ENERGY EFFICIENT ELECTRICITY USAGE AND LIGHTING SOLUTIONS FOR INDUSTRIAL PLANTS

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ABSTRACT

In recent years, there has been a growing interest about energy efficiency and conserving the environment in general. The study aims to evaluate industrial plant energy usage patterns and the potential for their improvement. Current electrical systems at factories often are inefficient according to present day technical standards. Technologies that are used in industrial plants are old and there is room for improvements. Transition towards a low-carbon emission economy for industrial plants will change the method of power production and also the way of how it is consumed. Converting conventional electrical grids to smart grids is an important step in energy economy. The focus on improvement of existing lighting systems has the potential of being one of the most significant short term actions to cut the expenses and decrease CO_2 *emissions.*

Keywords: industrial energy efficiency, efficient electricity usage, energy efficient lighting

INTRODUCTION

Industrial energy auditing method attempts to resolve differences among various auditing approaches. There are three main issues that have caused problems with performance monitoring of energy audit results and measures taken in the past.

- Standardization: Standard performance metrics provide a consistent basis for comparing energy performance among buildings;
- Versatility: The analysis is customized to the facility boundaries, energy configuration, goals and budget of analysis that apply to a given project;
- Economy of Effort: The data collection is carefully matched to the goals of the analysis and the study questions to avoid the common mistakes of too few or too many data.

Each procedure in this series should be done according to a standardized protocol that helps to quantify performance metrics (NREL, 2005).

Technical potential for improving industrial energy efficiency is substantial. The economic potential appears favorable even without putting any price on excess CO_2 emissions. Most of the improvements include various adaptations of existing technology (EOLBNL, 2010). However it is well known that there are numerous issues regarding the adaptation of such technologies. Yet, the main problem is lack of information, shortage of recognized professionals and no or limited access to capital needed for investments (CEA, 2010). In this paper two possible energy efficiency measures are considered - smart grids and efficient lighting systems.

Smarts grids provide a way to reduce transmission and distribution losses, optimize usage of operating infrastructure by providing regulation for power flows, shifting peak demands, channeling decentralized and renewable energy into the grid and managing consumption patterns of all users connected to the grid (EC, 2006).

Electrical lighting is one of the major energy consumers in industries where lighting is used constantly or inefficiently. Large energy savings are possible by using energy efficient lighting, effective illumination sensor usage, optimal system design and rising awareness about energy economy for workers. Correct and energy efficient usage of electric lighting provides a wide array of benefits. First, carefully designed lighting system, improves work conditions, visual performance and visual comfort. (NYCDoDC, 2005/2006). Next, it reduces heat gains, thus saving energy in air conditioning systems, and increasing thermal comfort.

ANALYSIS

Manufacturing and construction industries are the third largest energy consumers in Latvia after household and transport branches. Energy consumption in manufacturing and construction industries in 2007, 2008, 2009, and 2010 years were as follows: 16.6%, 16.4%, 16.2% and 18.3% of total energy consumption in Latvia. Energy efficiency measures are usually applied in order to maintain or increase competitiveness in given industry (EM, 2011).

As it is stated in Figure 1, energy consumption for manufacturing and construction industries had been very steady over the years. There are potentials for energy efficiency in every industry.

