Management of wind energy in sustainable development process in the Central Dobrogea (Istria region)

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Abstract: - This paper represents a strategic assessment of the environmental impact determined by the future construction of a wind park in Constanta region, necessary for the planning phase of the project as required by the principles of sustainable development but also European and national legislation. In this paper are presented the climatic factors which were monitored for one year, combined with biodiversity studies in the impact area (ROSPA0031 Danubius Delta and Sinoe Razelm complex and ROSCI065 Danubius Delta). Another goal of the study is to emphasize the impact of the wind farm construction effect on the economy and Istria region society. It also outlines the concerns of the impact on the environment (soil, water, air, landscape) in conjunction with data regarding noise, vibrations and flickering effect of the turbines on the residential zone. Wind PRO program enables to identify the worst case and to choose the optimal placement of turbines in relation to the ambient zone.

Key-Words: - wind farm, biodiversity, Wind PRO program, Environmental Impact Assessment, Natura 2000

1 Introduction
Power generation by using fossil fuels or nuclear requires unbearable costs on the environment, health and our economy. Instead of increasing dependence on polluting sources like coal, natural gas and nuclear power plants, we must turn our attention to clean resources and sustainable energy. The Earth has a limited capacity to satisfy the growing demand for natural resources in the socio-economic system and absorb the destructive effects of their use [3], [9], [14], [32]. Climate change, soil erosion and desertification, soil, water and air pollution [19], [22], [24], reduce the area of tropical forest systems and wetlands, extinction or endangerment of a large number of terrestrial and aquatic species of plants and animals, accelerated depletion of non-renewable resources, all this began to have negative effects, measurable effects, on the socio-economic development and quality of human life in vast areas of the planet.

In Romania, promoting the use of renewable energy sources (including wind energy), is one of the strategic objectives in the energy sector, in this respect being the medium-term target for the significant achieve objectives in green energy production. One of the advantages of using wind energy is the fact that it is available in proportion of two-thirds in the cold season [1], [17], [26], [38]. Thus, the wind energy is complementary to hydropower, knowing that water resources slow to a trickle in the cold periods. In addition, outsourcing costs should not be included in domestic consumers’ bills, which are borne by society [38], [39] (such as costs due to environmental pollution, health costs, occupational accidents, and so on).

The SEA (Strategic Environmental Assessment) evaluation can contribute to improving the decision process by analyzing the presumed effects on the environment. SEA Protocol of the United Nations Economic Commission for Europe - UNECE was adopted in Kiev in May 2003 and was later signed by 37 states and including the European Community [40]. The SEA Directive aims to identify and assessing the environmental effects of plans and / or programs, during the evaluation and before the adoption of the plan / program. This protocol creates the space for the implementation of SEA, but the text of the provisions of the Protocol is “recommendations” and not “requirements” [40]. Considering the advantages offered by SEA, it is necessary to identify alternative measures that may have the investor in the region by developing wind farm in Istria area (Central Dobrogea) [1], [37],
The study also aims to improve the economic efficiency and economic, social and environmental stability in Central Dobrogea by opening up opportunities more favourable than those initially evaluated.

2 Description of the area

Istria wind farm (IWF) site is located on several land plots of agricultural land and unproductive land located outside Istria village limits from Constanta (Figure 1). Location for 21 wind turbines placement covers of approximately 1257.93 hectares, in the southern part of the Istria village (located between Istria West Mound at an 117.4 m altitude and 42.8 m Istria South).

The location where the IWF will have to be placed was chosen taking into account social-economic and technical criteria (such as: costs of the building site training, access opportunities in the area, extent of damage of the environmental factors).

In the Table 1 are presented the indices for the use of land by wind turbines.

