ANALIZA FINANCIJSKOG RIZIKA U VREDNOVANJU PROJEKATA IZGRADNJE VJETROELEKTRANA

RISK ANALYSIS METHODOLOGIES FOR THE FINANCIAL EVALUATION OF WIND ENERGY POWER GENERATION PROJECTS

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Slijedom europske legislative i energetskih trendova, Hrvatska mora znatno povećati broj obnovljivih izvora energije u elektroenergetskom sustavu. Jedan od tržištu trenutačno najatraktivnijih su vjetroelektrane. S obzirom da europska iskustva razvoja, izgradnje i korištenja vjetroelektrana pretežno primjenjuju model projektnog financiranja, potrebno je ustanoviti okvir za analizu financijske isplativosti ulaganja u izgradnju vjetroelektrane. K tome, za povećavanje sigurnosti ovakvih investicija, potreban je brz i učinkovit sustav analize investicijskih rizika projekta kako bi se oni mogli smanjiti na planirane ili ekonomski podnošljive razine. S ovim ciljevima, u radu se prezentira model financijske ocjene projekata proizvodnje električne energije iz vjetroelektrana uz korištenje elemenata analize rizika. Korišteni su podaci iz projektnih podloga vjetroelektrane nazivne snage 18 MW, koja se planira izgraditi na području Zadarske županije u okolici Benkovca. Za slučajeve kada ne postoje referentni dokumenti za Hrvatsku korišteni su podaci i iskustva iz europskih projekata.

Pursuant to European legislative and energetics trends, Croatia must significantly increase the number of renewable energy sources in the electrical energy system. Wind power plants are among the most attractive on the market. Since the European experiences of the development, construction and utilization of power plants predominantly employ the project financing model, it is necessary to establish a framework for the analysis of the financial profitability of investments in the construction of a wind power plant. Moreover, in order to increase the security of such investments, a rapid and efficient system is required for the analysis of the investment risks of the project in order to reduce them on the planning or acceptable economic levels. With these goals, a model for the financial evaluation of wind energy power generation projects is presented, together with the elements of the risk analysis employed. The data used are from a project for a wind power plant with a power rating of 18 MW, which is planned for construction on the territory of Zadar County in the environs of Benkovac. In cases where there are no reference documents for Croatia, data and experiences from European projects are used.

Ključne riječi: analiza rizika, financijska analiza, obnovljivi izvori energije, vjetroelektrane
Key words: financial analysis, renewable energy sources, risk analysis, wind power plants

1 UVOD

Rastuća potrošnja električne energije, uvjeti sve nesigurnije opskrbe naftom i prirodnim plinom i očekivane klimatske promjene koje predstavljaju opasnost za energetske sustave s relativno velikim udjelom hidroelektrana, traži od stručnjaka da pozorno razmotre provedbu strategije energetskog razvoja Republike Hrvatske do 2020/2030. godine u okvirima najnovijih stajališta EU Komisije u svezi sigurnosti energetske opskrbe i uvozne ovisnosti zemalja članica EU [1].

Procjene eksperata [2] ukazuju da će u 2030. godini fosilna goriva pokrivati oko 70 % svjetske i 60 % europske proizvodnje električne energije. Te iste procjene kažu da će obnovljivi izvori energije imati sve značajniju ulogu u strukturi proizvodnje energije. Nuklearna energija pak zadržava umanjen, no još uvijek ozbiljan udio.

Prema podacima Eurostata [3], energetska uvozna ovisnost EU27 će 2030. godine porasti s 56 % (2005.) na 64 %, pri čemu će ovisnost EU27 o uvozu nafte iznositi 94 %, prirodnog plina 84 %, a kamenog ugljena 59 %.

Za razliku od navedene procjene eksperata, o ulozi fosilnih goriva u svijetu i Europi 2030. godine, Europska udruga za vjetroenergiju (European Wind Energy Assocation – EWEA) uvjerava Europsku komisiju i javnost da su obnovljivi izvori energije s naglaskom na energiju vjetra te provedba mjera učinkovite proizvodnje i potrošnje energije moguća rješenja za zaštitu klime, smanjenje uvozne ovisnosti i povećanje sigurnosti opskrbe energijom [4].

Trendovi u europskom, ali i hrvatskom zakonodavstvu stvaraju pozitivnu investicijsku klimu za rast proizvodnje električne energije iz vjetroelektrana, stoga je sveobuhvatno razmišljanje o projektima izgradnje vjetroelektrana postala i hrvatska stvarnost.

Projekti proizvodnje električne energije iz vjetroelektrana trend su diljem svijeta. Najizraženiji su u Europi, dok su u Hrvatskoj na samom početku. Razlozi značajne izgradnje i popularnosti vjetroelektrana su mnogobrojni, no prije svega su to:

- smanjivanje investicijskih i proizvodnih troškova zbog razvitka tehnologije korištenja energije vjetra,
- sve veća društvena briga za zaštitu okoliša i
- državni poticaji razvoju i izgradnji vjetroelektrana.

1 INTRODUCTION

The growing consumption of electrical energy, increasingly uncertain conditions for the supply of oil and natural gas, and the anticipated climate changes that pose danger for energy systems with a relatively high percentage of hydroelectric power plants require the careful professional study of the implementation of the energy development strategy of the Republic of Croatia up to 2020/2030, within the framework of the newest positions of the EU Commission regarding the safeguarding of the energy supply and import dependence of the Member States of the EU [1].

According to experts [2], fossil fuels will cover approximately 70 % of world and 60 % of European electricity production in the year 2030. These calculations state that renewable energy sources will have an increasingly significant role within the structure of energy production. Nuclear energy will maintain a lower but still significant percentage.

According to Eurostat data [3], the energy dependence of the EU27 will increase by the year 2030 from 56 % (2005) to 64 %, with 94 % dependence on oil imports, 84 % dependence on natural gas and 59 % dependence on anthracite coal.

In contrast to these expert predictions regarding the role of fossil fuels in the world and Europe in the year 2030, the European Wind Energy Association – EWEA is attempting to convince the European Commission and public that renewable energy sources with emphasis on wind energy and the implementation of measures of effective energy production and consumption could be a possible solution to climate protection, reducing energy dependence and increasing the security of the energy supply [4].

Trends in European and Croatian legislation are creating a positive investment climate for growth in the production of electrical energy from wind power plants. Therefore, the comprehensive consideration of projects for the construction of wind power plants has also become a reality in Croatia.

Projects for the production of electricity from wind power plants represent a worldwide trend, particularly in Europe, while in Croatia they are just beginning. There are numerous reasons for the significance and popularity of wind power plants, primarily the following:

- reduction of investment and production costs due to the development of the technology of harnessing wind energy, U ožujku ove godine Republika Hrvatska je donijela tri podzakonska akta iz područja obnovljivih izvora energije (OIE): Tarifni sustav za proizvodnju električne energije iz obnovljivih izvora i kogeneracije [5] određuje pravo povlaštenih proizvođača električne energije na poticajnu cijenu električne energije koju operator tržišta plaća za isporučenu električnu energiju; Uredba o naknadama za poticanje proizvodnje električne energije iz obnovljivih izvora energije i kogeneracije [6] određuje način korištenja, visinu, obračun, prikupljanje, raspodjelu i plaćanje naknade za poticanje proizvodnje električne energije iz postrojenja koja koriste obnovljive izvore energije; Uredba o minimalnom udjelu električne energije proizvedene iz obnovljivih izvora i kogeneracije čija se proizvodnja potiče [7] propisuje minimalni udio električne energije proizvedene iz postrojenja koja koriste OIE-e te određuje ciljeve Republike Hrvatske u proizvodnji električne energije iz postrojenja koja koriste OIE. Tim se dokumentima definira namjera Vlade RH da do kraja 2010. godine udio proizvodnje električne energije iz OIE, čija se prozvodnja potiče, u bruto potrošnji (proizvodnja + uvoz – izvoz) bude najmanje 5,8 %.

Europska iskustva razvoja, izgradnje i korištenja vjetroelektrana ukazuju na pretežitost primjene modela projektnog financiranja, prije svega zbog učinkovite raspodjele i upravljanja brojnih rizika, tehnoloških, pravnih i financijskih. Projektno financiranje je oblik financiranja izgradnje projekta u kojem je tijek novca (engl. *cash flow*) projekta ujedno i izvor i jamac povrata korištenih izvora financiranja. Kreditori i ulagači prihvaćaju da će im novac biti vraćen jedino iz stvorenog tijeka novca projekta i da im se to jamči jedino imovinom projekta. Prihvaćanjem tako ograničenog jamstva kreditori prihvaćaju da, u slučaju nedovoljnog tijeka novca projekta, neće regresirati taj manjak iz ostale imovine vlasnika izvan projekta. Banke u razumnim uvjetima prihvaćaju kreditiranje investicije u cijelosti, ako imaju dovoljnu kontrolu nad projektom, a što pak najčešće ostvaruju tako što su i same dijelom vlasnici projekta (26 % do 51 %).

Naglasak u ovom radu je na financijskoj analizi projekta izgradnje vjetroelektrane. Da bi se osiguralo isplativo financiranje projekta izgradnje vjetroelektrane, nužno je upravljanje rizicima na način da se na najmanju moguću mjeru smanji vjerojatnost pojave negativnog učinka u financijskim tijekovima projekta. Umjesto determinističke analize, u ovom se radu razmatra mogućnost stohastičkih promjena nekih od parametara koji utječu na isplativost izgradnje vjetroelektrana. Ovakvu analizu mogu primjenjivati

– increasing social concern for environmental protection, and
– government incentives for the development and construction of wind power plants.

In March of this year, the Republic of Croatia adopted three regulations in the area of renewable energy sources (RES): Tariff System for the Production of Electrical Energy from Renewable Sources and Cogeneration [5] determines the entitlement of authorized producers of electrical energy to incentive prices for electrical energy that the market operator pays for the delivery of electrical energy; Regulations for Compensation for Providing Incentive for the Production of Electrical Energy from Renewable Energy Sources and Cogeneration [6] determine the manner of use; the amount, itemized accounting, collection, allocation and payment of compensation for providing incentives for the production of electrical energy from plants that use renewable energy sources; and the Regulations on the Minimum Percentage of Electrical Energy Produced from Renewable Sources and Cogeneration, the Production of Which is Encouraged [7], stipulate the minimum percentage of electrical energy produced from plants that use renewable energy sources and establish the goals of the Republic of Croatia in the production of electrical energy from plants that use renewable energy sources. These documents define the intention of the Government of the Republic of Croatia that the percentage of the production of electrical energy from renewable energy sources in the total will be a minimum of 5,8 % by the end of the year 2010.

European experience in the development, construction and use of wind power plants shows a predominance of the application of project financing models, primarily due to the effective distribution and management of the numerous risks of a technological, legal and financial nature. Project financing is a form of financing the construction of a project in which the cash flow of the project is also the source and guarantor of the return of the sources of financing used. Creditors and investors accept that their money will only be returned from the cash flow created by the project and that this is only guaranteed to them by the project property. By accepting such a limited guarantee, creditors accept that in the event of the insufficient cash flow of the project, this deficit will not regress from the other property of the owner outside the project. Under reasonable conditions, banks agree to finance an investment in its entirety if they have sufficient control over a project, which they most often achieve by becoming partial owners of the project (26 % to 51 %).

The emphasis in this article is upon the financial analysis of a project for the construction of a wind power plant. In order to secure profitable financing of i projektanti, ali su ciljana skupina prije svega investitori i kreditori.

2 ZAŠTO GRADITI VJETROELEKTRANE?

Prema literaturi [2] i [8] do [10] osnovni su razlozi izgradnje vjetroelektrana sljedeći:

- proizvodnja električne energije sa što manjom infrastrukturom i što nižim troškovima pogona i održavanja te što manjim utjecajem na okoliš,
- proizvodnja vjetroelektrana doprinosi većoj sigurnosti opskrbe i smanjuje uvoznu ovisnost,
- cijena električne energije proizvedene u vjetroelektrani nije osjetljiva na promjene na tržištu primarnih energenata (nafta, ugljen i prirodni plin),
- korištenje energije vjetra je u suglasju s načelima održivog razvitka,
- energija vjetra je obnovljivi izvor energije čiji potencijal ostaje u nasljeđe budućim generacijama i bez je štetnih učinaka i posljedica na klimu,
- jedan MW instalirane snage omogućuje otvaranje 15 do 19 izravnih ili neizravnih radnih mjesta. Vjetroelektrane ostvaruju i do 10 puta veći učinak na zaposlenost od drugih energetski izvora (npr. nuklearnih elektrana),
- vjetroelektrane su energetska tehnologija s minimalnim učinkom na okoliš, nema procesa izgaranja, nema emisija štetnih tvari, nema utjecaja na kvalitetu zraka ili vode, nema degradacije tla. Nakon završetka životnog vijeka i demontaže postrojenja ne ostaje nikakav otpad koji treba trajno pohraniti i koji bi dugoročno štetno opteretio okoliš,
- u svezi s prostornim planiranjem vjetroelektrane su objekti koji se bez poteškoća integriraju u druge gospodarske aktivnosti poput vinogradarstva, uzgoja prizemnih poljoprivrednih kultura, ovčarstva, izgradnje plastenika, sušara, uzgoja bilja, pčelarstva, malih prerađivačkih pogona i drugo. Prednost vjetroelektrana jest u tome što se mogu smjestiti podjednako na neobradivim površinama (goletima, kamenjarima), na morskoj pučini ili na poljoprivrednom zemljištu (livade, pašnjaci, oranice),
- prednost vjetroelektrana je i relativno kratko vrijeme izgradnje (do godine dana od početka izgradnje),
- zemlje koje su se opredijelile za izgradnju vjetroelektrana i proizvodnju opreme za vjetroelektrane za svoje potrebe i svjetsko tržište, ostvarile su snažan znanstveni i industrijski

a project for the construction of a wind power plant, risk management is essential in a such manner that the possibility for the occurrence of a negative effect in the financial flows of the project is reduced to a minimum. Instead of deterministic analysis, in this article the possibility is considered of stochastic changes in some of the parameters that affect the profitability of building wind power plants. Such analysis can be applied by designers but the target group is primarily investors and creditors.

