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Regional Energy Transition: An Analytical Approach Applied to the Slovakian Coal Region †

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† This paper is an extended version of our paper published in 15th Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES), Cologne, Germany, 1–5 September 2020.

Abstract: This study presents an analytical framework supporting coal regions in a strategy toward the clean energy transition. The proposed approach uses a combination of value chain analysis and energy sector analysis that enables a comprehensive assessment considering local specificities. Its application to a case study of the Slovakian region Upper Nitra demonstrates practical examples of opportunities and challenges. The value chain analysis evaluates the coal mining industry, from coal extraction to electricity generation, in terms of jobs and business that are at risk by the closure of the coal mines. The complementary energy system analysis focuses on diversification of the energy mix, environmental impacts, and feasibility assessment of alternative energy technologies to the coal combusting sources. The results show a net positive cost benefit for all developed scenarios of replacing the local existing coal power plant. Although the installation of a new geothermal plant is estimated to be the most expensive option from our portfolio of scenarios, it presents the highest CO_2 reduction in the electricity generation in Slovakia—34% less compare to the system employing the existing power plant. In addition, the development of a new industrial polo around deep geothermal technology can boost the economic activity in the region by attracting investments in companies providing geological exploration services, transferring the local knowledge from the coal mining industry into an emerging sector.

Keywords: clean energy transition; coal region; value chain analysis; energy system modelling; cost benefit analysis; coal phase-out; socio-economic impacts

Citation: Gerbelová, H.; Spisto, A.; Giaccaria, S. Regional Energy Transition: An Analytical Approach Applied to the Slovakian Coal Region. *Energies* **2021**, *14*, 110. https://doi.org/10.3390/en14010110

Received: 18 November 2020
Accepted: 23 December 2020
Published: 28 December 2020

1. Introduction

In November 2016, the European Commission (EC) presented the Clean Energy for All Europeans Package [1] as an initiative to accelerate the clean energy transition within the context of the implementation of the Paris Agreement [2]. As part of the package, the EC works closely with selected coal and carbon intensive regions across the Member States supporting them in the development of projects and preparation and implementation of their Action Plans. The Slovakian region of the Upper Nitra was chosen as a pilot case to kick-start the relevant initiative: the so-called Coal Regions in Transition [3]. In January 2020, the EC commitment to support the transition in fossil-fuel-dependent regions became even more relevant with the establishment of a Just Transition Mechanism [4] proposed under the adopted European Green Deal [5]. This funding mechanism will be a key tool supporting the most affected territories in their structural changes while aiming at the climate and environmental objectives.

Local authorities will have a significant role in the transition process as they are familiar with the local socio-economic situation and preferences. Additionally, local authorities have the power to mobilize the promotion of the deployment of low carbon technologies and encourage innovation [6]. A good factual knowledge of the region is required to derive a succeeding economic diversification. As shown in the study case of Germany, the historical development of regions affects the economic resilience to the energy transition [7]. Hence, the adaptation process can differ, even among regions located in the same country. Specific characteristics of the region, such as natural conditions, energy consumption patterns, local economy, and specialized enterprises and services, represent different factors affecting the future regional development. Li et al. compared the electricity system evolution at the regional level across regions of the United Kingdom while representing the socio-technical preferences consulted with the local stakeholders [8]. The geographical analysis confirmed that the differences in the electricity generation and costs at the sub-national level reflect the individual regional assumptions.

A successful transition will require the participation of all regional stakeholders. The most affected actors are consumers, workers, communities and companies, all under the governance of the local authorities [9]. Regions that have historically relied upon coal mining are usually located in isolated areas, where all infrastructure is linked to the coal supply chain. This have created a sense of community pride challenging the local economic diversification. Moreover, coal mining is a labor-intensive industry. Thus, the biggest concern from the local perspective is a possible reduction in the local employment.

This is also the case of Upper Nitra. Its economy has been developing mainly around brown coal deposits at Nováky, Cígel', and Handlová, mined by deep mining methods. However, the perspective on the coal production is limited. The extracted brown is considered uneconomical due to the relatively low energy content. Since 1997, the Slovakian mines have not been autonomous enough to recover their costs and have received subsidies from the Slovak Government [10]. Historically, this was done in the form of state aid directly to the coal mining industry. At present, a nearby domestic brown-coal-fired power plant is entitled to surcharges for the electricity supplied to the grid to ensure security of supply at the local electricity node [11]. Hence, the purchase of the locally mined coal is maintained. The economic inefficiency of coal mining in Slovakia is reflected in the rate of coal mining, which gradually decreased from 4.8 million tonnes per year in 1990 to 1.83 million tonnes in 2017 [12]. The first large mine closed in 2015, and it is expected that after 2023, when support for the production of electricity from coal is discontinued, coal mining will significantly decline [13]. Consequently, this will bring local benefits to the environment and human health, which are beyond of the scope of here presented analysis. Section 4 discusses these impacts in a broader perspective.

