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The model of material-economic analysis of power technology life cycle

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Abstract: The aim of the paper is to present the mathematical apparatus used in the developed model of the material-economic analysis of the power technologies life cycle which takes into account factors such as: material inputs in different phases (construction, operation and disposal) of the power technology life cycle, environmental loads, construction costs, fuel costs, maintenance costs, direct and indirect environmental costs, sales revenue.

Moreover, in the paper the internal rate of return (IRR), the net present value (NPV) and the break-even point (BEP) were calculated, as well as the equivalent unit cost of electricity production (COE) and the equivalent unit cost of heat production (COH).

The simulation results will be presented for two low emission power technologies with a nuclear power plant and a gas-steam power plant.

Keywords

gas-steam power plant,
nuclear power plant,
economy analysis,
life cycle assessment

Model materijalno-ekonomske analize vijeka trajanja elektroenergetske tehnologije *

Izvorni znanstveni članak

Sažetak: Cilj rada je predstaviti matematički aparat koji se koristi u razvijenom modelu materijalno-ekonomske analize vijeka trajanja elektroenergetske tehnologije koja u obzir uzima čimbenike kao što su: ulazni podaci o materijalu u različitim fazama (izgradnja, rad i zbrinjavanje) vijeka trajanja elektroenergetske tehnologije, opterećenje okoliša, troškovi izgradnje, troškovi goriva, troškovi održavanja, izravni i neizravni troškovi za zaštitu okoliša, prihodi od prodaje. Štoviše, u ovom radu su izračunati interna stopa povrata (IRR), neto sadašnja vrijednost (NPV) i točka pokrića (BEP), kao i ekvivalentni jedinični trošak proizvodnje električne energije (COE) i ekvivalentni jedinični trošak proizvodnje toplinske energije (COH).

Rezultati simulacije bit će predstavljeni za dvije elektroenergetske tehnologije s niskim emisijama, nuklearnom elektranom i plinsko-parnom elektranom.

Ključne riječi

plinsko-parna elektrana,
nuklearna elektrana,
ekonomska analiza,
procjena vijek trajanja

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1. Introduction

Permanent increase in demand for electricity on the one hand and the reduction of pollutants emitted into the environment on the other hand gave rise to the main point of interest of the European Union energy policy, as well as the Polish one, which has become a request both to change the structure of energy sources of electricity, as well as to explore and use low carbon power technologies [1]. For this reason, in the last years a number of publications and reports showing different approaches to comparative and techno-economic analysis of power technologies have appeared [2-16].

In order to obtain the most reliably accurate results of a comparative analysis of power technologies, a number of variable parameters affecting the profitability of the investment were undertaken, taking into account its possibly minor impact on the environment. In part, such a comparative analysis should include all phases of the power technology life cycle including: construction, operation and disposal, in the context of both cost-effectiveness, emission levels, material consumption, as well as other environmental impacts.

Comparative analysis of the power technology containing the items mentioned above should be based on the LCA according to ISO 14040 standards series [10,19,20] which allows for the assessment of the environmental impact of electricity generation using:

- specific power technology;
- the type of fuel or energy carrier;
- desired location;

and taking into account a holistic approach, also related to elements of cumulative energy inputs such as:

- primary fuel acquisition;
- primary fuel pre-processing;
- primary fuel transportation;

and considering the entire life cycle involving the following phases:

- construction;
- operation;
- storage / disposal of waste;
- off from the movement and disposal facility.

Symbols/Oznake

A_i	- the amount of electricity produced per year, [MWh]; - količina godišnje proizvodnje električne energije [MWh]	NP_i	- Nitrification Potential [kgPO43--equiv./kg] - Potencijal nitrifikacije [kgPO43--equiv./kg]
AP_i	- Acidification potential [APi, $kgSO_2$-equiv./kg]; - Potencijal povećanja kiselosti u [Api, $kgSO_2$-equiv./kg]	NPV	- net present value [€]; - neto sadašnja vrijednost [€]
BEP	- break-even point [%]; - točka pokrića [%]	r	- interest rate [%]; - kamatna stopa [%]
c	- unit price of electricity [€]; - jedinična cijena električne energije [€]	R	- environmental loads [Mg]; - opterećenje okoliša [Mg]
CC	- refers to annualized carbon costs during the facility life time [€/MWh]; - odnosi se na godišnje troškove za ugljen tijekom životnog vijeka postrojenja[€/MWh]	SCI	- the specific overnight capital investment of the power generation facility [€/MW]; - specifična kapitalna ulaganja tijekom noći za postrojenja za proizvodnju električne energije [€/MW]
COE	- the equivalent unit cost of electricity production [€/MWh]; - ekvivalentni jedinični trošakproizvodnje električne energije [€/MWh]	t_B	- the period of construction phase [year]; - vrijeme faze izgradnje [god]
COH	- the total cost of heat production [€/toe]; - ukupni troškovi proizvodnje toplinske energije [€/toe]	t_{BE}	- the period of construction and operation [year]; - vrijeme izgradnje i rada [god]
CRF	- the capital recovery factor; - factor oporavka kapitala	t_E	- the period of operation phase [year]; - vrijeme faze rada [god]
CTS	- refers to annualized inputs for transport and storage of captured CO2 during the facility life time [€/MWh]; - odnosi se na godišnje ulazne podatke o prometu i spremniku CO2 tijekom životnog vijeka postrojenja [€/MWh]	VOM	- refers to the annualized variable operating costs during the facility life time, [€/MWh] or [€/toe]; - odnosi se na godišnje varijabilne troškove rada tijekom životnog vijeka postrojenja, [€/MWh] ili [€/toe]
d	- discount rate [%]; - diskontna stopa [%]	W_i	- the value of production in the i-year [€]; - vrijedost proizvodnje u i-godini €]
E_{el}	- energy inputs for power technology [TJ]; - ulazni podaci o energiji za elektroenergetske tehnologije [TJ]	W_{Jd}	- average annual unit sales of electricity [€]; - prosječna godišnja jedinična prodaja električne energije [€]
E_{LC}	- the quantity of energy produced by power technology within the whole life time [TJ]; - količina energije proizvedene elektroenergetskim tehnologijama unutar cjelokupnog životnog vijeka [TJ]	UE_{LC}	- energy recovery ratio [TJ/TJ]; - udio povrata energije [TJ/TJ]

