Article

Renewables—To Build or Not? Czech Approach to Impact Assessment of Renewable Energy Sources with an Emphasis on Municipality Perspective

Jan Macháč * and Lenka Zaňková

Institute for Economic and Environmental Policy, Faculty of Social and Economic Studies, Jan Evangelista Purkyně University, 40096 Ústí nad Labem, Czech Republic; zankova@e-academia.eu

* Correspondence: machac@ieep.cz

Received: 21 October 2020; Accepted: 3 December 2020; Published: 5 December 2020

Abstract: The process of decarbonization and increasing the share of renewable sources of energy (RES) arising not only from European Union targets leads to development, expansion, and construction of new RES. Municipalities thus face a decision whether to support/accept RES projects or not. Although energy managers are part of the municipality management in almost all bigger cities, mayors of smaller municipalities have to go through the decision-making process on their own. The aim of the paper is to present a newly developed approach for mayors and state representatives that helps them implement the process in a user-friendly way. The paper brings a description of an approach to RES impact assessment at a municipal level based on multicriteria analysis. The RES impacts are divided into four categories: economic, social, environmental, and innovation effects. The procedure is demonstrated on an example of assessment of four sources in Czechia.

Keywords: renewable energy sources; multicriteria analysis; municipality impact assessment; smaller municipality; decision making; negotiation between municipality and investor

1. Introduction

A European Union Directive has set the target of a 20% share of energy from renewable sources in the final energy consumption by 2020, thus increasing demand for these sources. Meeting the target has resulted in support to construction and operation of renewable sources of energy (RES) by Member States. Many mayors are thus facing the decision whether to support construction of RES in their municipality. They are thus interested in both positive and negative impacts of construction and operation of renewables. The EU set a further target in 2018—32% share of RES in total consumption. The investment in RES will thus continue in the coming years, increasing the pressure on mayors. Mayors, most importantly in smaller municipalities, frequently lack sufficient knowledge for assessing the impacts. Building of new RES in some EU countries is currently accelerating due to efforts towards decarbonization and elimination of nuclear power [1–3] and thus, at the same time, the pressure to reduce energy consumption and greenhouse gas emissions [4]. Construction and operation of RES is linked with numerous direct and indirect impacts, in both financial and non-financial form. These impacts have to be considered thoroughly before construction to make appropriate decisions about the building. The aim of such consideration is to avoid negative aspects affecting quality of life at the local level.

At present, several impact assessment processes are applied in Czechia. Regulatory impact assessment (RIA) involves impacts of legislative changes, mostly assessed at a national level. Impact assessment covers three categories of impacts: (i) economic, (ii) social, and (iii) environmental [5]. Impacts of RES are handled in more detail by the environmental impact assessment (EIA) process,
which is applied to construction of actual sources for identification and assessment of positive and negative environmental impacts associated primarily with the construction. A basic tool for impact assessment of RES applicable by mayors of smaller municipalities is missing not only in Czechia.

The objective of the paper is to introduce the reader to a newly developed tool capable of comprehensive assessment of the impacts of construction and operation of RES on a municipality/microregion level, which includes environmental, economic and social impacts on the municipality and its quality of life in the process of decision making on support. As the approach is comprehensive, the assessment makes use of multicriteria analysis, which makes it possible to assess numerous different criteria simultaneously that are otherwise incomparable. The tool developed is presented using four case studies in Czechia.

The following section describes results obtained from an extensive review of literature dealing with application of various tools in RES impact assessment. Section 3 contains a description of sub-steps of the multicriteria analysis and subsequent assessment, including a description of case studies to which the procedure has been applied. Section 4 highlights outcomes of the application of multicriteria analysis in the case studies. The results and the procedure are then discussed, including their limitations. The final section concludes.

2. Literature Review

An extensive search was conducted, indicating that there is currently no tool for comprehensive assessment of the total impacts of construction and operation of RES at the local level. According to [6], impact assessment is usually only made at the macroeconomic level, frequently in connection with assessment of meeting of the requirements of EU Directives and commitments associated with them. Based on [7,8] and the RIA and EIA processes, we identified key impacts and sorted them into four basic pillars, extending the original (i) economic, (ii) social, and (iii) environmental with a category of (iv) innovation effects. Innovation effects are impacts that do not directly influence the three above pillars but are rather effects with a development potential for future, representing positive or negative effects (opportunities or threats for the region). When assessing the impacts of construction and operation of RES in a specific location, it is necessary to consider only relevant impacts for the RES type in question, its implementation method, and local conditions.

2.1. Economic Effects

It follows from the analysis of literature relating to economic effects [9] that one of the key indicators falling into this category is gross domestic product (GDP), which can be used as an indicator of economic growth, regional in this case. It is difficult to obtain specific data on impact on regional GDP at the municipality or microregion level, but the impact on regional GDP is greater the more local companies are involved in the RES construction and operation. Other important economic effects include the municipality’s costs and incomes [10], particularly if the municipality itself is the construction investor. In this case, incomes may arise from state subsidies as support to RES; costs are then associated, for example, with maintenance of new roads or short-term costs of administrative burden [11]. The incomes or costs may also be affected by the structure of the agriculture, forestry, and water management sectors. According to [12], provision of biomass for renewables is an important source of income in agriculture/forestry. Impacts on the water management sector are mostly associated with operation of hydropower plants. RES are also associated with production of so-called waste heat, which can be used energy- and cost-efficiently as a source of heat for space or water heating or for further energy generation [13]. The use of subsidies is the final economic factor. Construction of renewable sources of energy in Czechia is supported under numerous support schemes.

2.2. Social Effects

As stated by, e.g., [14], RES also have significant social impacts. By means of social effects, they may contribute to sustainable development of the municipality/microregion. Generally, however,
this category of impacts tends to be overlooked, with attention typically focused on employment, but its regional impact is regarded as highly disputable. This category also includes impacts connected with the prices of energy (with a direct link to household expenditures), education and human capital, and impacts on appearance and perception of the municipality/microregion. In connection with regional impacts, the employment impacts are advisably divided into short term (connected with RES construction) and long term (connected with operation). Short-term impacts typically have a dimension exceeding the municipality itself. Process equipment suppliers operate at a national or global level and a large part of the components come from imports, so that the impact on short-term employment in the region is usually only connected with the construction works. Long-term employment differs depending on the RES type [15].