A gradual reduction of coal mining and coal use can be observed in national strategies in different countries of the European Union (EU), each of which faces its own specific challenges [14,15]. For example, Germany is often presented as a good example of implementing its phasing-out strategy. However, the study by Oei et al. [16] demonstrated that, in the past, implied policies in the Ruhr area have focused mainly on the local unemployment issues caused by mine closures. Yet, the coal-fired power plants continued their operation using imported coal. As in many EU countries, which are highly dependent on the coal supplies, this may be linked to a national concern about energy security. Security of energy supply is not of a monolithic conceptual nature. Cherp and Jewell [17] explain the impossibility of universally define energy security in the absence of a referent object. In other words, analyses of energy security are relevant to the entity receiving security, which can vary from a restricted group of residents or a specific sector or industry to society as a whole. A detailed exploration of the main contributing conceptualizing energy security is available in the available literature by references [17–19].

With regard to the concept of electricity security, energy transition is a systemic threat [20]. The motivation to finance electricity infrastructure, as in the case of Slovakia, is based on vulnerabilities that may arise from the exclusion of coal from the energy mix. Therefore, insights to the energy sector could help to identify whether the energy infrastructure strictly related with coal use could eventually play a role of critical infrastructure. A Critical Infrastructure, according the EU is "an asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions.” The Council Directive 2008/114/EC on the identification and designation of European critical infrastructures (article 2a) is an example such comprehensive perspectives examining the local and cross-border nature of vulnerabilities to inform exchanges between national and supranational governance level [21].

Against this background, this study presents a comprehensive analytical framework that contributes to a better understanding of the consequences of the energy transition emerging from the phasing out domestic coal production. The study elaborates on a conference input presented by the authors [22]. The first part demonstrates an empirical research to assess different business activities that are directly and indirectly linked to the main mining industry process from up- to down-stream. Special attention is paid to existing regional assets such as infrastructure and technical excellence. Furthermore, the energy modelling approach is used to explore and collect findings under scenarios of phasing out the coal from the energy mix. The analysis tries to identify whether the transition toward another technological setting would affect in a critical way the functioning of the system. The final outcome contributes in the local context to certain opportunities arising from the similarities between the status quo and alternative technological options envisaged in the transition away from the coal-based economy.

In this regard, the proposed approach focuses on multiple features of the industrial transformation with the aim to support the local authorities and stakeholders in the development of a coping strategy. The transition to clean energy, seen as an opportunity for regional development, ensures that the former mining area will continue to be an attractive area for the industries to invest and for the local citizens to live.

The structure of this article is as follows: Section 2 describes the methods used and their possible integration and also presents the studied region; Section 3 examines the coal value chain in terms of jobs and related business, provides insights into a perspective energy system, and explores possible challenges and opportunities in the local context; Section 4 discusses the different impacts of the local energy transition; and Section 5 provides some conclusions.

2. Materials and Methods

The proposed framework integrates value chain analysis and energy sector analysis. Each method provides comprehensive results on qualitative and quantitative bases and complement each other in the analysis.

2.1. Value Chain Analysis

The value chain analysis (VCA) is among the most frequently used methods assessing economic impacts at regional scale and it is extremely useful when the sectoral analysis has a micro geographical scope [23]. The VCA can be used to trace and monitor the intersectoral flows of capital, financial resources and labor when one segment of the value chain is stimulated by new policies or breaking economic or financial events [24]. Other authors used the VCA to assess the impacts of jobs from the development of renewable energy sector [25,26].

Termination of coal mining activities affects all parts of the coal value chain, from coal extraction to electricity and heat generation. The information aggregated by value chain segments allows mapping the industrial activities of interest from upstream to downstream. Figure 1 shows the basic coal industry value chain defined by four segments: acquisition of factors of production (Input); extraction and processing of coal (Mining), transportation and trade of the product (Transport); and final consumption of the coal resource (End Market).

The first segment, Input, includes the activities related to the provision of the production factors (mining and production equipment, land and extraction rights, acquisition from the government and landowners). The second segment, Mining, includes exploration, extraction, and processing activities, both at the surface and underground level. Transport is the third segment and includes the activities related to the transport services of input materials and final products. The last segment refers to the final markets characterized by economic activities that use coal products and by-products and is therefore called End Market. The end sector is the driver of the investments decision on the production factors of the input sector.