2 WHY BUILD WIND POWER PLANTS?

According to the literature, [2] and [8] to [10], the basic reasons for building wind power plants are as follows:

- electrical energy is produced with the least possible infrastructure and the lowest possible operational and maintenance costs, with the least possible impact upon the environment,
- the production by wind power plants contributes to the greater security of the supply and reduces import dependence,
- the price of electrical energy produced by wind power plants is not susceptible to changes on the market of primary energy sources (oil, coal and natural gas),
- the use of wind energy is consistent with the principles of sustainable development,
- wind energy is a renewable energy source, the potential of which will be part of the inheritance of future generations, without harmful effects and repercussions on the climate,
- one MW of installed capacity makes 15 to 19 direct or indirect job openings possible. Wind power plants have up to 10 times greater impact on employment than other energy sources (for example, nuclear power plants),
- wind power plants are the energy technology with the minimum environmental impact. They do not involve the combustion process, they do not have harmful emissions, they do not have an impact on the air or water quality and they do not cause soil degradation. After the end of the lifetime and disassembly of the equipment, no waste remains that has to be permanently stored or that would have long-lasting negative environmental impact,
- in connection with physical planning, wind power plants are facilities that can be integrated within other economic activities such as vineyards, the surface cultivation of agricultural crops, sheep raising, greenhouse construction, curing sheds, plant cultivation, beekeeping, small processing plants etc. without difficulty.

napredak u tom sektoru industrije (npr. Danska, Njemačka, Španjolska);

– vjetroelektrane kao decentralizirani proizvodni objekti, većinom izgrađeni na periferiji električnih mreža, u pravilu utječu na smanjenje električnih gubitaka u mrežama srednjeg i visokog napona,
– izgradnjom vjetroelektrana osnažuju se infrastrukturno nerazvijena područja,
– proizvodnja električne energije u vjetroelektranama je atraktivna i za zemlje u razvoju,
– proizvodnja električne energije u vjetroelektranama je trenutačno najpovoljniji oblik korištenja obnovljivih izvora energije,
– zahvaljujući iznimnom tehnološkom napretku u proizvodnji opreme i izgradnji vjetroelektrana u posljednjem desetljeću, korištenje vjetroenergije je dostupno i poduzetnicima s ograničenim financijskim mogućnostima.

3 EKONOMSKE ZNAČAJKE IZGRADNJE VJETROELEKTRANA

Kroz svoj vijek trajanja, vjetroelektrana ostvaruje prihode na temelju prodaje proizvedene električne energije kojom se pokrivaju rashodi i nastoji ostvariti dobit. Pri tome se rashodi, odnosno troškovi izgradnje i pogona vjetroelektrane mogu podijeliti u tri osnovne skupine:

– troškovi investicijskih ulaganja,
– troškovi pogona i održavanja i
– porezi i doprinosi.

Struktura investicijskih ulaganja vjetroelektrane, koja je uzeta kao primjer u ovom radu, predočena je u tablici 1. U cijenu opreme uključena je sljedeća oprema i usluge (ukupnog iznosa oko 1 000 EUR/kW):

– oprema ugrađena u kabinu vjetroturbine,
– lopatice,
– servisno dizalo,
– stup vjetroturbine,
– posebna armatura za temeljenje vjetroturbine,
– gromobranska zaštita,
– prijevoz vjetroturbine do lokacije,
– montaža opreme,
– oprema za daljinski nadzor i sustav upravljanja vjetroturbinom,
– oprema koja se ugrađuje po zahtjevu operatora sustava,
– standardna tehnička dokumentacija,
– osiguranje opreme koja je predmet isporuke,
– prvi servis vjetroturbine,
– standardno signalno svijetlo i

The advantage of wind power plants is that they can also be located on uncultivated surfaces (bare land, rocky ground, stone quarries), on the open sea or agricultural land (meadows, pastures or fields),

– another advantage of wind power plants is the relatively short construction period (up to one year from the beginning of construction),
– countries that have become oriented toward the construction of wind power plants and produce equipment for wind power plants for their own needs and the world market have made powerful scientific and industrial advances in this sector (for example, Denmark, Germany and Spain),
– wind power plants as decentralized production facilities are in the majority of cases built on the peripheries of electricity networks and as a rule affect the reduction of electricity losses in medium-voltage and high-voltage networks,
– the construction of wind power plants strengthens the infrastructures of underdeveloped regions,
– the production of electrical energy in wind power plants is also attractive for developing countries,
– the production of electrical energy in wind power plants is currently the most desirable form of utilizing renewable energy sources,
– owing to exceptional technological advances in the production of equipment and the construction of wind power plants during the past decade, the use of wind power is also accessible to entrepreneurs with limited financial means.

3 THE ECONOMIC CHARACTERISTICS OF THE CONSTRUCTION OF WIND POWER PLANTS

During the operational lifetime of a wind power plant, it produces income based upon the sale of the electrical energy generated, with which expenditures are covered and profit is attempted to be made. The expenditures, i.e. the costs of the construction and operation of wind power plants, may be divided into three basic groups:

– investment costs,
– operation and maintenance costs,
– taxes and contributions.

The structure of investment in the wind power plant used as an example in this article is presented in Table 1. The cost of equipment includes the following equipment and services (the total amount is approximately 1 000 EUR/kW):

– equipment installed in the wind turbine nacelle,
– blades,

– električna oprema ugrađena u vjetroagregat ili pokraj stupa vjetroturbine (blok transformator i srednjenaponska sklopna oprema).

Ostali troškovi poput građevinskih radova, troškova razvoja projekta, troškova zemljišta i priključka na mrežu kreću se oko 350 EUR/kW. Ukupni specifični troškovi izgradnje vjetroelektrane u našim uvjetima dakle iznose oko 1 350 EUR/kW. Za procjenu iznosa specifičnih troškova korišteni su prije svega podaci proizvođača [11] do [20].

– service elevator,
– wind turbine tower,
– special armature for tower foundation,
– lightning protection (grounding system),
– transport of wind turbine components to the installation site,
– assembly of components,
– remote control equipment and wind turbine control system,
– equipment installed at the request of the system operator,
– standard technical documentation,
– insurance for equipment delivered,
– first servicing of the wind turbine,
– standard signal light,
– electrical equipment installed in the wind turbine nacelle or next to wind turbine tower (block transformer and medium voltage switchgear).

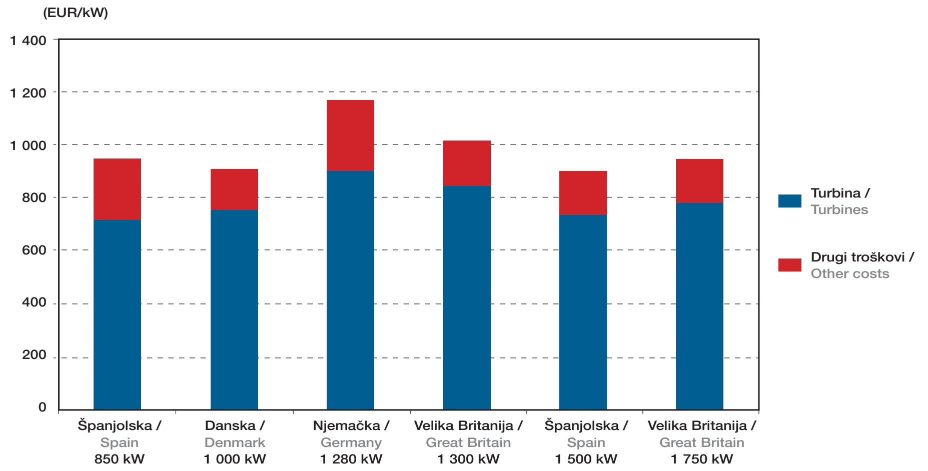
Other expenditures such as construction work, project development costs, land costs and connection to the network are approximately in the range of 350 EUR/kW. The total specific expenditures for the construction of wind power plants under our conditions are approximately 1 350 EUR/kW. For a calculation of the amounts of specific expenditures, data from producers are primarily used [11] to [20].

Tablica 1 – Struktura troškova vjetroelektrane na području Zadarske županije, u okolici Benkovca
Table 1 – Structure of the costs of wind power plant in the territory of Zadar County, in the environs of Benkovac

Opis / Description	Udio / Percentage (%)
Oprema / Equipment	72,0
Građevni radovi / Construction work	9,3
Razvoj projekta / Project development	9,4
Priključak na mrežu / Connection to network	9,3
Ukupno / Total	100,0

Za usporedbu s primjerom, na slici 1 su dani povijesni troškovi ulaganja u izgradnju vjetroelektrana u Europi. Iz slike se vidi da troškovi variraju u rasponu od 900 do 1 200 EUR/kW.

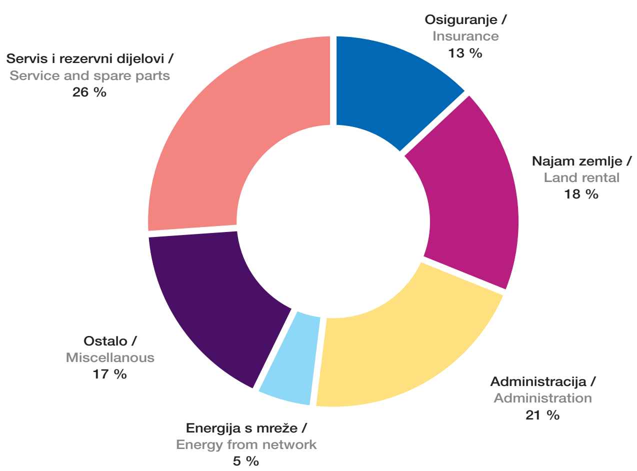
For comparison to the example, Table 1 provides the historical costs of investment in the construction of wind power plants in Europe. From the figure, it is evident that the expenditures vary within a range of from 900 to 1 200 EUR/kW.



Slika 1
Ukupni investicijski troškovi po kW instalirane snage [2]
Figure 1
Total investment costs per kW of installed capacity [2]

Prosječni vijek trajanja vjetroagregata procjenjuje se na dvadeset do trideset godina, odnosno na 120 000 do 180 000 radnih sati. Godišnja raspoloživost iznosi oko 98 %. Redoviti pregledi u pravilu se izvode svakih 6 mjeseci. U troškovima održavanja dominiraju troškovi održavanja vjetroagregata i troškovi održavanja opreme za prijenos i transformaciju električne energije. Troškovi održavanja pristupnih putova ovise o vrsti tla i padalinama i općenito su teško predvidivi. Temeljem podataka iz nekoliko europskih zemalja [2], općenito se troškovi pogona i održavanja procjenjuju na 1,2 do 1,5 EURc/kWh, a struktura troškova dana je na slici 2.

The average lifetime of a wind turbine is calculated at twenty to thirty years, i.e. 120 000 to 180 000 working hours. Annual availability is approximately 98 %. Regular inspections are conducted every 6 month, as a rule. Within maintenance costs, the expenditures for the maintenance of the wind turbine and the maintenance of equipment for the transfer and transformation of electrical energy predominate. The costs of maintaining access routes depend upon the type of terrain and precipitation, and are generally difficult to predict. Based upon data from several European countries [2], operation and maintenance costs are generally calculated at 1,2 EURc/kWh to 1,5 EURc/kWh, and the cost structure is presented in Figure 2.



Slika 2
Prikaz strukture troškova pogona i održavanja [2]
Figure 2
Structure of operation and maintenance costs [2]

3.1 Korištenje metode analize rizika u financijskoj analizi

Prikladna definicija rizika za određenu primjenu ovisi uvelike o opsegu i svrsi analize. Rizik je posljedica nesigurnosti, stoga može biti pozitivan ili negativan. Rizik se također može definirati kao standardna devijacija bilo koje varijable ili kao

3.1 Risk analysis methods used in financial analysis

The suitable definition of risk for a specific application depends greatly on the range and purpose of analysis. Risk is a consequence of uncertainly and therefore can be positive or negative. Risk can also be defined as a standard deviation for any variable whatsoever or as a combination of the probabilities kombinacija vjerojatnosti događaja i njegovih posljedica [21]. Daljnje definicije su da je rizik kombinacija frekvencije, ili vjerojatnosti, i posljedica određenog nepovoljnog događaja [22].