According to [6], the greatest impacts are observable for biogas stations/heating plants, where the entire supply chain is manifested. On the other hand, this area may only experience a relocation of employees who were previously involved in agricultural or forestry production for other purposes. The impacts connected with employment are typically shown per MW of installed capacity. Based on [15], the largest impact of new jobs in relation to 1 MW of installed capacity is attributed to biomass energy (16 jobs), followed by photovoltaic sources (6 jobs); hydropower plants and wind sources have the lowest ratios.

The purpose of RES construction may be sale of energy (thus, direct financial profit); for the investor (municipality/microregion), it may alternatively bring a reduction in costs of energy purchased for its own consumption [13,14]. Education and human capital are of a more indirect nature—RES construction and operation sometimes increases demand for more educated employees, thus leading to a need for improved education and further self-growth. The authors of [7] note impacts on municipality development, appearance, and perception. These types of effects are also examined by [16], who often use the term energy self-sufficiency, perceived as one of the development objectives. This pillar also includes the appearance of the municipality associated with the RES. RES construction is often connected among locals with the NIMBY (“not in my backyard”) effect—the inhabitants generally welcome the structure [17], but refuse it being built near their homes [18].

2.3. Environmental Effects

The environmental effects category is very diverse and wide. The impacts differ depending on the RES type and on local conditions. RES generally have neutral or negative impacts, the only exception being impacts on air and CO₂ production, which are significantly lower for most source types than for conventional energy sources. Environmental impact assessment in the form of assessing the entire life cycle of the source, so-called life cycle assessment (LCA); e.g., [19], is very popular in the world at present, but only a part of these impacts have a local character, which is why a large part of the impacts considered in the LCA is irrelevant for our paper. According to [20,21], and with a view to impacts considered in the EIA, we have selected the following areas of impacts as relevant. Impacts associated with soil erosion and quality and with land occupation are primarily related to biomass growing. Alongside erosion, predisposition of crops [22] results in loss of soil and nutrients; other renewable sources of energy may lead to erosion indirectly. However, this only concerns activities connected with construction of the RES.

Land occupation is primarily associated with photovoltaic power plants; as stated, e.g., by [21], this type of power plant occupies 2.8 ha of land per MW of capacity. However, other RES types are also connected with land occupation. In comparison with conventional sources, we can mention the lower efficiency of wind power plants compared to, e.g., nuclear in terms of land occupation. Another category of impacts is impacts on water quality and consumption and air quality in terms of CO₂ emissions. According to [23], water quality issues relate to eutrophication and impaired water quality in watercourses and reservoirs in conjunction with erosion; water consumption and temperature also have a significant effect. In terms of impacts on air quality, negative impacts are only meaningful from RES utilizing combustion equipment, but it can also be affected indirectly.
by transporting biomass to biogas stations or transporting waste to waste energy recovery (WER) facilities; generally, however, this impact can be regarded as positive. The situation is similar with CO\textsubscript{2} emissions [24]—the impact is positive not only at the microregional level but at a global one. Another type of cost in the environmental area is waste management, which is one of the basic aspects of a municipality’s agenda. As stated by, e.g., [25,26] or [27], municipal waste can be regarded as a valuable resource for RES. This pertains particularly to WER facilities, which utilize primarily mixed municipal waste, as well as biogas stations, which turn organic waste into energy. The last impact, very important to the population, is noise, but it is connected with RES mostly in the short term during construction, due to increased traffic. In the long run, noise is generally associated with wind power plants; according to [20], hydropower or geothermal power plants may also cause noise problems.

2.4. Innovation Effects

The last of the categories of impacts defined above is added innovation effects, which are mostly in the form of potential for further development. This pillar comprises the level of infrastructure at the local level, which is a necessary precondition for RES construction [28]; it may attract additional potential investors to the microregion as well. It includes roads and utility networks in particular. Another part is relationships in the business environment—involvement of local contractors has a major effect on the local environment, which is further enhanced in the case of contractor–client relationships, forming chains. In comparison with the assessment analysis made at the EU/national level, the local assessment does not involve, e.g., technological advancement and introduction level, technology adaptation capacity, or research and development. Building of individual RES influences these changes mostly at the macro level.

3. Materials and Methods

3.1. Current State and Future Development of RES in Czechia and EU

Czechia’s energy goals for the coming period until 2030 and subsequently until 2050 are based on the National Energy and Climate Plan, which each state of the European Union had to submit by the end of 2019. According to the EU plan and the updated national plan, Czechia plans to increase its share in gross final consumption of electricity from renewable sources to a total of 22% by 2030, which means increasing the share by about 6% in comparison with the current situation [29]. In comparison with previous national energy plans, it was expected that the share would reach 23% in 2050 [30]. According to [31], achieving the ambitious goal of increasing the share of RES to 22% in 2030 requires investments of EUR 12.6 billion in Czechia. Of the total amount, EUR 5.2 billion is earmarked for renewable sources producing electricity, which will be directed primarily to photovoltaic and wind sources.

Energy plans envisage a change in electricity production from almost all RES. In the case of the sun, it will be an increase in the photovoltaic power plants from the existing 2.25 GW to 3.8 GW, including the shutdown of old photovoltaic sources [31]. The total reported power of wind sources in Czechia is 280 MW as of 2020 and, according to the national plan, the capacity is to increase to 3.5–7 GW by the end of 2030 [32,33].

For biomass as a source of renewable electricity, the installed capacity is expected to increase from 414 MW by 2020 to 454 MW in 2030 using renovation of existing sources [34,35].

Hydropower plants have a total installed capacity of 1106 MW; no growth in the installed capacity is expected, as for the most part the potential of this source is already used. Only existing power plants will be renovated in order to increase their efficiency and install very small flow-through power plants. It is estimated that the output will increase to 1.1 GW by the end of 2030 [34].