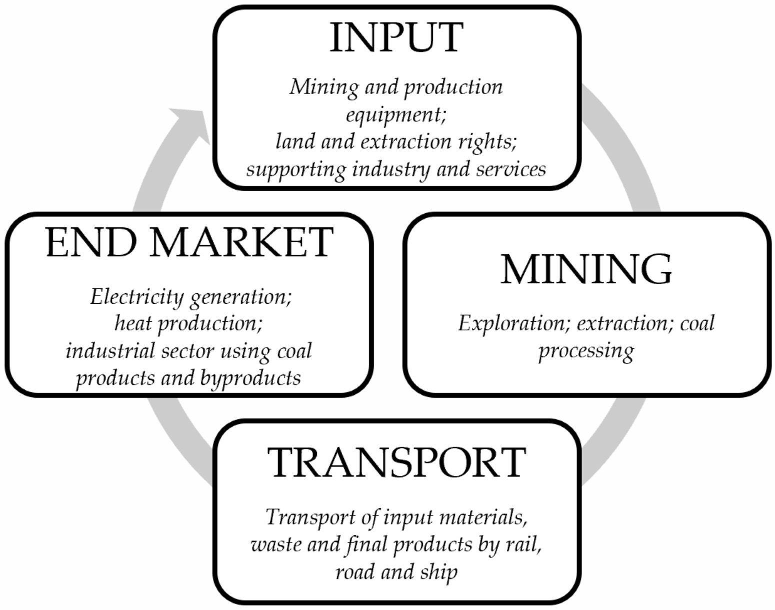

Figure 1. Representative diagram of the coal value chain.

The assessment via the VCA provides useful information about the current state of the mining industry and directly and indirectly related business activities. This is a fundamental step to evaluate the potential socio-economic impacts triggered by closures of coal mines. Additionally, the VCA offers a possibility to collect data and maps different business activities that are connected with the main coal activity. In this study, the collected information regarding the main economic variables on the firm-level activities are analyzed to quantify the impacts through the vale chain in terms of possible losses in jobs, companies' revenues, local taxes, and invested capital.

2.2. Energy System Analysis

The energy system analysis evaluates the direction of the potential transformation of the energy sector to alternative low carbon energy technologies. Two in-house energy modelling tools are used providing insights from different perspective on technical and economic impacts emerging from the coal mine closure. The first tool is the JRC-EU-TIMES, model, belonging to The Integrated MARKet ALlocation (MARKAL)—Energy Flow Optimization Model (EFOM) System (TIMES) family and developed by the Joint Research Centre (JRC) [27,28]. Energy system optimization models are well suited to quantify impacts of the transition on the energy system over a long period, such as investments in new technology capacity, energy mix, commodity flows, energy prices, or impacts of climate policies on carbon dioxide (CO_2) emissions and carbon price [29]. The implementation of the regional trends allows for providing more accurate results on the potential consequences on a local scale [30].

The modelling environment considers the whole range of technologies characterized by techno-economic attributes and connected through flows of energy. This network delivers energy services to the society under certain economic and policy constrains of the system. The objective function of the model is to minimize the total cost of the whole system in every period while satisfying the demand of energy services. The reference scenario for this study is aligned with the EU Energy Reference Scenario 2016 up to 2050 [31]. With respect to its application, additional scenarios are performed by analyzing the main effects of phasing out the production of coal and exploring the required diversification of the energy sector.

To complement this analysis, the resilience of the power system is assessed featuring the phasing out the brown coal-based generation capacities. The electricity system is analyzed with an in-house Europe-wide unit commitment and economic dispatch model [32]. The application of the dispatch model adds accuracy in investigating consequences on the power system, complemented with the economic aspect. The model runs in the PLEXOS power market simulation software environment and allows investigating consequences on the power generation adequacy checking for the presence of problems on the transmission network such as costs of outages, curtailments, and congestions [33]. Moreover, the techno-economic analysis of the power system provides detailed results on changes of electricity prices, volumes, electricity imports and exports and dispatch behavior under different defined scenarios [34].

The objective function is a maximization of social welfare in the electricity system while providing the necessary power to consumers under the optimal dispatch of power generators. The socio-economic welfare is defined from the marginal generation costs obtained via the techno-economic modelling, as presented in [35]. The welfare is estimated as a sum of consumer and producer surpluses. The electricity system is analyzed over a one-year period at an hourly time step. The model is comprised of 33 European countries (modelled as one power node per country) and the cross-border connections between these countries. Although our study aims at the regional level, effects on the electricity price caused by the cross-border trades are thus reflected.

The input data of the reference scenario corresponds to the ENTSO-E EUCO 2030 scenario [36]. The vision is built on the expectations of the European Transmission System Operators. To match our modelling target, alternative technology scenarios to the coal power plant are proposed. The marginal generation costs obtained via the techno-economic modelling defines the socio-economic welfare. Adding a factor of externalities and investment costs allows for estimation of the economic feasibility of different proposed scenarios via a cost–benefit analysis.

