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Tracing overhead transmission line corridors with regard to environmental and spatial qualities

1. Introduction

Slovenia is located in a geographically very important part of Europe, right in between the eastern and the western countries. Energy supply for consumers as well as energy marketing require a well-functioning utility line network, which is in Slovenia already well looped and connected with interconnecting lines into the international network. The existing international high voltage overhead lines connecting Slovenia to the neighboring countries, Croatia, Austria, and Italy, show positive trends of exchange of electrical energy with considerably high transit of energy through the Slovene electric energy network. The trend will undoubtedly increase by completion of two planned 400 kV overhead lines connecting Slovenia and Italy (transmission line Okroglo–Udine) and Slovenia and Hungary (transmission line Cirkovce–Pince-Heviz). Both transmission lines were launched by The Resolution on the National Energy Program of the Republic of Slovenia (Resolucija, 2003) and by The Document on the Development of Transmission Activity in Slovenia prepared by ELES d.o.o., respectively (Načrt, 2004).

In the year 2004 the EZS (Electro-technical Society of Slovenia) prepared for ELES d.o.o. two studies, aiming at investigating possible alternatives for the implementation of the 400 kV overhead transmission line Okroglo (Slovenia)–Udine (Italy). The first of the two studies elaborated the real need of the proposed line based on energetic as well as spatial criteria (Jakl et al., 2004). The second one analyzed construction possibilities, particularly from the point of view of alternative technical solutions and from the point of view of alternative spatial route alternatives (Porenta et al., 2004).

The first of the two studies followed the philosophy that was introduced by the Spatial planning Law (Zakon, 2002). When it mentions sustainability it uses the term temporary instead of lasting, even though lasting is a more frequent translation of the term sustainability in Slovenia. The use of the term temporary was intentional. According to the Spatial Planning Law every new development proposal should be assessed in order to disclose whether the new development is really needed. This philosophy is based on the presumption that we quite often strive for something that is really not needed and at the same time burden the environment inexcusably. A good example is the proposal for building wind generators in Slovenia. Wind generators represent one of the possible new energy sources, which is evidently not the only possibility for improving energy supply in Slovenia and it is even far from being among the best ones. But strivings for erecting them are incessant.

Within such assessment, analysis of spatial conditions is less important. Space cannot tell us whether something can or cannot be implemented. Strict taboos, with regard to spatial development, which appear nowadays as more and more extended area and give the impression that space can be a decisive factor for new developments, are rather an expression of a badly conceived decision making system within spatial planning. Unfortunately, this is not only a Slovene problem. It is rather all-European. Therefore, the contribution of spatial analyses to investigation of the fundamental question, whether the overhead transmission line Okroglo (SLO) – Udine (I) is really needed, should be perceived as an addition that could have some influence, but not the decisive one for the final answer. The two studies could also be defined as strategic environmental assessments dealing with spatial development strategies and policies, much higher level documents than are the documents that have to be assessed according to the Directive 2001/42/EC issued by the European Parliament and European Council (Directive, 2001), and the new Law on Environmental Conservation that was passed in the Slovene Parliament last year (Zakon, 2004). In fact, it follows the methodological framework prescribed by the new Slovene legislation, despite the fact that assessments of more abstract development documents tend to be rather diverse in their methodological structure. (Rydevik T.H., ed., 2002)

