# Saving Energy—Politics or Business?

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## ABSTRACT

Vladimir Lenin once remarked that politics was the most concentrated expression of economics. The recent history of nations shows that the greatest successes in the field of energy have been achieved by the wealthy countries in Western Europe, North America plus Japan. Recently, greater attention to energy saving and environmental protection is occurring in wealthy countries of the Middle East and the developing countries of China and India. Less wealthy countries lack the financial resources to implement widespread energy conservation and environmental protection improvements. Many leading international companies have transferred production facilities to these countries, reducing their production costs and taxes while avoiding the costs of energy savings improvements and stiffer environmental regulations elsewhere.

Many countries can be justifiably proud of their evolution toward energy efficiency. However, are optimal decisions regarding the use of energy efficient technologies always based solely on economics? The answer to this question is certainly not. The reasons are often related to political circumstances rather than economic. This article presents a pragmatic approach to feasibility assessments to achieve reductions in energy usage and generate energy cost savings. Case assessments including lamp replacements, wind turbine generators, frequency converters, throttling, and electric motors show that using energy efficient equipment is not always feasible. Their implementation is largely explained by political influences in the project implementation decision-making process.

## HISTORICAL INFLUENCES

The first energy crisis in October 1973 was spawned by an oil embargo by the Organization of Arab Petroleum Exporting Countries

(OPEC) in response to the Yon Kipper War. This forced the countries of Western Europe and North America to tackle in earnest the problems of energy saving as one way to ensure the security of energy supplies. Concerns regarding energy sources and costs have since acquired a permanent character in international politics.

Many positive steps towards energy conservation and efficiency have since occurred. Countries have succeeded in growing their economies with simultaneous reductions (rather than growth) in consumption of energy. The assumed correlation between energy use and gross domestic product (GNP) was decoupled. Newer types of energy-efficient equipment were successfully designed and placed in operation on a massive scale. Renewable power generation has become a solution to the environmental issues caused by fossil fuel use.

Moreover, energy saving was transformed from a political choice for the countries suffering from high energy costs and power shortages into a business for manufacturers of equipment, contractors, consulting organizations, banks and energy service companies (ESCOs). People in developed nations began understand the importance of deploying energy saving measures, while their governments encouraged the implementation of new technologies with supportive regulations.

## CASE EAMPLES

### Efficient Lamp Replacement

I once witnessed a conversation between an executive of a large Ukrainian enterprise and a salesman of a western company that produced energy-efficient lamps.

***Salesman****: "Our lamps are the most efficient, reliable, beautiful…"*

***Executive****: "Well, do you know that our enterprise uses still more reliable and efficient lamps?"* After the surprised salesman attempted but failed to object, the director added: *"I simply do not turn them on!"* This statement was made without substantiation and calculations, but for the enterprise energy expenses were insignificant. There were other more important projects for the enterprise and decisions to invest in those projects had already occurred.

It is not reasonable to reject proposals that under specific circumstances may prove to be more advantageous. However, to make a purchasing decision simply because it is common practice in western countries would be a mistake. In cases like this, it is expedient to calculate the comparative costs of imported compact fluorescent (CFL) or light emitting diode (LED) lamps with respect to incandescent lamps, determine whether their actual service life in the Ukraine and other post-Soviet countries can be validated, then verify lighting fixture efficiency and daily hours of operation. Perhaps it is better to introduce more daylighting by regularly cleaning the windows.

Economic assessments, such as net present value (NPV), simple payback period (SPP), or internal rate of return (IRR), should determine the expediency of implementing energy saving projects. Unfortunately, dealers of leading manufacturers of energy-efficient equipment seldom have command of the methodology of such calculations.