2.3. Integrated Approach

The combination of the above-specified methods provides a comprehensive assessment that can help in drawing a vision on the future development of the energy sector, while targeting specific issues of the region within its socio-economic context. The value chain analysis assesses the current state of the mining industry and connected activities and determines the potential socio-economic impacts triggered by closure of coal mines. The related background information is then implemented into the energy system analysis. The future scenario is designed to meet the constraints of security of energy supply, and considers existing infrastructure, knowledge and regional development priorities. In this way, the analysis provides, on the one hand, insights on the consequences of phasing out the coal mining activity and, on the other hand, the relative impacts of the switch from the status quo to alternative technological options.

The approach can be summarized in five steps:

Data collection and identification of actors related to the coal industry in the region.

Identification and analysis of various economic and social impacts triggered by closure of coal mines along the whole coal value chain.

Insights into the implications for the energy system and the security of energy supply complemented with the electricity generation adequacy.

Scenario analysis leading to alternative technological options, considering the existing infrastructure, capacity, and knowledge.

Possible similarities between the structure and characteristics of the coal value chain and those of alternative investment project(s) foreseen from the energy transition.

As a result, the analytical framework offers quantitative and qualitative assessments of possible losses and opportunities in terms of jobs, environmental benefits and profitability opportunities brought along by the alternative energy technologies. Additionally, it analyses stakeholders that are playing a fundamental role in the transition process and envisages requirements in terms of planning the local skills.

2.4. Case Study Description

The geographical scope of this analysis is Upper Nitra (shown in Figure 2). This territory is restricted to Partizanské and Previedza, two of the nine districts of the Slovakian administrative region Trenčín. Its area is 1261 km^2 (2.5% of the total area of the Slovak Republic) and has around 184,000 inhabitants [37]. Prievidza is the biggest district of the Trenčín region compared to the Partizanské district, which occupies the smallest area. Even though the analysis focuses mainly on the Upper Nitra region, it is important to recognize that activities of the coal industry can be interconnected within the surrounding regions.

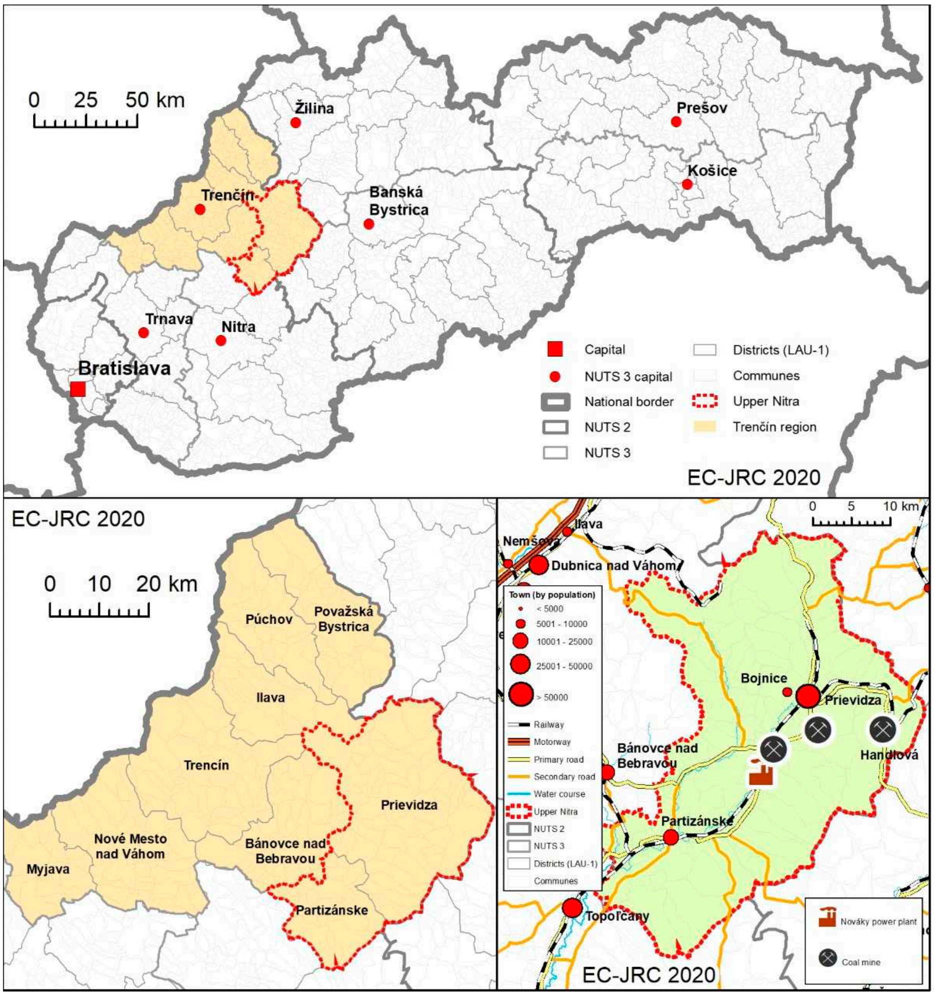

Figure 2. Location of Upper Nitra and coal mines.

