How the energy-efficiency can be understood? The core meaning of efficiency

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Abstract
The word „EFFICIENCY" is used in many publications in different meanings and purposes, sometimes even mistaken or misleading. In this paper, I attempt to show the complexity of issues described by this word, unify the scope and define its meaning and functions.
Due to the lack of practical and useful (causing concrete and appropriate actions) legal definition of efficiency, I felt urge to find and present the core meaning of this word. Therefore I conducted interdisciplinary research, including philology, management theory, economy and techniques.
Assessment of efficiency limited to reducing quantity and costs of used energy can be oversimplification. Every simplification creates danger of neglecting other important profit generating factors. Therefore, wider definition of efficiency seemed to be necessary before narrowing it to energy efficiency issues. The method estimating energy efficiency is proposed. Thus, efficiency issue is clarified and defined.

INTRODUCTION

Many travelled by TRAM, but few understood ENERGY EFFICIENCY issues. Tramways as an effective city transit system appeared in our lives much earlier than functional cars. First tramway line, 2,5 km long, was established in Berlin in 1881 – 6 years before four-wheeled car of Daimler. Tramway construction was almost perfect from the very beginning. Therefore, there was no reason for radical changes. Constructors limited themselves to partial modernization only. Technical performance is still satisfactory for contemporary users; however the changes happened in our approach to the energy consumption. The energy costs were escalated by growing environmental conscience of the society. This conscience resulted in setting laws promoting energy efficiency. European Union and subsequent Polish regulations can serve as an example.

If the prospects of further growth of individual city transport are considered, the limited availability of arterial roads constitutes a major obstacle. The electric city transport (tram, underground) is a very attractive alternative. Therefore, European Union countries are once again showing increased interest in trams.

Increasing use of public transport system can reduce the emission of pollutants into the air, traffic jams and the demand for parking space. There are also indirect advantages arising from abandoning individual car transport, such as increased physical activity, having a positive impact on the health of people using mass city transport.

According to Polish and EU law regulations the authorities responsible for implementing State policy are obliged to augment effectiveness of energy consumption, in order to meet the demands of international conventions on climate protection1; transport services development matters constitute a significant portion of items covered here2.

ENERGY EFFICIENCY ISSUES

The energy efficiency as one of strategic goals of the economic policy, possible contradiction to the idea of economic growth

Generally everyone accepts energy efficiency (understood as reasonable and economical energy consumption). This obvious attitude is blurred at the national economy level, where society expectations are limited to decrease of unemployment related to increase of production.

Current policy of Polish government presented in publication: *Enterprise – Development – Employment - Economic strategy for Poland* from 29th January 2002 indicates the following strategic goal: "Gradual comeback to development path of 5% growth of GNP3". Economic growth rated by means of GNP will be implemented by starting highways construction of 900 km up to the year 2005. This action will cause increase of energy consumption in creation of necessary infrastructure and its exploitation.

GNP rate growth is generated by the increase of the value (price or quantity) of energy sold. Due to short-term political goals, without permanent scientific evaluation and professional supervision, the growth can be generated by irrational and expensive use of energy.

One of GNP growth factors is the value of fuel sold to the users of new cars. For example selling more fuel to newly purchased 100 cars will be evaluated higher by GNP growth standards than exploitation of one environment friendly and energy efficient tram.

Short-term success approach to the GNP growth can harm our life standards by permanent environmental destruction. Economic success measured in a single year by GNP is less valuable in my opinion, than long-term energy efficiency.

To promote general energy efficiency issues we should start from proper defining the idea.

I defined energy efficiency term by analyzing law regulations and application areas.

Energy efficiency defined by legal regulations

European regulations

In the EU legal system, environmental protection is combined with the improvement of energy efficiency. Article 5 of the Council Decision of 25 January 1999 - program for

1 Kioto protocol expects taking action in the field of energy efficiency improvement.
2 Różycki A.W., Szramka R.: PEMP - polski program efektywnego wykorzystania energii w napędach elektrycznych, Biuletyn URE 5/2000
3 Gross National Product; the total value of all the goods and services produced in a country, in a single year

research, development and demonstration on "Energy, environment and sustainable development" accepted European research program emphasizing energy efficiency by:

1) promoting efficient energy usage in transportation to lower air pollution (pts. 6.1.4, 6.5.3 of the Work Program),
2) development and application of new methods of energy storage (6.3.1, 6.3.2, 6.3.3 of the Work Program), to support existing energy sources - to fulfil energy consumption level during rush hours - instead of building new power plants and distribution network.

