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«Central Asian Academic Research Center» LLP is pleased to announce that “News of NAS RK. Series of Geology and Technical sciences” scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of Geology and Technical Sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

«Орталық Азия академиялық ғылыми орталығы» ЖШС «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

ТОО «Центрально-азиатский академический научный центр» сообщает, что научный журнал “Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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ASSESSMENT OF OPTIMAL AND EFFECTIVE WIND FARM IMPLEMENTATION SITES IN THE SYSTEM ADVISOR MODULE

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Abstract. The trend of green energy development in Kazakhstan is gaining new momentum and approaches to the transformation of the energy sector to a new stage of its development are being comprehensively considered. This, in turn, is attributed to climate change, environmental sustainability, and the transition to low-carbon technology. The introduction of new, local energy nodes into the system of integration of electric energy distribution in the Southern zone of the Republic of Kazakhstan suggests solutions to the growing problems associated with the imbalance of electric energy. The construction of new infrastructure facilities and an increase in production capacities in the Turkestan region are gradually leading to significant problems in providing the region with reliable, uninterrupted and efficient electric energy. The regional electric grid company, local government agencies and investors in the region are given the primary task of increasing the

capacity of electric energy flows. This article fully describes potential locations and provides their geographical coordinates for the construction and commissioning of wind farms in the context of regions in the Turkestan region. Using the System Advisor Module application program, dependencies of wind turbine generating capacities on wind speed and atmospheric density are constructed, taking into account the time and seasonal series of the proposed regions. As a result, a graph of the distribution of electric energy generation was constructed.

Keywords: energy-independent country, wind farm management, systematic monitoring of wind farms, kinetic energy, atmospheric density, wind load profile

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SYSTEM ADVISOR MODULE ОРТАСЫНДА ЖЭС ІСКЕ АСЫРУДЫҢ ОҢТАЙЛЫ ЖӘНЕ ТИІМДІ ОРЫНДАРЫН БАҒАЛАУ

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Аннотация. Жаңа инфрақұрылымдық объектілердің құрылысы, Түркістан облысы бойынша өндірістік қуаттардың ұлғаюы өңірді сенімді, үздіксіз және тиімді электр энергиясымен қамтамасыз етуде біртіндеп елеулі проблемаларға алып келеді. Өңірлік электр желілік компанияның, облыстың жергілікті мемлекеттік органдары мен инвесторларының алдына электр энергиясы ағындарының қуатын арттыру міндеті жүктелген. Бұл мақалада елеуетті орындар толық сипатталған, Түркістан облысы бойынша өңірлер бөлінісінде ЖЭС салу және пайдалануға беру үшін олардың географиялық

координаттық деректері келтірілген. System Advisor Module қолданбалы бағдарламасының көмегімен жел құбырларының генераторлық қуаттарының желдің жылдамдығы мен атмосфералық тығыздығына тәуелділігі ұсынылған аймақтардың уақытша және маусымдық қатарларын ескере отырып құрылды. Нәтижесінде электр энергиясын өндіруді бөлу кестесі құрылды. System Advisor Module қолдану бағдарламасында алынған мәліметтер қажетті параметрлерді ескере отырып, жел электр станцияларын салу және пайдалануға беруді талдауға мүмкіндік береді. 2000 м биіктікте ауа тығыздығы орташа есеппен $0,8 \text{ кг/м}^3$ құрайды, ал $15\text{--}25^\circ\text{C}$ температура диапазонында жел ағынының тиімді коэффициенті шамамен 40% құрайды. Мұндай мәліметтер жел электр станцияларын салу үшін техникалық, экономикалық және геоэкологиялық көрсеткіштер бойынша оңтайлы болып саналады. 10 жел электр станциясынан тұратын жел электр станцияларын геотехникалық құрылымдар қатарына жатқызуға болады, ал геотехникалық мәліметтерді нормалау жел электр станцияларын салудағы маңызды аспект болып саналады. Табиғи факторларды талдау және техникалық-экономикалық есептеулер жел электр станцияларын салуға арналған учаскенің стандартты инженерлік қорғау шараларын сақтай отырып, көшкін мен эрозияға төзімді екендігін растайды. Аяз кезінде жер үсті суларынан және топырақтың ықтимал деформацияларынан қорғауға ерекше назар аудару керек.