The region has over 100 years of tradition in coal mining. The most important Slovakian brown coal deposits are located here. Today, Hornonitrianské báně Prievidza a.s. (HBP) is the only operating coal mining company in the country. Upper Nitra is an economically developed region with a relatively low unemployment rate and large density of the industrial sector [37,38]. Table 1 shows the historical evolution of the unemployment rate in Partizanské and Prievidza. Although the unemployment rate is relatively high in Prievidza, it is lower than the national average. Moreover, the rate considerably decreased in 2015. This can be linked to the substantial capacity enlargement of new multinational investors in the region specializing in the development, production and distribution of automotive parts. The region also has strong business activities in the field of engineering, rubber production, footwear and textile manufacturing, and, more recently, electro-technical production. Nevertheless, HBP is by far the most important company in the region in terms of employment [39]. Thus, the biggest concern from the local perspective is the change for the HBP employees.

Table 1. Unemployment trend in Slovakia and Upper Nitra.

Territory	2010	2011	2012	2013	2014	2015	2016	2017
				Year (%)				
Slovak Republic	12.46	13.59	14.44	13.5	12.29	10.63	8.76	7.35
Trenčín region	9.51	9.95	10.89	10.74	9.56	7.71	5.85	4.28
Prievidza district	12.05	12.88	12.97	13.9	12.47	10.37	8.13	6.11
Partizánske district	12.27	12.85	14.09	13.34	11.39	9.40	6.54	4.49

3. Results

The following subsections explore the economical, technical, environmental, and social dimension of various challenges and opportunities at the studied region.

3.1. Coal Value Chain

The VCA allows the mapping the firm-level activities from coal production to end consumption. The coal mining industry is the fundamental actor of the value chain. However, the relative network includes other businesses that are connected with the main coal activity, both directly and indirectly. The collection of the correct data targeting a small geographical scope is a tedious (but critical) part of the assessment. The selection process of the relative companies is following. First, the ORBIS, a database collecting information at a single company level worldwide, is accessed to search all companies active in Upper Nitra [40]. Identification of companies according to their Statistical Classification of Economic Activities in the European Community (NACE) narrows the selection [41]. Additionally, the national financial register is used as a search engine to map all linked companies, starting with HBP as an initial input. Since some companies cover more than one segment of the value chain, they are finally mapped according to their business activities. Achieving this goal was only possible by acquiring additional information directly from the local stakeholders. Moreover, the local authorities claim that many indirect businesses would also be negatively affected, such as the petrochemical industry, food industry, and collateral services. Although their impact will not be of the same magnitude, it is important to endorse the collateral services in the analysis. Finally, accessing the financial report of each company included in the value chain serves to obtain the historical financial situation at the firm level, its number of employees and their professional background. Using these steps enables us to allocate, to the best of our knowledge, the number of employees linked to each segment of the value chain, as presented in Figure 3.

The first segment of the VCA includes the activities related to the provision of the production factors, such as mining and production equipment, land and extraction rights, and acquisition from the government and landowners. Different existing industries from the region supply products, materials, and equipment to be used in the coal production, including rubber industry, metallurgic industry, or petrochemical industry [37].

The highest number of employees is allocated to the mining segment of the value chain and thus related to the HBP group. The main areas of activity of HBP are coal exploration, mining, and the sale of brown coal. In total, in 2017, HBP produced 1.83 million tonnes of coal, of which almost 94% was purchased by Slovenské elektrárne a.s., the owner of the Nováky thermal power plant and the biggest customer of HBP [12]. Although two other companies—the electricity and heat producer Bukóza Energo, a.s. and the steel industry US Steel Košice, s.r.o.—consume a share of the HBP coal, they operate in the Eastern Slovakia and thus are excluded from the analysis.