EU legal regulations related to energy consumption are divided into the following fields:

1) **energy efficiency of electric equipment** (Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances Council Directive 79/531/EEC; and sub-sequential Commission Directives: 94/2/EC, 95/12/EC, 95/13/EC, 96/60/EC, 97/17/EC, 98/11/EC and European Parliament Directive 96/57/EC and Council Directive 78/170/ EEC, 92/42/EEC),
2) implementation of **energy efficiency policy** (Council Directive 93/76/EWG; Council Decision of 16 December 1996 concerning a multi-annual program for the promotion of energy efficiency in the Community - SAVE II (96/737/EC),
3) implementing Energy Efficiency Treaty (Council Decision 98/181/EC).

Polish law regulations on energy efficiency

Among goals of Polish **Energy Act** dated 10 April 1997 (Journal of Laws dated 1997 No. 54, item 348 with later amendments), art. 1 p. 2 suggest creating conditions to economical usage of fuels and energy.

Art. 15 demands to include development of unconventional energy sources and efficient usage of the energy in energy policy plans. The Act determined the status and defined the duties of the Regulator. Duties of the President of the Energy Regulatory Authority of Poland include publication of information aiming at increasing the efficiency of fuels and energy consumption.

22nd February 2000 Polish government accepted "Energy policy plans up to the year 2020" – a document that emphases necessity to start actions leading to substantial lowering of energy-consumption in all sectors of national economy, including household and public services. This should result in improving energy supply safety and environmental protection. These goals should be reached by eliminating waste of energy and most environmentally harmful production technologies and the enhancement of the competitiveness of domestic producers thanks to lowering energy cost factor in the final product price.

EFFICIENCY. DEFINITIONS, APPLICATIONS, ASSESSMENT

The word „EFFICIENCY" is used in many publications in different meanings and purposes, sometimes even mistaken or misleading. In this paper, I attempt to show the complexity of issues described by this word, unify the scope and define its meaning and functions.

Due to the lack of practical and useful (causing concrete and appropriate actions) legal definition of efficiency, I felt urge to find and present the core meaning of this word. Therefore I conducted interdisciplinary research, including philology, management theory, economy and techniques.

Assessment of efficiency limited to reducing quantity and costs of used energy can be oversimplification. Every simplification creates danger of neglecting other important profit

generating factors. Therefore, wider definition of efficiency seemed to be necessary before narrowing it to energy efficiency issues.
The term efficiency seems to be:
1) abstract, with no simple concretized definition,
2) not derived directly,
3) not easy to quantify by unequivocal indicators,
4) surrogate to many close meaning words,
Therefore I define efficiency by goals of its usage.

Efficiency is a way of assessment in obtaining maximum profit or minimum costs of a given system, product or task.

The efficiency is an abstract term. Abstract terms are describing attributes and relations regarding general scientific rules and theories. Such terms result from intellectual elimination of superficial and nonessential features and the activity of abstracting - dealing only with substantial features for a given purpose. Abstracting stands for removing one thing from another, with which it is in union or association and expressing a quality or characteristic apart from any specific object or instance.

Production systems are compound by their nature. The efficiency is a term assessing such intricate systems. The process of evaluating complex systems is not easy. Therefore I decided to divide the process of efficiency analysis into stages of process of abstraction and gradual concretization. The first stage is construction of a theoretical model including the most important features of the examined process. Second stage constitutes shaping scientific rules, related to course and structure of this process. Third stage is enhancing the model by new features, assumptions, conditions which allows us to approach reality. The final stage is verifying theoretical results by comparing them with observations and equipment readings during real processes.

Phases of efficiency assessment

To simplify and extract homogenous problems, I suggest dividing methodology of efficiency assessment into following steps:

1. Setting-up **purpose** and actualization methodology,

2. Limitation of the analysis **scope** to direct area of influence and profits available to the user;

3. Division of the system variables into:

a) input (independent), representing necessary investment

b) output (dependent), representing expected profits, results

4. Extraction of basic rules;

5. Evaluation of math function assessing efficiency transformation of input- into output-variables,

6. Description of the results in a form expected by target group4 (comprehensive and useful).

Efficiency is a measure assessing purposefulness of the process; the way of transforming a given value of input variables into output ones. It put the valuation on the ability of the

4 audience

process to generate maximal profit out of limited quantity of resources. Therefore efficiency analysis is possible when goal, variables recognized as achievement factor and function allowing profits are found.