The installed capacity of biogas plants is 355 MW. No support is expected for increasing installed capacity of biogas stations for electricity generation, and the capacity is therefore expected to decrease to 287 MW by 2030 [34].
The biggest potential development is expected from heat pumps, which are currently subsidized in Czech households. It is estimated that the installed capacity will increase from 6621 to 12,069 TJ from 2020 to 2030 [34]. No growth is expected for other renewable energy sources.

According to the analyses and national energy plans mentioned above, photovoltaic and wind sources will be the most developed RES. In addition to partial replacement of old less efficient sources with more efficient ones, new sources will also need to be built. As stated, e.g., by [10,36], implementation of RES should be carried out in such a way as to consider landscape protection, biodiversity preservation, and integration within municipal planning and management.

At the EU level, installed capacity of RES almost doubled between 2007 and 2017 [37]. Based on the current level of meeting the national energy goals in the other EU member states [38] and the new targets for 2030 and 2050, an increase in the share will also be required in other EU countries. To achieve the new goals, large investments connected with building of new RES are expected [39]. Based on, e.g., [37], the largest investments are expected in photovoltaic and wind sources at the EU level in the next 10 years, which is in accordance with the situation in Czechia.

3.2. Multicriteria Analysis and Selection of Criteria

The recommendation in RIA is typically to use cost–benefit analysis, which assesses the total benefits and costs in monetary units. Its application requires quantification of all the impacts and their expression in monetary units [40]. However, this approach is too complex for the municipal level, and would not be applied due to its complexity. The most appropriate method for a simple and time, technology, and money-saving assessment of the total impact of RES on the region is apparently multicriteria analysis (MCA), which has been in widespread use for similar purposes [41–44]. MCA makes it possible to assess a project comprehensively and include various forms of data, information, and criteria in the decision making. It is used where it is impossible to express all the impacts in financial/monetary terms, or where the impacts can only be assessed partially in monetary terms and are difficult to compare [45].

Many studies, e.g., [44,46], propose MCA as an appropriate method for energy planning problems, including decision making related with RES. Methodologically, a number of different MCA approaches are applied to RES assessment such as the models DEMATEL, ANP, AHP, ELECTRE III, PROMETHEE, VIKOS, and TOPSIS, [44,47,48]. The MCA is mostly implemented at the regional and national level [46,48,49] to prioritize implementation and state support or prepare RES strategies in the region, at the level of one type of RES to compare different possible building locations or other characteristics of one type of RES [50], or as tool to compare different types of RES to provide arguments and recommendations for deciding which RES to implement [51,52].

The criteria used in our tool were identified based on current criteria used in the RIA process applied in Czechia and based on an extensive systematic literature review using the PRISMA Statement [53]. The thirty most relevant papers, e.g., [7,46,47,49,54], were analyzed in detail using content analysis. Impacts identified in RIA and in the literature review enter our internal database in the form of a code. Based on a qualitative analysis, similar codes were merged in one group to avoid their overlapping and double counting in the assessment. At the end, we defined 23 criteria relevant for local assessment at the municipality level, which were divided into four categories of effects (economic, social, environmental, and innovation). The overall impact on the municipality/microregion can be identified based on them. An overview of the effects in the four categories follows:

(i) Economic: Regional GDP, Costs for Municipality, Incomes for Municipality, Agriculture, Forestry, Water Management, Waste Heat, Alternative Sources–Use of Subsidies;
(ii) Social: Short-term Employment, Long-term Employment, Prices of Energy, Education and Human Capital, Impacts on Municipality/Landscape Appearance;
(iii) Environmental: Soil Erosion and Quality, Biodiversity, Water Quality and Consumption, Air Quality, CO₂ Emissions, Noise, Agricultural Land Occupation, Waste;
(iv) Innovation: Infrastructure Level, Business Environment.
These criteria were validated in interviews with 10 municipality representatives (mostly small municipalities) and in a workshop organized for this purpose. The most accurate definition of overall impact of construction and operation of a specific RES further requires distinguishing whether the effect makes an impact in the location and to what extent. For this purpose, the user progressively assigns degrees of impact/effect to each of the 23 criteria, as done in, e.g., [55], where 0 represents a neutral impact, negative integers are a negative impact, and positive ones are a positive impact. On the whole, the effect may attain values from $-3$ to $+3$ (from the most negative to the most positive effect). Sub-impacts have weights assigned to them so that we can distinguish their different importance based on the tool users’ subjective feelings while respecting the priorities and specifics of the municipality/microregion or its future development.

The result is then a balance of positive and negative impacts in the form of a positive integer (the resulting impact is positive) or a negative one (negative impacts prevail). The methodology of [56] extends each criterion with its description, definition of relevance for different RES types, and an indicative description of conditions under which the specific degree of impact in the interval $(-3;3)$ is assigned to the RES. The criterion Regional GDP, for example, may be assigned the value of $+3$ in the case where the construction and operation of the RES is significantly contributed to by local companies and the municipality or a business with its registered office in the municipality is the RES owner and operator. The criterion Noise may be assigned the most negative impact $(-3)$ in the case of a wind power plant, for example (considered a noisy energy source), when built in direct vicinity of human settlements. In contrast to that, positive values may be attained, for example, by the criterion Long-term Employment in the case where the RES operation secures new jobs in the microregion ($+3$).

Determination of the overall impact of a criterion requires assigning to each of them a specific weight that determines how crucial the criterion is for the assessment. These weights are assigned to each criterion based on a literature review of expert studies dealing with a survey among local public administration representatives [7,46,49] and consultation in Czechia, and they thus determine, along with the locally specific degree of effect (from $-3$ to $+3$) described above, the overall impact of the criterion on the microregion. To consider the relative importance among the criteria, the rank-order weighting method was applied [47]. The weights of the criteria originally defined for most of them by [7] and combined by [8] are 4, 7, 10, 12, with 4 being the lowest weight and 12 the highest. The system is based on relative importance of the criteria. Indicators for which the weights could not be determined based on the review made use of consultations and expert estimates based on similar criteria. The default setting of weights was validated as part the above-mentioned stakeholder involvement (interviews and a workshop with municipality representatives). In the first step, the stakeholders were asked to mention all possible impacts (criteria); in the second step, they were made to sort the importance of all the 23 defined criteria using cards. This perceived importance was compared with our proposed settings. Minor changes were made in the economic and innovative categories.