Symbols/Oznake

E_f	- energy of fuel inputs [GJ]; - energija ulaznog goriva [GJ]
FC	- refers to annualized fuel costs during the facility life time, [€/MWh] or [€/toe]; - odnosi se na godišnje troškove za gorivotijekom životnog vijeka postrojenja, [€/MWh] or [€/toe]
FOM	- refers to the annualized fixed operating costs during the facility life time in [€/MW] or [€/toe]; - odnosi se na godišnje fiksne radne troškovetijekom životnog vijeka postrojenja, [€/MW] or [€/toe]
IDC	- the interest during construction [%]; - kamate tijekom izgradnje [%]
GWP_i	- Global Warming Potential [kgCO_2-equiv./kg]; - Potencijal globalnog zagrijavanja [kgCO_2-equiv./kg]
I_i	- investment in i-year [€]; - ulaganje i -godina [€]
IRR	- Internal Rate of Return [%]; - Interna stopa povrata [%]
$J_{NM/W}$	- unit demand for material inputs related to the installed capacity of energy technologies [Mg/MWel]; - jedinična potražnja za ulaznim materijalom povezanim s instaliranom snagom elektroenergetskih tehnologija [Mg/MWel]
$J_{RCO2/W}$	- unit load of CO_2 emissions related to the total amount of energy generated during the life cycle of the power technology in [Mg/GWh]; - jedinično opterećenje emisijama CO_2 povezane s ukupnom godišnjom proizvodnjom električne energije tijekom životnog vijeka elektroenergetske tehnologije [Mg/GWh]
K_i	- the current production costs in the i-year [€]; - sadašnji troškovi proizvodnje u i-godini u [€]
K_{Jd}	- the unit cost of electricity production in power plants [€]; - jedinični trošak proizvodnje električne energije u elektrani [€]
LF	- the annual load factor of the facility; - godišnji factor opterećenja postrojenja
$m_{(m/p)}$	- mass of material inputs for each power technology component [Mg]; - masa ulaznog materijala svake komponente elektroenergetske tehnologije [Mg]

Subscripts/Indeksi

f	- individual fuel type; - pojedinačni tip goriva
i	- years 1,2,3,…,n; - godina 1,2,3,…,n
el	- type of energy technology; - tip energetske tehnologije
FB	- constructing phase; - faza izgradnje
FE	- operation phase; - faza rada
FZ	- disposal phase; - faza zbrinjavanja
NE	- energy inputs; - ulazna energije
NP	- fuel inputs; - ulazno gorivo
NM	- material inputs; - ulazni materijal
n	- the lifetime of the object; - životni vijek objekta
TB	- construction engineering; - građevina
TE	- electrical engineering; - elektroinženjerstvo

Symbols/Oznake

m_{el}	- mass of material inputs for power technology [Mg]; - masa ulaznog materija za elektroenergetsku tehnologiju [Mg]	TI	- other type of technique; - druga vrsta tehnike
m_f	- mass of fuel inputs [Mg]; - masa ulaznog goriva [Mg]	TM	- machine engineering; - strojarstvo

Presented in this article the concept of the material-economic model of life cycle analysis of power technology combines both aspects of the analysis of material-energy and environmental factors presented in [4,11-13, 18, 21], as well as aspects of the economic analysis presented in [2-3,5,21], taking into account external costs [6-7], supported by the analysis of life cycle assessment as described in ISO 14040:2008 [20].

2. Model description

The model of material-economic analysis of power technologies life cycle presented in the paper is based on the LCA according to ISO 14040 [20] and ISO 14044 standards, the methodology was shown in [2], the economic model was made in [3] and the model of energy and material inputs was presented in [4,21].