<table>
<thead>
<tr>
<th>Area considered</th>
<th>Ha</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>studied area</td>
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<td></td>
</tr>
<tr>
<td>area associated with the objective</td>
<td>746.14</td>
<td></td>
</tr>
<tr>
<td>area foundations</td>
<td>21x314 0.659</td>
<td>surface pulled aside</td>
</tr>
<tr>
<td>surface above ground ring</td>
<td>21x28 0.058</td>
<td>surface aside permanently removed</td>
</tr>
<tr>
<td>surface platform site organization</td>
<td>0.3000</td>
<td>surface pulled aside</td>
</tr>
<tr>
<td>access roads and platforms surface mounting</td>
<td>8.988</td>
<td>surface aside permanently removed</td>
</tr>
<tr>
<td>the land area pulled aside</td>
<td>1.249</td>
<td></td>
</tr>
<tr>
<td>the land permanently removed from agricultural</td>
<td>11.177</td>
<td></td>
</tr>
</tbody>
</table>

The considered urban indicators are: the percentage of occupancy (0.025 %) and coefficient of land use (0.00025%).

The proposed location for constructing IWF is bordered as follows: the North - agricultural land belonging to the Istria village and about 350 m are Istria; the South - agricultural lands and 2.9 km Nuntaşi village; the East - land covered with reeds belonging to the village Istria, and about 0.7 km there is Istria lake; the West - farmland and at a distance of 1.5 km is the railway.

Also, the location of wind turbines installations is partially situated (80%) in the protected area ROSPA0031 Danube Delta - Razim Sinoe. Distance to other Natura 2000 protected areas - ROSCI065 Danube Delta, is about 150 m. This has led to necessity of biodiversity monitoring in the area during of a calendar year.

2.1 Networking with other projects and programs

IWF plan realization is in agreement with the policy of Romania [9], [39], to promote the energy from renewable resources.

In the area where the IWF is to be placed are currently other wind farms in various stages of investment (Figure 2), such as:
- Mihai Viteazu I, II, III and IV wind power plants (WPP) with 74 Gamesa wind turbines type, G87 rated power of 2.0 MW (at a distance of 4.70 km from the current plan);
- Baia I, II, III, IV WPP with 64 Gamesa turbines type (G87/G90 and rated power of 2.0 MW) - at a distance of 9.20 km;
- Săcele I, II, III, IV with 52 Gamesa G87/G90 turbines type (at a distance of 6.14 km);
- Istria I WPP with 12 Gamesa G87/G90 turbines type (at a distance of 2.26 km);
- Fântânele East and West WPP with 139 wind turbines which are under construction (at a distance of 2.6 km).
We consider that the distances from the IWF to the other five parks (mentioned above) is too large to exist a direct correlation between the effects of those projects (whether they are considered in pairs or are taken into account simultaneously all the six parks). It should be noted that in Dobrogea are requests from investors to install a 4000 MW power capacity, which means a number of least than 2.000 wind turbines [39].

2.2 Assessment of environmental quality in the region of Istria

Monitoring of the region (January-December 2012) was performed during one year, which allowed us the real situation assessment. Thus, we can draw some initial conclusions on the need for implementation of this plan.

2.2.1 Topography and geomorphology of the area

From the geomorphologic point of view, the area is characterized by Quaternary formations represented by a macroporous loess complex of wind origin, that containing sandy or clay powder [23], [34]. These are disposed on successive layers of clay. Under these loess layers there is a silty clay and reddish with the fundament of green schists. In the area, seven boreholes have been made at depths between 1.20 and 6.0 m, until reaching the tough layers.

Gray topsoil layer varies up to a maximum depth of 0.9 m and loess and silty clay layer varies between 0.8 and 6.0 m, after which are situated the green shale layers. Sometimes the green schists are at the soil surface or on 0.4 m t depths.

The geological study have not shown active geological phenomena (landslides or collapses of land); maximum frost depth is 0.9 m. IWF will be located in E seismic area with $a_c = 0.16$ g seismic coefficient (peak ground acceleration value) and control period (corner) $T_c = 0.7$ sec.

2.2.2 Peculiarities of the climatic factors

The general climate of the Istria region is influenced by the temperate continental climate, presenting certain peculiarities for the location and also for the physical and geographical components of the territory [34]. The winds are caused by local geography. The day and night breezes are characteristic of this area. Aridity is increased by the intensity of solar radiation, which here achieve the highest values in the country (400÷500 Kj/cm²) [41]. For more suggestive rendering of a climatic conditions in the Istria region we used a graphical representation of Walter-Lieth diagram. The aim of this representation is to determine the intervals of droughts and dry, respectively wet and cold periods. For the diagram drawing were required multiannual monthly average temperatures and monthly average rainfall (Figure 3).

