



INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume 5, Issue 1)

Available online at: www.ijariit.com

Survey on energy saving strategies in industries

Ashwini Punse

punse_ashwini.ghrcemtechips@raisoni.net

G.H. Rasoni College of Engineering, Nagpur, Maharashtra

ABSTRACT

A modern area utilizes more energy than some flip side use parts and as of now, this segment is expanding about 37% of the world's complete conveyed energy. Energy is devoured in the mechanical area by a differing gathering of enterprises including fabricating, agriculture, mining, and development and for a wide scope of exercises, for example, preparing and get together, space moulding and lighting. This paper presents an exhaustive writing audit about modern energy sparing by the board, advances and arrangements. Most recent writings as far as proposition (MS and PhD), diary articles, gathering procedures, web materials, reports, books, handbooks on modern energy the executives, arrangements and energy investment funds systems have been gathered. Energy-sparing by the board including energy review, preparing projects and housekeeping next to some energy the board rehearses on the planet has been investigated. Energy-sparing innovations, for example, utilization of high proficiency engines (HEMs), variable speed drives (VSDs), economizers, spill avoidance and diminishing weight drop has been checked on. In light of energy sparing innovations results, it has been discovered that in the mechanical segments, a sizeable measure of electric energy, emanations and service bill can be spared utilizing these innovations. Recompense periods for distinctive energy funds measures have been distinguished and observed to be monetarily practical in most cases. At long last, different energy sparing strategies for a few chose nations were checked on.

Keywords— Industrial energy, Energy management, Energy saving by technology

1. ENERGY UTILIZATION

Energy is a fundamental requirement for various purposes in modern offices around the globe. An immense measure of the energy required for nations with quicker financial development. Energy is along these lines a critical factor for financial intensity and business. In any case, worldwide populace and energy needs are expanded inseparably. This worry must be tended to by the worldwide network to defeat any deficiency of energy assets later on. World advertised energy utilization is anticipated to increment by 33% from 2010 to 2030. Complete world energy utilize ascended from 82,919 ZW in 1980 to 116,614 ZW in 2000 and afterwards is relied upon to reach 198,654 ZW in 2030 as appeared in Fig. 1 [1]. The quickest development in energy request from 2006 to 2030 is anticipated for countries outside the

Organization for Economic Participation and Development (non-OECD countries). This is since, in ongoing decades, OECD nations have been on the move from assembling economies to benefit economies. All out non- OECD energy utilization was expanded by 73% contrasted with a 15% expansion in energy use among the OECD nations [1]. The USA expends 25% of the world's energy. Be that as it may, the hugest development of energy utilization is as of now taking put in China, which has been developing at 5.5% every year [1]. The modern part utilizes more energy than some flip side use segments, right now expending about 37% of the world's aggregate conveyed energy. Energy is devoured in the mechanical part by a differing gathering of businesses including fabricating, agribusiness, mining, and development and for a wide scope of exercises, for example, handling and get together space molding, and lighting. Over the following 25 years, worldwide mechanical energy utilization is anticipated to develop from 51,275ZWin 2006 to 71,961ZWin 2030 by a normal of 1.4% every year.

1.1. Modern energy utilization by areas

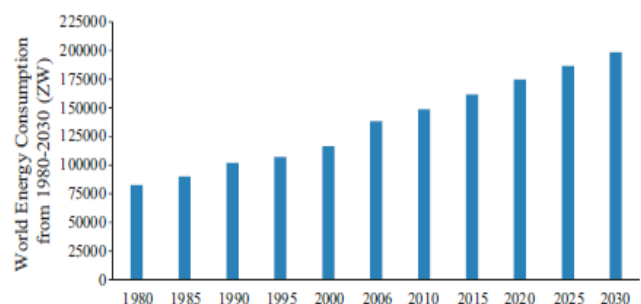


Fig. 1: World marketed energy consumption from 1980-2030 (ZW)[1]

At present, non-OECD economies expend 62% of worldwide conveyed energy in the modern division. Constantly 2030, modern energy use in the non-OECD is relied upon to develop at a normal yearly rate of 2.7%. The alleged "BRIC" nations (Brazil, Russia, India, and China) represent more than 66% of the development in non-OECD modern energy use. Since the OECD countries have been experiencing progress from assembling economies to benefit economies in late decades and have generally moderate anticipated development in financial yield, mechanical energy use in the OECD district, all in all, develops by a normal of just 0.2% every year from 2006 to 2030 [1].