2.1. Goal and scope

The goal of the analysis is to make a model which will allow for the comparison of power technologies and will help to establish an energy policy.

The scope of this model is limited to the process of electricity and thermal power production.

The main objective of the model is to provide an overview of the economic impact of the implementation of various power technologies in the form of comparative analysis, taking into account factors typical for the entire life cycle or its phases such as:

- material inputs;
- energy inputs;
- environmental loads;
- construction costs;
- fuel and energy costs;
- maintenance costs;
- direct and indirect environmental costs in the form of fees for emissions, waste disposal costs, waste storage;
- sales revenue.

Moreover, in the model the following additional assumptions were adopted:

- to compare different types of power technologies with the same life and the same or similar installed capacity;
- to take into account changes in prices, particularly fuel and electricity prices where the discount calculation is applied, using the factor of inflation as a discount rate;
- the model does not include exchange rate changes in the future.

2.2. Functional unit and system boundaries

Functional units are taken as 1 MWh of electricity and thermal power production is also taken as 1 MW installed capacity.

The system boundaries are shown in Fig.1.

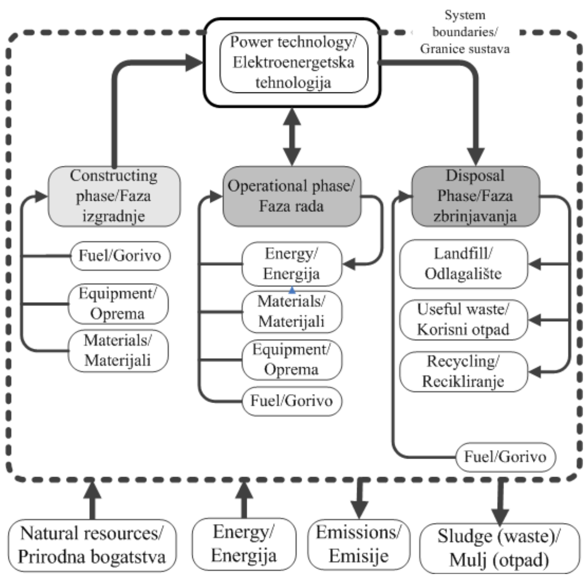

Figure 1. System boundaries.

Slika 1. Granice sustava

According to the LCA methodology adopted in the model (Fig.2) the following input parameters have been specified:

- material (analysis of individual and cumulative materials inputs);
- energy (analysis of individual and cumulative energy inputs);
- environmental loads (analysis of individual and cumulative emissions);

- the cost of constructing, operating (O & M) and disposal;
- CO2 emissions;
- market prices for energy carriers;
- and the following output parameters:
- unit costs KJd, COE, COH;
- average unit revenue from electricity sales WJd;
- indicators of the profitability of investments, NPV, IRR and BEP.