Efficiency definitions

Efficiency5 – stands for the ability to produce a good result without wasting time or energy. Efficiency is a result of economic activity described by proportion of effects to investment value. Economic efficiency is a partial element of a wider problem i.e. social efficiency. Social efficiency is analyzing economic and exceeding-economic aspects including environmental and political ones. Widening the scope of profits (e.g. customer's satisfaction, environmental protection) cannot offer indisputable results and evidence. The main reason for the above is a subjective way of profit recognition, lack of norms and a variety of issues not easy to describe in an abstract and concise manner.

Technical, allocation and global efficiency. Microeconomic evaluation of different company goals

Technical efficiency is related to the quantity of a given product. It is reached by production of maximum amount of items from determined volume of resources or production of given, predetermined amount of product using minimum resources.

On early stages of industrial era, the goal of every factory was to produce a maximum quantity of a product, because every amount could be sold on not saturated market.

When supply exceeded demand, rules and goals rapidly changed. Profit became generated by new goal: proper choose of product fulfilling customer's expectations instead of increasing sheer amount of produced items.

Fast making such proper choice of product or service combined with establishing saleable amount of products variety ensuring customer's satisfaction, became known as **allocation efficiency**.

The most technically efficient, economical mass production of no saleable items is a waste of resources and resulted in bankruptcies of many East European companies within transformation period.

Global efficiency combines technical and **allocation** efficiency with reference to environmental protection and future generation life standards. Short term customer's satisfaction should not be the ultimate goal. For example, disposable products guarantee customer's satisfaction, but create enormous amount of trash, affecting natural environment. Even if economically, the misuse is still an abuse of energy.

Efficiency in public transportation is not limited to lowering energy cost, but should regard also sufficient level of services to the public. The line between frugality and grotesque is thin. Permanent flow of slow going empty trams (probably very energy-efficient) would be ridiculous.

Efficiency. Application-oriented analysis

5 The meaning of word "efficient" is very much alike "economical" - not wasteful, careful with money or resources. Cost-effective production gives enough profit or gain compared with the amount of money spent.

Efficiency in management theory. Control stage

In the management theory efficiency is one of control process stages. Management theory demands evaluation methods – including use of energy. Such evaluation allows to motivate personnel to fulfill goals expected by the company. The very existence of any evaluation method - even lacking scientific integrity - is important due to psychological, motivating effect. For this purpose, efficiency measure need not comply with formal measuring standards required in physics. It can be even shown as descriptive evaluation, without proper quantification, tending rather to qualitative assessment.

Control over efficiency can be divided into following phases:

1. Setting-up norms and techniques of efficiency measurement – in the way understandable and acceptable to the personnel.

2. Proper timing of efficiency measurement.

3. The comparison of results with previously set standards.

4. Necessary corrections.

5. If set standards are out of reach there is lowering of standards due to motivation aspects of achievable goal.

Functional efficiency control system should contain the following attributes:

1. Precision necessary to locate real problems.

2. Being up-to-date – presenting current situation problems.

3. Focus on strategic control points (most important as affecting profit, possible major failure, easy to correct)

4. Economic realism – cost of measuring it should never exceed profits,

5. Organizational, structural realism – ability to adapt to existing organization reality, functions, rules and habits.

6. Coordination – harmless fitting in production process.

7. Flexibility – enabling immediate adjustment to necessary changes of goals – resulted from changing the outside world - with preservation of company values.

8. Functionality – providing information necessary to correct results.

9. Acceptance thanks to usefulness linked to usual duties and responsibilities (management – production or financial plans, engineer – supervision of current production and preventing failures, worker – equipment usage parameters and timing of work).

Assessment of energy efficiency by variables corresponding to numerous kinds of profits

Basing on previously listed efficiency definitions I suggest to:

1) extract various profit areas (results)
2) match variables representative for a given area

Efficiency indicators

The method of assessment of proposed investment depends on selected criteria.

The projects may be assessed with the help of different criteria: technical, economical, social, political or aesthetic. The objective assessment is difficult, since the projects are unique, in particular where state-of-the-art R&D results have been applied. Therefore the lack of standards in selecting universal assessment criteria can be faced.