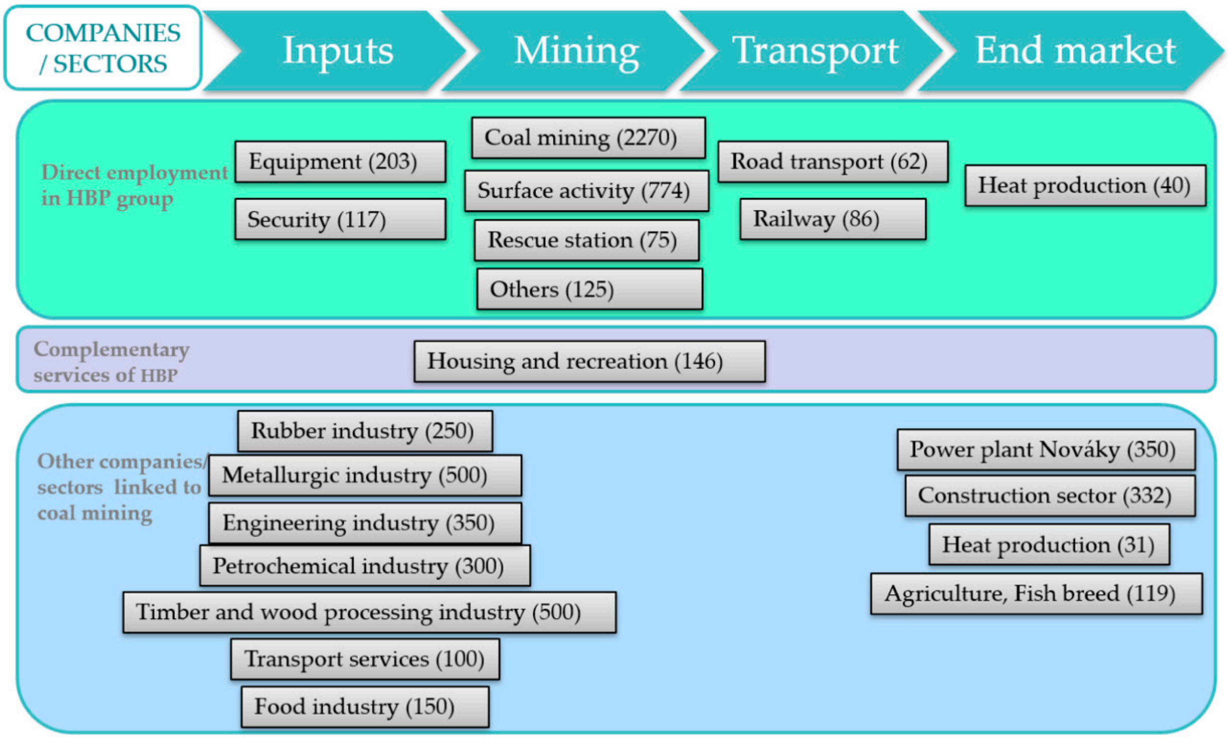

Figure 3. Number of employees per each segment of the coal value chain in Upper Nitra.

Other important long-term business partners of HBP are Handlovská energetika s.r.o. and Prievidzké tepelné hospodárstvo a.s., whose activities are within the production and distribution of the heat in the Upper Nitra region and thus belong to the last segment of the value chain. HBP partially owns both companies. HBP has in total a capital share in 11 companies covering diverse portfolio of activities, including Hornonitrianske bane zamestnanecka a.s., whose activities fall into two segments of the value chain. The company produces mechanized supports and other machinery and equipment to the mining sector. It also operates the railway transport of the coal to the Nováky power plant. Another associated company, Ekosystémy s.r.o., specializes in surface metal treatments, and HBP uses its service for the repair and maintenance of coal transporting wagons and containers and a technical examination of the railway line.

Additional companies belonging to the HBP group are Evots s.r.o., offering service of freight transport, excavations, demolitions and waste management; Priamos a.s., the intermediator of coal and waste products from HBP; HBP Security, a private security agency, which secures HBP sites; and the main Mining Rescue Station of Prievidza, which mainly supports the rescue service but also monitors emissions underground and provides chemical analysis of landfills gases. Moreover, the HBP group has been diversifying its business activity—for example, in the agriculture sector, having a commitment contract with AGRO GTV/Rybí Farma s.r.o, which directly uses the hot water from the mine to heat their greenhouses and to breed African Catfish. Likewise, HBP is an investor of several recreational and restauration services in the region.

3.2. Transition Scenario of the Energy Sector

As determined by the VCA, closing the coal mines would strongly affect end market companies whose business depends mainly on the coal supply. In this specific case, it is the close-by located power plant Nováky that consumes a significant amount of the coal production. The power plant is the main source of electricity in the region. However, the European Environmental Agency ranked this power plant as the 18th most polluting facility in Europe [42]. The estimated monetary cost of the health and environmental damage from the pollution to the air in a five-year period (2008–2012) ranges between 1.814 and

5.003 billion euros. Moreover, new investments to upgrade the power plant will be needed to ensure operation in compliance with the emission standards [43]. Besides, the Strategy of Environmental Policy of the Slovak Republic until 2030 states gradual phase-out of coal burning in the electricity sector as the prior target toward low carbon economy in Slovakia [44].

Given that, the energy system analysis focuses on alternatives to the coal combusting sources and at the same time meeting constrains of energy supply. The Slovakian energy system can be influenced by market forces, constrained by regulatory measures and/or influenced by policies. Accordingly, different scenarios are analyzed using JRC-EU-TIMES. The first scenario presented in this study considers a direct phasing-out of the coal supply in Slovakia starting in 2020. The results show that applying stringent regulatory measures of direct phasing out of the coal from the Slovakian energy system does not affect the total final consumption of the commodity. Instead, the imports of lignite from neighboring countries increased. Although it is clear that this scenario is not an effective measure to decarbonize the energy system, it was a useful exercise, which provided a technical support to the formulation of related energy policy measures. The representation of the scenario within the European-wide model reveals its advantage. The concept allows for studying the interdependency between the neighboring countries and thus considering concerns about the security of energy supply and the import dependence.