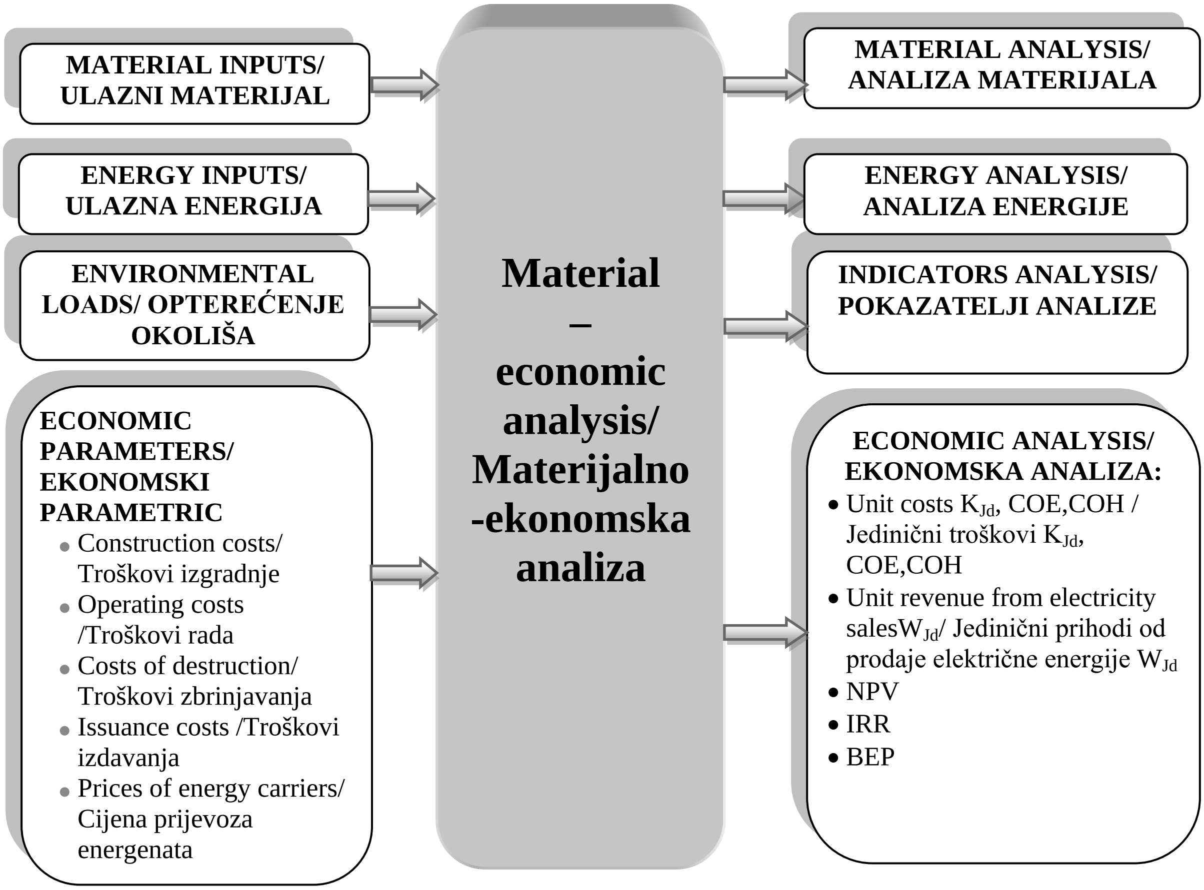

Figure 2. Block diagram of the model of material and economic analysis of power technologies

Slika 2. Blok dijagram modela analize materijala I ekonomije elektroenergetskih tehnologija

2.3. Material analysis

There are the following types of inputs in the area of power inputs: material inputs (NM), fuel inputs (NP) expressed in terms of mass balance as follows:

$$m_{el} = m_{el/FB} + m_{el/FE} + m_{el/FZ} \tag{1}$$

where:

$$m_{el/FB} = m_{el/(FB/TB)} + m_{el/(FB/TM)} + m_{el/(FB/TE)} + m_{el/(FB/TI)} \tag{2}$$

and:

- the equations for the constructing phase (FB):

$$m_{el/(FB/TB)} = \sum_{m=1}^{m=n} \sum_{p=1}^{p=n} m_{(m/p)/NM_{(FB/TB)}} \tag{3}$$

$$m_{el/(FB/TM)} = \sum_{m=1}^{m=n} \sum_{p=1}^{p=n} m_{(m/p)/NM_{(FB/TM)}} \tag{4}$$

$$m_{el/(FB/TE)} = \sum_{m=1}^{m=n} \sum_{p=1}^{p=n} m_{(m/p)/NM_{(FB/TE)}} \tag{5}$$

$$m_{el/(FB/TI)} = \sum_{m=1}^{m=n} \sum_{p=1}^{p=n} m_{(m/p)/NM_{(FB/TI)}} + \sum_{f=1}^{f=n} m_{f/NP_{(FB/TI)}} \tag{6}$$

- the equation for the operational phase (FE) can be presented in an analogous way to the equation of the construction phase (FB)
- the equation for the disposal (end of life) phase (FZ):

$$m_{el/(FZ/TI)} = \left(\sum_{m=1}^{m=n} \sum_{p=1}^{p=n} m_{(m/p)/NM_{(FZ/TI)}} + \sum_{f=1}^{f=n} m_{f/NP_{(FZ/TI)}} \right) \tag{7}$$

2.4. Energy analysis

The energy balance equation can be presented analogously to the analysis of the material equation:

$$E_{el} = E_{el/FB} + E_{el/FE} + E_{el/FZ} \quad (8)$$

where:

$$E_{el/FB} = E_{el/(FB/TB)} + E_{el/(FB/TM)} + E_{el/(FB/TE)} + E_{el/(FB/TI)} \quad (9)$$

and:

– the equation for the constructing phase (FB):

$$E_{el/(FB/TB)} = \sum_{m=1}^{m=n}\sum_{p=1}^{p=n} E_{(m/p)/NM_{(FB/TB)}} \quad (10)$$

$$E_{el/(FB/TM)} = \sum_{m=1}^{m=n}\sum_{p=1}^{p=n} E_{(m/p)/NM_{(FB/TM)}} \quad (11)$$

$$E_{el/(FB/TE)} = \sum_{m=1}^{m=n}\sum_{p=1}^{p=n} E_{(m/p)/NM_{(FB/TE)}} \quad (12)$$

$$E_{el/(FB/TI)} = \sum_{m=1}^{m=n}\sum_{p=1}^{p=n} E_{(m/p)/NM_{(FB/TI)}} + \sum_{f=1}^{f=n} E_{f/NP_{(FB/TI)}} + \sum_{e=1}^{e=n} E_{e/NE_{(FB/TI)}} \quad (13)$$

– the equation for the operational phase (FE) can be presented in a similar way to the equation of the construction phase (FB)

– the equation (14) for the disposal (end of life) phase (FZ):

$$E_{el/(FZ/TI)} = \left(\sum_{m=1}^{m=n}\sum_{p=1}^{p=n} E_{(m/p)/NM_{(FZ/TI)}} + \sum_{f=1}^{f=n} E_{f/NP_{(FZ/TI)}} + \sum_{e=1}^{e=n} E_{e/NE_{(FZ/TI)}} \right) \quad (14)$$

