency system can be implemented in the existing (through re-engineering model) as well as new upcoming projects.

SUMMARY

In this article, author has tried to explain the causes of Environmental degradation mainly due to human activities; Scope of the Paris Agreement and India's Commitment (by way of NDC) in reducing the carbon emissionsthrough Sustainable Development Mechanism. India's policies in various sectors have been discussed in details to achieve the targeted emission levels before 2030. As majority of the GDP contribution in our country is from Industrial sector, this paper further highlights, the importance of enhancing the Energy Efficiency of various Thermal & electrical Industrial utility systems. Certain critical design aspects and comparison of Conventional & High efficiency Utility systems and methodology of achieving the benchmarking norms have been discussed in detail. To conclude, at this juncture, Indian Industry must view this as an opportunity to realise the benefits of Optimising the Specific Energy Consumption and enhance its profit margins within Sustainability boundaries.

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