The overall impact of each criterion may therefore attain negative, neutral, or positive values based on assignment of a degree of effect. The overall impact of construction and operation of a RES type is then identified using the weighted sum method [47] by making a plain sum of all the criteria. The calculation of the overall impact is shown in Equation (1):

$$OIP = \sum_{i=1}^{n} DE_i \times WI_i$$

where $OIP$ is the overall impact of the project, $DE_i$ is the degree of effect of the criterion $i$, $WI_i$ is the weight of the impact of the criterion $i$, and $n$ is the total number of criteria.

The result indicates to the methodology user whether to continue the decision making on the construction or not.
3.3. Assessment Procedure

The tool divides the process of assessing impacts of renewable energy source operation on the region into several consecutive steps; see the diagram in Figure 1.

![Figure 1. Process of assessing regional impacts of renewable sources of energy (RES) according to multicriteria analysis (MCA).](image)

The first step is a project description, including an accurate definition of the planned project and, most importantly, a description of local conditions. Local conditions further affect the weights assigned to each impact and the criteria of greatest importance in the given area with respect to potential problems in the municipality or future targets and development activities for the region. At the same time, the project description needs to accurately define the planned project, including the RES type, the installed capacity, the project extent, and location. Special attention should be paid to the location.

The second step involves assessment of the criteria. In the proposed procedure, impacts associated with the construction are considered in addition to the future situation. In the assessment of the criteria, the authors proceed breaking the impacts down into criteria organized in the four pillars described above.

The third step of the assessment determines the overall impact of the planned RES construction project. The final assessment result is in the form of a positive or negative integer. To obtain it, the values of degree of effect have to be multiplied by the values of the weight of impact. The overall impact of each category is the sum of overall impacts of the criteria.

The final, fourth step involves a formulation of the position statement on accepting/rejecting the project. Based on the result, the mayor then decides whether the RES construction and operation project is appropriate for the municipality and whether to support it. For a planned project to be considered appropriate for support, the overall impact has to be greater than zero.

3.4. Data

The tool developed for local assessment of impacts of renewable sources of energy was tested on 21 examples. The aim of this pilot testing was to validate the procedure. Photovoltaic power plants, hydropower plants, biomass plants, and wind power plants were the subjects of the pilot testing. In each category, 4–6 plants were identified by members of the research team. The power plants in each category differ in aspects such as installed capacity, distance from developed areas, operator, landowner (private vs. municipality), region in Czechia, etc. Some of the sources were tested in the planning phase; some had already been implemented and their overall impact was thus assessed ex-post. The power plants were selected from different sources, such as the EIA information system [57] and various databases such as [58]. Data from these sources (in case of ex-post assessment) or from project plan descriptions (ex-ante assessment) were combined with other sources, such as cadastral maps, websites of municipalities, and local field research (location, impact on soil erosion etc.), to get a detailed description of the project.
For demonstration purposes, we selected two wind (WPP 1 and WPP 2) and two photovoltaic (PPP 1 and PPP 2) power plants as sources with currently the greatest development potential that are comparable based on selected technical specifications. The four sources presented below had been implemented at the time of the assessment. In cases where the assessment was made ex-ante, there was the option for the municipality to negotiate project modifications with the investor to achieve a better score, i.e., more positive impact on the municipality.

The selected sources are located in three different administrative regions. They are municipalities with up to 2000 inhabitants, classified as villages. Table 1 shows the basic characteristics of the four selected renewable sources of energy. For each energy source, we provide the region in which it is located, the year of commissioning, the installed capacity, whether owned by the municipality or a private operator, and whether local companies were involved in the construction or operation, which affects the regional GDP among other things. The indicators important for quality of life of the municipality inhabitants are the distance from developed areas and whether the operator offers the inhabitants preferential energy prices.

Table 1. RES description.

| Power output (MW) | WPP 1 | WPP 2 | PPP 1 | PPP 2 |
|-------------------|-------|-------|-------|-------|
| Region            | 6     | 8     | 29.9  | 35.1  |
|                   | Central Bohemian | Usti nad Labem | South Bohemian | Central Bohemian |
| Year of commissioning | 2008  | 2005  | 2010  | 2010  |
| Operated by municipality/private operator | Private | Private | Private | Private |
| Preferential energy prices | YES | YES | NO | NO |
| Local companies involved in construction and operation | YES | NO | NO | NO |
| Distance from developed areas in municipality | 500–1000 m | 0–500 m | 0–500 m | 0–500 m |

4. Results

Two photovoltaic and two wind power plants were selected for a practical demonstration of the methodology described above. Default impact weights were assigned to each of the 23 criteria, divided into four pillars. Afterwards, the impact weights were multiplied by the degree of effect, which was determined for each of the RES based on specific properties and location.

Table 2 below shows the criteria divided into the four pillars with the predetermined weights. The right-hand side of the table shows the overall impacts (weight x degree of impact) of each criterion for the RES; positive, neutral, and negative. The table contains two wind power plants and two photovoltaic power plants for comparison. Two pairs of RES both with contradictory results have been selected based on similar installed capacities to enable their correct comparison. For the sake of clarity, the table omits criteria that were neutral for all the renewable energy sources. In the economic pillar, the neutral criteria were Costs for Municipality, Water Management, Waste Heat, and Alternative Sources—Use of Subsidies. The irrelevant criterion in the social pillar was Education and Human Capital; in the environmental pillar, they were Water Quality and Consumption, CO₂ Emissions, and Waste.
4.1. Economic Effects

The criterion Regional GDP depends on involvement of local companies; it is clear from the table that no local companies were involved in the construction or operation of WPP 2 and PPP 1, and the regional GDP is thus not affected by the construction. Incomes for Municipality is the criterion that causes significant differences in the results. In the case of WPP 1 and PPP 2, the RES construction is a source of additional income in the form of lease or sale of necessary land or income associated with enterprise income tax. On the contrary, the case of WPP 2 is construction of a power plant on private land with no realized incomes for the municipality.