2.5. Indicator analysis

– Indicator of material evaluation – unit demand for material inputs related to the installed capacity of power technologies, in [Mg/MWel]

$$J_{NM/W} = \frac{\sum_{m=1}^{m=n} m_{m/NM}}{E_{LC}} \quad (15)$$

– Indicators of environmental assessment – unit load of CO2 emissions related to the total amount of energy generated during the life cycle of the power technology, in [Mg/GWh]

$$J_{R_{CO_2}/W} = \frac{R_{CO_2}}{E_{LC}} \quad (16)$$

– Global Warming Potential (GWP)

$$GWP = \sum GWP_i \cdot m_i \quad (17)$$

– Acidification Potential (AP)

$$AP = \sum AP_i \cdot m_i \quad (18)$$

– Nitrification Potential (NP)

$$NP = \sum NP_i \cdot m_i \quad (19)$$

The value of GWP_i, AP_i and NP_i is taken from [24].

2.6. Economic analysis

The following equations are the main equations of an economic analysis describing the interaction between the input and output parameters included in the model:

The average unit cost of electricity generation:

$$K_{Jd} = \frac{\sum_{i=1}^{t_B} I_i (1+d)^{-i} + \sum_{i=1}^{t_E} K_i (1+d)^{-i}}{\sum_{i}^{t_{BE}} A_i} \quad (20)$$

The levelized cost of electricity production (21) [2]:

$$COE = \frac{SCI \cdot (1+IDC) \cdot CRF + FOM}{8760 \cdot LF} + VOM + FC + CC + CTS \quad (21)$$

The interest during construction [2]

$$IDC = \sum_{i=1}^{t_B} I_i (1+r)^{t_B-(i-1)} - 1 \quad (22)$$

the capital recovery factor [2]

$$CRF = \frac{d \cdot (1+d)^n}{(1+d)^n - 1} \quad (23)$$

The total cost of heat production [2]:

$$COH = \frac{SCI \cdot CRF + FOM}{8760 \cdot LF} + VOM + FC \quad (24)$$

The Net Present Value (NPV) [22]:

$$NPV = \sum_{i=1}^{t_{BE}} \left[W_i - \left(I_i + K_i \right) \right] \left(1 + d \right)^{-i} \quad (25)$$

The Internal Rate of Return (IRR) [22]:

$$\sum_{i=1}^{t_{BE}} \left[W_i - K_i \right] \left(1 + IRR \right)^{-i} - \sum_{i=1}^{t_{BE}} I_i \left(1 + IRR \right)^{-i} = 0 \quad (26)$$

The Break Even Point BEP [23]:

$$BEP = \frac{K_{Jd}}{c} \quad (27)$$

The unit average revenue from electricity sales:

$$W_{Jd} = \frac{\sum_{i=1}^{t_E} W_i (1+d)^{-i}}{\sum_{i}^{t_{BE}} A_i} \quad (28)$$

3. Input data

According to the assumption no.1 accepted in the model, the life-steam gas power plant has been extended to the lifetime of the nuclear power plant – that is to 40 years. During this time in the Gas-steam power plant the gas turbine will be changed twice. Similarly, the material inputs, energy inputs and environmental burdens of the gas-steam power plants (4x 353MW) have been converted to the installed capacity almost the same as is possessed by nuclear power plants (1410MW). The material, energy and environmental data for this study are based on reports shown in [13,17,18]. For economic analysis, the data presented in [2,4-7] was used.

Basic data parameters and indicators of the benchmarks of the studied examples of the gas-steam and nuclear power plants are presented below, in Table 1.

Table 1. The basic parameters and indicators of the gas-steam and nuclear power plants

Tablica 1. Osnovni parametri i pokazatelji plinsko-parne i nuklearne elektrane

Description/Opis	**Gas-Steam Power plant/Plinsko-parna elektrana**	**Nuclear Power plant/Nuklearna elektrana**
Cost of investment/Troškovi investicije [€/kW]	635 [2]	2680 [2]
Construction period/Vrijeme izgradnje [a]	3 [2]	6 [2]
Installed capacity/Instalirana snaga [MW_{el}]	1412 [4]	1410 [2]
Installed capacity of thermal energy/Instalirana toplinska snaga [MW_t]*	900	900
Time use of thermal power during the year/Vrijeme korištenja toplinske energije tijekom godine[h/a]*	4500	4500
Decline rate of electric power during the use of thermal power*/Pad stope električne energije tijekom korištenja toplinske energije	0,2	0,2
Investment Issue/Vrijednost ulaganja [mln €]	1009	4288
Economic life time/Ekonomski vijek trajanja [a]	40	40 [2]
Usage factor/Faktor učinka [%]	85	85
Fuel Cost/Trošak goriva [€/MWh]	60,70	2,84
VOM + FOM [thousand €/MW]	25 [2]	90 [2]
Cost of CO_2 emission/ Trošak CO_2 emisija [€/MWh]	7,96	0,40
Electricity price/Cijena električne energije [€/MWh]**	74,91	
Thermal Power price/Cijena toplinske energije [€/GJ]**	7,33	
Discount rate/Diskontna stopa	0,1	