2. Overhead transmission lines as a feature in the landscape

An overhead transmission line is one of those infrastructure facilities which provoke negative reactions when observed. Commonly running through naturally more conserved areas they look like foreign bodies, particularly when their poles are constructed according to the rationality of technical and financial standards. (Lovejoy D., 1979; Pogačnik A., 1999; Pravilnik, 1988) Despite the fact that overhead transmission lines can be perceived differently, some totally reject them, while some are even not aware of their presence. Despite the different attitudes towards overhead lines they are part of the cultural landscape and should be assessed as such. The last statement means that overhead transmission lines should be accommodated as much as possible to the actual physical situation in the landscape. When they are observable they should be perceived as a logical part of the landscape scenery and landscape structure. Guidelines which are broadly accepted throughout the world are mostly based on this sense of logical landscape structure. The overhead transmission lines should not run over the land, where they may disturb or corrupt actual land use, e.g. close to airports and spots for paragliding and similar sports, over military areas, over settled areas, particularly tourist areas. They should not require cutting of trees. Furthermore, overhead transmission lines should avoid forests, orchards or similar agricultural plantations. They should run parallel to the spatial borders like forest edges, foothill lines etc. When passing over a ridge they should not run directly perpendicular to it, they should avoid hilltops and the bottom of mountain passes. Their run through the landscape should be hidden to the majority of observers. They should be placed into the visual shadow from points with greatest concentration of observers. All this means that much can be done to diminish the negative impacts of overhead transmission lines when conservation requirements are brought into consideration in the earliest phases of their corridor and alignments planning. (Marušič J., Jakl F., 1998) A good example of spatially and environmentally sound planning of overhead transmission line is the planning of the 400 kV overhead transmission line Slovenia–Hungary. (Marušič J. et al., 1997; Marušič J. et al., 1996)

Within the two studies, mentioned in the introductory section, several alternative alignments of the overhead transmission line from Okroglo (SLO) to the border with Italy were proposed. The studies determined that the overhead transmission line could be traced through the area without provoking conflicts with more valuable parts of the landscape or protected areas.

When the studies were already in their concluding phases the Italians presented their approach and spatial analysis performed in order to determine the suitable corridors for the overhead line from Udine (I) to the border with Slovenia. In addition to the already known two possible entry points in Slovenia, they also proposed the third one. With a new possible border crossing, the analysis of the Slovenian side had to be augmented. Additionally, even the analysis has been changed. Instead of new suitable alignments, new suitable corridors were searched for.

3. Searching for a suitable corridor according to the Law on physical planning

The search for a suitable corridor for the 400 kV overhead transmission line connecting Okroglo (SLO) and three points on the Italian-Slovenian border was performed by applying two analytical procedures.

The first method is based on the presumption that the real problem faced when an overhead transmission line has to be erected is the confrontation of two conflicting claims. Firstly, the overhead transmission line has to be rationally planned, i.e. it has to be technically, functionally, and economically acceptable. And secondly, the overhead transmission line has do be at the same time planned in a way that environmental impact is reduced to the lowest and acceptable levels. This approach is prescribed by the Slovenian Law on spatial planning (Zakon, 2002). According to this approach, three types of models have to be prepared: attractiveness, vulnerability and suitability models. These three types of models simulate the conflicts that accompany every development action, every intervention, and every new activity. The conflict can be resolved only by searching for a compromise. Postulating that an overhead line must not to be seen from a busy road or from a tourist spot, the solution would be to locate it behind a ridge or any topographic barrier. Such a solution can be technically and functionally equally acceptable and even economically suitable. An environmentally better proposal is sometimes also economically successful. The key to the reconciliation of conservation and development claims is the analytical procedure in which the claims of both sides are simulated within the spatial context.

The attractiveness analyses are performed by the use of attractiveness models in which the functional, technical and economic criteria are applied. The attractiveness criteria are, e.g. the shortest path between two terminal points, accessibility to the f construction site (i.e. existence of roads and flat land), ground stability, land cover, efficient and simple construction operations, low maintenance costs etc. Important to note is that determining construction costs in absolute figures and connecting them to the landscape characteristics before the overhead line alignment is traced is not a very easy task. But it is possible to express costs in relative relations, i.e. to define areas where costs are smaller or higher. The relative values can be expressed as scores on an interval scale, most commonly 1–5 or 1– 10.