Technical quantitative indicators are suitable for typical investments where additional analyses are needless.

In subsequent analysis, the different modernization variants will be considered separately.

Using any criterion, its numerical value must be determined; the analyzed variants must be arranged according to this value, check, whether these variants fulfill the minimum demand of efficiency. If the answer is yes, then those variants must be selected which can be implemented with the help of company's own financial resources.

When choosing a criterion, multitude of criteria and wide analysis spectrum do require a search for compromise between thematic correctness (in accordance with theoretical rules) and practical simplicity of the method, which facilitates its implementation. Additionally, it is difficult to accurately determine the parameters which must be assessed over a long period of time. Thus, it may be more profitable to adopt less precise methods, since the final results might be better.

The selection criteria must be adapted to the possibilities of data acquisition. The use of precise criteria does not necessarily correspond to high accuracy of calculations, if doubtful data is used.

In theory, the indicators are divided into synthetic and partial ones. The synthetic indicators are more general in character; they assess many project characteristics simultaneously.

For instance, synthetic indicators help to evaluate efficiency (defined as the ratio of effects to expenditure), or its components – effects (production, services) or outlay (work, materials, fixed assets).

The synthetic indicators should not be identified with parameters independent on company's decisions, such as government agencies or bank regulations (e.g. depreciation rates, tax rates, and interest rates).

Different isolated phenomena are assessed by directly related indicators, i.e. partial indicators. The partial indicators6 may assess the parameters of production (e.g. number of manufactured products, assortment and quality factors), outlay characteristics (e.g. outlay quantity and their qualitative parameters), the manufacturing process (use of machinery and facilities, working time), relations between outlays and effect (productivity of people and assets).

Project's efficiency assessment is conducted whilst taking into account synthetic indicators, supplemented by descriptive evaluation elements. This facilitates the correct project selection, even if possible discrepancies occur due to single unfavorable estimation of less significant element assessed by means of partial indicators.

Examples of different scope efficiency indicators

6 cf. CZEKAJ J.: *Kontrakty długoterminowe a rynek energii elektrycznej w Polsce,* Prezes Urzędu Regulacji Energetyki - Biblioteka Regulatora, Warszawa, styczeń 2001r., (Long *term contracts and electricity market in Poland.* In Polish)

Variables representative of different efficiency areas are listed below in order of increasing scope:

1) Physical:
   a) amount of energy spared,
   b) decrease of power value contracted,
2) Economic:
   a) annual financial value of energy spared,
   b) total net present value of energy efficiency investment (IRR, NPV indicators),
3) Marketing profits - customer's satisfaction,
   a) product (service) knowledge and recognition increase,
   b) market share (eg. in number of passenger using popularized trams),
4) Public relation level benefits, described at the level of social efficiency, analyzing economic and non-economic aspects such as social, political and cultural ones including environmental protection, number of positive entries in media, etc.
5) Political profits – a number of votes generated by efficiency promotion in public transport, results of public opinion pool.

As it has been mentioned, widening the scope of efficiency profits (e.g. customer's satisfaction, environmental protection) cannot offer indisputable results and evidence, due to the subjective way of profit recognition, lack of norms. It is hard to describe a variety of issues in an abstract and concise manner. So there is a need to start from general level description of the needs in order to properly set expectation of investment results. Additionally assumptions and postulates about future market conditions (prices, market share, and interest rates) must precede the final efficiency assessment.

EFFICIENCY TESTS. FROM STRATEGIC LEVEL NEEDS QUALITATIVE DESCRIPTION TOWARDS THUS CONCRETIZED QUANTITATIVE EFFICIENCY INDICATORS

Profitability assessment requires expressing in qualitative terms a vast range of investment needs, setting goals and expected parameters values, then finally, basing on these assumptions we may calculate quantitative efficiency indicators. At this stage of analysis, it is scientifically tempting to divide these terms into qualitative and quantitative.