To a limited extent, the landowners realize some incomes associated with the lease or sale of related land to the investor. Benefits for the municipality further include use of subsidies, which are utilized not only for the RES construction itself but also for development of related infrastructure, leading to savings of municipal funds.

4.2. Social Effects

The employment assessment differs. The formation of new jobs is not very likely in the case of the wind power plants, in contrast to the photovoltaic power plants, where new jobs are assumed for operating, maintenance, and supervision of the power plants. The results for the criterion Prices of Energy differ by RES type. In the case of the wind power plants, preferential energy prices for consumers in the municipality/microregion were negotiated in advance, which brings non-negligible positive impacts primarily in the form of savings on household expenditures on energy.

4.3. Environmental Effects

Noise plays a key role among the criteria of the environmental pillar. In the case of WPP 2, the structure is located in direct vicinity of human settlements, and the noise level is therefore regarded as annoying. WPP 1 is at a similar distance from developed areas, but the operating noise level is lower due to local conditions. For the other sources, the noise was a problem mostly in the short term in connection with the RES construction (e.g., due to increased traffic). The criterion Agricultural Land Occupation has a negative effect on the overall RES impact. It is clear from the difference between the two RES types that photovoltaic power plants occupy many times more land than wind power plants, which demand only a small patch of land to build and affect land use in a wider area only by their
safety zones. The construction of the sources affects erosion in all cases due to the terrain configuration and interventions during the construction.

4.4. Innovation Effects

A benefit of increased overall impact of RES occurs in cases where the construction includes building of new infrastructure; among our case studies, this is the case of WPP 1 and PPP 2 (construction of a new power substation).

4.5. Overall Impact Assessment

The overall impact can be determined using a sum of the sub-criteria. Table 3 shows the values for each of the pillars (economic, social, environmental, and innovation) for each renewable energy source in the case study and the overall positive or negative impact values.

| Pillar        | WPP 1 | WPP 2 | PPP 1 | PPP 2 |
|---------------|-------|-------|-------|-------|
| Economic      | 64    | 17    | 44    | 71    |
| Social        | 0     | 0     | 4     | 18    |
| Environmental | −55   | −82   | −62   | −55   |
| Innovation    | 18    | 4     | 4     | 18    |
| Total         | 27    | −61   | −10   | 52    |

It is clear from the results that the criteria may offset one another. The criteria of the economic pillar are always positive for the four selected RES; they attain the highest values for WPP 1 and PPP 2. The social pillar is not demonstrated as significant in this case; in spite of that, it may have a significant effect on the overall results in some cases. On the contrary, the environmental criteria have a very prominent effect on the overall impact value—they are always negative in light of their contents and are influenced mainly by Noise and Agricultural Land Occupation. The negative environmental impacts may be offset primarily by the criteria of the economic pillar.

5. Discussion

The tool developed and presented in the paper does not have an ambition to substitute for the EIA tool commonly used in practice and also serving as an assessment of environmental impacts. It constitutes only a preliminary assessment intended to provide mayors of smaller municipalities with a quick appraisal of the plan to construct a RES without the necessity to expend funds on consultations and expert analyses. The aim is to raise mayors’ awareness of possible impacts. This type of analysis provides results in the form of expectations, which support the decision making and can be used to avoid any confusion in the later steps related to implementation of RES in the municipality.

In contrast to EIA, it makes a more comprehensive assessment with overlaps into the economic and social dimensions. A more detailed assessment of environmental aspects is thus left up to the EIA process upon the project plan approval. A low environmental impact scored as part of this comprehensive assessment need not mean low actual environmental impacts. Species composition and impact of the plan on it, for example, are not handled in detail in the results described above.

The process of assessing local impacts of RES construction and operation is bound with a certain degree of subjectivity on the part of the tool user. The tool developed in the Czech language contains a detailed description of individual criteria, including the degree of effect for each criterion and conditions, which should help the user to select the corresponding degree within the interval (−3; 3). This part of the tool should eliminate the subjective component.

The assessment is focused on the local (municipal) level; therefore, impacts associated with the national level such as other innovation aspects are not included. The ambition of the evaluation is not
to cover all impacts, but the ones relevant at the local level. Some of the local impacts can be involved only to a limited extent. These are mainly aspects related to the NIMBY effect and to recreational and aesthetic functions. The perception of these impacts related with new RES construction may differ significantly among the municipality inhabitants. The inhabitants’ subjective evaluation may not correspond with the mayor’s preferences. As a result, the acceptability of a measure for the inhabitants may not be as high as may appear based on the tool presented. The results may not match. To ensure complete impact analysis, the inhabitants’ preferences should be explored using a questionnaire survey. In many cases, they may perceive the impacts differently. They may ignore some of the criteria partly as irrelevant (e.g., regional GDP).

The same problem with subjectivity of the assessment may occur with the weights. The tool presented is based on elementary MCA, so the weights are simply assigned to each criterion using a rank-order weighting method. The user can apply the default weights determined based on an extensive literature review. It is possible to change the default weights by including users’ own ones to follow users’ priorities. The default weights were determined based on impact importance in comparison with other criteria. This approach, based on the rank-order weighting method and transfer of the weights, entails a number of inaccuracies [47]. More accurate results could be obtained by setting weights purely on the basis of stakeholder involvement and using pair-wise comparison in the form of an analytic hierarchy process [59]. However, this procedure would require a sufficiently large sample of stakeholders to make the weights representative and applicable in general in Czechia.

Very often, multicriteria analysis is used when comparing project options. In this case, it is used to compare two or more options; therefore, accuracy of results is important. The Czech tool was developed primarily for assessment of a single planned/implemented RES to provide the stakeholders with a basic analysis of impacts. It is primarily a matter of providing stakeholders with a basic overview; detailed analysis does not make sense.

The differences between the criteria and pillars offset one another on the whole—negative results of environmental criteria may be offset by economic, social, or innovation criteria. Based on the criteria and the weights assigned to them, the user of the manual can take some inspiration and try to modify and adjust the original RES construction plan or to change its location within the municipality.