Түйін сөздер: энерготәуелсіз мемлекет, жел электр станцияларын басқару, жел электр станцияларын жүйелі бақылау, кинетикалық энергия, желдің профильді жүктемесі

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ОЦЕНКА ОПТИМАЛЬНЫХ И ЭФФЕКТИВНЫХ МЕСТ РЕАЛИЗАЦИИ ВЭС В СРЕДЕ SYSTEM ADVISOR MODULE

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Аннотация. Развитие инфраструктуры и увеличение производственных мощностей в Туркестанской области постепенно приводят к росту потребности в надежном, бесперебойном и эффективном электроснабжении региона. Перед региональной электросетевой компанией, местными органами власти и инвесторами стоит первоочередная задача повышения мощности перетоков электрической энергии. В статье представлены потенциальные площадки для строительства и ввода в эксплуатацию ветроэлектростанций (ВЭС) по регионам Туркестанской области, а также приведены их географические координаты. С использованием прикладной программы System Advisor Module (SAM) построены зависимости генерирующей мощности ветровых турбин от скорости и плотности воздуха с учётом временных и сезонных изменений климатических условий. На основании расчётов составлен график распределения выработки электрической энергии. Полученные в модуле System Advisor данные позволяют проводить технико-экономическую оценку целесообразности строительства и эксплуатации ВЭС с учётом климатических и геоэкологических параметров. На высоте 2000 м плотность воздуха составляет в среднем $0,8 \text{ кг/м}^3$, при температуре $15\text{--}25 \text{ }^{\circ}\text{C}$ эффективный коэффициент ветрового потока достигает около 40 %. Такие показатели считаются оптимальными для размещения ветроэнергетических установок с точки зрения технической, экономической и экологической эффективности. Рассмотрено влияние природных факторов на устойчивость площадок для ВЭС. Результаты инженерно-геологических расчётов показывают, что выбранные площадки устойчивы к оползням и эрозии при соблюдении стандартных мер инженерной защиты. Особое внимание рекомендуется уделить защите от поверхностных вод и возможных деформаций грунта при морозном пучении.

Ключевые слова: энергетическая независимость, управление ВЭС, мониторинг работы ВЭС, кинетическая энергия, атмосферная плотность, профиль ветровой нагрузки

Introduction. Today, the entire global community is striving to become an energy-independent country by building new directions in the field of green energy development. One of the main tasks in this matter is to assess the territorial features of the selected regions for the construction and commissioning of new alternative energy hubs. In their research work (Qolipour et al, 2018; Baležentis et al, 2017), foreign scientists propose effective modeling methods for conducting

systematic monitoring of wind farms, followed by a reduction in operating costs, as well as an increase in its reliability and technical and economic efficiency. In the author's work (Petersen et al, 2020), the methods of optimal design of wind power plants by scaling and integrating wind farms are considered. As a result, the data obtained confirmed that the expected annual energy production can be increased by 4% due to the integration of wind farm management.

In the research paper (Kornilova et al, 2023; Wu et al, 2011; Mangara et al, 2019), the key issues of modeling and numerical investigation of the atmospheric boundary layer in combination with a wind turbine are considered. During the creation of the mathematical model, issues such as multiscale, consideration of a highly rough, inhomogeneous surface, wind unevenness in amplitude, direction and frequency, and turbulence generation were taken into account.

Today, the digitization of static and dynamic data in real time plays an important role in creating optimal management of wind farms. Large energy companies, planners, as well as local government agencies are interested in creating a common computing network (Hewitt et al, 2018; Xia et al, 2019; Faiz et al, 2024) to obtain accurate analysis of potential strategic planning locations in the construction and commissioning of new large wind farms. In the course of such research, one of the main aspects is the creation of cloud, geographic information platforms and remote zanding platforms to obtain the necessary climatic and meteorological factors.