**Example***: In order to illuminate work areas, one can use either one CFL with the service life of 10,000 hours or ten conventional incandescent lamps with the service life of $T$ = 1,000 hours each. The price of conventional incandescent lamp ($PR_{il}$) equals $0.34 USD, while the price of a CFL ($PR_{eel}$) was $10.65 (U.S.). The power of one incandescent lamp amounts to $P_{il}$ = 100 W, while that of a CFL is $P_{eel}$ = 21 W. Calculations were conducted for the following values of electricity tariff $t_{el}$: $0.02/kWh, $0.04/kWh, $0.06/kWh, $0.08/kWh, and $0.1/kWh. The task is to compare the feasibility of implementing the system of lighting on the basis of one CFL (first alternative) or on the basis of 10 conventional incandescent lamps taking into account the rated service life (10,000 hours/1,000 hours = 10 lamps, second alternative).

The calculations were performed for different values of the rate for bank credits (from 10 to 120 percent annually) for the case when the lighting system operates 24 hours per day.

The results of calculating purchase and operation costs for the CFL (*Co1*) and the ten incandescent lamps (*Co2*) for the case of the electricity tariff $t_{el}$ = $0.02/(kWh) are presented in Figure 1. The intersection point of plots for *Co1* and *Co2* has the coordinates interest rate, $i = 0.137$ and lamp cost *Co* = $12.95. The analysis shows that the use of the CFL at $t_{el}$ = $0.02/kWh will be economically viable only in the case of available credit at an annual interest rate less than 13.7%. Difficulties in attracting such investments in the Ukraine at the electricity tariffs at the time of the assessment made the use of CFLs uneconomical. Nevertheless, there

*This example was made using prices and recommendations for the National Standard of Ukraine DSTU 4065-2001 [2].

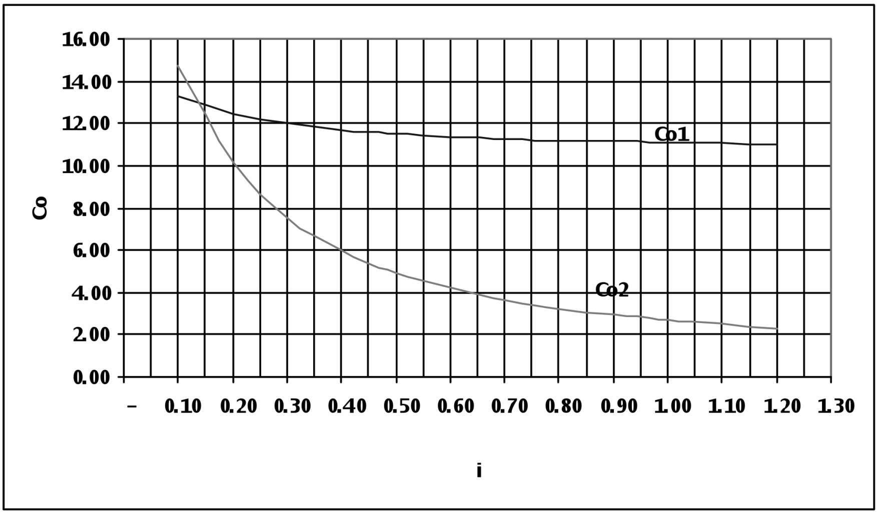


**Figure 1. Purchase and operation costs of one energy-efficient lamp (*Co1*) and ten incandescent lamps (Co2) for case $t_{el}$ = \$0.02/kWh at interest rate *i*.**

was a robust market for installing energy-efficient lamps and fixtures in offices of commercial buildings.

The results of similar calculations performed for incremental electricity tariffs are presented in Table 1.

The analysis indicates that the use of CFLs instead of incandescent lamps (given the price for these lamps at the time of assessment and the cost of credit and electricity tariffs) was economically viable only when electricity prices rose above $0.06/kWh.