The vulnerability analysis is based on a series of vulnerability models which are prepared in order to simulate the impact of construction works and the operation phase of overhead transmission line on most vulnerable environmental systems. The vulnerability criteria incorporate the restrictions of land use because of the requirements for nature and landscape conservation, and because of the environmental conservation requirements and limitations that are defined by different types of spatial reserves and spatial plans. The latter, namely the spatial reserves, can be considered as the highest level of conservation value, i.e. the most vulnerable areas. Here too, the scoring system is based on a scale, commonly 0–3 or 0–5.

Suitability models represent synthesis of two opposing claims by defining compromise or different types of compromise between the two.

4. The Italian approach

The second approach has been adopted from the Italian planning group. The analysis on the Italian side was carried out by the GRTN – The National Transmission Network Administrator from Rome (Udine Ovest, 2004). The method is based on a single model and on a presumption that different landscape characteristics can be limiting factors for an overhead transmission line, some can only be less favorable while some may be favorable for construction of overhead line, and some even neutral. Such landscape characteristics are airports, military grounds, densely or sparsely developed areas, stable/unstable soils, areas exposed to erosion, natural reserves and parks, special biotopes, areas of high cultural value, prime agricultural lands – vineyards, broadleaved, mixed, and coniferous forests, riverbanks, mountain areas over 1600 m above sea level, etc. The particular landscape characteristics are categorized into three groups of criteria, so called EPA criteria – Exclusion, Repulsion and Attraction criteria. The area holding characteristics considered as exclusion criterion cannot be included into the possible corridor for an overhead transmission line. The repulsion criterion characterizes an area as a *better-not-to-be-included-into* corridor, while the attraction criterion defines an area that is best adopted for construction of an overhead transmission line. The deficiency of such an approach is that the suitability problem is not very clearly defined as it is in the Slovene approach. Its advantage is the possibility to carry out comparison of the two parts of the overhead line by applying the same European data, like the CORINE land cover. Indeed, the data used in analysis were quite similar on both side of the border although there could be some serious differences among them too. Sometimes the data are not equally classified, particularly when they represent features defined by the legislation, e.g. protected areas, ground stability and liability to erosion. It is important as it has already been said that land cover data were taken from the

CORINE land cover maps, an all-European land cover mapping system, which introduces a quite unique data structure.

5. Corridor, as a planning instrument on the strategic planning level

After the creation of the basic analytical models, according to the Slovene as well as Italian approach, the next step, i.e. the tracing of the corridor, was done. The cost weighted function of the ArcGis (ESRI) programme package was used. It enables the connection of two terminal points considering the so-called friction values. In this case the friction values are in fact the environmental values. The programme optimizes the location of overhead transmission line on the basis of the length of transmission line and conservation costs. Fig. 4 shows the alternative corridors calculated on the base of the ERA criteria analysis connecting Okroglo (SLO) as a starting point and three points on the borderline: Srednje, Golo Brdo and Vrtojba. Fig. 5 shows the alternative corridors calculated on the basis of the Slovenian approach. Within the strip defined as a best corridor for the overhead transmission line the alignment should be searched for.

6. Comparison of the corridors for 400 kV overhead transmission line Okroglo (SLO)–Udine (I)

In this case, the comparison of the corridors represents technically quite simple task. The overlapping of map is used as a technique. There are maps of corridors and maps of suitability models. The overlapping of them means a pixel by pixel comparison. Pixel or picture element is the carrier of mapped values. The suitability values are expressed numerically for each pixel – picture element that builds the cartographic representation of a model. The count of pixels that are within the corridor enables the comparison of alternative corridors.

Table 3 shows the comparison of the three corridors is carried out for the Slovene side. The total and the average impact of all pixels that are within each of the three corridors were calculated.

Table 4 is a comparison based on the highest impact of the three corridors on the Slovene side are represented. In this case, the preposition is that most important for the selection of the best corridor are the most severe environmental impacts of the overhead transmission line.