In a next step, an alternative low carbon scenario imposing further stringency in the climate targets by applying CO_2 reduction of 95% in 2050 compared to 2010 is applied. Indeed, the low carbon scenario involves restructuring of the energy mix, which consisted in 24% nuclear, 24% natural gas, 21% coal, 20% oil, and 11% renewable energy source (RES) and waste in the reference year 2016. The reduction in CO_2 emissions forces the decline of coal in energy consumption and imposes the end of the brown coal power plant production. The total final consumption of energy increases over the studied period and it is compensated by electricity, natural gas, and biomass supply. Compared to the reference scenario for 2016, the national energy mix has a higher share of renewable resources in the final energy consumption by 2%, 38%, and 67% in 2030, 2040, and 2050, respectively. Among RES technologies that emerge from the results of the low carbon scenario, the electricity capacities expand from 2020 to 2050 by 13.2 GW_e of solar PV (photovoltaic), 0.7 GW_e of geothermal and 0.6 GW_e of wind onshore (Figure 4).

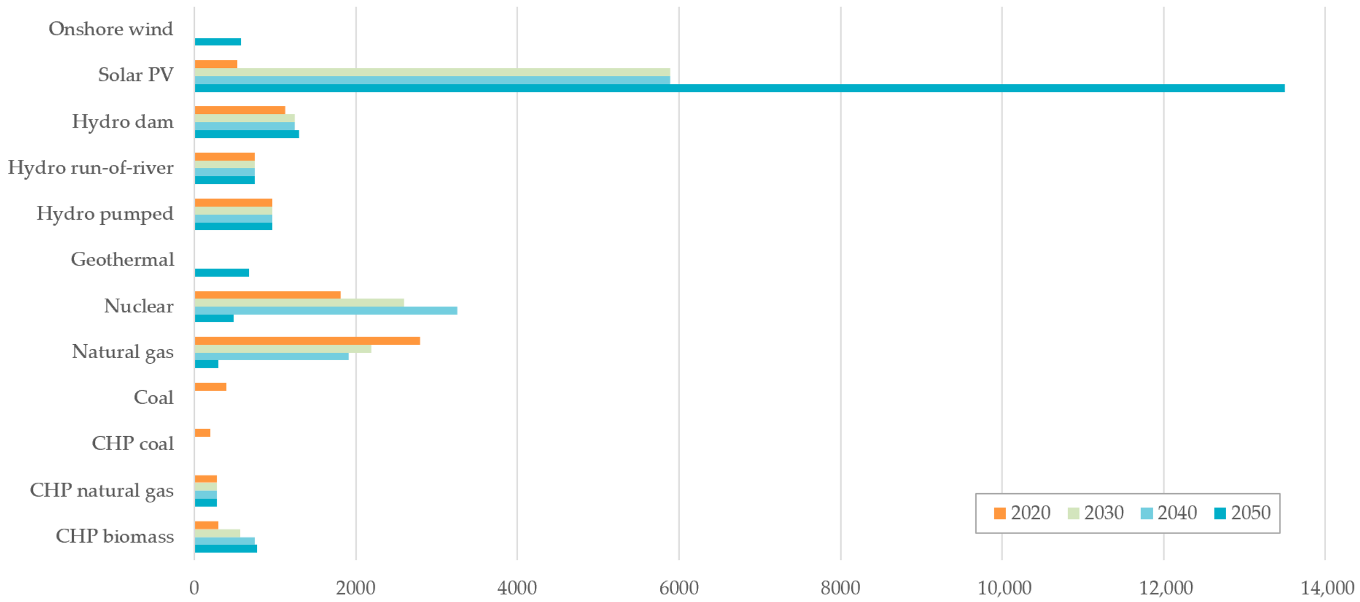

Figure 4. Installed capacities of the electricity generation by technology production under the low-carbon scenario in 2020, 2030, 2040, and 2050 in MW_e.

In the above presented techno-economic assessment, the most important driver is the reduction of CO_2 emissions at the nationally least cost option. The portfolio of prospective alternatives for local electricity generation at national level includes wind, solar, geothermal, biomass, and natural gas (also as combined heat and power (CHP)). Nevertheless, the actual energy mix differs across the Slovakian regions. The Nováky power plant is the only brown coal power plant in Slovakia and the largest local source of energy in Upper Nitra. The region made significant investments in the existing coal related infrastructure and has long experience in underground mining. To make the most of the existing regional assets, such as infrastructure and technical excellence, different alternative technologies to the existing brown coal power plant were consulted with the local authorities. The most promising scenarios are evaluated in the following analysis in terms of cost-benefits.