1.2. The significance of energy productivity in the industry

Mechanical advancement over the world will result in additional energy use and will prompt more grouping of nursery gases, for example, carbon dioxide (CO₂) and different discharges, for example, sulfur dioxide (SO₂), nitrogen oxide (NO_x) and carbon monoxide (CO) which all have terrible ramifications for the world's atmosphere like rising temperature, dry season, surges, starvation and financial mayhem [8]. The Intergovernmental Panel on Climate Change (IPCC) announced that proceeded with discharges will prompt a temperature increment of somewhere in the range of 1.4 and 5.8 8C over the period from 1990 to 2100. Moreover, The Department of Energy (The United States of America) featured that, worldwide carbon discharges are rising over 2% every year and by 2015 might be over half above 1997 dimension, all of which due to expanding energy request and Wasteful method for energy use [9].

In industry, energy productivity can be enhanced by three diverse methodologies as pursuing:

1. Energy savings by management.
2. Energy saving by technologies.
3. Energy saving by policies/regulations.

In this study, each part of these approaches is discussed in details.

2. ENERGY MANAGEMENT

Energy the executives are the procedure of taking care of energy demand at the point when and where it is required. This can be accomplished by altering and upgrading energy utilizing frameworks and strategies to decrease energy prerequisites per unit of yield while holding consistent or lessening absolute expenses of creating the yield from these frameworks [11,12]. The energy the board started to be viewed as one of the fundamental elements of modern administration during the 1970s as the outcome of the rising cost of energy and reports about the drawing nearer depletion of world energy assets [11]. and more dependable outcomes [7].

2.1 Types of energy savings by management

There are numerous sorts of energy sparing by the executives. In this survey three sorts will be talked about as pursuing:

1. Energy review.
2. Energy effectiveness courses and preparing the program.
3. Housekeeping.

2.1.1. Energy review: Energy review is an assessment, study and investigation of energy streams for energy preservation to diminish the measure of energy contribution to the system without adversely influencing the yield. The energy review is the key for basic leadership in the zone of energy the executives. Energy review is along these lines a solid and efficient methodology in the modern segment. It causes any association to investigate its energy use furthermore, find territories where energy use can be decreased and waste can happen, plan and practice achievable energy preservation techniques that will improve their energy effectiveness, serve to distinguish all the energy streams in an office, evaluate energy use, trying to adjust the complete energy contribution with its utilization [15]. In any industry, the three best working costs are regularly found to be energy (both electrical and warm), work and materials. In the event that one was to identify with the sensibility of the expense or potential expense investment funds in every one of the above segments, energy would perpetually develop as the best ranker, and hence energy the executives work

2.1.2. Energy proficiency courses and preparing program:

Energy proficiency courses and preparing programs are very critical to building familiarity with individuals who are included

in the mechanical area. By and large, there are two different ways to get mechanical energy to the executives' course. The first is significant to engineers working in the industry, while the second depends on the energy of the executives' course at the college level. In both of these, energy the executive's endorsement is given to the members who complete the course effectively and present an energy protection report. This report covers a case study, which is a genuine on-location consider or on the other hand investigation performed for an industry. These courses, when all is said in done, centre on lawful, innovative, ecological, social and prudent measurements of energy effectiveness comprises a vital territory for cost decrease [12]

2.1.3. Energy-sparing by housekeeping: In industry, proficient generation and a decent workplace are reciprocal. The end of wasteful aspects and mishap risks caused by horrible conditions in the work environment is basic in taking care of business effectively and securely. The thoughtfulness regarding these vital subtleties is broadly alluded to as "great housekeeping". Housekeeping includes each period of modern tasks. It is more than simple tidiness. It requires systematic conditions, the evasion of blockage, and consideration regarding such subtleties as an efficient format of the entire work environment, the stamping of walkways, sufficient capacity game plans, and reasonable arrangement for cleaning and support [41].

2.1.3.1. Components of a decent housekeeping effort. The accompanying is a portion of the essential components of decent housekeeping that spare energy in any mechanical organization [41].