It is clear from the results that it makes sense to argue the location of the project, be it because of the land occupation or, most importantly, the noise level, because construction of RES in direct vicinity of human settlements has a very negative effect on the overall impact. The tool user, a municipal mayor for example, thus has an open door for negotiation with the potential investor regarding improvements and setting of the best possible conditions; the overall impact can be improved, for example, by negotiating lower energy prices for local consumers.

6. Conclusions

Mayors, in smaller municipalities above all, are exposed to increasing administrative burden. If they are deciding about the potential construction of a new renewable energy source, they face the decision whether to support the project or not. Bigger cities normally have an energy manager, but this role is assumed in smaller municipalities by the mayor among their other tasks. The tool presented in the paper offers the mayor an opportunity to handle the decision-making process efficiently using multicriteria analysis. This type of analysis allows users to fully access a project and include different types of data, information, and criteria in decision making that cannot be easily expressed in any common units such as monetary value. An emphasis in the decision making is put on knowledge of local specifics, and the criteria and their weights are predetermined based on an extensive literature review. The tool user assigns the values based on how the criterion is affected in the municipality.

The RES impacts are divided into four categories: economic, social, environmental, and innovative. The aim was to involve all significant positive and negative impacts and provide a complex view at the municipality level; therefore, 23 criteria were defined. These criteria are subject to a procedure which starts with a detailed analysis of the RES project. Based on the RES description and local
conditions, each criterion is assessed in the interval (−3; 3). Considering the weights, the total impact can be calculated.

Clear recommendations follow from the results of the method application to specific cases of four renewable sources of energy—two wind and two photovoltaic power plants. It is clear from the results which of the projects the mayor should have recommended for further, more detailed analysis and which one to reject, because it would not bring any benefits to the municipality/microregion based on any of the criteria. However, the project need not be rejected wholly—the assessment results can be used for negotiating project modifications with the investor. Among the social impacts, for example, the mayor can negotiate better energy prices for local inhabitants and the municipality itself, as was the case with WPP 1 and PPP 2. Among the economic impacts, greater involvement of local companies offers itself. This impact assessment can be applied by potential investors as well as mayors and non-governmental organizations in the region. It may serve as a first step of feasibility studies currently in use or as part of negotiation between the municipality and the investor.

As follows from the pilot testing, the presented procedure provides the necessary information on the key impacts of the RES, which can be further used in negotiations with the investor. Due to the effort to simplify the procedure as much as possible, the methodology may not always bring completely accurate results thanks to the methods used. However, its significance lies more in the comprehensive provision of basic information for the mayor’s political decision making.

Further development of the procedure is possible on two levels: (i) in the current tool, the weights are mostly set using a literature review and should be replaced by weights gained completely by means of stakeholder involvement in Czechia, (ii) the analysis could be upscaled to the national level to use similar methods for assessment of impacts at the local and national level.

Author Contributions: Conceptualization, J.M.; methodology, J.M. and L.Z.; formal analysis J.M. and L.Z.; investigation, J.M. and L.Z.; resources, J.M. and L.Z.; data curation, L.Z.; writing—original draft preparation, L.Z. and J.M.; writing—review and editing, J.M.; funding acquisition, J.M. and L.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the project “Economic support for strategic and decision-making processes at national and regional level, leading to sustainable energy use of agricultural biomass, while respecting food self-sufficiency and soil conservation” (grant number: QK1710307, Ministry of Agriculture programme) and the project Smart City—Smart Region—Smart Community (grant number: CZ.02.1.01/0.0/0.0/17_048/0007435, Operational Programme Research, Development and Education of the Czech Republic).

Acknowledgments: We would like to thank the reviewers for their thoughtful comments and efforts towards improving our manuscript. We would like to thank also all representatives of small municipalities which helped us to set the weights applied in our tool.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript or in the decision to publish the results.

References
1. Skordoulis, M.; Ntanos, S.; Arabatzis, G. Socioeconomic evaluation of green energy investments: Analyzing citizens’ willingness to invest in photovoltaics in Greece. IJESM 2020, 14, 871–890. [CrossRef]
2. Gürtler, K.; Postpischil, R.; Quitzow, R. The dismantling of renewable energy policies: The cases of Spain and the Czech Republic. Energy Policy 2019, 133, 110881. [CrossRef]
3. Alper, A.; Oguz, O. The role of renewable energy consumption in economic growth: Evidence from asymmetric causality. Renew. Sustain. Energy Rev. 2016, 60, 953–959. [CrossRef]
4. Brożyna, J.; Strielkowski, W.; Fomina, A.; Nikitina, N. Renewable Energy and EU 2020 Target for Energy Efficiency in the Czech Republic and Slovakia. Energies 2020, 13, 965. [CrossRef]
5. Staroňová, K.; Pavel, J.; Krapež, K. Piloting regulatory impact assessment: A comparative analysis of the Czech Republic, Slovakia and Slovenia. Impact Assess. Proj. Apprais. 2007, 25, 271–280. [CrossRef]
6. Del Río, P.; Burguillo, M. Assessing the impact of renewable energy deployment on local sustainability: Towards a theoretical framework. Renew. Sustain. Energy Rev. 2008, 12, 1325–1344. [CrossRef]
7. Kazak, J.; Hoof, J.; Szewrański, S. Challenges in the wind turbines location process in Central Europe—The use of spatial decision support systems. *Renew. Sustain. Energy Rev.* 2017, 76, 425–433. [CrossRef]

8. Vežmar, S.; Topić, D.; Spajić, A.; Šljivac, D.; Jozsa, L. Positive and Negative Impacts of Renewable Energy Sources. *Int. J. Electr. Comput. Eng. Syst.* 2014, 5, 15–23.