The data obtained in the System Advisor Module application program makes it possible to analyze the possibility of building and commissioning wind farms, taking into account the necessary parameters. At an altitude of 2000 m, the air density averages 0.8 kg/m³, while in the temperature range of 15-25°C, the effective wind flow coefficient is approximately 40%. Such data is considered optimal for the construction of wind farms in terms of technical, economic and geoeological indicators.

Wind farms consisting of 10 wind farms can be classified as geotechnical structures, and the rationing of geotechnical data is considered an important aspect in the construction of wind farms.

The analysis of natural factors and technical and economic calculations confirms that the site for the construction of wind farms is resistant to landslides and erosion while observing standard engineering protection measures. Special attention should be paid to protection from surface waters and possible soil deformations during the frost heave.

Materials and research methods. The following districts of the Turkestan region were taken as the studied objects: Chulak – Kurgan, Suzak and Tulkubassky districts. These areas have favorable characteristics in the construction and commissioning of new wind power plants. Wind gusts in these areas reach 20-25 m/s, which makes it possible to efficiently convert the obtained kinetic energy into electrical energy.

Chulak-Kurgan is a locality (class P — locality) in the Turkestan region, Kazakhstan (Asia). It is located at an altitude of 466 meters above sea level, the population is approximately 10,836 people.

The geographical coordinates of the Chulak – Kurgan region are given below:

43°45'54" n.l (north latitude)

69°10'53" e.l (east longitude)

The standard time zone for Chulak Kurgan is UTC/GMT+6

The geographical location of the Chulak – Kurgan region was obtained using Google Earth. A geomaps with a satellite image of the Chulak –Kurgan region is shown in Figure 1.

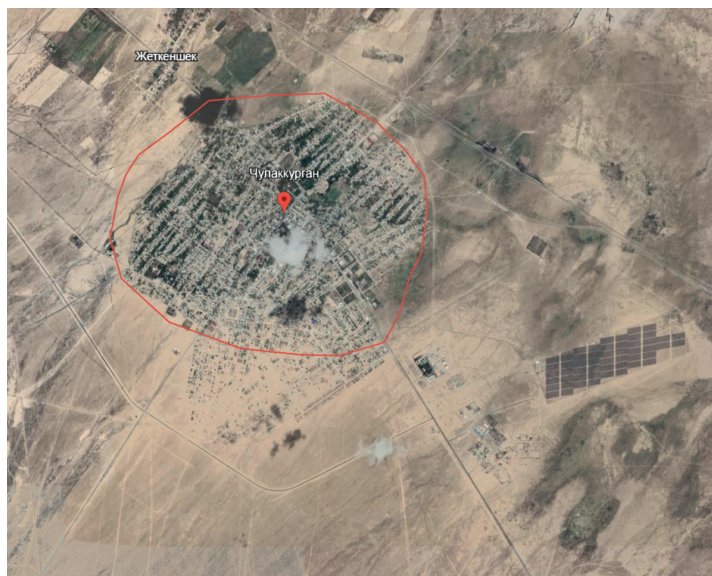


Figure 1 – Geomaps with satellite image of Chulak – Kurgan region

Suzak is a locality (class P —locality) in the Turkestan region, Kazakhstan (Asia) with the regional font code of Eastern Europe. It is located at an altitude of 585 meters above sea level, with an estimated population of about 61,512 people.

The geographical coordinates of the Suzak region are given below:

45°09'02" n.l (north latitude)

68°63'93" e.l (east longitude)

The standard time zone for Suzak is UTC/GMT+5

The geographical location of the Suzak district was obtained using Google Earth. A geomaps with a satellite image of the Suzak district is shown in Figure 2.