S obzirom da se financijska analiza radi za određeno vrijeme u budućnosti neizbježno se u ulaznim parametrima analize nalazi određeni stupanj nesigurnosti u izraženim vrijednostima pojedinih parametara, mogućih promjena parametra u budućnosti te mogućih korelacija između parametara.

Analiza rizika dio je šire discipline – upravljanja rizikom. Obično se upravljanje rizikom sastoji od identifikacije rizika, analize rizika, određivanja reakcija na rizike, promatranja rizika i izvješćivanja o mjerama uklanjanja ili smanjenja rizika [23]. Stoga se upravljanje rizicima sastoji od promjene ili ublažavanja neželjenih stanja u koja sustav može doći na željeni način uz određenu vjerojatnost. Cilj je smanjiti moguće posljedice na planirane ili ekonomski podnošljive razine [24].

Načelno je analizu rizika moguće podijeliti na kvalitativnu i kvantitativnu analizu. Podfaze unutar ova dva polja analize određuju se ovisno o potrebama i vrsti projekta te odabranoj metodi analize rizika. Kada se kroz bilo koji kreativni proces (*brainstorming*, analiza iskustava sa sličnih projekata, razgovori, scenariji, ankete...) odrede svi potencijalni rizici, provodi se kvalitativna analiza rizika. To uključuje različite metode određivanja važnosti identificiranih rizika i predstavlja pripremu za daljnju analizu uzimajući u obzir željenu količinu detalja koji se razmatraju. Rezultati kvalitativne analize rizika mogu uključivati ljestvicu rizika poredanih po utjecaju i vjerojatnosti pojavljivanja, grupe rizika prema kategorijama (bilo da se radi o njihovim uzrocima ili o mogućim reakcijama na rizike), listu rizika koji zahtijevaju hitnu reakciju te pravila praćenja promjena pojedinih rizika s vremenom [25].

Kvantitativna analiza rizika se vrši na rizicima koji su odabrani kvalitativnom analizom kao najznačajniji, te im se dodjeljuju numeričke vrijednosti. Koristeći tehnike iz teorije vjerojatnosti (poput Monte Carlo analize ili analize stabla događaja), moguće je odrediti razdiobu vjerojatnosti nekog rizika, pod uvjetom da su poznate razdiobe vjerojatnosti varijabli.

Najraširenije metode analize rizika su: testiranje ekstremnih događaja (engl. *stress testing*), testiranje scenarija, metoda srednji – optimistični – pesimistični slučaj i analiza osjetljivosti kao jednostavniji oblici, te VaR (Value at Risk) metoda, Standard AS/NZS 4360 (Australija i Novi Zeland)

of an event and their consequences [21]. Further definitions are that risk is a combination of frequency or probability, and the consequences of a specific undesirable event [22].

Since the financial analysis is performed for a specific time in the future, it is inevitable that there will be a certain degree of uncertainty in the expression of the values of individual input parameters, eventual future changes in the parameters and possible correlation among the parameters.

Risk analysis is a part of a broader discipline – risk management. Risk management generally consists of risk identification, risk analysis, determining the reaction to risk, risk monitoring, and reporting on the measures for eliminating or reducing risk [23]. Therefore, risk management consists of changing or ameliorating an undesirable situation for a system in a desirable manner with a specific probability. The goal is to reduce eventual consequences at the planning or acceptable economic levels [24].

In principle, risk analysis can be divided into qualitative and quantitative analyses. The sub-phases are determined according to the needs and type of the project and the selected method of risk analysis. When all the potential risks have been determined through some type of creative process (brainstorming, analysis of experiences from similar projects, discussions, scenarios, questionnaires etc.), qualitative risk analysis is performed. This includes various methods for determining the importance of identified risks and provides preparation for further analysis, taking into account the desired quantity of the details to be considered. The results of qualitative risk analysis include a risk scale in the order of impact and the probability of occurrences, risk groups according to categories (regarding their causes or potential reactions to risks), a list of risks that require an urgent response and rules for monitoring individual risks over time [25].

Quantitative risk analysis is performed for risks that are selected through qualitative analysis as the most significant, which are assigned numerical values. Using techniques from the theory of probability (such as the Monte Carlo method or event tree analysis), it is possible to determine the probability distribution of a risk, provided that the probability distribution of the variables are known.

The most widespread methods for risk analysis are as follows: stress testing, scenario testing, the mean, optimistic and pessimistic cases and sensitivity analysis as simple forms, the Value at Risk (VaR) method, Standard AS/NZS 4360 (Australia and New Zeland) and PMBOK® Guide (Project Management Body of Knowledge, Project i metoda PMBOK® (Project Management Body of Knowledge, Project Management Institute – PMI, SAD) kao složenije. Model opisan u ovom radu izrađen je kao određeni presjek ovih metoda.

Management Institute – PMI, USA), as more complex. The model described in this article was prepared as a cross section of these methods.

3.2 Model za proračun isplativosti vjetroelektrane

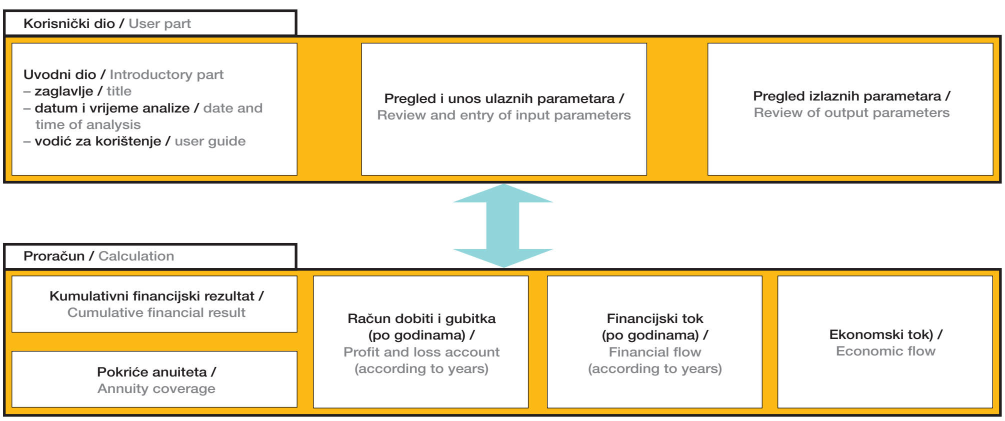
Model analize rizika izrađen je u Microsoft Excelu®, a za uključivanje analize rizika korišten je komercijalni dodatak (engl. *add-on*) Crystal Ball® [26]. Izbor je učinjen temeljem široke dostupnosti odabranih programskih alata i jednostavnosti njihove uporabe.

Model je koncipiran tako da se sastoji od korisničkog dijela i proračunskog dijela. Korisnik unosi ulazne varijable na jednom mjestu i odmah može pratiti izlazne varijable, bez ulaženja u dio gdje se obavljaju kalkulacije. Proračunski dio služi korisniku za pregled financijskih kretanja unutar proračuna iz godine u godinu, a dodani su i prikazi grafovima kako bi se povećala preglednost. Osnovni koncept prikazuje slika 3.

3.2 Model for the evaluation of the profitability of wind power plants

The model for risk analysis was prepared using Microsoft Excel®. A commercial add-on, Crystal Ball®, was used for the inclusion of risk analysis [26]. The choice was based upon the wide availability of the selected program tools and the simplicity of their use.

The model consists of the user part and the calculation part. The user enters the input variables in one place and can immediately follow the output variables, without entering the part where calculation is performed. The calculation part provides the user with an overview of the financial trends within the calculation from year to year. Graphs are added in order to increase the clarity of presentation. The basic concept is presented in Figure 3.



Slika 3
Konceptualni prikaz razvijenog modela za financijsku analizu
Figure 3
Conceptual presentation of the model developed for financial analysis

Model se koristi kao alat u izradi cjelovite financijske analize projekta te za testiranje scenarija kretanja vrijednosti pojedinih parametara. Analiza rizika vrši se temeljem prethodno definiranih vjerojatnosnih razdioba ulaznih varijabli. Ulazne varijable i njihove razdiobe parametriraju se u skladu s najboljim dostupnim informacijama i iskustvom. Iterativnim postupkom i korištenjem analize osjetljivosti razdioba vjerojatnosti izlaznih varijabli moguće je uočiti pretpostavke koje su postavljene preširoko, kao i analizirati utjecaj vjerojatnosti pojedinih ulaznih varijabli na izlazne.

The model is used as a tool in preparing a comprehensive financial analysis of a project and testing the scenario of the trends in the values of individual parameters. Risk analysis is performed on the basis of the previously defined probability distribution of input variables. Input variables and their distribution are parametered pursuant to the best available information and experience. Through an iterative procedure and analysis of the sensitivity of the probability distribution of the output variables, it is possible to identify overly broad assumptions and analyze the impact of the probability of individual input variables on the output variables.

3.2.1 Ulazne varijable

Za proračun isplativosti projekta u modelu su odabrani sljedeći ulazni parametri:

- broj sati rada vjetroelektrane – kako bi se uključila moguća varijabilnost iz godine u godinu, korištena je aproksimacija trokutastom raspodjelom s minimumom od 2 200 sati, najvjerojatnijom vrijednošću od 2 300 sati i maksimumom od 2 400 sati, prema literaturi [27] do [33],
- investicija po kW instalirane snage vjetroelektrane – u cijenu investicije uračunati su svi troškovi razvoja i izgradnje, troškovi mjerenja potencijala vjetra na lokaciji i troškovi ishođenja dozvola i suglasnosti. S obzirom da ovi troškovi mogu varirati ovisno o lokaciji, kao i mogućim dodatnim troškovima u skladu sa ranijim razmatranjima, ti se troškovi za planiranu vjetroelektranu aproksimiraju trokutastom raspodjelom s minimumom od 1 300 EUR/kW, najvjerojatnijom vrijednošću od 1 350 EUR/kW i najvećom vrijednošću od 1 400 EUR/kW,
- cijena električne energije za prvih 12 godina (s uključenom potporom) – aproksimira se trokutastom raspodjelom s minimumom na 605 HRK/MWh, najvjerojatnijom vrijednošću od 650 HRK i maksimumom od 650 HRK. Tarifni sustav [5] određuje cijene za prvih 12 godina kao punu tarifu sa 60 % domaćeg udjela u izgradnji elektrane ili manje ako je udio domaćih manji od 60 %. U proračunu se, u ovom radu, pretpostavlja da je vjetroelektrana proizvedena od domaćih proizvođača,
- cijena električne energije za ostalih 8 godina (bez uključene potpore) – nakon 12 godina (istekla potpora), cijena električne energije aproksimira se trokutastom raspodjelom s minimumom na 360 HRK/MWh, najvjerojatnijom vrijednošću od 370 HRK/MWh i maksimumom od 380 HRK/MWh,
- struktura sredstava (Vlastita/Kredit) – za potrebe simulacije je omjer variran poradi stvaranja pregovaračkih pozicija s potencijalnim ulagačima. Aproksimacija je izvedena trokutastom raspodjelom s minimumom od 15 %, najvjerojatnijom vrijednošću 20 % i maksimumom 25 %,
- broj godina kredita – parametar nije variran već je, u ovom radu, za proračun postavljen fiksno na 15 godina,
- kamatna stopa - izjednačena je s interkalarnom stopom. Aproksimira se uniformnom razdiobom s minimumom od 5,63 % i maksimumom od 6,19 %. Aproksimacija je učinjena s obzirom da kreditor radi vlastitu analizu rizika i s obzirom na dobivene informacije može varirati kamatnu stopu,
- interkalarne kamate – na svaki iskorišteni dio kredita obračunava se kamata od trenutka

3.2.1 Input variables

For the calculation of the profitability of projects, the following input parameters have been chosen for the model:

- the number of hours of operation of the wind power plants – in order to include possible variability from year to year, an approximation of triangular distribution was used with a minimum of 2 200 hours, the most probable value of 2 300 hours and a maximum of 2 400 hours, according to the literature, [27] to [33],
- investment per kW of the installed capacity of the wind power plant – in the investment cost, all the expenditures of development and construction, the costs of measuring the wind potential at the location and the costs of obtaining permits and approvals are included. Since these costs can vary, depending upon location, as well as potential additional expenditures pursuant to previous considerations, these costs for the planned wind power plant are approximated by triangular distribution with a minimum of 1 300 EUR/kW, the most probable value of 1 350 EUR/kW and the highest value of 1 400 EUR/kW,
- the cost of electrical energy for the first 12 years (with subsidies included) – this is approximated by triangular distribution with a minimum of 605 HRK/MWh, the most probable value of 650 HRK and the maximum value of 650 HRK. The tariff system [5] determines the prices for the first 12 years as a full tariff with 60 % domestic production or less if the percentage of domestic production is lower than 60 %. In the calculation in this article, it is assumed that the wind power plant has been manufactured by domestic manufacturers,
- the price of electrical energy for the remaining 8 years (without including subsidies) – after 12 years (the expiration of the subsidies), the price of electrical energy is approximated by triangular distribution with a minimum of 360 HRK/MWh, the most probable value of 370 HRK/MWh and the maximum value of 380 HRK/MWh,
- the structure of assets (equity/credit) – for the purposes of simulation, the ratio is varied in order to achieve the actual negotiating positions with potential investors. Approximation is performed by triangular distribution with a minimum of 15 %, the most probable value of 20 % and the maximum value of 25 %,
- the number of years of credit – this parameter is not varied. For the calculation in this article, it is assumed to be fixed at 15 years,
- the interest rate – the interest rate is made equal to the compounded rate. It is approximated by uniform distribution with a minimum of 5,63 % and a maximum of 6,19 %. Approximation was performed because the creditor performs his own risk analysis and may vary the interest rate, according to information obtained,

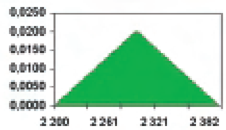
korištenja do početka otplate kredita. Kod kredita koji se koriste odjednom, interkalarna kamata obračunava se od dana iskorištenja do početka redovite otplate kredita [34]. U primjeru iz rada se izjednačava s kamatnom stopom kredita,
– aranžerska naknada – trošak ugovaranja kredita. U simulaciji je postavljena fiksno na iznos od 1,35 % iznosa kredita,
– amortizacija za prvih i drugih 10 godina – u simulaciji je stopa za prvih 10 godina postavljena fiksno na 5,57 % te za drugih 10 godina na 4,43 %,
– troškovi pogona i održavanja (EUR/MW) – aproksimirani su trokutastom raspodjelom s minimumom od 35 000 EUR/MW, najvjerojatnijom vrijednošću od 40 000 EUR/MW i maksimumom 45 000 EUR/MW godišnje,
– troškovi koncesije (kao postotak prihoda) – postavljeni fiksno na 1,50 % prihoda godišnje,
– diskontna stopa - postavljena fiksno na 7 %,
– tečaj eura – postavljeno fiksno na tečaj 1 EUR = 7,4 HRK, nisu simulirane varijacije tečaja,
– PDV – postavljeno na propisanih 22 %: Nisu simulirane moguće promjene u budućnosti,
– porez na dobit – postavljeno na propisanih 20 %. Nisu simulirane moguće promjene u budućnosti.

Distribucije promjenjivih varijabli grafički prikazuje tablica 2.

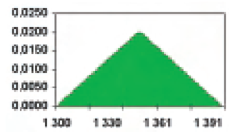
– compounded interest on every part of credit used – interest is calculated from the moment of use to the beginning of the repayment of the loan. For credit used at once, compounded interest is calculated from the date of the use to the beginning of the regular repayment of the loan [34]. In the example from this article, it is equal to the interest rate on the loan.,
– compensation to the negotiator – the cost of negotiating credit. In the simulation, this is entered as a fixed amount, 1,35 % of the amount of credit,
– amortization for the first and second 10 years – in the simulation, the rate for the first 10 years is assumed as fixed at 5,57 % and for the second 10 years at 4,43 %,
– operation and maintenance costs (EUR/MWh) – these costs are approximated by triangular distribution at a minimum of 35 000 EUR/MW, the most probable value of 40 000 EUR/MW and a maximum of 45 000 EUR/MW annually,
– concession costs (as a percentage of revenue) – these costs are assumed to be fixed at 1,50 % of the annual revenue,
– the discount rate – this is assumed to be fixed at 7 %,
– the EUR exchange rate – this is assumed to be fixed at the exchange rate of 1 EUR = 7,4 HRK. Exchange rate variations are not simulated,
– VAT – VAT is assumed to be at the stipulated 22 %. Possible changes in the future are not simulated,
– profit tax – profit tax is assumed to be at the stipulated 20 %. Possible changes in the future are not simulated.

The distribution of changeable variables is presented graphically in Table 2.

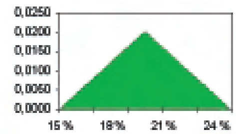
Tablica 2 – Prikaz razdioba vjerojatnosti odabranih promjenjivih ulaznih varijabli
Table 2 – Presentation of the probability distribution of selected changeable input variables



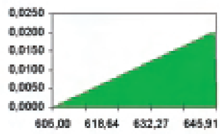
Broj sati rada / Number of hours of operation



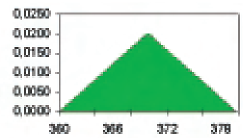
Investicija u izgradnju / Investment in construction (EUR/kW)



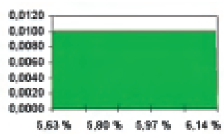
Udio vlastitih sredstava / Percentage of equity capital



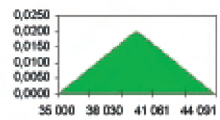
Cijena električne energije tijekom prvih 12 godina (sa subvencijom) / Price of electrical energy during the first 12 months (with subsidy) (HRK/MWh)



Cijena električne energije nakon prekida subvencija / Price of electrical energy after the termination of the subsidy (HRK/MWh)



Kamate / Interkalarna stopa / Interest / Compounded rate



Troškovi pogona i održavanja / Operation and maintenance costs (EUR/MW)

3.2.2 Izlazne varijable

Odabrane izlazne varijable su:

– dobit poslije poreza, kumulativno – izračunava se iz računa dobiti i gubitka. Konačan iznos nakon prestanka rada vjetroelektrane predstavlja sumu dobiti iz svake godine,
– kumulativni neto primitci financijskog tijeka – iznos neto primitaka pokazatelj je likvidnosti po razdobljima poslovnog plana ili investicijskog projekta, izražen u kunama. Promatramo kumulativne neto primitke kako bismo mogli odrediti ekonomski tijek cijelog projekta,
– kumulativni neto primitci ekonomskog tijeka – ako su neto primici ekonomskog tijeka u nekoj godini vijeka projekta pozitivni, tada je došlo do povećanja imovine projekta u toj godini. Imovina je smanjena, ukoliko su oni negativni, a ostala je nepromijenjena kada su jednaki nuli. Promatramo kumulativne neto primitke kako bismo mogli odrediti ekonomski tijek cijelog projekta,
– čista sadašnja vrijednost (engl. *Net present value*, NPV) – definirana je formulom:

3.2.2 Output variables

The selected output variables are as follows:

– after-tax profit, cumulative – this is calculated from the profit and loss account. The final amount after the termination of the operation of a wind power plant represents the sum of the profits from each year,
– cumulative net revenues from financial flow – the net amount of revenues is an index of liquidity according to the periods of the business plan or investment project, expressed in kunas. We examine the cumulative net revenues in order to determine the economic flow of the entire project,
– cumulative net revenues of the economic flow – if the net revenues of the economic flow in a year during the project are positive, there has been an increase in the property of the project in that year. Property is reduced when the net revenues are negative and remains unchanged when they equal zero. We examine the cumulative net revenues in order to determine the economic flow of the entire project,
– net present value, NPV, is defined by the following formula:

$$NPV(C,t,d)=\sum_{i=0}^{N}\frac{C_i}{(1+d)^i}, \quad (1)$$

gdje su:

t – vrijeme tijeka novca,
N – ukupno vrijeme projekta,
d – diskontna stopa,
C_i – neto tijek (iznos) novca u određenoj točki vremena, a
C_0 – tijek novca na početku investicijskog perioda ($t = 0$),

– interna stopa rentabilnosti (engl. *Internal Rate of Return* – IRR) – diskontna stopa koja postavlja NPV dobivenih tijekova novca u vremenu na nulu i definirana je formulom:

whereas:

t – the time of the cash flow,
N – the total time of the project,
d – the discount rate,
C_i – the net cash flow (amount) at a particular point in time, and
C_0 – the cash flow at the beginning of the investment period ($t = 0$),

– the internal rate of return, IRR, is the discount rate that sets the net present value of the obtained cash flow over time to zero, and is defined by the following formula:

$$NPV(C, t, IRR) = 0. \quad (2)$$

U modelu, NPV i IRR se računaju pomoću ugrađenih funkcija Excela npv i irr, na temelju tijekova novca kroz 20 godina, što je pretpostavljeni životni vijek sustava.

In the model, the NPV and IRR are calculated using the add-on Excel functions npv and irr, based upon cash flows over 20 years, the assumed lifetime of the system.

3.3 Tablični proračun i vizualizacija

U model su postavljene realne vrijednosti za planiranu vjetroelektranu snage 18 MW. Model je sadržan u jednoj tablici (engl. *worksheet*), kako bi se olakšao nadzor nad svim izlaznim varijablama simulacije i povećala preglednost proračuna, no funkcionalno je podijeljen na poglavlja.

Prva tri poglavlja modela prikazuje tablica 3, a sadrže vodič za tumačenje boja te pružaju pregled ulaznih parametara, te pregled izlaznih parametara. Proračun pojedinih parametara uz prikaze financijskih tijekova dan je u nastavku modela. Prikaz strukture ulaganja i financiranja prikazuje tablica 4.

3.3 Tabular calculation and visualization

The assumed real values that can be achieved for the planned wind power plant with a power rating of 18 MW are provided in the model. The model is contained in a worksheet to facilitate control over all the output variable simulations and increase the clarity of the presentation of the calculation but is functionally divided into chapters.

The first three chapters of the model are presented in Table 3. They contain a guide for interpreting the colors and provide an overview of the input and output parameters. A calculation of individual parameters with a presentation of the financial flows is provided in the continuation of the model. A presentation of the investment and financing structure is provided in Table 4.

Tablica 3 – Glavni, početni dio modela – ulazni i izlazni podaci
Table 3 – Main, initial part of the model – input and output data

Vodič za tumačenje boja / Guide for the interpretation of colors

(tamnozeleno / dark green)	Unešena vrijednost, uz varijabilnost (simulacije) / Entered value, with variability (simulation)
(svijetlozeleno / light green)	Unešena vrijednost, fiksno u proračunu / Entered value, fixed in the calculation
(narančasto / orange)	Izračunata vrijednost / Calculated value
(sivo / grey)	Fiksna vrijednost / Fixed value
(plavo / blue)	Promatrana izlazna vrijednost / Observed output value

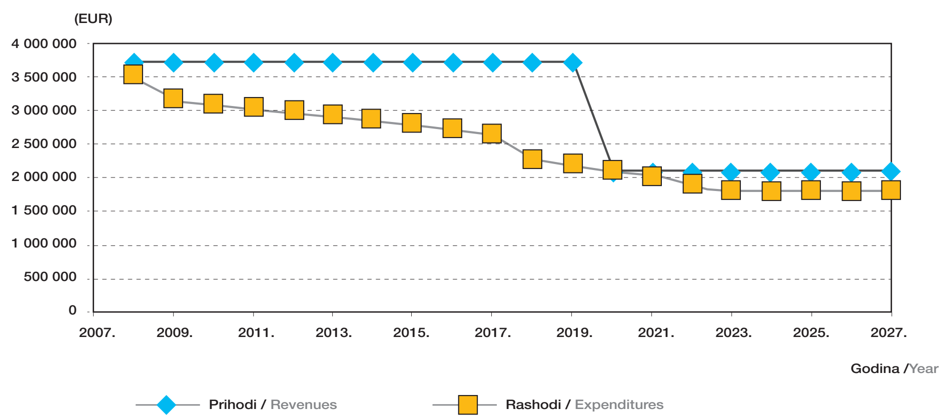
Pregled ulaznih parametara / Input parameters				
Investicija po kW instalirane snage / Investment per kW of installed capacity		1350	EUR/kW	
Broj sati rada / Number of hours of operation		2300	h	
Cijena električne energije / Price of electrical energy	prvih 12 godina / first 12 years	650	HRK/MWh	
	drugih 8 godina / second 8 years	370	HRK/MWh	
Struktura sredstava / Asset structure		20 %	Vlastita sredstva / Equity capital	
		80 %	Kredit / Credit	
Broj godina kredita / Number of years of credit		15	Godina / Year	
Kamatna stopa / Interest rate		5,63 %		
Interkalarne kamate / Compounded interest		5,63 %		(= kamatna stopa) / (= interest rate)
Aranžerska naknada / Compensation to negotiator		1,35 %		
Amortizacija / Amortization	prvih 10 godina / first 10 years	5,57 %		
	drugih 10 godina / second 10 years	4,43 %		
Pogon i održavanje / Operation and maintenance		40 000	EUR/MW	
Koncesija / Concession		1,50 %		(kao postotak prihoda) / (as a percentage of revenue)
Diskontna stopa / Discount rate		7,00 %		
Tečaj EUR / EUR rate of exchange	1 EUR=	7,4	HRK	
PDV / VAT		22 %		
Porez na dobit / Profit tax		20 %		
Pregled izlaznih parametara / Output parameters				
Dobit poslije poreza, kumulativno / After-tax profit, cumulative		9 885 659	HRK	
Kumulativni neto primici / Cumulative net revenues		14 198 423	HRK	(financijski tok) / (financial flow)
Kumulativni neto primici / Cumulative net revenues		18 245 189	HRK	(ekonomski tok) / (economic flow)
Čista sadašnja vrijednost / Net present value		362 645	HRK	
Interna stopa rentabilnosti / Internal rate of return		7,22158 %		