Similar calculations performed by a company called Ekektromekhanika during an energy audit of the Kiev Metro, where lighting in-

**Table 1. Electric prices, interest rates and lamp costs.**

| $T_{el}$, $/kWh | *i*, rel. units | *Co*, $ |
|---|---|---|
| 0.02 | 0.137 | 12.95 |
| 0.04 | 0.28 | 13.15 |
| 0.06 | 0.44 | 13.27 |
| 0.08 | 0.62 | 13.3 |
| 0.1 | 0.79 | 13.33 |

stallations operate an average of 20 hours per day, demonstrated that fluorescent lamps were the most efficient even when disposal costs were included, next followed by CFLs, while incandescent lamps were the most costly. Hence, fluctuations in lamp prices and electricity tariffs change the economics associated with using different kinds lighting equipment which influences the priority of installing new lighting equipment.

**Wind Turbine Generators**

Almost 10 years ago a Danish commune installed a wind turbine generator (WTG) having the power of 200 kW (at the cost of ≈ €200,000 EUR) using loan proceeds at an annual interest rate of 8%. This WTG produced and average of 5,000,000 kWh annually. With an electricity cost of 0.43 Danish Krone (€0.0581) for one kWh, this production yields an economic value of 215,000 DKK annually. The following expenses are mandatory during each year:

| | |
|---|---|
| - Insurance | 10,000 DKK |
| - Service and maintenance | 12,000 DKK |
| - Repairs | 8,000 DKK |

Calculations showed that the payback period of this project was 13.3 years, only slightly less than the service life of such installations which is 15 to 20 years. Using a WTG service life of 15 years, the NPV related to implementation was €13,985, while the IRR was about 9.1%. The internal rate of return is only slightly higher than the interest rate of 8% per annum, which seems insufficient from a business investment viewpoint.

Implementation of such projects from an economic perspective is rather risky, yet may be justified by the minimization of economic and political risks. Such risks include the high probability of energy curtailments, rising electricity prices, and the use of higher cost fossil fuels.

**Electric Drive Systems With Frequency Converters**

Promotional materials of manufacturers of electric drive systems frequently include a statement similar to this: *"The use of frequency converters in variable drives of pumping units makes it possible to save 20% to 50% of the electric power consumed."*

Figure 2 shows a comparison of the efficiency of different techniques designed to control the capacity of equipment with fan-type load characteristics [1]. The following notations were used in this figure:

*a* Throttling
*b* Blade rotation of the distributor
*c* Variable hydraulic couplings or electromagnetic slip couplings
*d* Variation of the resistance in the rotor circuit of the induction motor
*e* Control of the turbomachine rotation speed free of losses (ideal curve)

The analysis indicates that the most rational technique for controlling the capacity of blade type machines is the efficient variable speed control of drive motors. In order to achieve a 50% saving, the machine in question should operate continuously with the capacity reduced by 40% to 50%. This stipulates the need of pump operation with the efficiency reduced by 3% to 5%, since in this case the installation does not operate under the nominal conditions (i.e., outside the region of maximum efficiency of the pump, motor, and frequency converter). At such variable speeds, control ranges of the motor speed ω ($0.5 \bullet \omega_r \leq \omega \leq \omega_r$, where $\omega_r$ is rated angular frequency of the drive motor of a blade type machine) reveal that the use of a wound-rotor slip recovery system is more expedient when compared with the use of frequency converters.

At rotational speeds 15% to 20% below their rated speeds, the expediency of using frequency converters on electric motors becomes still more ambiguous. Advocates of frequency converters may argue that this technology has no alternative when there is a need to vary the capacity from zero to the rated value. However, when a motor operates at lower speeds, drive system efficiency can decrease incrementally by 5%, 10% or more. In such cases it is necessary to analyze the possibility of using multiple unit pumping (compressor) stations allowing for step control of the capacity. For example, pumping stations at ore mining and processing mills and water treatment plants commonly use five to ten pumps each. In the power industry the parallel operation of pumping units on a common pipeline is also used. Several options of controlling the capacity of such pumping stations are possible [2,3]. These include:

- Using a frequency converter for both the capacity control of one of the pumps and the sequential start of all pumping units.