Data analysis obtained by measuring wind direction (weathercock) and wind velocity (anemometer) for a year, highlights the following: prevailing winds blow from the E and NE (which is 18.7% of the total) and rarely from NV (continental area)- Figure 4.

In the Istria area, climatic regime is affected by the Black Sea influence, both the thermal and dynamic aspect. Thus, there is great variation in air
circulation system. The degree of the winds instability are high, the direction and the speed, have a limited range and a periodic character. The wind velocities are generally moderate and the storms are quite rare.

2.2.3 Hydrography in Istria region
In Istria wind farm area location (IWF) there are flowing water courses with temporary character (like Istria stream) [23], [34] which is at 0.5 m distance from the northern boundary of the park. There are also, some salt water lakes, such as Istria Lake which is at a 0.6 km distance from the eastern boundary of the wind farm construction area.

After the field situation assessment, we have concluded that the location of the 21 wind turbines does not represent a significant influence on the specified water supplies, because these are located far from the surface waters in the area.

2.2.4 Habitats, flora and local fauna identifying
From the total IWF surface of 1257.93 ha, an area of 285.73 ha is covered by natural and semi-natural habitats [7], [13], [33]. In the rest of areal (on 972.20 ha) there are agricultural crops dominated by cereal crops, oilseed rape and sunflowers (Figure 5).

Fig.5 Distribution of grassland in the IWF perimeter areas (green polygons represent areas with grassland; black outline represents the boundary IWF perimeter).

The important fact is that in the plan initially were proposed 26 wind turbines, but because of the impact on bird migration pathways, the turbines number had been reduced to 21 turbines (see Figure 7). Thus, we'd removed first five turbines that were orientation east towards in the Istria Lake.

The main superior plants associations form the grasslands in IWF area are:
- Hordeetum hystricis Wendelbg.1934
- Bromo-Cynodontetum I.Pop 1970
- Medicaginii minimumae Festucetum valesiacae Wagner 1941
- Artemisio austriacae-Poetum bulbosae Pop 1970
- Artemisio austriacae-Poetum bulbosae Pop 1970 cynodontetosum (Turcu 1959) I.Pop1970
- Cynodonti-Poetum angustifoliae Rapaics ex Soo 1957.

In natural and semi-natural grassland from Istria area, the dominant habitat is 34.92 Ponto-Sarmatian steppes (with Dichantium ischaemum) which have no counterpart in Natura 2000 habitat classification [18]. Instead, there are also conservation interest habitats, according to current legislation [27], [31], such as: Ponto-Sarmatian steppes (Natura 2000 code: 62C0*). They are spread over a total area of 50 ha, of which approximately 40 ha are situated in the area between no. 23 and 24 wind turbines (on the west side of the park). The rest of this surface is island distributed in the parts of IWF centre.

Regarding the analysis of vertebrate faunistic data [10], [16], [25], we can note the presence of reptiles’ species of Podarcis taurica and Lacerta agilis. Due to the 2 km distance from the Istria lake, it is possible the transient presence of Pelobates fuscus and P. syriacus species.

During the assessment period, we have counted using direct observation method (assessment on the linear routes), a number of 158 bird species. 54 species of these are mentioned in Annex no. 3 of Romania Government Emergency Ordinance no. 57/2007 (for Special Protection Areas) and 26 bird species are mentioned in Annex no. 4A of Romania Government Emergency Ordinance no. 57/2007 [30]. Among the nesting species, 18 species have been identified in the IWF area. 5 species of these are listed in Annex no. 3 of the Government Emergency Ordinance no. 57/2007, and 5 species are listed in Annex no. 4B of the same ordinances (is requiring strict protection).

The other eight bird species identified by us as a nesting from this area, are species which does not present special conservation value as required by law.

3 Environmental sensitive issues - potential impact
The goal of the information obtained from terrain must provide the plan’s possibility to aggravate, reduce or affect the environmental issues.
3.1 Impact on biodiversity

The problem described in this situation is the IWF neighborhood and overlapping with Natura 2000 sites: ROSCI065 Danube Delta (IWF perimeter overlaps most part in the western area - 150m) and ROSPA0031 Danube Delta - Razim Sinoe [18] (overlapping of about 80%) - Figure 6 A and B.