Tablica 4 – Struktura ulaganja i financiranja za vjetroelektranu snage 18 MW (2007.)
Table 4 – Investment and financing structure for wind power plant with a power rating of 18 MW (2007)

	Ulaganja / Investment	(EUR)	
1	Ulaganje (troškovi izgradnje bez PDV) / Investment (building costs without VAT)	24 300 000	
2	PDV / VAT (22 %)	5 346 000	
3	Aranžerska naknada / Compensation to negotiator (1,35 %)	262 440	
4	Interkalarne kamate / Compounded interest (5,63 %)	697 726	
5	Ukupno ulaganje (1+2+3+4) / Total investment (1+2+3+4)	30 606 166	
	Financiranje / Financing	(EUR)	
1	Vlastita sredstva / Equity capital	4 860 000	
2	Vlastita sredstva (aranžerska naknada) / Equity capital (compensation to negotiator)	262 440	20 % investicije / investment
3	Krediti s interkalarnim kamatama / Loan with compounded interest	25 483 726	
	– kredit za osnovna sredstva / Loan for fixed assets	19 440 000	
	– interkalarne kamate za kredit za osnovna sredstva / Compounded interest for loan for fixed assets	547 236	80 % investicije / investment
	– kredit za obrtna sredstva (za PDV) / Credit for current assets (for VAT)	5 346 000	
	– interkalarne kamate za kredit za obrtna sredstva / Compounded interest on loan for current assets	150 490	
	Ukupno / Total (1+2+3)	30 606 166	

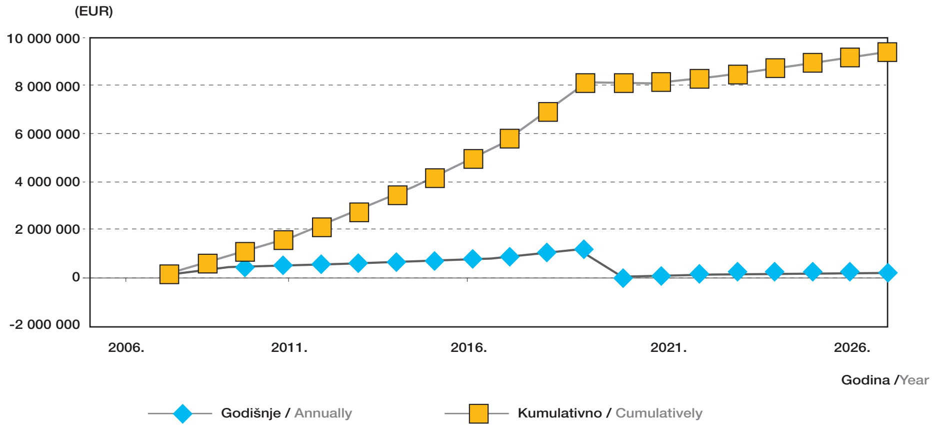
U nastavku modela prikazuje se račun dobiti i gubitka. To je prikaz prihoda i rashoda, te utvrđivanje dobiti prije i nakon poreza na dobit. Ovim računom se utvrđuje računovodstvena dobit ili gubitak. Temeljne kategorije su godišnji troškovi pogona i održavanja, amortizacija, kamate na kredit (tijekom trajanja kredita), troškovi koncesije. U modelu se dobit prije i poslije poreza prikazuje godišnje i kumulativno iz godine u godinu. Zadnji korak je vizualizacija rezultata, što prikazuju slike 4 i 5.

The profit and loss account is presented in the continuation of the model. This is a presentation of revenues and expenditures, and the determination of profits before and after profit tax. With this account, the accounting profit or loss is determined. The basic categories are the annual expenditures of operation and maintenance, amortization, interest on credit (for the duration of the loan) and concession costs. In the model, profits before and after taxes are presented annually and cumulatively from year to year. The last step is the visualization of the results, as presented in Figures 4 and 5.



Slika 4
Račun dobiti i gubitka – prihodi i rashodi
Figure 4
Profit and loss account – revenues and expenditures

Slika 5
Račun dobiti i gubitka – dobit poslije poreza, godišnje i kumulativno
Figure 5
Profit and loss account – after-tax profit, annually and cumulatively



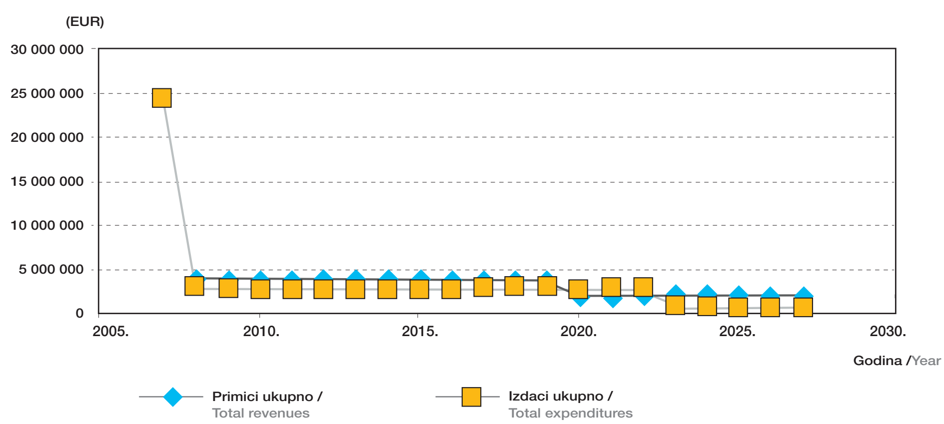
Financijski tijek tablično prikazuje primitke, izdatke i neto primitke. Primitci se sastoje od prodaje električne energije, te vlastitih sredstava uloženih u projekt. Pod izdatke se obračunavaju troškovi investicije (ukupni trošak projekta), zbrojeni troškovi održavanja i koncesije, otplata anuiteta te ostali troškovi (u simulaciji su to troškovi kredita za obrtna sredstva s interkalarnom kamatom) te porez na dobit ukoliko je u toj godini poslovanje bilo pozitivno. U zadnjem dijelu financijskog tijeka tablično su prikazani ukupni primici i izdaci, te neto i kumulativni neto primici za potrebe ocjene financijskog tijeka cijelog projekta. Zadnji korak je vizualizacija rezultata, što prikazuju slike 6 i 7.

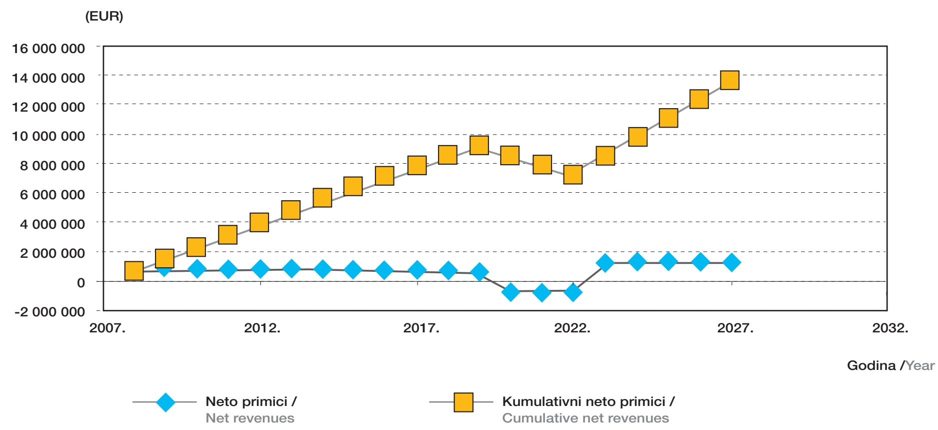
Potom se analizira kumulativni neto rezultat, što prikazuje tablica 5.

The presentation in the table of financial flow shows the revenues, expenditures and net revenues. Revenues consist of the sale of electrical energy and the equity capital invested in the project. Expenditures include investment costs (total project costs), the sum of the costs of maintenance and concession, the repayment of annuities and other costs (in the simulation these are credit costs for current assets with compounded interest) and profit tax if operations showed a profit for that year. In the last part of the financial flow, there is a tabular presentation of the total revenues and expenditures, the net revenues and the cumulative net revenues for the purposes of estimating the financial flow of the entire project. The last step is the visualization of the results, as presented in Figures 6 and 7.

The cumulative net result is then analyzed, as presented in Table 5.

Slika 6
Financijski tijek – ukupni primitci i izdaci
Figure 6
Financial flow – total revenues and expenditures





Slika 7
Financijski tijek – neto i kumulativni neto primici
Figure 7
Financial flow – net revenues and cumulative net revenues

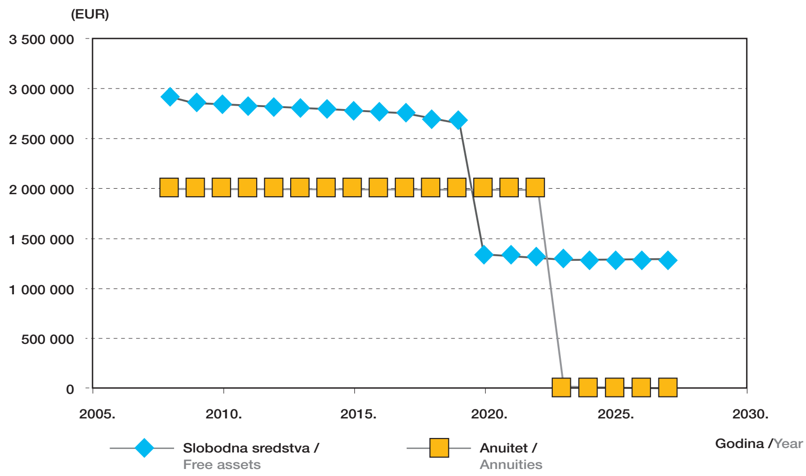
Tablica 5 – Kumulativni financijski rezultat
Table 5 – Cumulative financial result

	Opis / Description	(EUR)
1	Prihodi / Revenues	60 197 838
2	Rashodi / Expenditures	47 052 602
3	Porez na dobit / Profit tax	2 215 953
4	Zadržani dobitak / Retained profits (1–2–3)	10 929 284
5	Amortizacija / Amortization	24 300 000
6	Bruto akumulacija / Gross earnings (4+5)	35 229 284
7	Otplata glavnice kredita / Repayment of loan principal	19 987 236
8	Neto akumulacija / Net earnings (6–7)	15 242 048

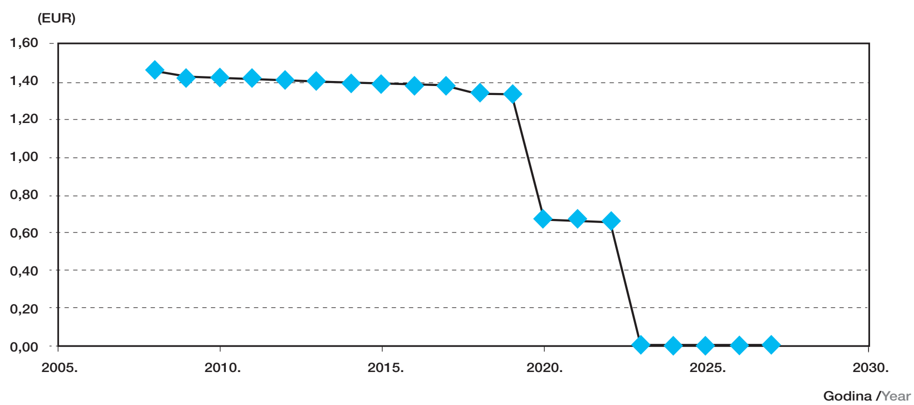
U svezi s analizom likvidnosti, potrebno se ukratko osvrnuti na mogućnost podmirenja anuiteta. Slobodna sredstva za otplatu anuiteta u ovom su slučaju razlika između prihoda od prodaje električne energije i troškova pogona i održavanja te poreza na dobit. Odnos slobodnih sredstava za otplatu anuiteta i veličine anuiteta predstavlja omjer pokrića anuiteta (slika 8 i 9) Ukoliko je omjer pokrića iznad 1 tijekom trajanja kredita tada su slobodna sredstva za otplatu kredita veća od anuiteta. To znači da projekt u tim godinama stvara dovoljno novčanih sredstava za otplatu kredita, te kažemo da je u tom razdoblju projekt likvidan. Iz slike 8 možemo vidjeti da postoji određeno razdoblje nelikvidnosti koje traži poslovne odluke o dodatnom zaduživanju ili upravljanja amortizacijom. Iterativnim postupkom također se utvrdilo da bi pri trajanju kredita od 12 godina omjer pokrića bio veći od 1 kroz sve godine trajanja kredita, čime je stvorena nova informacija kojom se može pristupati financijskim institucijama.