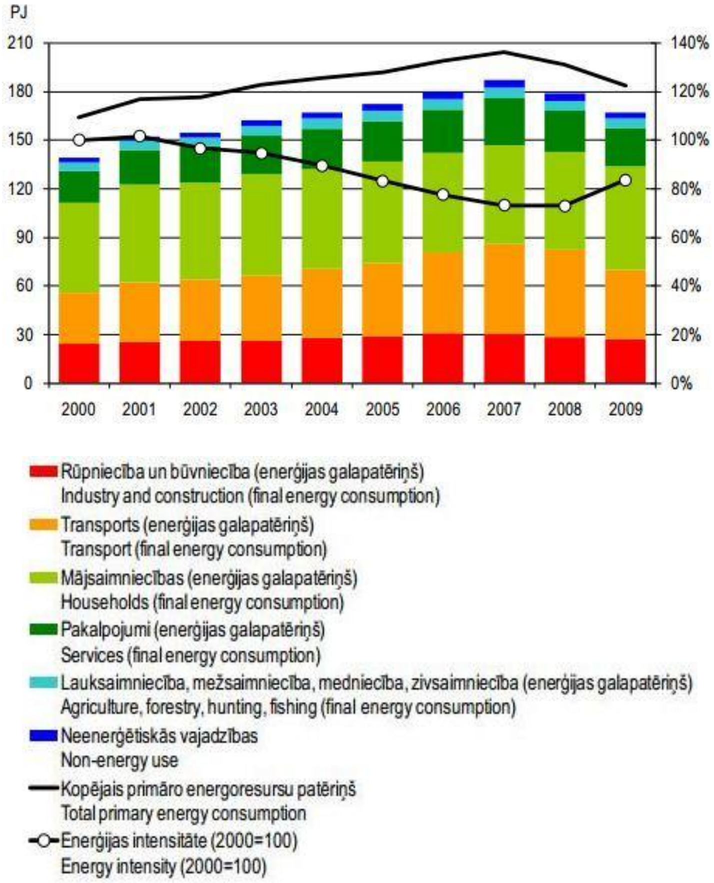


Figure 1. Final energy consumption by sectors (EM, 2011)

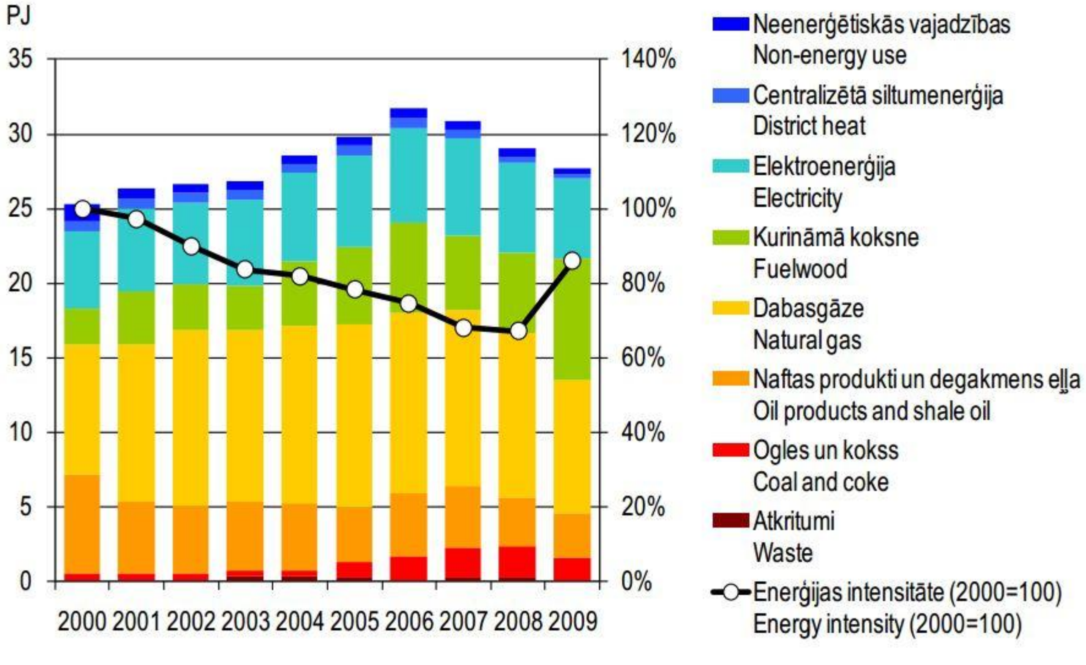


Figure 2. Final consumption in industry and construction (EM, 2011)

The share of electricity in total energy demand had been steady over the years and was as follows: 19.8% in 2009, 21.3% in 2008, and 21.6% in 2007 and similar for the previous years as well. But the total energy demand has been increasing over the years. World experience and overall world practice show that energy efficiency has a great potential in the industrial sector and the potential savings are ranged from industry, individual companies and buildings, but the savings are often in the range from 10 to 40% of total energy usage (EM, 2011).

SMART GRIDS

Conventional electricity distribution systems are very complicated and extensive, but almost entirely passive, with little inter-communication and very limited control ability. Only the biggest consumers have commercial electricity monitoring systems either by voltage or by drawn current. The interaction between consumer loads and the power system itself is very poor (EC, 2006).

Smart communication systems offer the possibility of much greater control and monitoring of the grid than it is utilized in most cases now. Monitoring and controlling the grid offers the possibility of energy management and economy. Smart grid is an opportunity to use information and communication technologies in order to revolutionize the electrical power system. But due to the large size of the system and scale of the required investments switching to smart grid requires careful justification.