Qualitative efficiency indicators. Strategic, top-level management level sets goals through wide scope analysis

A wide variety of criteria influence the economics of energy efficiency investment. In addition to economic, middle[7] management factors, there are a number of intangible issues, that may play a role in the decision analysis. I propose to appreciate some qualitative terms. These are important at the strategic level of company management. Top-level management sets goals enabling progress by:

1) Looking for profits through a change in activity scope,
2) Long term plans (exceeding annual budget plans),
3) Acceptance of a higher risk level,
   a) safety measures,
   b) instability of energy price,
4) Environmental protection:

7 Responsible for day-to-day running of the company

a) emission concerns,
b) global warming issues – greenhouse effect

5) Public relations.

Artificial transformation of the qualitative terms into quantitative measures may cause losses of information needed for intuitive assessment (top-level management). Additionally, in the long run quantitative indicators are less reliable. Old, fixed quantitative information not adjustable to the future reality outlives its usefulness. Some profits are estimated, not precisely counted. To set reachable goals management is forced to use qualitative terms. Additionally this guarantees positive opinion of the integrity represented by top managers, expected by subordinates, driven by psychological needs. The managers are like parents, they are expected to keep their promises.

The top-level management is responsible for new technologies and product creation. Emerging technologies - R&D projects are very expensive at the beginning. New product does not generate fast profit. At the start, it must be finance from sources generated by the sale of existing products by existing product sell. Increased number of modern trams will support return on investment in technology based on new energy-efficient technologies (recuperative braking).

Quantitative efficiency indicators. Middle management level analysis

CEO (top-level management) sets goals, boundaries and assumptions of efficiency analysis.

Next, it is possible to give precise instructions to middle management in order to carry out quantitative financial analysis. Middle management cannot set goals and expect working on indisputable measurable indicators. E.g. it is indisputable to have equipment sparing 5 kWh, instead of a product which is more fashionable, popular and politically correct.

In real life most of qualitative opinions can be changed into quantitative indicators. For example cleaner air can be changed into given level of CO2, SO2 emission. These quantitative indicators are typical to middle management processes.
This **middle management** character is:

1. Short term,
2. Low risk
3. Constant in activity scope,

This enables limitation of current expenses, providing continuation of the same activity.

Middle management analysis limits the scope of efficiency analysis.
Regarding this level of responsibility the energy-efficiency benefits include:

1. Improved power quality and reliability
2. Contracted power adjustment,
3. Energy cost decrease
4. No needs for additional equipment (infrastructure distribution investment)

Global efficiency. Value of different investment results

Complex analysis of all investment effects

Analysis of investment increasing efficiency calls for complex investigation of all results within the whole company structure. Therefore any investments (and consisting of modernization, development or introducing technological innovations) cannot be considered

separately, i.e. disregarding of the other departments of the company. It has a significant impact on future money flow in the whole company.

The operational costs are changed; the output level can go up, due to promotion of ecological transport. These profits can be evaluated directly for a company functioning in "owners profit seeking", free market economy. Otherwise the assessment of all profits and results caused by investments are not easy.

CONCLUSION

Global efficiency combines technical and allocation8 efficiency with reference to the level of services carried out for the public, environmental protection and life standards.

A fundamental rule about assessing new project value is that Discounted Cash Flows Method does not finally influence decision.

There are multiple valuation approaches for analyzing the expected return on a new initiative (net present value). Modern investment is expensive but it reduces the cost in customer services. Therefore analysis cannot fully predict result. In that situation no one can ignore CEO's business judgment.

Chief Executive Officer has an intuitive sense of where the shareholder value is in a given technology initiative. It is his task to ensure that the company uses the best technology for its strategic priorities.

One important question to ask while considering any major project is if this technology can be leveraged across business segments to serve multiple needs.

In the era of tight budgets9, new technologies aren't worth much unless they deliver real value to the business.

Investment values for shareholders, customers and employees

The question in assessing investment value is: "What value?" or "Value for whom?" The shareholders, employees and customers are assumed to have different view of what constitutes a good investment.

Shareholders

For "Tramwaje Śląskie" S.A. (like for most companies) it is the shareholder's definition of value that ultimately matters most. What's the return on the investment? Will this new initiative provide economic value by improving quality, cutting costs or increasing revenue?

Employees

To people working in the company, the most worthwhile initiatives are those that make their job attractive and free them up to perform more pleasing, more valuable tasks.

Customers

Technology10 initiative is worthwhile if it makes company reliable, more convenient and interesting to deal with.

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8 Company functioning in free market economy evaluates the marketing effects resulting from environmental protection investments.
9 2003 - huge cutting down municipal public transport budget expenses

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