In connection with liquidity analysis, it is necessary to turn briefly to the possibility of annuity settlement. Free funds for the repayment of an annuity in this case are the difference between the revenue from the sale of electrical energy and the costs of operation and maintenance and profit tax. The ratio of the free assets for the repayment of an annuity and the amount of the annuity represent the ratio of annuity coverage (Figures 8 and 9). If the coverage ratio is over 1 during the duration of the loan, the free assets for the repayment of the loan are greater than the annuity. This means that during these years the project creates sufficient financial assets for the repayment of credit, and we say that during this period the project is solvent. From Figure 8, we can see that there is a certain period of insolvency that requires business decisions regarding additional indebtedness or amortization management. By an iterative procedure, it is also determined that in the case of a 12-year loan, the ratio of coverage was greater than 1 through all the years of the loan, thereby creating new information with which it is possible to approach financial institutions.

Slika 8
Pokriće anuiteta – prikaz odnosa slobodnih sredstava i anuiteta za kredit na 15 godina
Figure 8
Annuity coverage – ratio between free assets and annuities for a 15-year loan

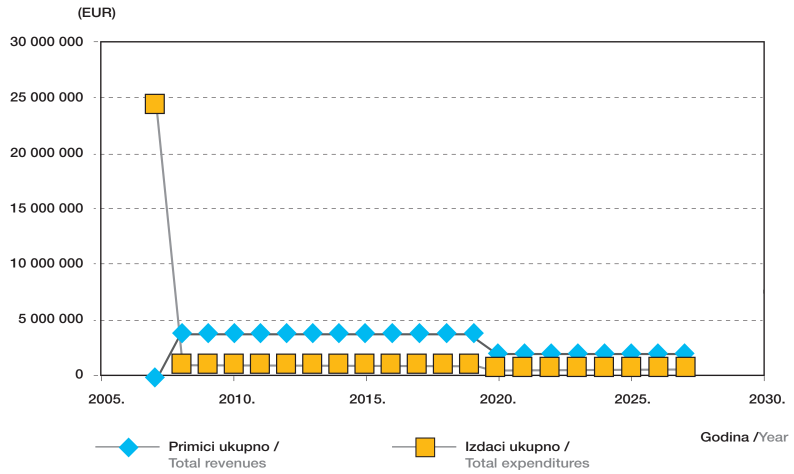


Slika 9
Pokriće anuiteta – prikaz omjera pokrića za kredit na 15 godina
Figure 9
Annuity coverage – coverage ratio for a 15-year loan

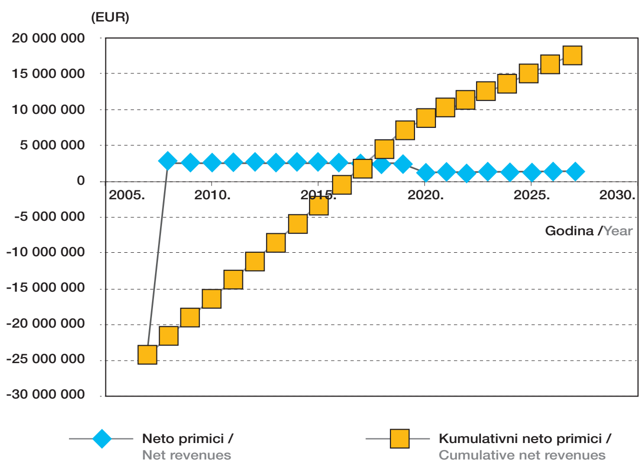


Zadnji dio financijske analize je tablični proračun ekonomskog tijeka. Za izračun primitaka (prihod od prodaje električne energije) i izdataka (investicija, pogon i održavanje, porez na dobit) vlastita sredstva i kredit su svedeni na nulu. Za izračun rashoda, prihoda te poreza i dobiti, kamate na kredit su svedene na nulu. Iz toga se dobivaju neto primitci iz kojih onda možemo izračunati čistu sadašnju vrijednost i internu stopu rentabilnosti. Vrijednosti su prikazane tablično za svaku godinu, a za preglednost se koriste grafovi, koje prikazuju slike 10 i 11.

The last part of the financial analysis is a tabular calculation of the economic flow. For the calculation of revenues (income from the sale of electrical energy) and expenditures (investment, operation and maintenance costs, profit tax) equity capital and credit are reduced to zero. For the calculation of expenditures, revenues, taxes and profits, loan interest is reduced to zero. From this is obtained the net revenues from which we can then calculate the net current value and internal rate of profitability. The values are presented in a tabular manner for each year and graphs are used for clarity of presentation, as shown in Figures 10 and 11.



Slika 10
Ekonomski tijek – prikaz ukupnih primitaka i izdataka
Figure 10
Economic flow – total revenues and expenditures



Slika 11
Ekonomski tijek – prikaz neto i kumulativnih neto primitaka
Figure 11
Economic flow – net and cumulative net revenues

3.4 Rezultati simulacije

Modeliranje rizika provedeno je u skladu s prijašnjim poglavljima. Korištenjem Monte Carlo metode za analizu rizika implementirane kroz dodatak MS Excelu®, simulirano je 10 000 iteracija, a kao rezultat nastale su razdiobe vjerojatnosti prezentirane u nastavku. Veći broj iteracija ima mali utjecaj na numerički rezultat i može se koristiti samo za grafičko izglađivanje krivulja. Granične vrijednosti pojasa pouzdanosti od 80 % (10 % najmanjih i najvećih vrijednosti se odbacuje) određene su iz numeričke analize podataka dobivenih simulacijom ovdje nisu prezentirane.

Kako bi se odredilo koje pretpostavke imaju najveći utjecaj na razdiobe vjerojatnosti izlaznih varijabli, pozitivan ili negativan, provedena je analiza osjetljivosti. Analiza osjetljivosti pokazuje kako se mijenja učinkovitost projekta ako se mijenjaju kritični parametri projekta.

3.4 Simulation results

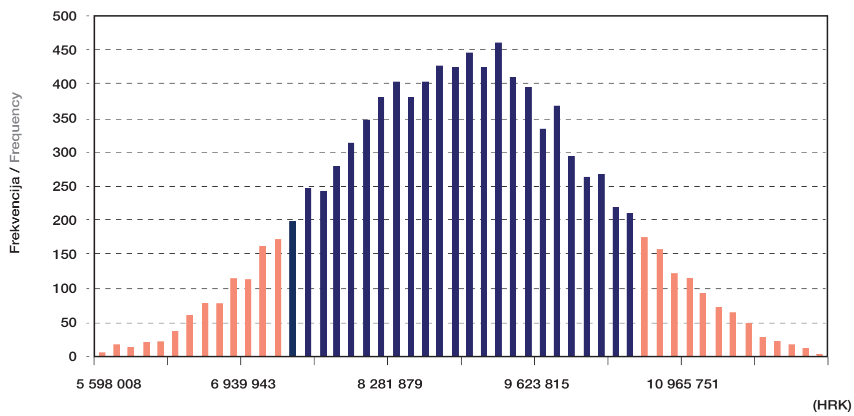
Risk modeling is conducted according to the previous chapters. Using the Monte Carlo method for risk analysis implemented through an add-on for Microsoft Excel®, 10 000 iterations were simulated, which resulted in the probability distribution presented below. The larger number of iterations have a small impact on the numerical result and can only be used to provide a smoother curve. The boundaries of the reliability zone of 80 % (10 % of the lowest and highest values are discarded) determined from the numerical analysis of data obtained through simulation are not presented here.

In order to determine which assumptions have the greatest impact on the distribution values of the output variables, positive or negative, sensitivity analysis was performed. Sensitivity analysis shows that the effectiveness of the project is altered if the critical parameters of the project are altered.

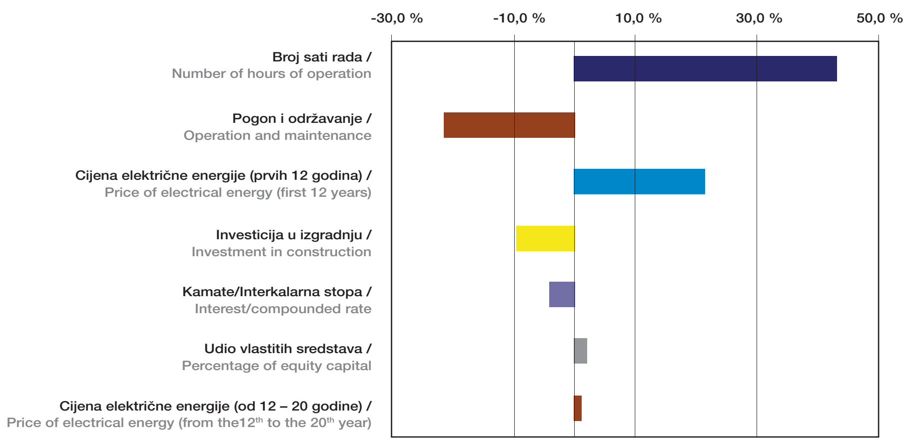
Raspon vrijednosti dobiti poslije poreza prema računu dobiti i gubitka prikazuje slika 12. Cijeli raspon je od 5 089 805 HRK do 12 745 040 HRK, sa srednjom vrijednošću od 8 885 750 HRK. Širina raspona je 7 655 235 HRK, a standardna devijacija 1 198 157 HRK. Područje od 80 % pouzdanosti je od 7 324 427 HRK do 10 461 333 HRK. Rezultat provedene analize osjetljivosti za tu varijablu prikazuje slika 13.

The range of values for after-tax profit according to the profit and loss account are presented in Figure 12. The entire range is from 5 089 805 HRK to 12 745 040 HRK, with an average value of 8 885 750 HRK. The width of the range is 7 655 235 HRK and the standard deviation is 1 198 157 HRK. The range of 80 % reliability is from 7 324 427 HRK to 10 461 333 HRK. The results of the sensitivity analysis performed for this variable are presented in Figure 13.

Slika 12
Račun dobiti i gubitka – dobit poslije poreza
Figure 12
Profit and loss account – after-tax profit

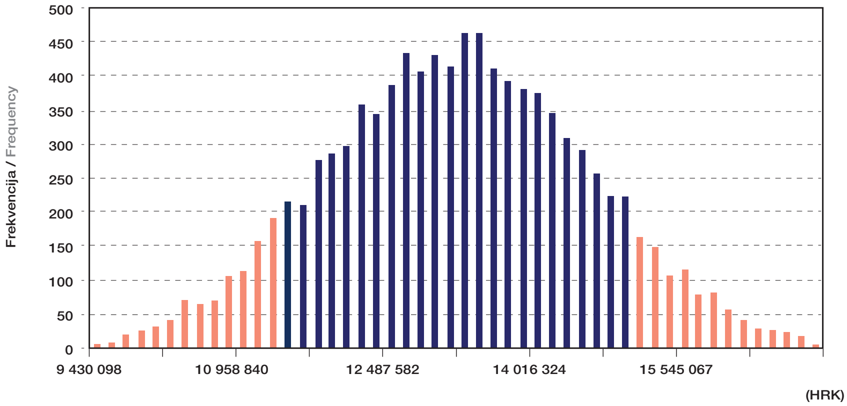


Slika 13
Analiza osjetljivosti – dobit poslije poreza iz računa dobiti i gubitka
Figure 13
Sensitivity analysis – after-tax profit from the profit and loss account

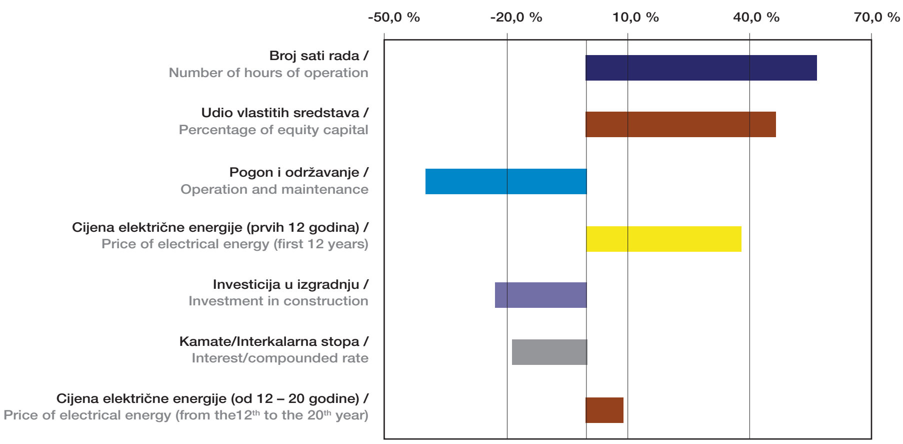


Raspon vrijednosti kumulativnih neto primitaka prema računu financijskog tijeka prikazuje slika 14. Cijeli raspon je od 8 449 934 HRK do 17 516 142 HRK, sa srednjom vrijednošću od 13 175 516 HRK. Širina raspona je 9 066 208 HRK, a standardna devijacija 1 364 948 HRK. Područje 80 % pouzdanosti je od 11 394 845 HRK do 14 941 338 HRK. Rezultat provedene analize osjetljivosti za tu varijablu prikazuje slika 15.