- Application of additional pumps of fractional power with operation controlled by an appropriate converter.

Other options are also possible involving the use of cycloconverters for starting the main pumping sets. In this case, the capacity control and matching of operation modes of individual pumps can be performed by an economically substantiated combination of different techniques: beginning from throttling in the case of a small speed control range and up to the application of frequency converters.

The use of frequency converters implies the need of applying motors of special design (more expensive than those of the general-purpose design for industry-wide applications and often of higher power for scattering additional losses related to the operation of the converter). For electric drive systems in the Ukraine, their selection should be performed in accordance with local standards [4,5].

So why use frequency controllers in such cases? Is it energy savings or regulation that drive the decision making process? After that I began to understand the meaning of the question, I began to understand that the use of energy efficient equipment can often be a political rather than economic decision.

**Throttling**

It is generally believed that throttling is always untenable in terms of cost-effectiveness. In order to understand the fallacy of this statement, it is sufficient to analyze the position of curves *a* and *e* in Figure 2. Accounting for the efficiency of a frequency converter under the rated conditions of no more than 0.95–0.97 even for very large (high power) units, from the viewpoint of energy consumption throttling is more expedient than the application of the most advanced frequency converter during the capacity control of blade type machines in the range from 95% to 97% of the rated value. With due regard for the relationship between the costs of a throttle (valve) and frequency converter, it appears that even at the highest prices of electric power, throttling proves to be more cost effective when compared to the “frequency converter—motor” system in the variable speed range from about 0.9 to 0.92 to the rated value. From a maintenance and reliability perspective, valves are less troublesome than any converter!

**Energy-Efficient Motors**

Many engineers in industrialized countries believe that energy saving electric motors must replace the motors of general-purpose design. For example, the policy of the European Union (EU) with respect to Poland is to stimulate production of energy-efficient motors. Plants producing energy-efficient motors are entitled to a 20% compensation of their production cost. This program offers an incentive for plants to manufacture and sell more efficient motors rather than motors of conventional design.

Both efficiency and power factor of energy-efficient motors are typically 3% to 5% higher than general purpose motors. Energy saving motors require 30% to 35% more iron, 20% to 25% more copper, and 10% to 50% more aluminum. Using more advanced and expensive technologies to produce energy saving motors, their cost should be 20% to 40% more than that of conventional electric machines. To obtain benefits from the use of energy-efficient motors, we must ensure their operation with maximum possible loads, which implies the use of relatively expensive protection means. In such cases, the cost of protection means should not exceed ≈ 10% of the cost of the electric motor; however, for small motors with rated power of several kW, the protection devices may cost more than the motors themselves. For larger motors rated from 50 to 100 kW, the cost of protection devices is within 10% of the cost of the motor. However, the efficiency and power factor of these larger motors differs from motors of general-purpose design by no more than 0.5% to 1.0%. Therefore, savings are less significant.

Simple calculations indicate that in the Ukraine using present electricity tariffs and the estimated the service life of electric motors with rated power of several kW, the use of energy saving electric motors will not be recouped during their entire period of their operation. So, why are energy efficient electric motors so widely used in the western countries? The answer lies in the legislation of these countries, which stimulates the use of energy saving equipment. Countries in the west have higher quality protection devices that allow electric motors to operate at higher load factors and during longer periods. At present, the Ukraine lacks regulated incentives to stimulate the use of energy saving motors. This is the reason why energy saving motors will not be cost-effective there in the near future.

This assessment may be useful for the companies producing energy-effective equipment and those striving to expand their markets in the countries of the former Soviet republics. It is also useful for politicians in developed countries who make decisions on stimulating production and sale of certain types of energy-efficient equipment and technologies. Regardless, it is the project's economic characteristics and corresponding analysis that should determine the expediency of implementing energy saving projects.