Lighting: Well-dispersed counterfeit light and successful utilization of accessible sunshine could spare energy fundamentally.

Waste evacuation: Adequate offices to avert clog and scatter. A portion of these components are:

- (a) **Paint the dividers:** Light-hued dividers reflect light. Grimy or dim hued dividers ingest light.
- (b) **Maintain the light fittings:** Attention to light fittings ought to be a necessary piece of any great housekeeping program. Grimy lights and shades, and lights whose yield has disintegrated with use deny representatives of fundamental light. It's been found that lighting proficiency might be enhanced by 20– 30% basically by cleaning the lights and reflectors.
- (c) **Dispose of scrap and forestall spillage:** It's a typical practice to give the floor a chance to get all the waste and after that invest time and energy tidying it up. It is clearly better to give helpful holders to scrap and waste also, instruct workers to utilize them. Wellbeing will profit, the cost will be spared, and the industrial facility will be a superior place in which to work.
- (d) **Look after your medical aid adapts:** First guide offices and hardware ought to be held under perfectly clean conditions, what's more, completely loaded so they are constantly prepared in case of mishaps or sickness.
- (e) **Inspect fire-control gear:** It is fundamental to guarantee that all putting out fires gear, for example, dousters and fire hoses are routinely assessed and maintained in great working control. Fire insurance ought to be in great working request. Entryways and ways out ought to dependably be stayed far from hindrances.
- (f) **Regular upkeep:** Maintenance is the most essential component of good housekeeping. Standard upkeep permits the supervisory crew to fix apparatus, broken windows, harmed entryways, faulty pipes, and releasing, broken floor surfaces. A decent support program will make arrangement

for the investigation, oil, upkeep and fix of devices, hardware, machines and procedures.

3. ENERGY SAVING TECHNOLOGIES

Uses of innovations can possibly decrease mechanical energy sue. Mechanical energy use can likewise be decreased utilizing variable speed drive in engine worked framework, high productive engines, and productive spouts in compacted air framework, squander warm recuperation framework in boilers and so forth. Some of them are talked about as beneath.

3.1. Variable speed drive

A variable speed drive is an electronic power converter that creates a multi-stage, variable recurrence yield that can be used to drive a standard air conditioning acceptance engine, and to regulate and control the engine's speed, torque and mechanical power yield. This application offers noteworthy energy sparing whenever connected in numerous modern applications [19]. Air conditioning drive can be portrayed by diverse terms. AFD, variable speed drives (VSD), VFD and inverters all are utilized, yet have similar importance. VSD's has been utilized to give noteworthy funds in various applications around the globe [20, 21]. The liking Laws (additionally called the cubic Laws) expresses that siphon yield or stream are specifically corresponding to the speed of the siphon. Accordingly, to create a half stream, the siphon would be kept running at half speed. At this working point, the siphon would require just 12.5% of evaluated torque ($0.5^3 = 0.125$ or 12.5%) [22]. VSD additionally offers a noteworthy yearly bill sparing and discharges decrease; for instance, the nourishment producer Northern Foods in the UK accomplished a yearly energy sparing of 769 MWh/year, over £30,000 sparing a year in power costs, compensation time of only 10 months, what's more, yearly CO2 decrease of 338 ton [23]. From a mechanical advantage angle, orientation keeps running at diminished speeds ordinarily last any longer than their full speed partners. Likewise, drives inalienably "delicate begin" the determined mechanical hardware. This delicate begin broadens not just the life of the engine and orientation, yet in addition, radically decreases belt mileage [23].

3.1.1. Variable speed control system: One of the numerous conceivable circuits to control the speed of an enlistment engine is schematically spoken to in figure 2 [24].