Table 5 shows comparison of the corridors on both the Italian as well as on the Slovene side of the border, based on the factors that were defined by the Italian group. In order to disclose which of the corridors is more acceptable, the factor-by-factor comparison is needed. The procedure has some deficiency in its consistency. The weights for each of the factors were applied within the calculation of the shape of the corridor. Here, the weights are neglected. By this, the calculation of the severity of the impact, e.g. the higher importance of the exclusion criteria, was not included into the comparison table.

In Table 6: *The average impact on individual picture element calculated on the base of the »ERA« (Exclusion – Repulsion – Attraction) criteria*, the comparison of the three corridors on the Slovenian side is represented. In this case, the parameters defined in the Italian evaluation model (»ERA« criteria) are weighted according to the weights that were used for shaping the corridors.

Rank order, i.e. higher or lower suitability of the individual corridor is defined in three of the tables, namely, Table 3, Table 4, and Table 5, in which such an operation was possible. It is obvious that on the Slovene side of the border the most northern corridor is far the most suitable in all respects when considering individual factors or by using each of the methods applied. It is the shortest one. But that is not the only reason for such a conclusion. It demonstrates lower environmental impact also by calculating the average impact of the corridor. The same calculation was not possible on the Italian side of the border.

7. Conclusions

The 400 kV overhead transmission line connecting Okroglo (SLO) and Udine (I) can be placed into the landscape avoiding major conflicts, especially avoiding protected areas.

The comparison based on the criteria applied within the determination process of corridor tracing, i.e. »ERA« criteria (Exclusion, Repulsion, and Attraction criteria defined by the GRTN – The National Transmission Network Administrator), calculated total and highest impact (based on the vulnerability models according to the Slovenian legislation) shows that for the Slovene part of the 400 kV overhead transmission line the most northern alternative corridor is without no doubt the best option. The second best it the one in the middle. The least acceptable is the southern-most corridor which runs over the more naturally preserved areas. It crosses the Landscape Park Porezn–Davča, the river Idrijca, which is included into the European conservation system Nature 2000 and crosses the Regional park Trnovski gozd. It runs through Čepovan Valley, a highly appreciated dry valley. In a considerable broad extent it impacts the forested areas and continuously urbanized areas.

The northern-most corridor shows the lowest impact on the Slovene side of the border. The second best corridor is the corridor in the middle, while the worst alternative is the one located further south.

Considering the methodological aspects of the study, there are important conclusions. The corridor does represent an important planning tool when decisions taken on the higher planning levels, e.g. on the national level, are to be transferred to lower levels, e.g. municipal level. It is most common for the higher levels that the infrastructure is planned in a very abstract way, e.g. as a straight line that connects two points. Such a representation of a planned utility line has no real sense on the local level. On the other side, the corridor is a correct spatial representation of the utility line though not very precise. Moreover, it is even better spatial representation of a utility line than its alignment because it leaves enough space for locals to take part in the decision making process. It is also an adequate tool for a temporary limitation for other types of development.

The planning of the Okroglo (SLO)–Udine (I) overhead transmission line is a very good example of the necessity of the use of transparent planning method. It is obvious that criteria, data and models are to be explicitly defined when the interests, which may be even conflicting, of two countries are confronted. Moreover, it is extremely important that explicitly defined criteria are used when a productive reconciliation is needed.

It is also very important that the model that creates the base for the decision making process simulates the system as it is in the real world, i.e. the conflicting situation between the economic and functional criteria, from one side, and the conservation requirements from the other. Mixing conflicting criteria into one unique model does not simulate the real situation. While from the developmental point of view the analysis has to disclose the lowest costs areas, e.g. plain areas, the lowest distances to the existing roads, etc. the conservation claims may favour the same areas as those that should be protected. On the plains and in the areas close to the roads the overhead transmission line is maximally visually exposed and, therefore, less acceptable. But note that not all plains are equal and even the distance to the road is a rather complicated feature. The application of »ERA« criteria based model does not enable resolving such a situation. Moreover, the »ERA« criteria based model was calibrated by try-and-error method. Such a model can hardly stand any harsh criticism that can always emerge when broad public or non-governmental organizations are consulted.

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