*) assumptions/pretpostavke

**) adopted in 2010, average prices of electricity produced in the gas-steam power plant and thermal energy on the local market in accordance with the tariff approved by the ERO. (Energy Regulatory Office in Poland)/prihvaćeno u 2010., prosječna cijena proizvedene električne energije u plinsko-parnoj elektrani i toplinske energije na domaćem tržištu u skladu s cjenikom koji je odobrio ERO. (Ured za regulaciju energije u Poljskoj)

4. Results and discussion

The pre-specified relationship between the input and output parameters of the model was calculated as well as the results of the material inputs, energy inputs, fuel inputs and emission charges and also indicators analysis of the power technologies life cycle: gas-steam and nuclear power plants were presented in Figures 3–9.

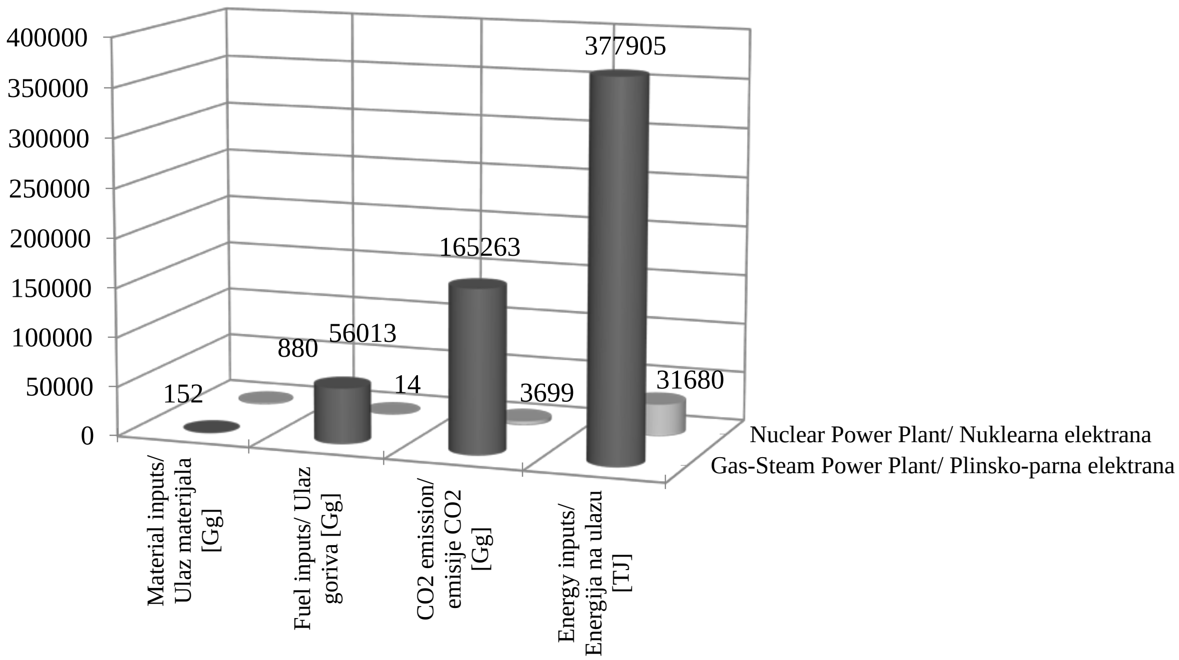

Figure 3. The volumes of material, fuel, energy inputs and CO_2 emissions occurring throughout the life cycle of power plants: gas-steam and nuclear

Slika 3. Količina materijala, goriva, ulazne energije i emisija CO_2 koje se javljaju tijekom životnog vijeka elektrane: plinsko-parne i nuklearne

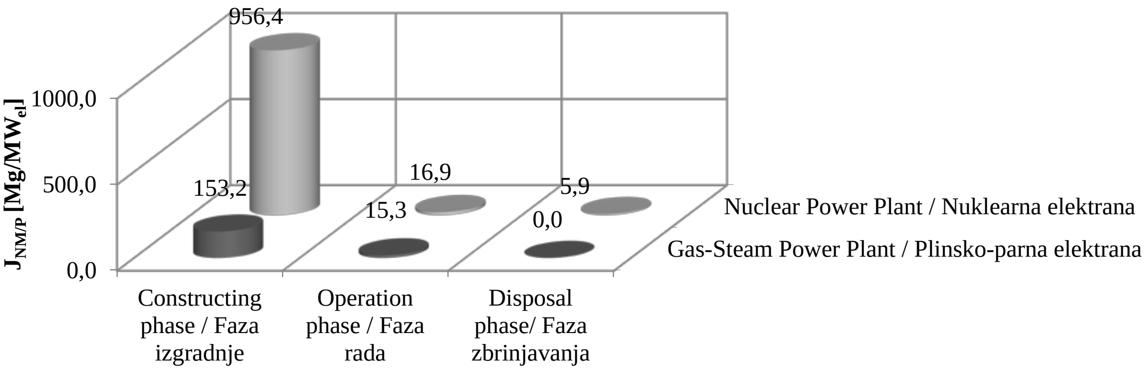

Figure 4. Evaluation index of material input in the form of unit resource requirements for material related to the total amount of installed capacity, in [Mg/MW$_{el}$]

