RESEARCH STUDY ON
EMERGING ENERGY EFFICIENT TECHNOLOGIES IN INDUSTRIAL FIELD

Lipi K. Chhaya
Nirma University
lipi.chhaya@nirmauni.ac.in

Abstract-An effective use of energy has become vital to meet the challenges of global warming and fuel insufficiency. To overcome these challenges, the responsibility of industries is significant. Industries can develop green manufacturing, green retailing, green chemistry and smart grid technology. The industries can also develop the use of green telecommunication, heat recovery system, turning organic waste material into energy, heat to steam conversion, waste to energy conversion etc. for energy solutions. Green information and communication technologies can also be developed. Green IT is embarking on a new period of growth by using virtualization, recycling and effective power usage. The zero carbon emanation buildings with self generated power are efficient solutions. **Industry uses a large amount of energy to power a diverse range of** manufacturing and resource extraction processes. Many industrial processes require large amounts of heat and mechanical power, most of which is delivered as **natural gas**, **petroleum fuels** and as an **electricity**. In addition , some industries generate fuel from waste products that can be used to provide additional energy.Since industrial processes are so diverse , it is impossible to describe the multitude of possible opportunities for energy efficiency in industry. Many depend on the specific technologies and processes in use at each industrial facility. However there are number of processes and energy services that are widely used in many industries. This study describes the importance of energy efficiency in meeting global environment change goals and optimizing energy use.

Key Words**:** Green IT, Green telecommunication, Zero carbon emission buildings, Green manufacturing, Green retailing, Green chemistry, Smart grid technology

I.INTRODUCTION

Technology is developing at a very rapid rate. With the advancement in technology, environmental concern has become crucial requirement. As traditional industries struggle with the public's increasing environmental consciousness, there is a number of new green industries that are receiving more attention. There are many facets of green industries as defined below.

Green Manufacturing

If an industry uses unconventional manufacturing methods which are eco friendly then that process can be called green manufacturing. Many traditional engineering companies have created new markets in the solar, wind and environmental industries. By manufacturing parts for wind turbines, solar panels and geothermal equipments, conventional manufacturing companies can become more profitable.

Green retailing

Green retailing is retrofitting an existing retail business to meet the demands of consumers who want environmentally friendly products and services. This industry is quickly rising as more green products are available and the increased demand by the public.

Green Chemistry

The green chemistry industry involves the design of chemical products and processes that decrease or eliminate the use of hazardous substances. Many large companies are rushing to develop environment friendly products.

Green Buildings

Most buildings are not close to being energy efficient. Most residential and commercial property wastes heat and energy through poor design or unawareness. The buildings should be eco friendly with zero carbon emission. This is a economical and easy way for consumers and companies to save energy and money.

Green IT

IT companies are focusing on effective storage and utilization of data. Intel has increased its annual green power purchases by 75 percent, retaining the top spot in the Environmental Protection Agency's (EPA) ranking of Green Power Partnership companies.

Hitachi Data Systems and Hitachi. Ltd. are establishing a new industry standard for next-generation green data center implementations around the globe. Hitachi's sophisticated architecture is designed to offer the highest levels of energy efficiency and reduce carbon emissions by 20 percent while also lowering IT management costs.

Green Telecommunication

The term Green telecommunication can be defined as the technology which uses convergence of energy efficient methodologies at different stages to minimize the adverse effects of technology on environment. Recently, it has been shown that the accumulation of greenhouse gases in the atmosphere is growing more rapidly than initially predicted. This understanding has led to a push towards "green" wireless communications that strives for improving energy efficiency as well as reducing environmental impact. Reduction of the green house gases produced or caused by the telecommunication sector is referred to as greening of telecommunication. Green telecommunication has many facets. It can be classified broadly in terms of greening of telecommunication networks, green telecommunication equipment manufacture, atmosphere friendly design of telecommunication buildings and safe telecommunication waste disposal. As network equipments have become more IP-based, the energy consumption required has progressively increased. Green wireless communication can be achieved with the use of Green Handover, Green codes, Green Electronics, Green power amplification systems, Green antennas and Green Base Transceiver Stations using renewable energy sources.

Smart Grid Technology

The smart grid industry is an effort to modernize the electric transmission grid with upgraded, automated, interactive technology. This is hoped to save energy, decrease cost and increase reliability of the transmission grid. The updating of the grid will also help with the additions of the new energy sources which will require additional transmission lines to unite locations with renewable energy facilities. The term "Smart Grid" refers to a transformation of the electricity delivery system so it monitors, protects and automatically optimizes the operation of its interconnected elements – from the central and distributed generator through the high-voltage transmission network and the distribution system, to industrial users and building automation systems, to energy storage installations and to end-use consumers and their thermostats, electric vehicles, appliances and other household devices [1].