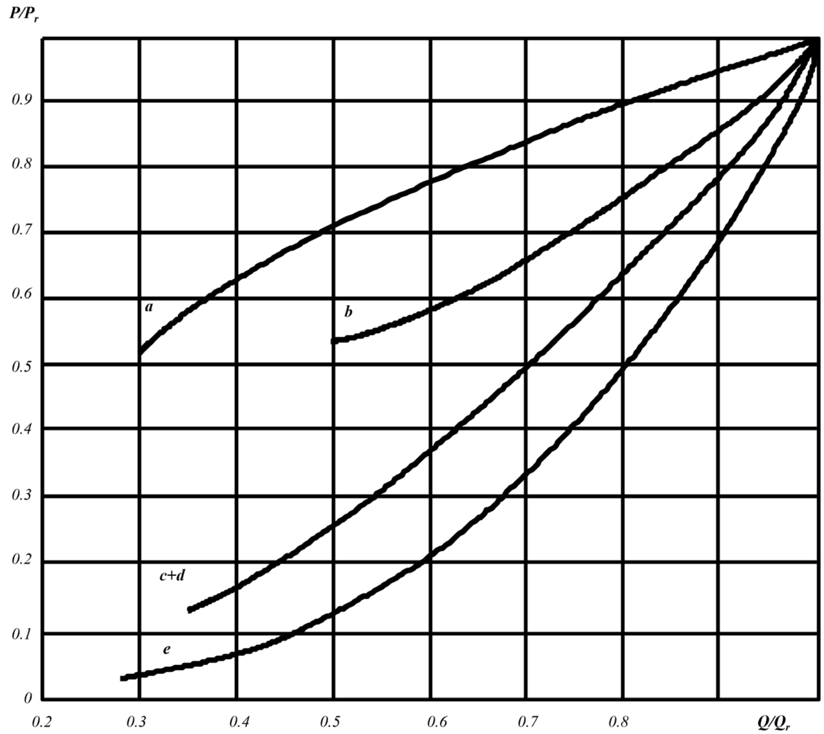


**Figure 2. Comparison of the cost-effectiveness of the capacity control of mechanisms with "fan" type characteristic of load [1].**

## SUMMARY

This article shows that using energy efficient equipment and technologies is not always economically feasible. Unfortunately, the material resources of many countries are limited and energy efficient equipment is often given a low priority due to the costs of implementation. The decision to pursue uneconomical technologies is largely explained by the political decision-making process or a regulatory environment favorable to the project. When developing energy saving measures it is advisable to consider the broader economic circumstances that would make energy efficient technologies more justifiable. These might include:

- Term of the project (operating life of the equipment being considered)
- Cost of energy (tariffs)
- Change in tariffs over time
- Cost of money (interest rates on loans and other credit terms)
- The internal rate of return for the enterprise
- Equipment cost for each alternative
- Cost of installation and adjustment of equipment for the alternative
- Duration of equipment operation
- Equipment service life
- Financial and technical risks

**References**

[1] Bogopolskii, B., Berlovskii, M., Kovalev, S., et al. (1963). Automation of mining fan installations. Moscow: Gosgortekhizdat, page 134.
[2] Mamalyga, V. (1998). Kiev: Enterprise “Elektromekhanika,” page 118.
[3] Mamalyga V. (1996). Technical and economic analysis of the results of investigating electric motors of auxiliary mechanisms of power-generating units at the thermoelectric power station and development of the reference requirements for a pilot project. Final report, Supervisor of the work. Kiev: Enterprise “Elektromekhanika,” page 29.
[4] Mamalyga, V. (2001, 2004). National Standard of Ukraine DSTU 3886-99, Energy saving and energy audit in electric drive systems, method of analyses and selection. See http://www.epe-association.org/epe/index.php?main=/epe/documents.php%3Fcurrent=847.
[5] Mamalyga, V. (1998). Power saving in electric drivers: Rational, modes of operations and principle of sufficiency in design. *PEMC* 7: 186-191. Prague.

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