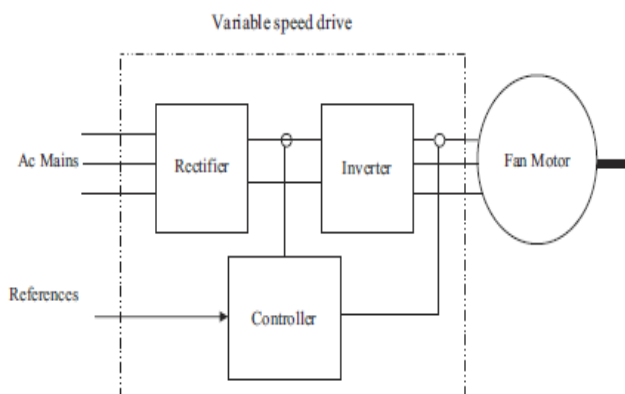


Fig. 2: The block diagram of the variable speed drive system [24]

3.2. Waste heat recovery from flue gas by the economizer

Waste heat is heat, which is created in a procedure by a method for fuel burning or synthetic response, and after that "dumped" into the condition despite the fact that it could at present be reused for some valuable furthermore, monetary reason. The methodology of how to recoup this warmth depends to some

extent on the temperature of the waste warmth gases and the financial matters included. The economizer is a gadget used to recuperate the squander warm from the pipe gas and comprises of a progression of level cylindrical components and can be portrayed as an uncovered cylinder and expanded surface sorts [25]. Advantages of waste warmth recuperation can be extensively ordered in two classes; Direct and roundabout advantages; coordinate advantages incorporate recuperation of waste warmth that affects the proficiency of the process and decrease in the utility utilization and expenses. Backhanded benefits include Reduction in contamination, Reduction in gear sizes, for example, fans, stacks, conduits, burners, and so forth and fuel utilization [25].

3.3. High proficiency engines

The heft of power utilization in the modern area is by electric engines. Exercises and procedures in the business depend vigorously on electric engines including for compacting, cutting, pounding, blending, fans, siphons, materials passing on, air blowers furthermore, refrigeration. There are four fundamental kinds of misfortunes in a squirrel-confine enlistment engine:

- (a) Stator and Rotor misfortunes (I2R misfortunes in stator and rotor windings).
- (b) Canter (Magnetic) misfortunes; this is the entirety of the hysteresis and swirls current misfortunes of the covered stator and rotor canter.
- (c) Grating and windage; this is the misfortune because of fans and the bearing grating.
- (d) Stray misfortunes; this is the singular amount of all misfortunes in the engine which can't be ascribed to one of the other four segments. It is primarily because of electrical sounds and stray flows in the engine. It must be stressed that a standard engine is as of now an effective gadget with effectiveness above 80% over a large portion of the working go, ascending over to above 90% at full load. Be that as it may, engine makers have possessed the capacity to build the effectiveness further with the accompanying extra upgrades:
 - Enhanced steel properties,
 - More slender covers,
 - Increment conductor volume,
 - Changed opening structure,
 - Narrowing air hole,
 - Enhanced rotor protection,
 - Increasingly proficient fan structure.

3.4. Energy savings through leak prevention in air compressors

Holes speak to a huge wellspring of squandered energy in the mechanically compacted air frameworks. Air spills are the single most noteworthy wellspring of energy misfortune in assembling offices with compacted air frameworks. Holes can squander 20–half of a blower's yield. Halting breaks can be as straightforward as fixing an association or as intricate as supplanting broken hardware, for example, couplings, fittings, pipe segments, hoses, joints, deplete, and traps. Breaks happen regularly at the joints, associations, elbows, lessening brambles, sudden developments, valve frameworks, hoses, tubes, channels, hoses, check valves, help valves, expansions, and the hardware associated with the packed carriers. This break can cause a drop in framework weight influencing creation. Likewise, to the expanded energy utilization, breaks can make air devices less effective and antagonistically influence a generation, abbreviate the life of gear, lead to extra upkeep necessities and expanded unscheduled downtime. Holes cause an expansion in blower energy and support costs. Power misfortunes expanded exponentially as the width of opening increment as appeared in figure 3 [31, 32].

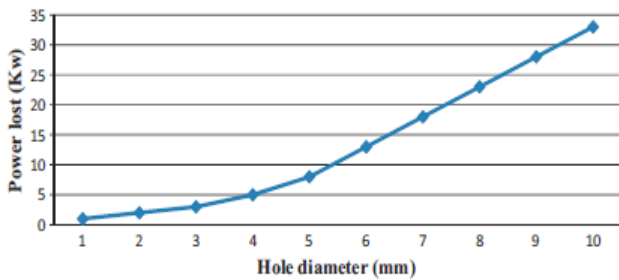


Fig. 3: Dependence of power loss on hole diameter at 600 kPa [31]

The expense of compacted air spills is the expense of the energy required to pack the volume of lost air, from barometrical weight to the blower's working weight. The expense of packed air releases increments as the distance across of the hole increments. Table 9 demonstrates the expense of energy lost for various breadths of the hole [34]. Breaks may effortlessly be situated through their murmuring when other plant tasks are inert. In a few circumstances, it might be important to hang tight for a planned plant shutdown. Brief fixes can frequently be made by setting a cinch over the break [35].