II.ALTERNATIVES FOR POWERING TELECOMMUNICATIONS BASE STATIONS-A CASE STUDY OF MOTOROLA

The last decade has seen exponential progress in wireless and mobile communication. The escalation of mobile networks coupled with intense competition has sharpened operators' center of consideration on deployment logistics, security, and cost. One challenge is how to power the telecommunication networks. Incompatible power grid coverage, challenging terrain, and possible theft add to the cost of conventional fuel based power systems. In addition, lawmaking pressures and the potential for Carbon trading revenues are causing the Wireless and Mobile Telecommunications Industry to become careful of its impact on carbon emissions. "Green" considerations are coming into eminence in network design. There are many alternative power options. Table-1 provides an overview of Wind,

Solar, Fuel Cell, and Pico Hydro Technologies and the ideal setting, benefits and issues, and the state of the industry for each. In addition, under normal conditions, there will be times when an unconventional power solution provides surplus electricity.

Ideal Setting	Benefits	Issues	State of the Industry
- Coastal locations or hilly areas - Wind speeds of 4mph - 30mph, averaging at least 8 mph across a 4 hour period	-Minimal OPEX and efficient for DC generation - Small footprint	- Cost per kW produced currently higher than Solar or Diesel -Minimum wind speed ~4-6 mph needed	Commercial installations available for domestic applications and for specific technology applications, particularly in remote areas such as Artic and UK Hebbridean islands
- Areas with long/good sunlight ~ 6-8 hours/day - Space available for the array	- Minimal OPEX - Cheaper than turbines for same KW output, expecting further price reduction	Cost higher than diesel, array can be a target for vandalism of theft	Fairly mature, commercial installations. 3rd generation PV may offer significant cost savings.
- Access to atmosphere for oxygen and water vapor output - Protected from very low temperatures	-Energy efficiency - Fuel flexibility	- Hydrogen fuel source availability and storage - Cost - Maturity of alternatives to Hydrogen	Commercial systems proven and available
High rainfall, hilly terrain	Not as susceptible to short weather conditions	Requires specific water flow conditions (e.g. river with a gradient)	Small, localized applications

Table 1: Overview of Wind, Solar, Fuel Cell, and Pico Hydro Technologies
Source: Motorola

WIND AND SOLAR

Solar and wind power have progressed in recent years with costs gradually falling. The point is being reached where they can be considered as supplementary or even the prime power source for cell sites in difficult and remote locations. As the cost of wind and solar technology continues to go down, and the price and scarcity of fossil fuels increase, solar and other renewable energies will turn out to be increasingly cost effective compared with conventional power sources. While wind and solar are independent power sources, here they are combined to highlight how Motorola is combining the two sources to provide consistent energy to base stations. Solar power is generated using the photovoltaic properties of semi-conductors to convert light energy into electrical energy. Manufacturing costs for solar cells have been declining by 3-5% per year in recent years. For wind power, a wind turbine attached to an electrical generator converts wind power into electrical energy. Globally, wind power creation has quadrupled from 2000 to 2006. It accounts for 20% of electricity use in Denmark, 9% in Spain, and 7% in Germany [2]. The global acceptance of wind and solar as commercially practicable technologies, together with the falling costs and growing reliability of the technologies, make them cost effective technologies to adapt to a telecommunications environment. Motorola has been conducting an extensive study on the use of a wind and solar combination as a source of power. In 2005, a wind and solar trial was launched at Motorola's facility in UK. Wind and solar energy power a Horizon II DC Mini BTS in a 4 carrier configuration 24 hours per day, 7 days per week. Currently, a four month wind and solar trial is being conducted with MTC Namibia. Wind and solar energy will power live traffic from a commercial base station in a 6 carrier configuration using a Horizon II DC Macro BTS.Figure-1 shows the wind/solar installation in Namibia.