The range of the value of cumulative net revenues according to the financial flow calculation is presented in Figure 14. The entire range is from 8 449 934 HRK to 17 516 142 HRK, with an average value of 13 175 516 HRK. The width of the range is 9 066 208 HRK, and the standard deviation is 1 364 948 HRK. The range of 80 % reliability is from 11 394 845 HRK to 14 941 338 HRK. The results of the sensitivity analysis performed for this variable are presented in Figure 15.



Slika 14
Financijski tijek – kumulativni neto primitci
Figure 14
Financial flow – cumulative net revenues

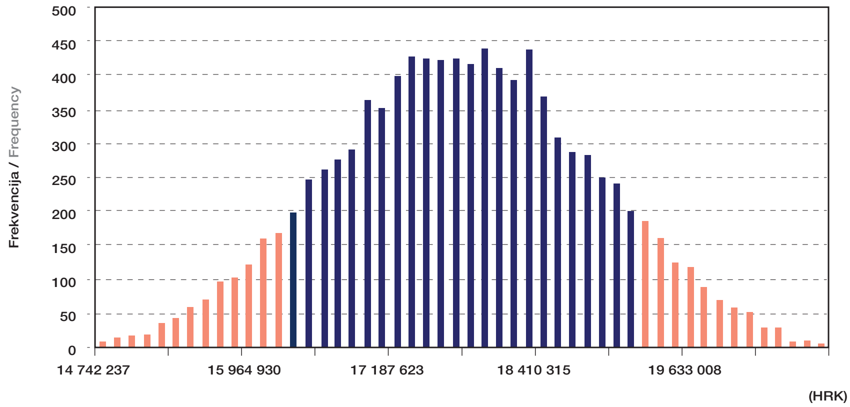


Slika 15
Analiza osjetljivosti – kumulativni neto primitci iz financijskog tijeka
Figure 15
Sensitivity analysis – cumulative net revenues from financial flow

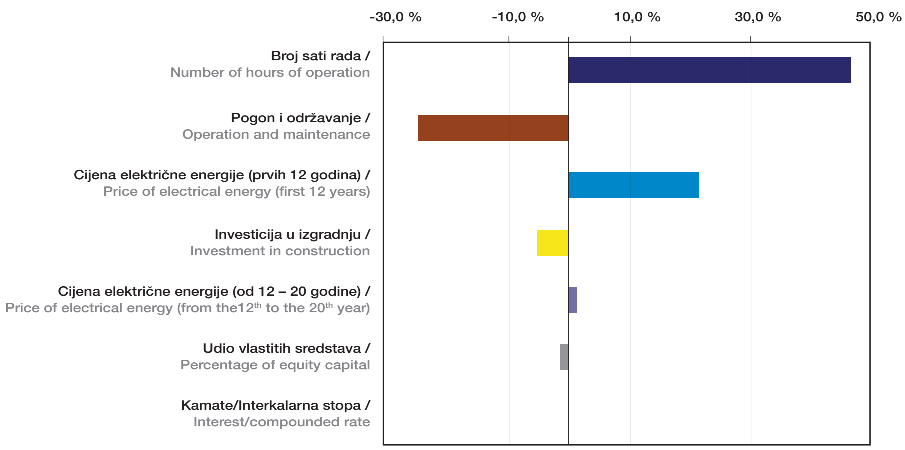
Raspon vrijednosti kumulativnih neto primitaka prema računu ekonomskog tijeka prikazuje slika 16. Cijeli raspon je od 14 373 288 HRK do 21 103 033 HRK, sa srednjom vrijednošću 17 737 834 HRK. Širina raspona je 6 729 745 HRK, a standardna devijacija 1 091 690 HRK. Područje 80 % pouzdanosti je 16 321 495 HRK do 19 177 604 HRK. Rezultat provedene analize osjetljivosti za tu varijablu prikazuje slika 17.

The range of the values for cumulative net revenues according to the economic flow calculation are presented in Figure 16. The entire range is from 14 373 288 HRK to 21 103 033 HRK, with an average value of 17 737 834 HRK. The width of the range is 6 729 745 HRK and the standard deviation is 1 091 690 HRK. The range of 80 % reliability is from 16 321 495 HRK to 19 177 604 HRK. The results of the sensitivity analysis conducted for this variable are presented in Figure 17.

Slika 16
Ekonomski tijek – kumulativni neto primitci
Figure 16
Economic flow – cumulative net revenues

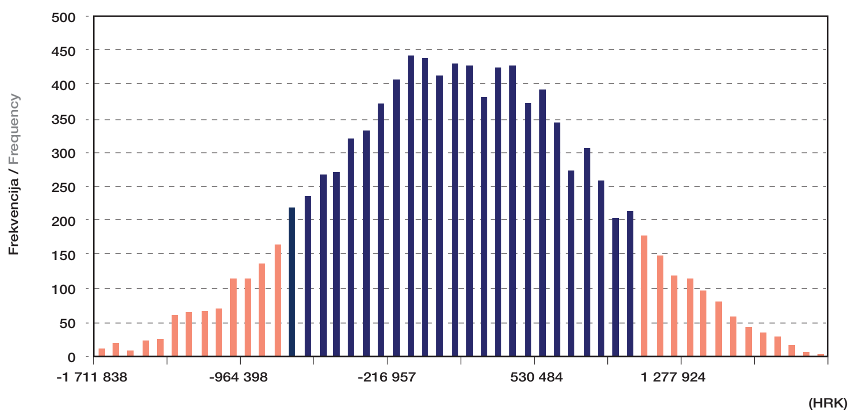


Slika 17
Analiza osjetljivosti – kumulativni neto primitci iz ekonomskog tijeka
Figure 17
Sensitivity analysis – cumulative net revenues from the economic flow

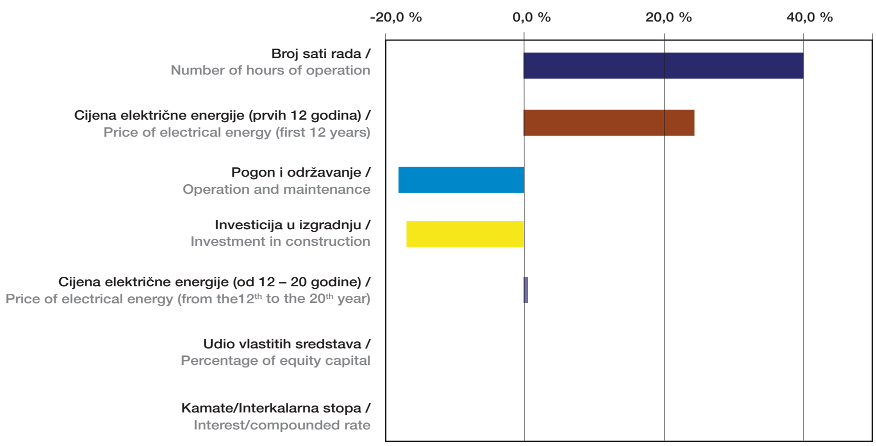


Raspon vrijednosti čiste sadašnje vrijednosti projekta prikazuje slika 18. Cijeli raspon je od – 1 983 184 HRK do 2 315 638 HRK, sa srednjom vrijednošću 119 391 HRK. Širina raspona je 4 298 822 HRK, a standardna devijacija 667 358 HRK. Područje 80 % pouzdanosti je od –743 831 HRK do 993 674 HRK. Rezultat provedene analize osjetljivosti za tu varijablu prikazuje slika 19.

The range of the values of the net present value of the project is presented in Figure 18. The entire range is from –1 983 184 HRK to 2 315 638 HRK, with an average value of 119 391 HRK. The width of the range is 4 298 822 HRK, and the standard deviation is 667 358 HRK. The range of 80 % reliability is from –743 831 HRK to 993 674 HRK. The results of the sensitivity analysis performed for this variable are presented in Figure 19.



Slika 18
Čista sadašnja vrijednost
Figure 18
Net present value

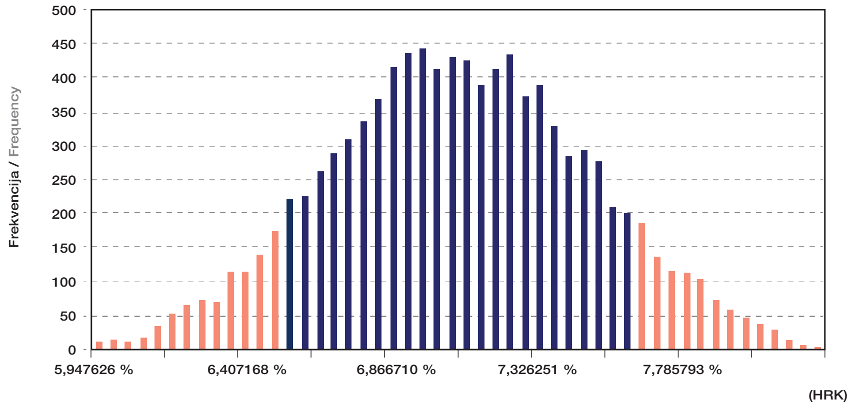


Slika 19
Analiza osjetljivosti čiste sadašnje vrijednosti
Figure 19
Sensitivity analysis of net present value

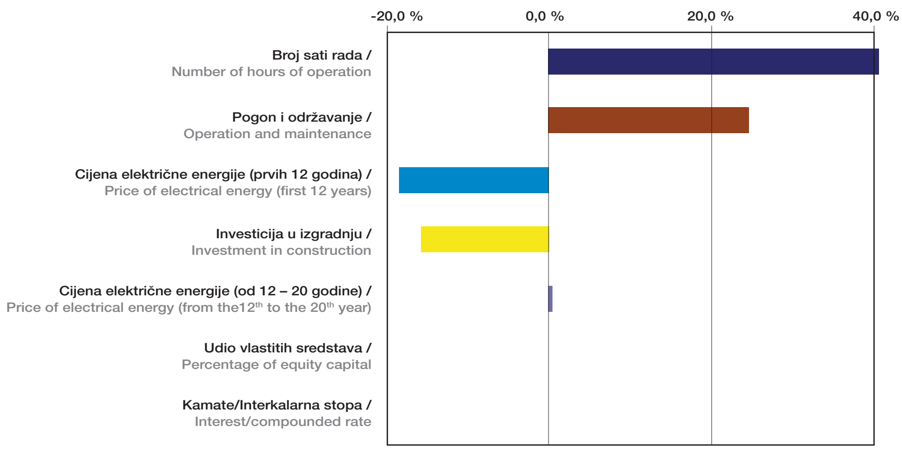
Raspon vrijednosti interne stope rentabilnosti prikazuje slika 20. Cijeli raspon je od 5,79 % do 8,43 %, sa srednjom vrijednošću 7,07 %. Širina raspona je 2,65 %, a standardna devijacija 0,41 %. Područje 80 % pouzdanosti je od 6,54 % do 7,61 %. Rezultat provedene analize osjetljivosti za tu varijablu prikazuje slika 21.

The range of the values of the internal rate of return is presented in Figure 20. The entire range is from 5,79 % to 8,43 %, with an average value of 7,07 %. The width of the range is 2,65 %, and the standard deviation is 0,41 %. The range of 80 % reliability is from 6,54 % to 7,61 %. The result of the sensitivity analysis performed for this variable is presented in Figure 21.

Slika 20
Interna stopa rentabilnosti
Figure 20
Internal rate of return



Slika 21
Analiza osjetljivosti interne stope rentabilnosti
Figure 21
Sensitivity analysis of the internal rate of return



Analiza čiste sadašnje vrijednosti (NPV) ukazuje da je vrijednost pozitivna za cijeli raspon izlaznih vrijednosti (s prethodno ustanovljenim razdiobama vjerojatnosti ulaznih varijabli). Iako umjerena, stvara se nova vrijednost, i može se zaključiti da je ulaganje financijski isplativo.

Analiza interne stope rentabilnosti ukazuje da je IRR jednak ili veći kamatnoj stopi kredita u cijelom rasponu vrijednosti izlazne varijable.

3.5 Diskusija o međuovisnosti ulaznih i izlaznih varijabli

Neizbježno se postavlja pitanje mogućnosti utjecanja na ulazne podatke kako bi se dobila pozitivnija financijska slika projekta za potrebe izrade kreditnog elaborata. S obzirom da je model u svojoj suštini deterministički (variraju se samo ulazne varijable, ne i model), promjenom ulaznih parametara slijedeći analize osjetljivosti

Analysis of the net present value (NPV) shows that the value is positive for the entire range of output values (with the previously established probability distribution of the input variables). Although moderate, a new value is created and it can be concluded that investment is financially profitable.

Analysis of the internal rate of return shows that the internal rate of return (IRR) is equal to or greater than the credit interest rate throughout the entire range of the values of the output variable.