Slika 4. Procjena pokazatelja ulaza materijala u obliku jediničnog potencijala potreba za materijalom povezanim s ukupnom količinom instalirane snage, u [Mg/MW$_{el}$]

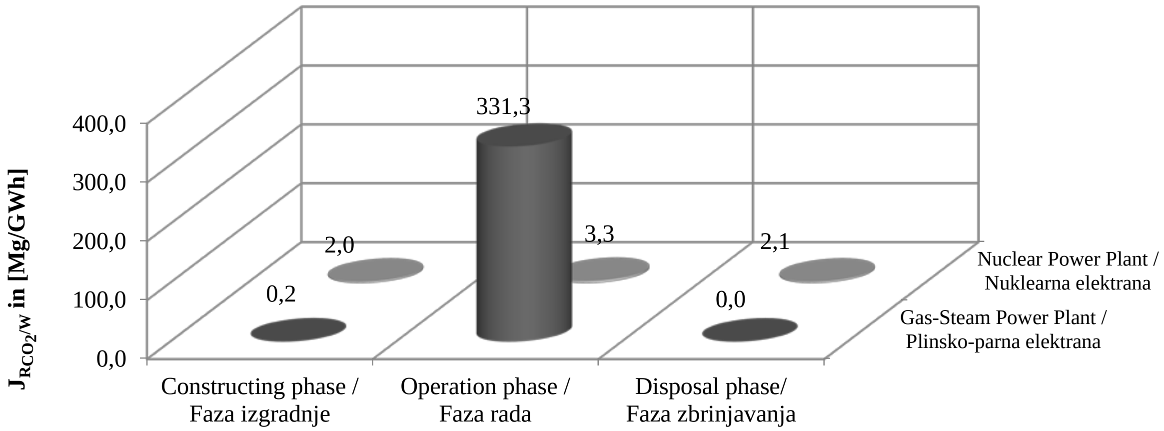

Figure 5. Indicator of environmental assessment in the form of a unit load of CO_2 emissions related to the total amount of energy generated during the life cycle of the power technology, in [Mg/GWh]

Slika 5. Pokazatelj procjene utjecaja na okoliš u obliku jediničnih emisija CO_2 povezanim s ukupnom količinom proizvedene energije tijekom životnog ciklusa elektroenergetskog postrojenja, u [Mg/GWh]

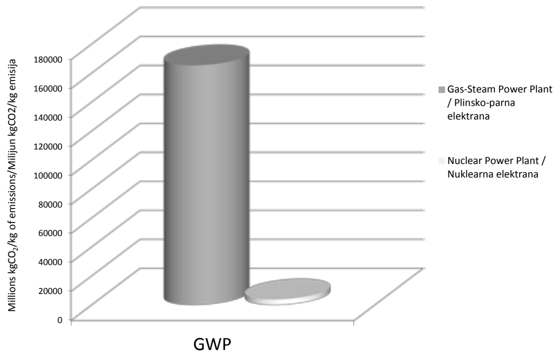

Figure 6. Global Warming Potential

Slika 6. Potencijal globalnog zagrijavanja

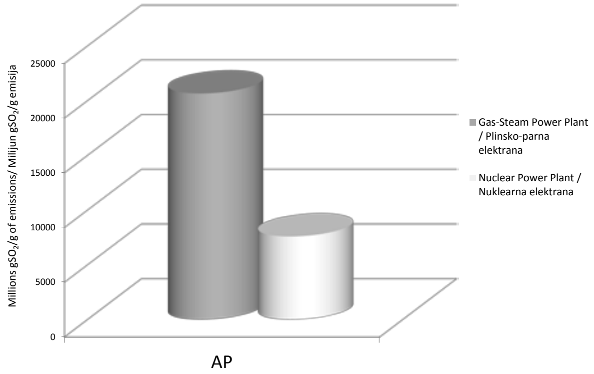

Figure 7. Acidification Potential

Slika 7. Potencijal zakiseljavanja

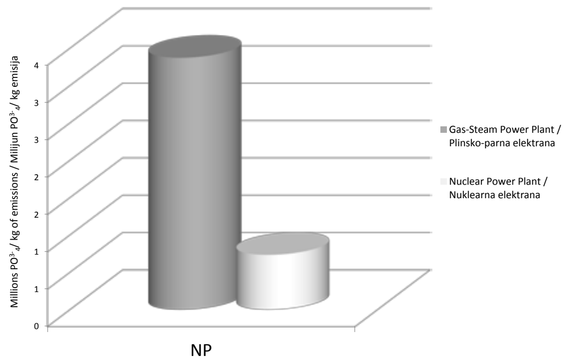

Figure 8. Nitrification Potential

Slika 8. Potencijal nitrifikacije

The graphs presented in Figures 3–8 related to the comparative analysis of the gas-steam and nuclear power technologies indicate that:

For the evaluation of materials: the largest investment both in the material inputs within the whole life cycle (Figure 3) and in the material inputs presented in the form of the unit rate of demand for material inputs referred to as the installed capacity (Figure 4) occurs in the area of the nuclear power plant.