Figure-1: Wind/Solar installation in Namibia
Left: Solar Array, Battery & Power Controller
Right: Wind Turbine

FUEL CELLS

Fuel cells are emerging as a strong unconventional power source candidate. The technology has grown in recent years and has many benefits compared to generators, such as fuel efficiency, climate resistance, reliable start-up, and being very compact (e.g. fitting in a 19" rack). Their silent operation means there will be no sign that a power source is operating on the cell site, reducing the possibility of theft. Having reached volume manufacturing and with prices declining, they will challenge conventional engine driven generators in terms of price and trustworthiness. Fuel cells operate by converting a fuel, such as hydrogen, into electricity without combustion. There are several types of fuel cells, of which the most promising for telecommunications is the Proton Exchange Membrane Fuel Cell (PEMFC). The PEMFC operates at low temperatures, and runs at 40-60% efficiency. Motorola is implicated in fuel cell research for networks and mobile devices. Figure 2 is the set up for an experiment to use fuel cells to power TErrestrial TRunked RAdio (TETRA) networks [2], used in public security communications and other Private Mobile Radio networks. Motorola is also exploring micro fuel cell technologies as a substitute for rechargeable batteries in mobile devices. In partnership with various companies, Motorola is developing technologies such as:

- Hybrid fuel cell technologies for radios
- A hydrogen generator as a miniature fuel-cell power source
- Improving PEM fuel cell performance, durability, and manufacturability using single wall carbon nanotubes

Fuel cell technology is maturing and escalating rapidly. We will likely seeing a growing number of commercial applications and the use of alternative fuels as the input energy source for fuel cells.

Figure-2: TETRA Fuel cell experiment

PICO HYDRO

The term pico hydro refers to especially miniature hydro systems. There is a large prospective market for pico hydro due to following advantages.

• Small water flows are required.
• Small communities in the rising world are often not linked to a power grid.
• Locally manufactured pico hydro systems have lower long term costs per kilowatt than solar, wind, or diesel systems.
• Hydro systems provide constant energy during times of normal rainfall.

Today, the primary use of pico hydro is for lighting and basic electrical needs in distant areas. However, areas with high rainfall, steep flowing streams and rivers offer an ideal source of power for wireless communication network base stations, allowing the low cost, low maintenance deployment of wireless communications to promising markets. Figure-3 is an example of a basic pico hydro system set up to power a base transceiver station. The potential energy stored in the elevated water supply flows through a pipe called a penstock, to drive a turbine which drives a generator which converts the mechanical energy to electrical power. Typical energy efficiency in such is a system is 40-50%. Alternative hydro solutions include submersible and tidal systems. Pico hydro systems have been successfully deployed in trials around the world. For example, in Kenya, the Micro Hydro Centre at Nottingham Trent University effectively generated 2.2kW of electricity for under $6500 [2]. Commercially, governments and action groups are supporting hydro power. For example, the government may provide grants, loans, or tax benefits. Further study and trials will be required to fully understand how best to deploy pico hydro, mostly, in the telecommunications sector.