Smart grids are beneficial not only to power producers, but also consumers; the technologies used in smart grids provide information about energy usage and the possibility to manage the energy flow. This is achieved through advanced sensors and computerized remote controls that are designed to limit outages and network losses. These devices are interlinked to communication networks to enable consumer participation and to manage the integration of distributed energy sources (renewables, energy storage, combined heat and power). This allows the interconnected components to be optimized and monitored, and to help ensure efficient and reliable system operation. Figure 3 represents general smart grid vision and the different participants involved, converting a traditional one-directional power grid into a fully interconnected network. For the smart grid to become fully functional and usable, the energy sector will have to overcome two main challenges (CEA, 2010):

1. Level of implementation: issues of standardization and certification, operation, system testing, and consumer participation;
2. Financial issues: large amounts of funding are needed throughout the lifecycle of the smart grid development.

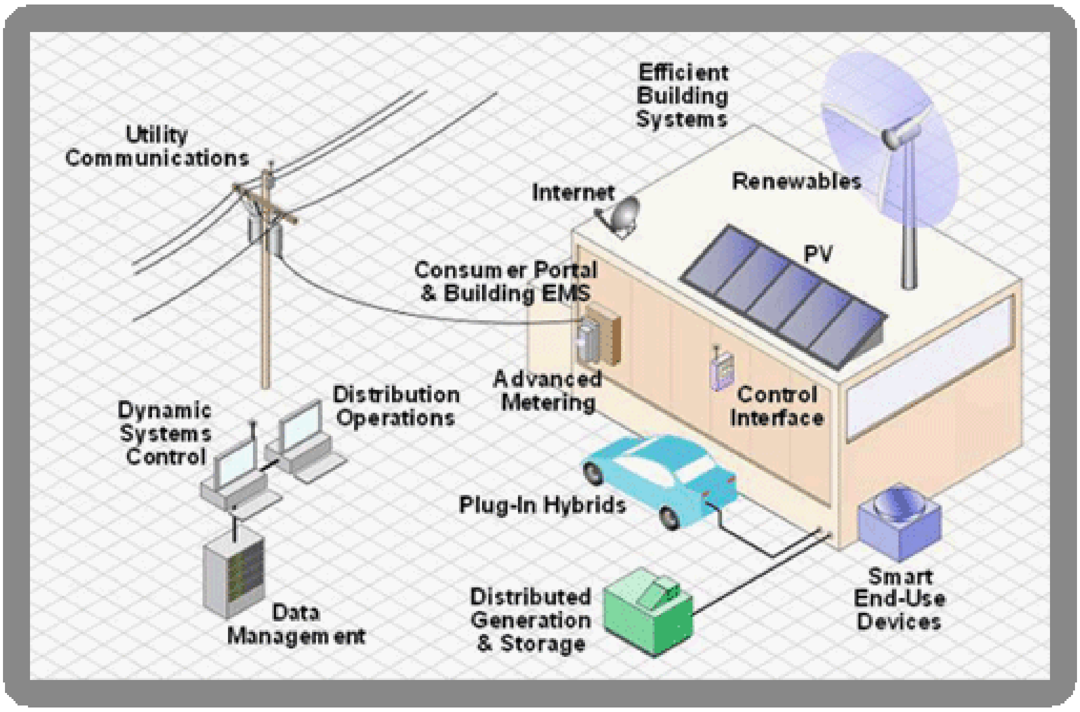


Figure 3. Schematic representation of smart grid idea (Bassein, 2010)

ENERGY EFFICIENT LIGHTING

The focus on improving the efficiency of electric lighting has the potential to be one of the most significant short-term initiatives to decrease power consumption and CO_2 emissions. There are multiple possibilities of energy economy regarding lighting usage and the physical lighting fixture itself. But there are numerous barriers that industries must overcome in order to introduce energy efficient lighting systems:

- Financial barriers are due to the higher initial cost of energy efficient lighting products, relative to conventional lighting and control systems;
- Market barriers may include: high quality lighting systems are not widely available due to low demand; the lack of promotion of energy efficient lighting products;
- Information barriers result from the lack of awareness and information about energy efficient lighting among professionals and the general public;
- Regulatory institutional barriers involve: lack of government interest; insufficient enforcement of policies; the need for more qualified personnel; priority on increasing supply rather than on reduction of consumption;
- Technical barriers include a lack of resources and infrastructure such as recycling and testing facilities, also pilot projects; and problems with electrical power supply, including outages, power surges and voltage variations;
- Environmental and health risk perception barriers include concerns about quality of light; possible exposure to electromagnetic fields; and possible exposure to hazardous materials that may be contained in the electronics or other lamp components.