For the evaluation of energy efficiency: the nuclear power plant had greater energy efficiency than the gas-steam power plant. This is clearly demonstrated by the energy inputs required, as depicted in Figure 3.

For the environmental assessment: the nuclear power plant has lower CO_2 emissions throughout the power technology life cycle (Figure 3). Large emission of the gas-steam power plant flows directly from the CO_2 emissions generated during combustion of fuel in the form of natural gas. However, as it can be seen from the ratio of CO_2 emissions, unit loads referred to the total amount of energy produced during the power technology life cycle (Figure 5) in the construction phase and the disposal phase; the gas-steam power plant has a lower emission. The same tendency is observed in case of GWP (Fig. 6), AP (Fig. 7) and NP (Fig. 8).

According to the adopted model dependencies between the input and output variables characterizing the economic parameters, the following indicators were calculated and summarized in Table 2:

- the unit cost of electricity generation KJd, taking into account the price changes over time;
- the levelized cost of electricity production (COE);
- the total cost of heat production (COH);
- the interest during construction (IDC);
- the capital recovery factor (CRF);
- the updated net equity value (NPV);
- the internal rate of return (IRR);
- the Break-even Point (BEP);
- the average unit sales of electricity WJd, taking into account changes in prices over time.

According to data presented in Table 2, the electricity sale price at € 74.91 and the model assumptions for all indicators show the return on investment, that is: NPV, IRR, and BEP of the construction of both power plants is profitable, but profitability of the construction of a nuclear power plant is much higher than the return of the investment costs in the gas-steam power plants. This is mainly due to the share in the variable costs, the cost of fuel (natural gas), which in the case of the gas-steam power plant is at about 20-tuple higher than the actual cost of nuclear fuel in accordance with the data adopted in [2].

Table 2. Received value of indicators reflecting the output parameters of the model.

Tablica 2. Dobivena vrijednost pokazatelja koji se odražavaju na izlazne parametre modela

Factor/Faktor	**Value/Vrijednost**	
	Gas-Steam Power plant/Plinsko-parna elektrana	Nuclear Power plant/Nuklearna elektrana
NPV [mln €]	312,08	2 280,16
IRR [%]	13	15
BEP [%]	85	17
IDC[%]	635000	2680000
CRF [%]	21	41
COE [€/MWh]	79,24	67,28
COH [€/toe]	1,79	2
K_{Jd} [€/MWh]	129,20	25,53
W_{Jd} [€/MWh]	150,09	149,05

Considering the levelized cost of electricity production COE (79.24 €/MWh) calculated in accordance with the EU methodology [2], for the gas-steam power plant it exceeds the established sales price of electricity (74.91 €/MWh). However, the variability of the sales price of electricity over time is invisible; after three years of operation of the gas-steam power plant these two values are equal. In the case of the nuclear power plant this value is at the lower level (67.28€/MWh).

The analyses of the average annual unit cost of electricity KJd and the average unit sales of electricity WJd that both plants produce will be profitable. At the same time profits from the nuclear power plant will be much higher than the ones from the gas-steam power plant.

5. Conclusions

A model of the material and the economic analysis required for the two types of power generation technologies based on the analytical and computing tools developed in recent years by a team of researchers at the West Pomeranian University of Technology in Szczecin was presented.

These tools feature an innovative approach and methodology that were mainly based on:

- energy and material balance and the prospectus,
- required analysis and functional system,
- required analysis, LCA closed in the EN ISO 14040 and EN ISO 14044 standards.

The presented tool is based on VBA programming in Excel.

The model for economic analysis states the supplement of analytical and computing tools that form the basis of the assessment of power technologies in terms of material and energy. The model of material-economic analysis of the power technology allows projection of the cost of construction in terms of economic power (the period of return of the invested capital and the unit cost of electricity production), material and energy, as well as the impact on the environment. For this reason, it might provide a useful tool in making difficult decisions related to a new construction and modernization of existing power plants.

The model of material-economic analysis based on the life cycle assessment method pays particular attention to the costs of materials, energy and environmental loads related to the construction, operation, and decommissioning of power technologies.

The model presented in the paper is constantly under development and modification in order to obtain a tool that in a simple and transparent way allows for the verification of power technologies in terms of profitability, not only the construction and operation of energy technologies, but also impediments to environmental control and decommissioning.

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