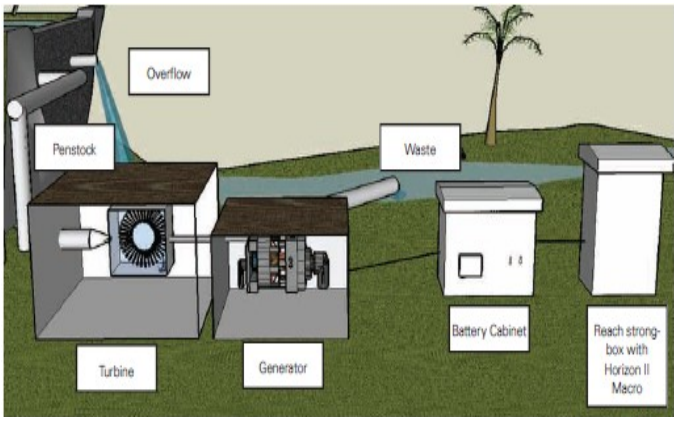

Figure-3: Pico Hydro System

III.ECO-SUSTAINABLE WIRELESS SERVICE-A CASE STUDY OF ALCATEL LUCENT

Alcatel-Lucent has developed inventive technologies which have already led to the successful deployment of more than 300 solar-powered wireless base transceiver stations worldwide, and that have an anticipated global market potential of 100,000 alternative-energy-powered stations by 2012 [3]. It has become increasingly apparent that diesel generator powered stations are becoming a much less practicable option for network operators looking to develop into new markets. First, from an environmental standpoint, diesel gensets are noisy, dirty and exhaust unsafe hydrocarbons into the atmosphere during their operation. Second, diesel gensets are ultimately too pricey. Their function and maintenance typically accounts for 35 percent of the total cost of ownership of a base transceiver station (BTS). With fuel costs on the increase, that percentage will continue to ascend. In addition, diesel-powered BTS sites are unreliable. These generators can go through a variety of types of failures and are responsible for 65 percent of the outages that result in a loss of telecommunication services. When a breakdown or failure does occur, it takes significant time and money to get a technician to the site to effect repairs. Merely getting the diesel fuel to a remote site can also be a challenge. One such network in Kenya needs 100 trucks operating on a full-time basis just to carry sufficient fuel to keep its stations equipped. The intrinsic instability of diesel fuel itself must also be taken into consideration. The fuel has a limited shelf life and can quickly degrade and build up contaminants, a process that is accelerated in warmer, tropical climates. Theft and wreckage of generators and fuel can also pose significant troubles at remote locations and in struggling economies. Stations in these regions often require the realization of costly security measures. Doing the right thing for the atmosphere is always a lot easier when it also makes financial sense. To that end, unconventional energy sources for wireless base stations consist of eco-efficient solutions that employ cost-effective, trustworthy and sustainable methods of power generation for locations off the grid. For sites that are already on the grid, switching to an alternative source of energy can mean substantial cost savings for the network operator as well as the opportunity of actually generating returns by reselling excess electricity that the site produces. Alcatel-Lucent's state-of-the-art research facility in Villarceaux, France is the world's first alternative energy laboratory and pilot site dedicated to the telecommunication industry is the center for the progression of energy-autonomous 'green connectivity'. Alcatel-Lucent has built a solid approach to address energy efficiency — including the challenge of bringing alternative energy to wireless networks [3].

Power Efficient Techniques

An energy-efficient system starts with the base station, with the goal of providing the lowest possible power utilization for the highest possible traffic and coverage. Alcatel-Lucent has a very well-built energy-efficiency strategy embedded in all of its product lines, spanning the following:

- *At the hardware level:* High-efficiency power amplifiers, highly integrated modules (such as the Twin TRX in GSM), or the multi-carrier power amplifier for GSM, W-CDMA and LTE.

- *At the software level:* Dynamic software version of the power consumption to the traffic carried with dynamic power saves in GSM, automatic carrier switch-off in W-CDMA, etc.

- *At the site level:* 'No air conditioning' utilizing outdoor cabinets, 'no feeders' implementing distant radio head technology.

- *At the wireless network level:* High-coverage radio solutions like the Twin TRX in coverage mode in GSM, beam forming in WiMAX, etc.

Taking the equipment out of the cover

Previously, station equipment had to be contained within an enclosed shelter that required to be constantly cooled with expensive, energy-hungry air conditioning systems. Alcatel-Lucent has been able to take the technology out of the shelter, drastically reducing OPEX (by as much as 40 percent) through appreciably lesser power consumption.

Higher coverage with smaller number of cell sites

Technologies such as the Twin TRX in coverage mode in GSM, the sub-1 GHz frequencies in W-CDMA and the beam forming technology in WiMAX offer best-in-class

radio performances, providing superior levels of coverage for wireless networks. Greater coverage means smaller number of cell sites are required (a latest case study in Kenya showed that Alcatel-Lucent GSM equipment could decrease the number of cell sites by up to 40 percent), which translates into considerable savings in time and money, as well as lower power consumption [3].

IV.MICROGRID TECHNOLOGY –A CASE STUDY OF NTT

NTT group has been involved in the conservation of energy for the sake of improving the economy. A micro grid was constructed to study an authentic proof. The grid combines various distributed power sources such as fuel cells, solar cells, and NaS batteries. The outline of the test system is shown in Fig.4. The energy control system operates the distributed generators to control the influence on the commercial electric power lines wherein the micro grid system is connected. This control system also optimizes the generation scheduling in terms of plummeting price and ecological impact [4].