Figure 2 – Geomaps with satellite image of Suzak district

Tulkubas is a locality (class P — locality) in Turkestan province, Kazakhstan (Asia). It is located at an altitude of 823 meters above sea level, and has a population of approximately 115,000 people.

The geographical coordinates of the Tyulkubassky district are given below:

42°29'24" n.l (north latitude)

70°17'24" e.l (east longitude)

The standard time zone for Tulkubas is UTC/GMT+5

The geographical location of the Tyulkubassky district was obtained using Google Earth. A geomaps with a satellite image of the Tulkubassky district is shown in Figure 3.



Figure 3 - Geomaps with satellite images of Tyulkubassky district

A generalized wind map for the Turkestan region is shown in Figure 4.

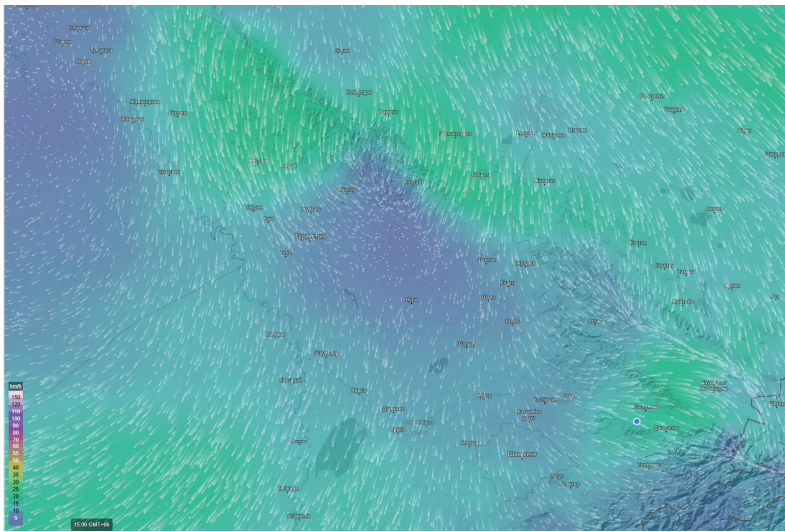


Figure 4 – A generalized wind map for the Turkestan region

Results and discussion. During the calculations in the System Advisor Module environment, geographical coordinate data of the estimated area was entered. In turn, when obtaining the necessary data, they were based in the NET environment, which allows the development of technologies and strategies for improving the efficiency and placement of wind turbines, as well as its integration into electric grids. The dependence of the wind turbine power on the wind velocity distribution $P=f(v)$ is shown in Figure 5

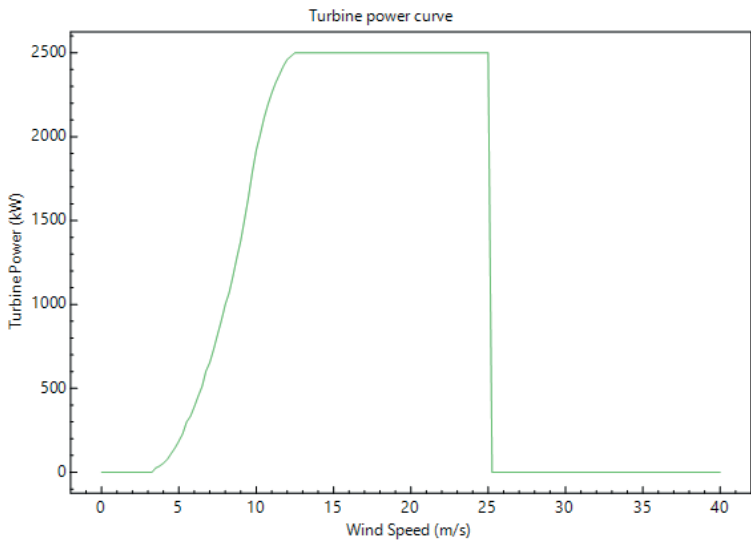


Figure 5 – Dependence of wind turbine power on wind velocity distribution $P=f(v)$

The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of January is shown in Figure 6