9. Carroll, P. Does regulatory impact assessment lead to better policy? *Policy Soc.* 2010, 29, 113–122. [CrossRef]

10. del Rio, P.; Burguillo, M. An empirical analysis of the impact of renewable energy deployment on local sustainability. *Renew. Sustain. Energy Rev.* 2009, 13, 1314–1325. [CrossRef]

11. Kunze, C.; Busch, H. The social complexity of renewable energy production in the countryside. *Electron. Green J.* 2011, 1, 1–18. [CrossRef]

12. Frantál, B.; Proušek, A. It’s not right, but we do it. Exploring why and how Czech farmers become renewable energy producers. *Biomass Bioenergy* 2016, 87, 26–34. [CrossRef]

13. García, N.P.; Zubi, G.; Pasaoglu, G.; Dufo-López, R. Photovoltaic thermal hybrid solar collector and district heating configurations for a Central European multi-family house. *Energy Convers. Manag.* 2017, 148, 915–924. [CrossRef]

14. Fitriyana, D.; Prabawati, M.; Tanuwijaya, F.; Naimah, D. Multi-criteria analysis for renewable energy generation: A case of Tokyo. In *IOP Conf. Series: Earth and Environmental Science, Proceedings of the 2019 3rd International Conference on Energy and Environmental Science, Seoul, Korea, 26–29 January 2019*; IOP Science: Bristol, UK, 2019; Volume 291, pp. 20–27.

15. Dvořák, P.; Martinát, S.; der Horst, D.V.; Frantál, B.; Turečková, K. Renewable energy investment and job creation; a cross-sectoral assessment for the Czech Republic with reference to EU benchmarks. *Renew. Sustain. Energy Rev.* 2017, 69, 360–368. [CrossRef]

16. Trutnevye, E.; Stauffacher, M. Opening up to a critical review of ambitious energy goals: Perspectives of academics and practitioners in a rural Swiss community. *Environ. Dev.* 2012, 2, 101–116. [CrossRef]

17. Ntanos, S.; Kyriakopoulos, G.; Chalikias, M.; Arabatzis, G.; Skordoulis, M.; Galatsidas, S.; Drosos, D. A Social Assessment of the Usage of Renewable Energy Sources and Its Contribution to Life Quality: The Case of an Attica Urban Area in Greece. *Sustainability* 2018, 10, 1414. [CrossRef]

18. Kaldellis, J.K.; Kapsali, M.; Kaldelli, E.; Katsanou, E. Comparing recent views of public attitude on wind energy, photovoltaic and small hydro applications. *Renew. Energy* 2013, 52, 197–208. [CrossRef]

19. Lohse, C. Environmental impact by hydrogeothermal energy generation in low-enthalpy regions. *Renew. Energy* 2018, 128, 509–519. [CrossRef]

20. Holma, A.; Leskinen, P.; Myllyviita, T.; Manninen, K.; Sokka, L.; Sinkko, T.; Pasanen, K. Environmental impacts and risks of the national renewable energy targets: A review and a qualitative case study from Finland. *Renew. Sustain. Energy Rev.* 2018, 82, 1433–1441. [CrossRef]

21. Workman, F.; Berman, J.; Thomas, C. *Environmental Impacts of Renewable Energy*; The University of Vermont: Burlington, VT, USA, 2016.

22. Abbassi, S.A.; Abbassi, N. The likely adverse environmental impacts of renewable energy sources. *Appl. Energy* 2000, 65, 121–144. [CrossRef]

23. Gasparatos, A.; Doll, C.; Esteban, M.; Ahmed, A.; Olang, T. Renewable energy and biodiversity: Implications for transitioning to a Green Economy. *Renew. Sustain. Energy Rev.* 2017, 70, 161–184. [CrossRef]

24. Ahmed, A.; Sutrisno, S.W.; You, S. A two-stage multi-criteria analysis method for planning renewable energy use and carbon saving. *Energy 2020*, 199, 117475. [CrossRef]

25. Nizami, A.-S.; Shahzad, K.; Rehan, M.; Ouda, O.; Zain Khan, M.; Ismail, I.; Almeelbi, T.; Basabi, J.; Demirbas, A. Developing waste biorefinery in Makkah: A way forward to convert urban waste into renewable energy. *Appl. Energy* 2017, 186, 189–196. [CrossRef]

26. Moya, D.; Aldás, C.; López, G.; Kaparuju, P. Municipal solid waste as a valuable renewable energy resource: A worldwide opportunity of energy recovery by using waste-to-energy technologies. *Energy Procedia* 2017, 134, 286–295. [CrossRef]

27. Bong, C.P.C.; Ho, W.S.; Hashim, H.; Lim, J.S.; Ho, S.C.; Tan, W.S.P.; Lee, C.T. Review on the renewable energy and solid waste management policies towards biogas development in Malaysia. *Renew. Sustain. Energy Rev.* 2017, 70, 988–998. [CrossRef]