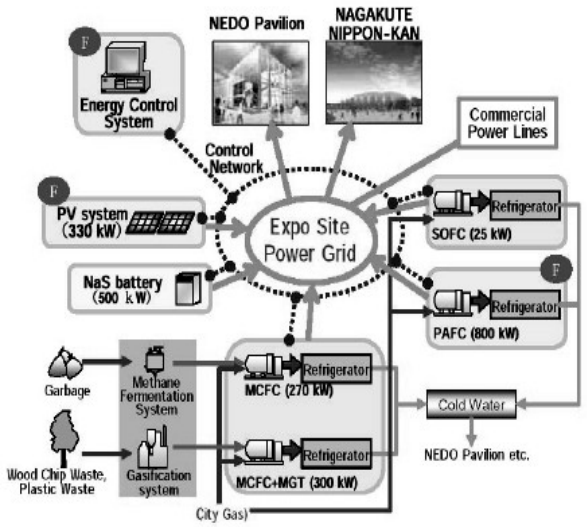

Figure-4: Micro grid Technology by NTT

V.GREEN COMPRESSOR-A CASE STUDY OF DRESSER-RAND'S DATUM® C COMPRESSOR

Necessity truly is the mother of invention. Such a case could be applied for Dresser-Rand's DATUM® C compressor. While the natural gas pipeline industry was at one time restricted to rural areas, in current years, the ever-expanding network of transmission pipelines and stations has become common-place, including in heavily colonized areas. As a result, gas suppliers have had to balance the burden for a reliable source of natural gas with the environmental and aesthetic concerns of their neighbors. Companies have been forced to search for novel and innovative ways to reduce noise and emissions from their pipeline operations. DATUM C compressor offers noteworthy environmental benefits including emission-free design, silent operation, reduced footprint, no on-site leakage from shaft seals, and magnetic bearings that eradicate need for oil lubrication and subsequent oil disposal. One of the most vital design characteristics of the DATUM C is its use of magnetic bearings. Because of the magnetic bearings, there is no need for an oil lubrication system, which allows for a considerable reduction in overall footprint and weight compared to a traditional compressor with oil lubricated bearings. The whole system is oil free and environment friendly [5].

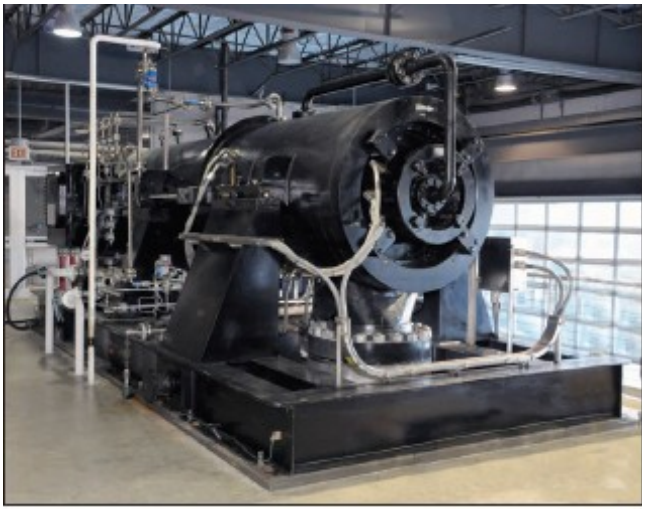

Figure-5: Dressser Rand's Datum-C Compressor

VI.EXAMPLES OF SOME 'GREEN' INDIAN COMPANIES

(1).Green banking is initiated by IndusInd bank. IndusInd opened the country's first solar-powered ATM and pioneered an eco-savvy change in the Indian banking sector. The bank is planning for more such initiatives in addressing the challenges of climate change. IndusInd's solar-powered ATM expects to save around 1,980 Kw of energy annually.

(2). HCL technologies have taken steps in solving the problem of toxics and e-waste in the electronics industry. HCL is committed to phasing out the hazardous vinyl plastic and

Brominated Flame Retardants from its products and has called for a Restriction on Hazardous Substances legislation in India.

(3). India's largest oil producer, ONGC, has developed energy-efficient, green crematoriums that will soon replace the traditional wooden pyre across the country. ONGC's Mokshada Green Cremation initiative will save 60 to 70% of wood and a fourth of the burning time per cremation.

(4). ITC strengthened their dedication to green technologies by introducing 'ozone- treated elemental chlorine free' bleaching technology for the first time in India. The result is an entire new range of top green products and solutions which is environmentally friendly multi-purpose paper that is less polluting than its traditional counterpart.

VII. CONCLUSION

Industries are taking green initiatives by using environment friendly technologies at different levels. It should be a part of CSR to establish harmony between human and nature. Government must take steps to encourage such industries.

VIII.REFERENCES

[1].National Institute of Standards and Technology, Standards Identified for Inclusion in the Smart Grid Interoperability Standards Framework, Release 1.0, Sept. 2009, [Online]. Available: http://www.nist.gov/smartgrid/standards.html.

[2].Motorola white paper on alternatives of powering base stations

[3]. Alcatel lucent white paper on Eco sustainable wireless services.

[4]. "Aichi World Exposition and Its Environment-Friendly Energy-Demand-&-Supply System," NTT FACILITIES JOURNAL, vol. 42, No. 248, March 2005

[5]. www.dresser-rand.com.