One of the approaches to lessen spills is to bring down the interest air weight of the framework. The lower the weight differential over a hole or release, the lower the rate of the stream, so decreased framework weight will result in diminished spillage rates. Balancing out the framework header weight at its most reduced handy range will limit the spillage rate for the framework.

3.5. Energy investment funds because of weight drop

By and large, framework weight can be brought down, along these lines sparing energy. Most frameworks have at least one basic applications that decide the base adequate weight in the framework. The murmuring of the air breaks can once in a while be heard even in high-commotion fabricating offices. Weight drops at the end-use focus on the request of 40% of the blower released weight is definitely not exceptional. However, a typical reaction to such an issue is the establishment of a bigger blower as opposed to checking the framework also, discovering what the issue is. The last restorative activity is normally taken simply after the bigger blower likewise neglects to dispense with the issue. The energy squandered in compacted air frameworks on account of poor establishment and upkeep can account for up to half of the energy devoured by the blower, and it is trusted that about portion of this sum can be spared by rehearsing energy preservation measures [35].

Limiting weight drop requires a frameworks approach in plan and upkeep. Air treatment parts ought to be chosen with the most minimal conceivable weight drop at indicated most extreme working conditions and best execution. Makers' proposals for support ought to be pursued, especially in air sifting and drying hardware, which can have to harm dampness impacts like pipe consumption. At long last, the separation the air goes through the dissemination framework ought to be limited.

4. ENERGY SAVING BY POLICIES/REGULATIONS

Energy Policy is the way by which a given substance (frequently legislative) has chosen to address issues of energy advancement counting energy creation, dissemination and utilization. The qualities of energy strategy may incorporate enactment, global settlements, impetuses to speculation, assentions, rules for energy protection, tax collection, energy proficiency guidelines, energy manage marks [37]. Energy strategies are utilized broadly in the modern area to meet explicit energy use or energy proficiency

targets. Modern energy strategy can be seen as a device for building up a long haul vital arrangement, covering a time of 5–10 a long time, for expanding modern energy productivity and diminishing ozone-harming substance emanations. This arrangement connects with not just the proficiency in the modern area. A portion of these strategies and programs as incorporate [38– 43]:

- Directions/benchmarks,
- Monetary approaches,
- Understandings/targets,
- Revealing/benchmarking

4.1. Directions/models

Directions and models are the required strategies for moving forward energy proficiency. Directions and guidelines are ordinarily connected to specific bits of hardware, for example, engines, boilers, and so forth. Likewise, controls can necessitate that modern office's direct energy reviews, utilize an energy supervisor, or embrace energy the executive's framework. Instances of controls and measures in a few nations appear.

4.2. Monetary approaches

Monetary approaches incorporate inconvenience of charges, impose refunds, speculation assess credits, and building up venture bank loaning criteria for advancement of energy proficiency. Tax collection strategies are compulsory methods for affecting the presentation of energy proficiency. Tax collection strategies can likewise impact energy effectiveness using charge discounts or speculation impose credits. Venture bank loaning criteria can be set up to give a higher need for subsidizing ventures that enhance energy productivity [38].

4.3. Assentions/targets

Assentions are utilized generally in the modern division to meet explicit energy use or energy effectiveness targets. Such understandings, which are commonly however not constantly intentional, are characterized as "assentions among government and industry to encourage wilful activities with attractive social results, which are empowered by the legislature, to be attempted by the members, in light of the members' personal circumstance". An assention can be planned in different ways: two basic strategies are those dependent on indicated energy productivity enhancement targets and those dependent on explicit energy use or carbon outflows decrease duties. Either an individual organization or a mechanical subsector, as spoken to by a gathering, for example, an industry affiliation, can go into such understandings. A portion of these approaches is organized.