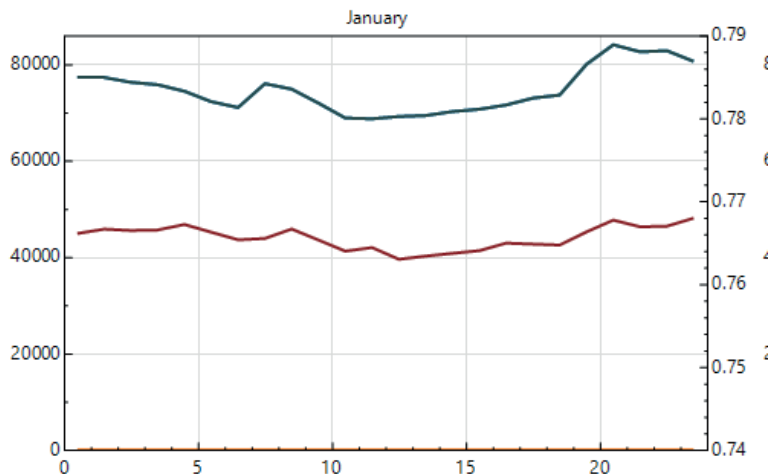


Figure 6 - Dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of January

The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of February is shown in Figure 7.

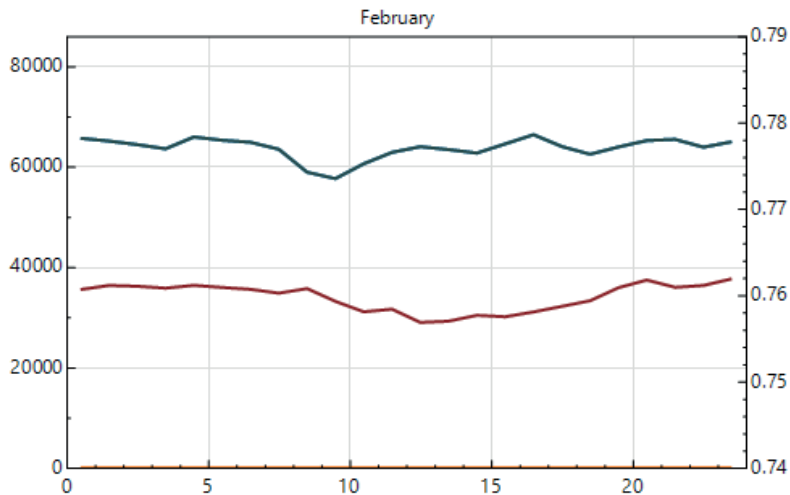


Figure 7 - Dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of February

The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of April is shown in Figure 8.

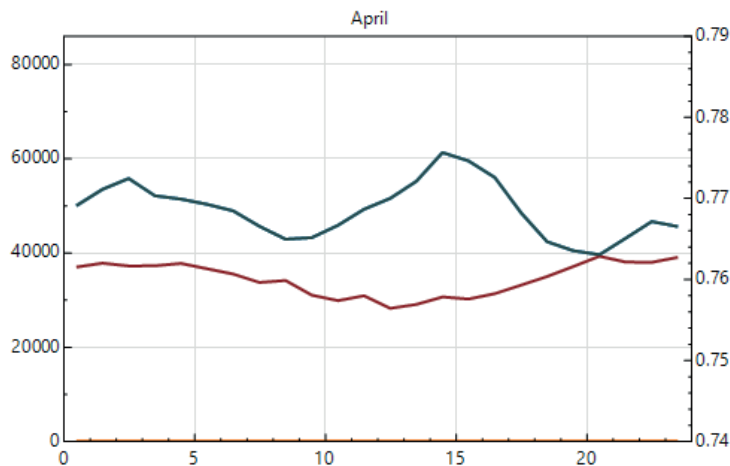


Figure 8 - The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of April

The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of November is shown in Figure 9.