Fig.6A The IWF location from on different Sites of Community Interest

As regards the location to other Special Protection Areas, IWF is located about 10.5 km from the southern boundary of ROSPA0100 “Casimcea Steppe” [18] and about 14 km from ROSPA0019 “Dobrogea Gorges” (values in the Figure 6 shows the distance between the boundary of the protected area and the nearest wind turbine in a straight line). The result of the analytical calculations shows that in the situation of implementation of the plan there will be long-term and medium degradation.

The long term means that it will be permanently affected 38.619 m² of land with natural and semi-natural habitats [7], [27], of which 12.105 m² are ponto-sarmatian steppes (Natura 2000 code: 62C0*) and 26.514 m² respectively represent different semi-natural habitat types which are not conservative interest (including degraded lands). These are represented by: base of the tower to support nacelle, tower base for the pavement, means of access and working platform.

The medium term means that it will be affected 33.705 m² that are including: the surface occupied by wind turbine foundation which are not includes the tower base and associated pavement (1.220 m² are ponto-sarmatian steppes (Natura 2000 code: 62C0*) and 2.485 m² are semi-natural habitat which are not conservative interest (including degraded lands).

Due to the low density of invertebrates’ population, amphibian species identified in IWF land area, they will not be affected by long-term (insignificant impact). In the case of Podarcis taurica species is expected a insignificant negative potential impact on short-term (during the arrangement of the road sectors and wind power installation). In the case of Lacerta agilis population species the impact is even smaller due to the presence on the periphery of the park, in the area between 11 and 12 turbines.

For the nesting bird Anthus campestris, Galerida cristata şi Oenanthe oenanthe species, extending the network of roads, determine the creation of places of refuge, realizing in this way a significant positive impact on short, medium and long term [4], [5], [36]. Field observations during 2012 (January to December) have allowed us the processing of avifaunistic data of the ecological point of view.

The analytical environmental indicators that we took into account (abundance, dominance, constant, index of ecological significance), have shown that in the IWF area is predominant the euconstant and constant population (57.14%), followed by the accessories populations (14.28%) and accidents populations (23.80%). Most of the species are included in Passeriformes order.

We estimate a 30% growth on small mammals’ population and Passeriformes, due to roads expansion, substrate fragmentation and the refuge places creation that represents a positive impact on these species, but may represent a significant negative impact to the raptor birds’ species (Falco tinnunculus, Buteo buteo, B. lagopus şi B. rufinus) [21]. Big migrating birds species, as well as wild geese and swans winter populations, must avoid wind turbines 1, 2, 3, 4, and 5 this results in additional energy costs for this birds in periods when the energy reserves are limited, which is a negative impact [8], [20]. This negative impact must be taken into account because IWF is creating "the dam effect" on avifauna. Wind turbines (11 and 14; 17 and 18; 22 and 25) are approximately along of the same hypothetical axis on the north-south
direction. Therefore, from the IWF total 21 turbines number, for the blades action surface calculation we will take in consideration only the 18 units. Also, the total areas in which are operating the movable elements of wind power (airspace between 50 m and 150 m measured from the ground) is 106.956 m² (5942 m² x 18). The distance between the wind turbines at the eastern edge (turbine 6) respectively on the western edge (turbine 26) of the network is 5.7 km, thus the space between 50 m and 150 m has a total area of about 570.000 m² (5.700 m wide x 100 m height). Therefore, the area in which the mobile elements of wind power are operating represents 19.2% of the space between 50 m and 150 m on width of 5.7 km on the energy network.

“Dam effect” manifests on 19.2% of airspace between 50 m and 150 m (measured from the ground), under favourable weather conditions to wind turbine functioning (from East to West). On unfavourable meteorological conditions functioning for the wind turbines (blizzard, fog and lack of wind), the power stations represents only physical obstacle for birds flying in transit, so the impact is much lower [6], [11].

After monitoring and achieving the environmental impact assessment, we have proposed the optimal choice of IWF location (aspect described in section 3.4).