5. CONCLUSION

In this audit, different energy funds methodologies, for example, energy investment funds by the board, advancements and arrangements have been audited. The job of energy the board is fundamental and has enormously extended in ventures. Top administration of the organization takes an interest in arranging different energy the executives extends on a normal premise. It has been discovered that energy sparing advances for instance utilization of high effective electric engines, diminishing evaporator pipe gas temperature, utilization of variable speed drive to coordinate load prerequisite has been observed to be financially savvy energy sparing measure to lessen energy utilization of significant energy utilizing hardware in the mechanical offices. These investment funds techniques observed to be monetarily reasonable as a rule. Alongside energy investment funds, a sizeable measure of discharge can be diminished utilizing different energy investment funds procedures. It was likewise seen that viable open strategies are

additionally expected to diminish mechanical energy utilization alongside discharge decrease.

6. REFERENCES

- [1] U.S Energy Information Administration. Global Energy Outlook 2009: World Energy and monetary Outlook; 2009, Available Online at:<http://www.eia.doe.gov/oiaf/ieo/world.html>,<http://www.eia.doe.gov/oiaf/ieo/>
- [2] United Nations Industrial Development Organization (UNIDO). Approaches for advancing mechanical energy proficiency in creating nations and change economies; 2008, Available online at <http://www.greenhouse.gov.au/challenge/html/about/about.html>,http://www.unido.org/fileadmin/media/records/pdf/Energy_Environment/ind_energy_efficiencyEbookv2.pdf.
- [3] Worrell E, Price L. Approach situations for energy proficiency enhancement in industry. *Energy Policy* 2001;29:1223– 41.
- [4] Sinton JE, Fridley DG, Levine MD, Yang F, Zhenping J, Xing Z, et al. China Energy Databook. Lawrence Berkeley National Laboratory 1996 [LBL-32822 Rev. 4].
- [5] National Bureau of Statistics. China Statistical Yearbook 1999. Beijing: China
- [6] Yanjia W. Energy effectiveness strategy and CO₂ in China's industry: tapping the
- [7] Price L, Worrell E, Sinton J, Yun J. Mechanical energy proficiency arrangement in China. In: Procedures of the 2001 ACEEE summer contemplate on energy proficiency in industry. Lawrence Berkeley National Laboratory 2001 [LBNL-50452].
- [8] Mahlia TMI. Outflows from power age in Malaysia. *Inexhaustible Energy* 2002;27:293– 300.
- [9] Mahmoud A, Shuhaimi M, Abdel Samed M. A joined procedure mix furthermore, fuel exchanging technique for emanations decrease in compound process plants. *Energy* 2009;34:190– 5
- [10] Hepbasli An, Ozalp N. Improvement of energy productivity and the executive's execution in the Turkish mechanical part. *Energy Conversion and The board* 2003;44:231– 49.
- [11] Petrecca G. Mechanical energy the board: standards and applications. USA:
- [12] Bureau of Energy Efficiency. The energy the board and review; 2010 [Online] Accessible at <http://www.em- ea.org/Guide%20Books/book-2/2.8%20Waste%20Heat%20Recovery.pdf>
- [13] Kannan R, Boie W. Energy the board rehearses in SME— contextual investigation of a pastry kitchen in Germany. *Energy Conversion and Management* 2003;44:945– 59.
- [14] Turner W, Doty S. Energy the executive's handbook. Fairmont Press; 2009.
- [15] Saidur R. An audit on electrical engines energy use and energy investment funds. *Inexhaustible and Sustainable Energy Reviews* 2010;14:877– 98.
- [16] PTMPusat Tenaga Malaysia. High productivity engines for modern and business divisions in Malaysia; 2010, Available online at <http://www.ptm.org.my/mieceip/pdf/High%20Efficiency%20Motors%20for%20Industrial%20and%20Commercial%20Sectors%20in%20Malaysia.pdf>
- [17] Sola A, Xavier A, Kovalski J. Energy efficiency in production engineering courses. In: Third international conference on production research—Americas' region; 2006.