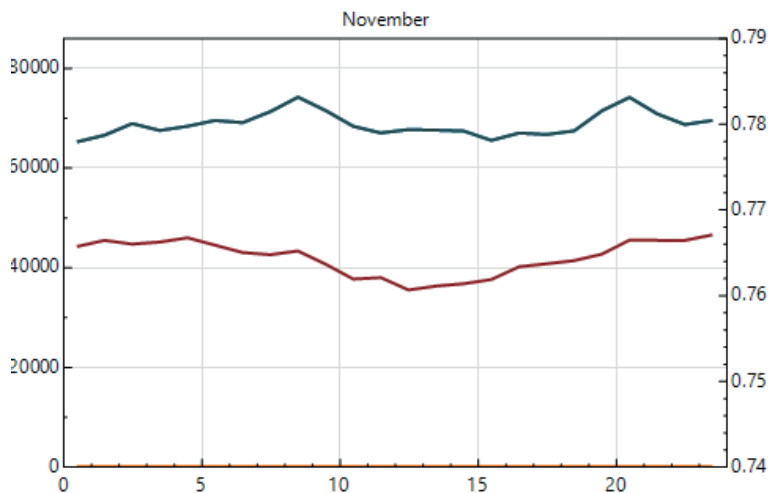


Figure 9 - The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of November

The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of December is shown in Figure 10.

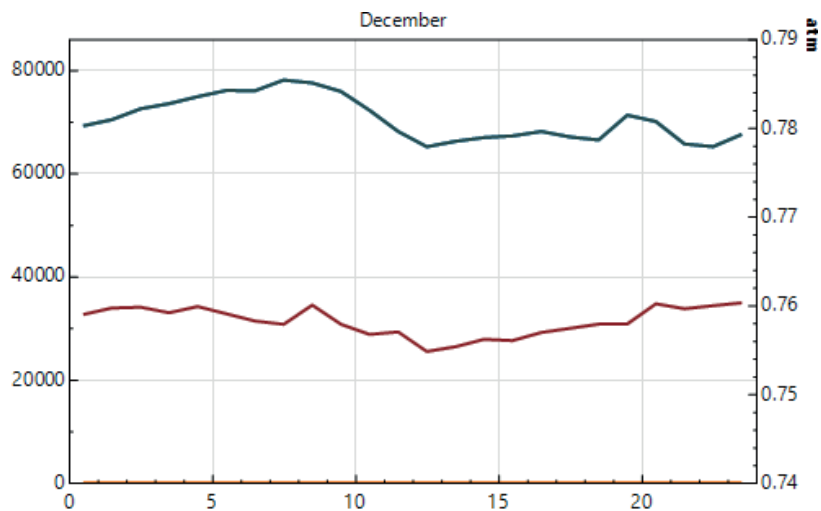


Figure 9 - The dependence of wind turbine power on the distribution of wind speed and atmospheric density for the month of December

The annual wind load profile is shown in Figure 11

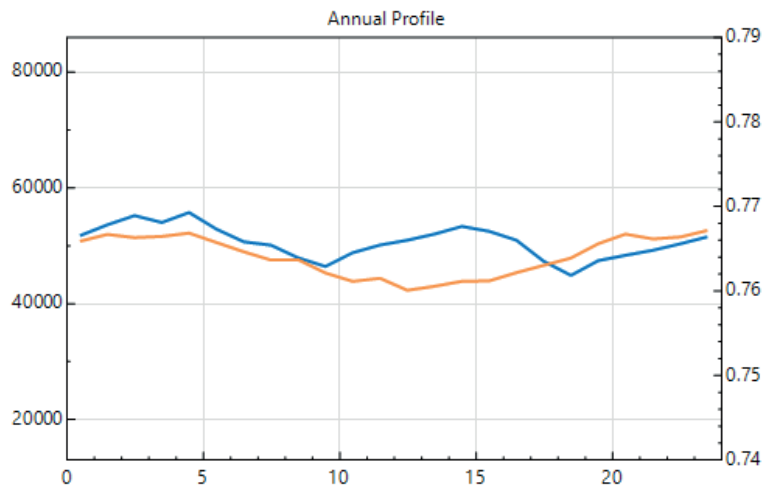


Figure 11 - The annual wind load profile

Allowable electrical losses, environmental losses, operational losses, and emergency losses are shown in Figure 12.