3.5 Discussion of the interdependence of the input and output variables

The question is inevitably posed regarding the possibilities of influencing input data in order to obtain a positive financial picture of the project for the purposes of preparing a credit study. Since the model is essentially deterministic (only the input variables vary, not the model), change in the input utječe se na izlazne vrijednosti. No, to i jest cilj analize svake investicije. Dobivene razdiobe pojedinih parametara financijske analize, kao i osjetljivost, skreću nam pozornost na potrebu upravljanja samo nekim rizicima radi postizanja isplativosti projekta. U zapadnim zemljama postoji praksa standardiziranja određenih parametara varijabli koje su bitne u analizama investicija u vjetroelektrane. To se čini upravo zato da bi se smanjile mogućnosti utjecanja na rezultat i time iskrivljavanje financijske slike projekta.

Zamišljeni način uporabe ovog modela je korištenje najboljih javno dostupnih ili prikupljenih podataka za projekt izgradnje vjetroelektrane, uz simulaciju nesigurnosti onih varijabli za koje se mogu odrediti opravdani rasponi vrijednosti promjene u budućnosti. Jednom izrađen, takav model može se priložiti u investicijsku studiju kao investitorova financijska analiza potpomognuta analizom rizika. Umjesto fiksnog procjenjivanja konačnih izlaznih varijabli poput NPV i IRR, korištenjem analize rizika moguće je utvrditi konačnu vrijednost varijable, ali uz vrijedan dodatak postotka sigurnosti s kojim se može reći da je dobivena konačna vrijednost točna.

Pri pregovorima se, bez analize rizika, isti model može koristiti kao jednostavno i efikasno sredstvo za brzu analizu utjecaja promjene pojedinih parametara na konačnu financijsku sliku projekta.

4 ZAKLJUČAK

Prema [35], vjetroenergija je izvor energije čiji se globalni potencijal procjenjuje između 20 000 i 50 000 TWh električne energije na godinu, na kopnenim lokacijama, čemu treba pridodati i veliki potencijal iznad morske površine (ukupna svjetska potrošnja električne energije u 2000. godini iznosila je oko 13 000 TWh). Prema sadašnjim spoznajama u Republici Hrvatskoj se može izgraditi vjetroelektrana instalirane snage oko 2 000 MW s očekivanom proizvodnjom od oko 4 TWh električne energije godišnje (godišnja bruto potrošnja danas je oko 17 TWh).

Da bi se izgradila vjetroelektrana, koja će pouzdano proizvoditi električnu energiju i ostvarivati ekonomska očekivanja investitora treba osigurati brojne uvjete. To su prije svega: pronalaženje slobodne lokacije s odgovarajućom jakosti vjetra, odabir primjerene opreme (sa stanovišta elektroenergetskog sustava te brzine i količine vjetra), odabir priključka na elektroenergetski sustav, sklapanje dugoročnog ugovora o kupoprodaji

parameters according to the sensitivity analysis affect the output values. However, this is the goal of the analysis of every investment. The obtained distributions of the individual parameters of the financial analysis, as well as sensitivity analysis, turn our attention to the need to manage some of the risks in order for the project to be profitable. In Western countries, there is a practice of standardizing certain parameters of variables, which are essential in the analyses of investments in wind power plants. This is done precisely in order to reduce eventual influences on the result and thereby distortion of the financial picture of the project.

The envisioned manner for the use of this model is the use of the best publicly accessible or collected data for the project of the construction of wind power plants, with simulation of the uncertainties of those variables for which it is possible to determine the justified ranges of future value changes. Once devised, such a model could be included in an investment study as the investor's financial analysis supplemented by risk analysis. Instead of a fixed estimate of the final output variables such as net present value (NVP) and internal rate of return (IRR), by using risk analysis it is possible to determine the final value of a variable together with the valuable addition of the percentage of certainty with which it is possible to state that the obtained final value is accurate.

During negotiations, the same model can be used without risk analysis as a simple and efficient mean for the rapid analysis of the effects of the changes of individual parameters on the final financial picture of a project.

4 CONCLUSION

According to [35], wind energy is an energy source with a global potential between 20 000 TWh and 50 000 TWh of electrical energy per year on land locations, to which should be added the great potential over marine surfaces (the total world consumption of electrical energy in the year 2000 amounted to approximately 13 000 TWh). According to current knowledge, in the Republic of Croatia it is possible to construct wind power plants with installed capacity of approximately 2 000 MW, with anticipated production of approximately 4 TWh of electrical energy per year (annual consumption today is approximately 17 TWh).

In order to build a wind power plant that will produce electrical energy reliably and meet the economic expectations of investor, it is necessary to secure numerous prerequisites. These are, first električne energije te osiguranje povoljnih uvjeta financiranja izgradnje.

Investicija u izgradnju vjetroelektrane je kapitalno intenzivan projekt. Kako bi investitor povećao sigurnost svoje investicije, potreban je brz i učinkovit sustav analize investicijskih rizika projekta. To se podjednako odnosi i na kreditora i na onoga tko razvija projekt. Dobra procjena rizika može ukazati na slabosti prijedloga i na njihovo pravodobno otklanjanje.

U numeričkom modeliranju rizika, svaki se rizik transformira u razdiobu vjerojatnosti mogućih ishoda. Rezultati analize su vrijednosti i grafikoni koji pružaju točnu informaciju o količini rizika koji se preuzima.

Najosjetljiviji dio modela je određivanje ulaznih varijabli i njihove razdiobe. U ovom radu to je učinjeno korištenjem financijskih parametara dostupnih iz iskustava unutar Hrvatske i EU.

Temeljem provedene analize na primjeru vjetroelektrane od 18 MW na području Benkovca može se zaključiti:

- vjetroelektrana koja je uzeta kao primjer financijski je isplativ projekt, iako s umjerenom profitabilnošću,
- analiza osjetljivosti pokazuje da su najutjecajniji rizici povezani s brojem sati rada (što je u skladu s nalazima drugih studija isplativosti ovog tipa investicije u EU), a da cijeni izgradnje vjetroelektrane i troškovima pogona i održavanja treba posvetiti pozornost.

Nadalje se može ustvrditi da je prezentirani model fleksibilan jer omogućuje promjene u ulaznim razdiobama vjerojatnosti te pruža mogućnost dodavanja novih varijabli (razni eskalatori, leasing, i sl.). Model je uz neznatne dorade moguće primijeniti i na druge projekte obnovljivih izvora.

of all, the finding of free locations with the suitable wind strength, the selection of suitable equipment (from the standpoint of the electrical energy system and the speed and quantity of the wind), the selection of a connection point to the electrical energy system, entry into long-term contract on the sale of electrical energy and securing favorable conditions for financing construction.

Investment in the construction of wind power plant is a capital intensive project. In order for the investor to increase the safety of his investment, a rapid and effective system for the analysis of the investment risks of the project is necessary. This equally applies to the creditor and the party who develops the project. Good risk assessment can point out the weaknesses of a proposal, facilitating their elimination in time.

In numerical risk modeling, each risk is transformed into the probability distribution of possible results. The results of analysis are values and graphs that provide precise information on the amount of risk being undertaken.

The most sensitive part of a model is the determination of the input variables and their distribution. In the article, this was performed using financial parameters available from experience within Croatia and the EU.

Based upon analysis performed on the example of the wind power plant of 18 MW in the territory of Benkovac, the following may be concluded:

- the wind power plant that is taken as an example is a financially profitable project, although with moderate profitability,
- sensitivity analysis demonstrates that the most influential risks are connected with the number of hours of operation (which is in agreement with the findings of other profitability studies of this type of investment in the EU), and that the cost of the construction of a wind power plant and the operation and maintenance costs require attention.

Furthermore, it can be stated that the model presented is flexible because it permits changes in the input distribution probabilities and the addition of new variables (various escalators, leasing etc.). With minor adjustments, the model can also be applied to other projects involving renewable energy sources.

LITERATURA / REFERENCES

[1] Directive 2005/89/EC of the European Parliament and of the Council of 18 January 2006 concerning measures to safeguard security of electricity supply and infrastructure investment, 2005
[2] EWEA: Wind Energy – The Facts, 2003 (http://www.ewea.org/index.php?id=91)
[3] Eurostat: Europe in figures, Eurostat yearbook 2006-07, February 2007 (http://epp.eurostat.ec.europa.eu)
[4] EWEA: Strategic Overview of the Wind Energy Sector, 10 January 2007 (http://www.ewea.org/index.php?id=194)
[5] Tarifni sustav za proizvodnju električne energije iz obnovljivih izvora i kogeneracije, Narodne novine broj 33/2007
[6] Uredba o naknadama za poticanje proizvodnje električne energije iz obnovljivih izvora energije i kogeneracije , Narodne novine broj 33/2007
[7] Uredba o minimalnom udjelu električne energije proizvedene iz obnovljivih izvora i kogeneracije čija se proizvodnja potiče, Narodne novine broj 33/2007
[8] Enwind, Program korištenja energije vjetra, nove spoznaje i provedba, Energetski institut Hrvoje Požar, Zagreb, prosinac 2001.
[9] Enwind, Program korištenja energije vjetra, prethodni rezultati i buduće aktivnosti, Energetski institut Hrvoje Požar, Zagreb, travanj 1998.
[10] LABUDOVIĆ, B., Obnovljivi izvori energije, Energetika marketing, Zagreb, 2002.
[11] Windtest, Kaiser-Wilhem-Koog GmbH, Windpotentialmessung, 2007, (http://www.windtest.de)
[12] Windtest, Kaiser-Wilhem-Koog GmbH, Windpotential und Energieertragsberechnung, 2007, (http://www.windtest.de)
[13] Windtest, Kaiser-Wilhem-Koog GmbH, Vermessung des Leistungverhaltens von WEA und Windparks, 2007, (http://www.windtest.de)
[14] Vestas, Produktbeschreibung V90 – 3.0 MW, OptiSpeedTM Windenergieanalage, 2007, (http://www.vestas.com)
[15] Vestas, Produktbeschreibung V90 – 2.0 MW, OptiSpeedTM Windenergieanalage, 2007, (http://www.vestas.com)
[16] Bundesverband WindEnergie e.v, Fakten zur Windenergie (Von A bis Z), Berlin, 2005
[17] NORDEX N90/2500 LS – Annual energy yield, 2007, (http://www.nordex-online.com)
[18] Power Curve NORDEX N90/2500 LS, 2007, (http://www.nordex-online.com)
[19] Nordex Service Suite – Das mehrstufige Service, Programmm für alle Windenergieanlagen der Nordex Gruppe, 2007, (http://www.nordex-online.com)
[20] ENERCON, Technical specifications, Service and Maintenance, Tower and foundation, Grid connection, System control, 2007, (http://www.enercon.de)
[21] International Organization for Standardization (ISO), Risk management vocabulary: guidelines for use in standards, ISO/IEC Guide 73:2002 definition 3.1.1, first edition, Geneva, 2002
[22] International Electrotechnical Commission (IEC), IEC 60300-3-9 Ed. 2.0: Dependability management – Part 3-9: Application guide – Risk analysis of technological systems, first edition, Geneva, 2006
[23] CLEIJNE, H., RUIJGROK, W., Modelling Risks of Renewable Energy Investments, Report of the Green-X Project within the 5th framework programme of the EC, KEMA, Netherlands, July 2004
[24] TAPIERO, C., Risk and Financial Management: Mathematical and Computational Methods, John Wiley & Sons, June 2004
[25] MUŽINIĆ, F., Analiza i modeliranje rizika za projekte vjetroelektrana, magistarski rad, Fakultet elektrotehnike i računarstva, Zagreb, 2007.
[26] Crystal Ball Professional 7.2.2, Denver, Colorado: Decisioneering Inc.
[27] Ammonit Gesellschaft für Messtechnik GmbH, Windmessung für eine korrekte Energieprognose, 2007
[28] FARAGÓ, T., KATZ R.W., Extremes and Design Values in Climatology, WMO/TD – No. 386 WCAP – 14, 1990
[29] GAJIĆ-ČAPKA, M., PERČEC-TADIĆ, M., PATARČIĆ, M., Digitalna godišnja oborinska karta Hrvatske, Hrvatski meteorološki časopis 38, 2003.
[30] GUMBEL, E.J., Statistics of Extremes, Columbia University Press, New York, 1958.
[31] JENKINSON, A. F.: The Frequency Distribution of the Annual Maximum (or Minimum) Values of Meteorological Elements, Quartly Journal of the Royal Meteorogical Society 87, John Wiley & Sons, 1955
[32] TROEN, I., PETERSEN, E. L.: The European Wind Atlas, Proceedings of the European Wind Energy Association Conference and Exibition, Rome, 1986
[33] ZANINOVIĆ, K., SRNEC, L., PERČEC-TADIĆ, M., Digitalna godišnja temperaturna karta Hrvatske, Hrvatski meteorološki časopis 39, 2004.
[34] GORENC, V., Rječnik trgovačkog prava, Masmedia, Zagreb, 1997.
[35] ARCHER, C., JACOBSON, L., MARK Z., Evaluation of Global Wind Power, Journal of Geophysical Research – Atmospheres, Washington, 2005

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