3.2 Impact on soil and water

Soil pollution represents any activity that produces disruption of the normal functioning of the soil as support and living environment within the natural or artificial ecosystems. Pollution affects the properties and soil fertility and the pollutants cannot be removed from the soil, except through natural decomposition (very slow or impossible process) [9], [39]. The excavations allow scraping the surface of the land on which they build access roads, platforms and foundations. Pollution produced in this case is due to disturbances of form that can lead to flooding and landslides. Soil pollution can occur in two distinct phases: stage of the construction and the IWF use phase.

The IWF location does not include permanent surface waters. If the organization of construction site is provided with hygienisation areas, the wastewater will be collected in sealed containers and will be treated in a wastewater treatment plant. Another option would be to transport the staff for hygienisation in the special places usually at the construction firms’ main buildings. This option would eliminate the production of waste water on site. Electric energy-production process from wind potential does not involve the use of water [1]. Under these condition the site does not produce wastewater. The waters that may appear on the site result from precipitated and they are drained for the crops.

3.3 Impacts from noise, vibration and flickering effect using WindPRO

Noise and vibration impacts for IWF should be treated in two distinct situations, respectively: in the period of the construction and during electric energy production. The noises generated during construction - installation activities off the wind turbines are characteristic to the equipment operation involved to achieve of the investment.

The heavy machinery that works with high-powered thermal engines may increase noise level to 100 ÷ 110 dB. The noise level estimation at different distances for all 21 turbines, which will be installed in the location near Istria village, will be made with WindPRO simulation program [42]. Based on a computational algorithm of noise, we drawn a constant noise level curves of map (Figure 7).

Fig.7 Noise level cumulated with IWF (21 turbines) and Istria I (12 turbines)

These maps contain the effect given by the composition of noise and vibration due to the simultaneous operation of the 21 turbines from IWF.
and the 12 turbines that existing in northern current project at a distance of 2.26 Km.

WindPRO simulation program measured 40-45 dB noise at a distance of 200 m in open field.

Initially geographical coordinates shall be entered, followed by the location of each turbine in according with Stereo 70 coordinates and turbine dates– Figure 7. Then it identifies noise sensitive area and Decibel module will be used to simulate the way in which sound waves propagate by functioning of the wind turbine (35-55 dB).

Finally, it is noticed that the noise fades if the power generated by the turbine (depending on wind speed) decreases. Beside this, the technical characteristics of turbines allow the limitation of the operation speed (also noise reduction) making it possible the impact reducing. In addition, there are proposed some measures for reducing the impact, for example: working hour’s restrictions, noise suppressors’ equipment use, and so on.

In this study we took into account the turbine shadowing / flickering effect impact by creating a WindPRO program simulation (Shadow module). The module allows the simulation impact of taking into account either input parameters (the probability of a turbine rotor to have a specific position on a sensitive area, sunshine duration and its angle in the sky- which can vary according to the season), or by the worst option for that location.

In the shadow impact simulation was chosen the ("worst case"):
- sunshine duration is continuous;
- wind turbine is functioning continuously;
- the rotor will be always perpendicular to the Sun's position and will be covered about 20% by the rotor;
- angle of influence begins at 3 ° above the horizon (at lower values are considered a neutral impact).

Figure 8 shows the simulation Shadow module, where the shadow generated by turbines in the worst situation is 30-50 hours / year on the outskirts of Istria village. In the calculation, the 12 turbines from Istria I have been taken into account.

Fig. 8 Shadow impact / flickering effect of the IWF turbines cumulated with the Istria I ("worst case")

Finding the “real” impact of shadow (Figure 9) involves the introduction of other variables such as:
- the sunshine duration varies depending on the month;
- we considered that the cardinal on the site and the rotor will not always follow the sun (like in „worst case”), but its position will depend on the wind direction - turbines are equipped with wind blades orientation system.

Fig. 9 Shadow impact / flickering effect of the IWF turbines cumulated with the Istria I („real case”)

We observe that on the outskirts Istria village, the shadow turbine generator fits in intervals 0-20 hours / year.

3.4 Choosing the best location

As an alternative analysis method for the IWF location, we have taken into account the following elements: specific wind potential for this site, impact on the population of neighboring localities, impact on the main environmental factors and socio-economic impacts.