The most efficient lamps for general illumination in the consumer sector use one-fifth to one-sixth of the electrical power to produce the same amount of light as the least efficient lamps and last up to 35 times longer (UNEP, 2012)

The first step in deciding whether a company would benefit from phasing out inefficient lighting is to understand how much electricity is currently being consumed for lighting, and what potential savings are available by moving towards more efficient lighting. Moving towards energy efficient lighting can be beneficial to other building systems as well, for example efficient lighting systems generate less heat and therefore the load for cooling or the air conditioning system is reduced. Another important thing is using those lighting patterns that can be modified and adopted as energy efficiency measures.

RESEARCH

Research was conducted in order to obtain lighting usage patterns and determine possible measures for energy saving by optimizing the lighting system and adding sensor controls for lighting appliances. Research was conducted using the Steinel PROLog (Figure 4.) lighting audit sensor. Usually this sensor is placed in the areas where the potential energy losses could be found due to unnecassary artificial lighting. The sensor must be placed where people would cross the sensors reception area (Figure 5.) and it registers the movement patterns and frequency in a 21-28 day period. The sensor is designed for rooms without any automatic lighting control systems. The sensor data processing enables the system to determine the important data set for the lighting system design:

1. Amount of daylight. Daylight is often available through windows or skylights. But natural light is present only at certain times of the day and the amount of light from windows changes throughout the seasons. Availability of daylight is also affected by window properties such as g-value and percentage of glazing; also dirt on windows can sometimes play a huge role in reducing the amount of daylight.
2. Usage patterns of the room measured. Due to a built in occupancy sensor it is possible to register how often and for how long the light is actually needed in the room. By coupling usage patterns and time of available daylight it is possible to determine when artificial lighting is needed (or when auditing existing systems – whether artificial lighting is needed at all). In order to decide when artificial lighting is needed a normative illuminance at a specific workplace must be determined and set in the audit sensor.

Economical calculations have been conducted. Two scenarios are calculated and the economic data compared. The first scenario is the existing real life situation (existing lighting fixtures, for window condition and room usage patterns). The second scenario is calculated with new lighting fixtures and using an occupancy sensor, window condition is treated as unchanged (although often only by cleaning the window glass significant savings can be achieved). The scenarios are calculated for one, three, five and ten years. In the economical calculations three main parts of savings are considered, cost of used energy (and therefore CO_2 emissions), cost of changing lighting fixtures and the maintenance cost itself. Measurements were conducted in a room with low worker movement intensity, but the lighting was controllable only manually. Existing room parameters and results are shown in Table 1 and Figures 6 to 8.

Figure 4. Steinel PROLog audit sensor (Steinel, 2012)

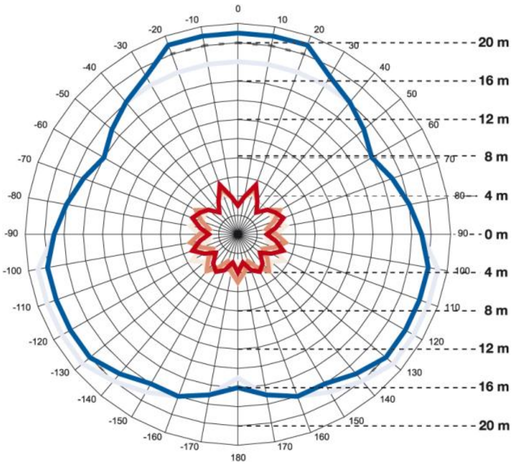
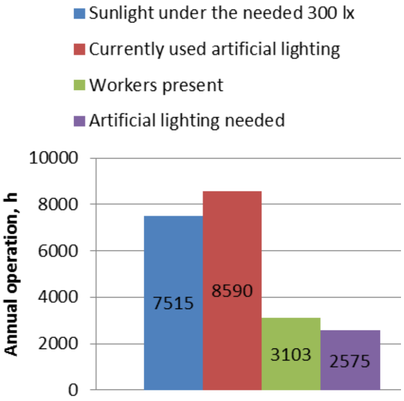