- [18] McKane A, Williams R, Perry W, Li T. Setting the standard for industrial energy efficiency. *Industrial Management Issues* 2010;9:70.
- [19] Mecrow BC, Jack AG. Efficiency trends in electric machines and drives. *Energy Policy* 2008;36:4336–434.
- [20] Saidur R, Rahim NA, Ping HW, Jahirul MI, Mekhilef S, Masjuki HH. Energy and emission analysis for industrial motors in Malaysia. *Energy Policy* 2009;37:3650–8.
- [21] Saidur R. Energy consumption, energy savings, and emission analysis in Malaysian office buildings. *Energy Policy* 2009;37:4104–13.
- [22] Lo'n'nberg M. Variable speed drives for energy savings in hospitals. *World Pumps* 2007;2007(494):20–4.
- [23] Tolvanen J. Saving energy with variable speed drives. *World Pumps* 2008; 32–3.
- [24] Ozdemir, Engin. Energy conservation opportunities with a variable speed controller in a boiler house. *Applied Thermal Engineering* 2004;24:981–93.
- [25] Beureau of Energy Efficiency. Waste heat recovery; 2009, Available online at: <http://www.em- ea.org/Guide%20Books/book-2/2.8%20Waste%20Heat%20Recovery.pdf> [Accessed 5.10.09].
- [26] Abdelaziz EA. Energy economical and environmental analysis of industrial boilers. Master thesis. Malaysia: University of Malaya; 2010.
- [27] Willems D. Advanced system control and energy savings for industrial boilers; 2009, Available online at <http://74.125.153.132/search?q=cache:CfMOhmytbagJ:ww w.cbboilers.com/Energy/Technical%2520Articles/Citrus%2520Engineering%2520Conference%2520paper%2520rev%2520h.%2520doc.doc+ADVANCED+SYSTEM+CONTROLS+AND+ENERGY+SAVINGS+FOR+INDUSTRIAL+BOILERS&cd=1&hl=en&ct=clnk&gl=my&client=opera>
- [28] Tripathy SC. Energy conservation with efficient electric drives. *Energy Conversion* 1994;36:125–34.
- [29] Saidur R, Mahlia TMI. Energy, economic and environmental benefits of using high-efficiency motors to replace standard motors for the Malaysian industries. *Energy Policy* 2010;38:4617–25.
- [30] Saidur R, Rahim NA, Masjuki HH, Mekhilef S, Ping HW, Jamaluddin MF. End use energy analysis in the Malaysian industrial sector. *Energy* 2009;34:153–8.
- [31] Kaya D, Phelan P, Chau D, Sarac HI. Energy conservation in compressed-air systems. *International Journal of Energy Research* 2002;26:837–49.
- [32] Galitsky C, Worrell E. Energy efficiency improvement and cost saving opportunities for the vehicle assembly industry. Lawrence Berkeley National Laboratory 2008 [LBNL-50939-Revision].
- [33] U.S. DOE. Minimize compressed air leaks; 2010, Available online at: [http://www.energystar.gov/ia/business/industry/compressed _air3.pdf](http://www.energystar.gov/ia/business/industry/compressed_air3.pdf)
- [34] PS (Plant Support). Compressed air ultrasonic leak detection guide; 2010, Available online at: [http://www.plantsupport.com/down load/UCAGuide.pdf](http://www.plantsupport.com/download/UCAGuide.pdf)
- [35] Saidur R, Rahim NA, Hasanuzzaman M. A review on compressed-air energy use and energy savings. *Renewable and Sustainable Energy Reviews* 2010;14:1135–53.
- [36] D'Antonio M, Epstein G, Moray S, Schmidt C. Compressed air load reduction approaches and innovations. In: Proceedings of the twenty-seventh industrial energy technology conference; 2005.
- [37] Jacobs NB. Energy policy: economic effects, security aspects and environmental issues. Nova Science Publishers Inc.; 2009.

- [38] Price L, Worrell E. International industrial sector energy efficiency policies. Lawrence Berkeley National Laboratory 2000 [LBNL-46274].
- [39] Bertoldi P. The use of long-term agreements to improve energy efficiency in the industrial sector: overview of the European experiences and proposal for a common framework. In: Proceedings of the 1999 American council for an energy-efficient economy summer study on energy efficiency in industry. Washington, DC: ACEEE; 1999.
- [40] Chidiak M. Voluntary agreements for energy efficiency in five EU countries.
- [41] Dufort VM, Infante-rivard C. Measuring housekeeping in manufacturing industries. The Annals of Occupational Hygiene 1999;43:91-7.