28. Bhattacharya, M.; Paramati, S.R.; Ozturk, I.; Bhattacharya, S. The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Appl. Energy* 2016, 162, 733-741. [CrossRef]
29. The Chamber of Renewable Energy Sources. *Vice Než 300 Miliard Korun Investic Rovozov Čisté Energetiky v ČR do 2030* (More than 300 Billion Crowns of Investments will bring the Development of Clean Energy in the Czech Republic by 2030); The Chamber of Renewable Energy Sources: Prague, Czech Republic, 2020.
30. Ministry of Industry and Trade. *Aktualizace Státní Energetické Koncepce České Republiky (Update of the State Energy Concept of the Czech Republic)*; Ministry of Industry and Trade: Prague, Czech Republic, 2009.
31. Valentová, M.; Knápek, J.; Mikeska, M.; Vasiček, J. *Investment needs for 2030 energy and climate targets in Czechia Buildings and renewable energy supply sectors*; Czech Technical University: Prague, Czech Republic, 2020.
32. Ministry of Industry and Trade. *Draft National Plan of the Czech Republic in the Field of Energy and Climate*; Ministry of Industry and Trade: Prague, Czech Republic, 2018.
33. The Chamber of Renewable Energy Sources. *Analýza větrné energetiky v ČR (Analysis of Wind Energy in the Czech Republic)*; The Chamber of Renewable Energy Sources: Prague, Czech Republic, 2015.
34. Ministry of Industry and Trade. *Updated Draft National Plan of the Czech Republic in the Field of Energy and Climate*; Ministry of Industry and Trade: Prague, Czech Republic, 2019.
35. The Chamber of Renewable Energy Sources. *Česko na cestě k uhlíkové neutralitě Analýza Vnitrostátního plánu ČR v oblasti energetiky a klimatu (aktualizace) (The Czechia on the Road to Carbon Neutrality. Analysis of the National Plan of the Czech Republic in the Field of Energy and Climate (Update))*. The Chamber of Renewable Energy Sources: Prague, Czech Republic, 2019.
36. Poggi, F.; Firmino, A.; Amado, M. Planning renewable energy in rural areas: Impacts on occupation and land use. *Energy* 2018, 155, 630–640. [CrossRef]
37. Child, M.; Kemfert, C.; Bogdanov, D.; Breyer, C. Flexible electricity generation, grid exchange and storage for the transition to a 100% renewable energy system in Europe. *Renew. Energy* 2019, 139, 80–101. [CrossRef]
38. Eurostat. Available online: https://ec.europa.eu/eurostat/databrowser/view/t2020_31/default/table?lang=en (accessed on 20 November 2020).
39. Enerdata. *Costs and Benefits to EU Member States of 2030 Climate and Energy Targets*; Enerdata: Grenoble, France, 2014.
40. Vandermeulen, V.; Verspecht, A.; Vermeire, B.; Van Huylenbroeck, G.; Gellynck, X. The use of economic valuation to create public support for green infrastructure investments in urban areas. *Landsc. Urban Plan.* 2011, 103, 198–206. [CrossRef]
41. Gigović, L.; Pamučar, D.; Božanić, D.; Ljubojević, S. Application of the GIS-DANP-MABAC multi-criteria model for selecting the location of wind farms: A case study of Vojvodina, Serbia. *Renew. Energy* 2017, 103, 512–521. [CrossRef]
42. Jeong, J.S.; Ramírez-Gómez, Á. Optimizing the location of a biomass plant with a fuzzy-DEcision-MAKing Trial and Evaluation Laboratory (F-DEMATEL) and multi-criteria spatial decision assessment for renewable energy management and long-term sustainability. *J. Clear. Prod.* 2018, 182, 509–520. [CrossRef]
43. Yang, Y.; Ren, J.; Solgaard, H.S.; Xu, D.; Nguyen, T.T. Using multi-criteria analysis to prioritize renewable energy home heating technologies. *Sustain. Energy Technol. Assess.* 2018, 29, 36–43. [CrossRef]
44. Çelikbilek, Y.; Tüysüz, F. An integrated grey based multi-criteria decision making approach for the evaluation of renewable energy sources. *Energy* 2016, 115, 1246–1258. [CrossRef]
45. Kremer, P.; Hamsted, Z.; McPhearson, T. The value of urban ecosystem services in New York City: A spatially explicit multicriteria analysis of landscape scale valuation scenarios. *Environ. Sci. Policy* 2016, 62, 57–68. [CrossRef]
46. Georgopoulou, E.; Lalas, D.; Papagiannakis, L. A multicriteria decision aid approach for energy planning problems: The case of renewable energy option. *Eur. J. Oper. Res.* 1997, 103, 38–54. [CrossRef]
47. Wang, J.-J.; Jing, Y.-Y.; Zhang, C.-F.; Zhao, J.-H. Review on multi-criteria decision analysis aid in sustainable energy decision-making. *Renew. Sustain. Energy Rev.* 2009, 13, 2263–2278. [CrossRef]
48. Grilli, G.; De Meo, I.; Garagnani, G.; Paletto, A. A multi-criteria framework to assess the sustainability of renewable energy development in the Alps. *J. Environ. Plan. Manag.* 2017, 60, 1276–1295. [CrossRef]
49. Burton, J.; Hubacek, K. Is small beautiful? A multicriteria assessment of small-scale energy technology applications in local governments. *Energy Policy* 2007, 35, 6402–6412. [CrossRef]
50. Cavallaro, F.; Ciraolo, L. A multicriteria approach to evaluate wind energy plants on an Italian island. *Energy Policy* 2005, 33, 235–244. [CrossRef]
51. Goumas, M.; Lygerou, V. An extension of the PROMETHEE method for decision making in fuzzy environment: Ranking of alternative energy exploitation projects. *Eur. J. Oper. Res.* 2000, 123, 606–613. [CrossRef]
52. Topcu, Y.I.; Ulengin, F. Energy for the future: An integrated decision aid for the case of Turkey. *Energy* 2004, 29, 137–154. [CrossRef]

53. Page, M.J.; Moher, D. Evaluations of the uptake and impact of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement and extensions: A scoping review. *Syst. Rev.* 2017, 6, 263. [CrossRef] [PubMed]

54. Iglinski, B.; Iglinska, A.; Cichosz, M.; Kujawski, W.; Buczkowski, R. Renewable energy production in the Łódzkie Voivodeship. The PEST analysis of the RES in the voivodeship and in Poland. *Renew. Sustain. Energy Rev.* 2016, 58, 737–750. [CrossRef]

55. Mourmouris, J.; Potolias, C. A multi criteria methodology for energy planning and developing renewable energy sources at a regional level: A case study Thassos, Greece. *Energy Policy* 2013, 52, 522–530. [CrossRef]

56. Macháč, J.; Dubová, L.; Zaňková, L.; Matějka, J.; Nobilis, L.; Maňhal, J. Metodika zjišťování vlivu obnovitelných zdrojů energie na hospodářství a životní prostředí mikroregionu/MAS (Impact assessment methodology of renewable energy sources on economy and environment of micro-region / Local Action Groups). Institute for Economic and Environmental Policy: Ústí nad Labem, Czech Republic, 2018. Available online: http://www.ieep.cz/wp-content/uploads/2017/09/Machac.pdf (accessed on 5 December 2020).

57. CENIA. Available online: https://portal.cenia.cz/ieiasea/view/eia100_cr (accessed on 20 November 2020).

58. Sequens, E. Calla. Available online: https://www.calla.cz/atlas/ (accessed on 20 November 2020).

59. Saaty, T.L. Rank from comparisons and from ratings in the analytic hierarchy/network processes. *Eur. J. Oper. Res.* 2006, 168, 557–570. [CrossRef]

**Publisher’s Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).