In Figure 10 is presented the location of the 26 turbines (proposed as the initial version).

Fig. 10 The initial plan

Environmental impact factors cannot be accepted due to its proximity to Istria Lake - located at 670 m from the most eastern turbine that includes a lot off birds feeding and night resting places.
For a better optimization of all stakeholders, was decided the reduction the number of turbines (an optimum of 21 turbines located on a 963.54 Ha surface, at a distance of 2.2 km from Istria Lake and at a distance of 722 m up to the village (Figure 11) [35].

The negative impact on biodiversity is diminished until neutral or even positive effect, on medium and long term.

The literature [2], [38] mentions several safety rules, namely: wind turbines must be located at least 400m distance from the water (in our case 2.2 Km); at least 500 m distance from the protected areas with ecological value; 300 m distance from nature reserves to reduce the risk on birds; 1000 m distance from crowded settlements, towns and urban centres (in our case, 750 m from the Istria village with 1,400 population).

The Rojanski method [28] used in order to assess IWF placing impact, allows finding an ecosystem global pollution index, $I_{PG}$ (through comparative studies between the ideal state of the environment and actual condition). Thus, $I_{PG}$ reported at the evaluation scale described by Rojanski [28], [29] is 1.06.

Global pollution index obtained ($I_{PG} < 2$), estimates that investment activities would produce a minimum overall water, air, soil environment contamination, close to the ideal situation.

The optimal situation chosen involves following:
- footprint reduction by utilization a transformer located inside the turbine;
- rotor diameter reduction from 100 m to 87/90 m, which implies a 20% lower air surface movement of blades and the reduction of the barrier effect;
- increasing the turbine tower height from 78 to 100m, decreases the impact on birds who use heights flight up to 50 m, in feeding periods;
- modern turbines use, turbines that have possibility of adjusting the pitch and wind turbine speed.

A very low rotation speed of the blades will remove the hitting the birds impact and they can fly right through the blades.

### 3.5 Socio-economic impact

IWF plan implementation will result in some positive impacts on different durations, on social and economic life of the community [12].

It is a sure thing that the investment in the Istria zone makes changes on social indicators, because it involves both simple and complex operations that require high qualification [15]. These operations require human resources that are provided in the area or immediately adjacent areas. For these operations has been required workforce on the average 10 people / day for 40÷45 days.

Another implication of the project is given by the economic activity of this economical agent, which is an income source for the area. Another very important aspect is that the local workforce will be involved in the projects at an early stage.

### 4 Conclusion

The quantification of environmental factors is necessary in the assessments that need indicators agreeing. In this case it is necessary to transform the qualitative aspects in quantitative sizes. For this purpose will make a scale from +2 (with large positive influence) to -2 (the largest negative influence) – table 2.

<table>
<thead>
<tr>
<th>Environmental elements</th>
<th>Construction</th>
<th>Operation</th>
<th>Decommissioning</th>
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<td>-1</td>
</tr>
<tr>
<td>atmosphere</td>
<td>-1</td>
<td>+2</td>
<td>-1</td>
</tr>
<tr>
<td>water</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>soil / geology</td>
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<td>0</td>
<td>0/-1</td>
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<tr>
<td>biodiversity</td>
<td>0</td>
<td>0/-1/-2</td>
<td>0</td>
</tr>
<tr>
<td>social</td>
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<td>+2</td>
<td>+2</td>
</tr>
<tr>
<td>Total</td>
<td>0/-1</td>
<td>4/3/2</td>
<td>0/-1</td>
</tr>
</tbody>
</table>

Overall, the environmental impact can be considered positive, the largest influence in the environmental analysis are the „atmosphere” and „social” elements.

Depending on the biodiversity impact, which cannot be accurately estimated until the commissioning of the wind farm, the total impact can take different values.

The negative impact during construction period and decommissioning / replacement can be considered as having a lower real value than the registered (-1) value, due to the small time duration.

IWF expected impact implementation plan on environmental is in acceptable limits and can be
placed into the principle of sustainable development zone - „The principle of support capacity” [1], [14], [37], [39].

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