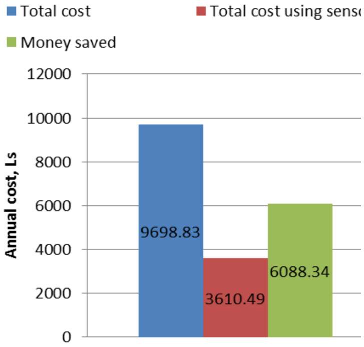
Figure 5. Sensor active range (Steinel, 2012)

Table 1

Room data		Results	
Windows type	Old wooden windows	Sunlight under the needed 300 lx	7515h
Amount of sunlight	50 lx	Currently used artificial lighting	8590h
Power of one lighting appliance	58W	Workers present	3103h
Existing lights	13 rows, 3 columns 2x58W	Artificial lighting actually needed	2575h
Total power of one lighting fixture including ballast	130 W	Annual energy for lighting	130657 kWh
Total lighting power	15.2 kW	Truly needed energy for lighting	39172 kWh
Normative (needed) lighting	300 lx	Lighting fixture life expectancy, existing	1.16y
Existing lighting usage pattern	24 h	Lighting fixture life expectancy, with sensors	3.11y
Data of measurement		Service cost, existing system	Ls 552.78
Month	September of 2012	Service cost, with sensors	Ls 207.16
Results obtained	299650	Energy economy for 1 year	82038.88 kWh
Duration of measurement	21 day	CO_2 economy for 1 year	41019.44 kg

(Source: Created by the author)





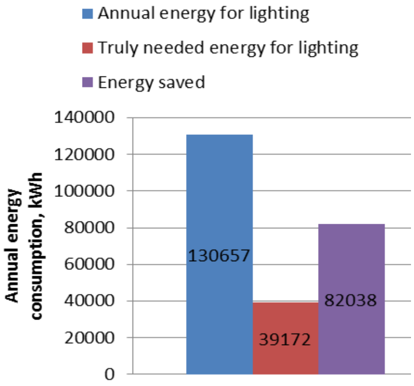


Figure 6. Annual operation, h
(Source: Created by the author)

Figure 7. Annual cost, Ls
(Source: Created by the author)

Figure 8. Annual energy consumption
(Source: Created by the author)

In figures 6-8 possible energy savings and costs are illustrated. The following issues were identified:

- The daylight is not sufficient for most of the time for quality work conditions, Figure 6.
- Artificial lighting is used all of the time, despite some of the time daylight is available and most of the time there are no workers present, Figure 6.
- Artificial lighting is needed only 29.9% of the time, Figure 6.
- The possible achievable savings per year are up to Ls 6083.34 - reduction of 62.8 %, Figure 7.
- The total energy needed for lighting is only 29% or 39172 kWh of the energy currently used, total energy saved by using sensor lighting systems – 91485 kWh, Figure 8.

CONCLUSIONS

1. In order to obtain the best possible result of the industrial energy audit the need for standardization is identified. Standardization gives the best possible opportunity to compare similar facilities in the same industry and analyze the results.
2. There is a large technical potential for improving industrial energy efficiency. Economic potential of energy efficiency in industrial appliances is substantial not only because of the CO_2 emission quotas, but also because most of the improvements include various adaptations of existing technology.
3. There are numerous issues regarding adaptation of technologies such as lack of information, shortage of recognized professionals and no or limited access to capital needed for investments.
4. Energy consumption in Latvian manufacturing and construction industries in 2007, 2008, 2009, and 2010 were as follows; 16.6%, 16.4%, 16.2% and 18.3% of total energy consumption.
5. Conventional electricity distribution systems are very complicated and extensive, but are almost entirely passive with little communication and very limited control ability and therefore only the biggest consumers have electricity monitoring system. The interaction between consumer loads and the power system itself is very poor.
6. Electricity grid monitoring and controlling offer the possibility of energy management and economy. Smart grid is an opportunity to use information and communication technologies in order to monitor and control the grid.
7. Smart grids are beneficial not only to power producers, but also consumers; the technologies used in smart grids provide information about energy usage and the possibility to manage the energy flow. The main advantages of smart grid limited outages and decreased network losses.
8. The focus on improving the efficiency of electric lighting has the potential to be one of the most significant short-term initiatives to decrease power consumption and decrease CO_2 emissions.
9. There are multiple possibilities of energy economy regarding lighting usage and the physical lighting fixtures itself.
10. Barriers of implementing energy efficiency measures for lighting systems: financial, informational, technical, environmental and governmental.
11. Results of the research shows that there is significant savings potential by using sensor controlled lighting systems. In this particular case, the total money saved per year is as much as Ls 6088.34.

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