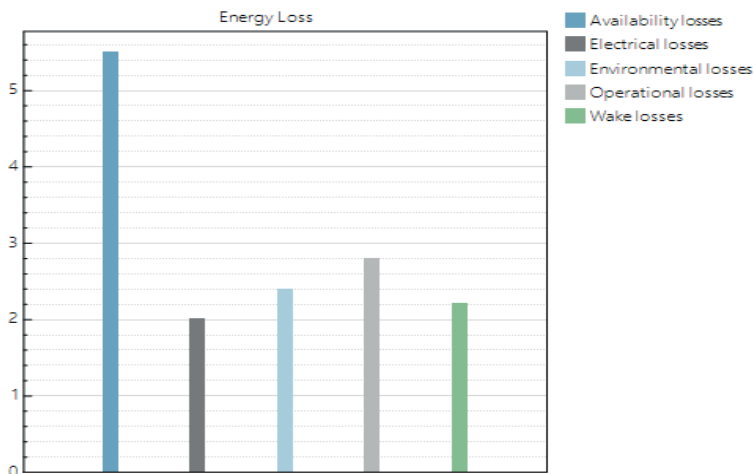


Figure 12 – Allowable electrical losses, environmental losses, operational losses, and emergency losses

The graph of the electric power generation system is shown in Figure 13

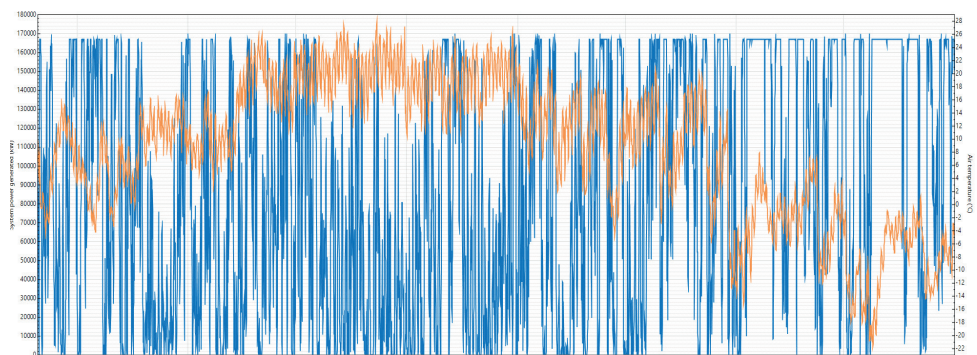


Figure 13 – The graph of the electric power generation system

The data obtained in the System Advisor Module application program makes it possible to analyze the possibility of building and commissioning wind farms, taking into account the necessary parameters. At an altitude of 2000 m, the air density averages 0.8 kg/m³, while in the temperature range of 15-25°C, the effective wind flow coefficient is approximately 40%. Such data is considered optimal for the construction of wind farms in terms of technical, economic and geocological indicators.

Wind farms consisting of 10 wind farms can be classified as geotechnical structures, and the rationing of geotechnical data is considered an important aspect in the construction of wind farms.

The analysis of natural factors and technical and economic calculations confirms that the site for the construction of wind farms is resistant to landslides and erosion

while observing standard engineering protection measures. Special attention should be paid to protection from surface waters and possible soil deformations during the frost heave.

Conclusion. The creation of an expert analysis system based on climatic, meteorological and geographical data will make it possible to create optimal sites for the construction of wind farms.

In this article, the calculation and selection of the location of wind turbines in the proposed area is implemented using the application software product System Advisor Module.

The data obtained confirms once again that the assessment of data in the construction and commissioning of wind farms makes it possible to make accurate forecasts in real time.

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