The modelling exercise is performed using the European power dispatch model. The reference scenario assumes the total capacity of the brown coal power plant in Slovakia 221 MW_e in 2030, which is comparable to estimates of the ENTSO-E EUCO 2030 scenario [45]. Three alternative scenarios for the existing coal power plant are proposed: (1) conversion to burn natural gas, (2) conversion to burn biomass, or (3) replacing the existing power plant with a new geothermal power plant of the same capacity.

Table 2 shows the electricity system performance of the modelling exercise under selected scenarios. All three alternative scenarios, compared to reference, lead to higher electricity exports and lower imports in Slovakia. Electricity price drops in all alternative scenarios where the Nováky brown-coal-fueled power plant is replaced with another generation type. Lower price slightly increases power demand. The scenario of the new geothermal plant has the highest price drop as a consequence of the lowest marginal generation cost compared to combustion fuels. Likewise, net exports increase significantly under this scenario. The decrease of coal in the energy consumption would have a positive effect on the environment. The analysis results show reduction of CO_2 emissions in the power generation in Slovakia by 332.7, 649.6, and 670.9 thousand tonnes in the scenarios of fuel conversion to natural gas, fuel conversion to biomass, and new geothermal plant, respectively.

Table 2. Cross-border flows, generation mix, and electricity prices in Slovakia in 2030.

	Reference	**Conversion to Natural Gas**	**Conversion to Biomass**	**New Geothermal Plant**
Power demand (GWh)	32,292	32,301	32,300	32,298
Power imports (GWh)	2432	2326	2326	2236
Power exports (GWh)	13,266	13,365	13,346	13,938
Power generation (GWh)	43,126	43,341	43,320	44,000
Wind	578	578	578	578
Solar	801	801	801	801
Hydro	7711	7723	7723	7707
Hydro pump	251	250	250	244
Natural gas	2994	4127	3036	2961
Hard coal	696	695	695	696
Brown coal	928	0	0	0
Oil	4	4	4	5
Geothermal	0	0	0	1847
Biomass	0	0	1070	0
Uranium	29,162	29,162	29,162	29,162
Reduction in CO_2 emissions (thousand tonnes)	n.a.	332.7	649.6	670.9
Electricity price (euros per MWh)	70.14	70.09	70.09	70.06

It should be noted that this study focuses on phasing out the domestically mined brown coal. Slovakia also imports relatively large amount of hard coal from Ukraine. The hard coal is consumed primarily in Eastern Slovakia in the steel industry and in the thermal power plants in Vojany [34]. The hard coal power plant generates around 695 GWh of electricity annually, corresponding to 1.6% of the total electricity generated in Slovakia.

Figure 5a presents the changes in socio-economic welfare in Slovakia expressed as a difference between the alternative and the Reference scenarios. Increase in the consumer surplus is 2 million euros per year for all three alternative scenarios. Producer surplus has the highest increase for the case of the geothermal plant (28 million euros per year) as the marginal generation cost is zero and thus it operates constantly at maximum available capacity.

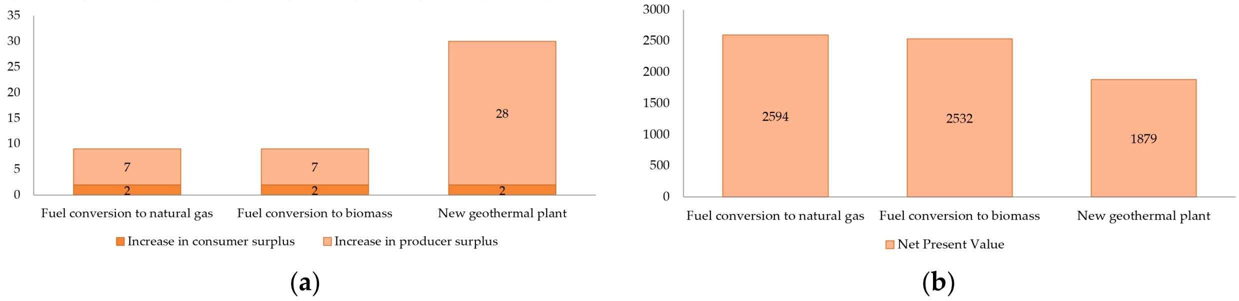

Figure 5. (**a**) Changes in socio-economic welfare in Slovakia compared to the reference scenario (million euros per year); (**b**) NPV2030 of different alternative projects 2030–2059 (million euros).

Figure 5b shows the economic feasibility of each proposed scenarios estimated via cost–benefit analysis. The calculation is composed of three elements: (1) previously obtained social welfare, (2) related investment costs and fixed operation and maintenance (O&M) costs, and (3) estimated environmental externalities. The investment costs are assumed to be 100 million euros for both, brown coal-to-gas and brown coal-to-biomass fuel conversions [46,47]. A new flash steam geothermal plant of 221 MW_e capacity is estimated to be 988 million euros [48]. The applied annual fixed O&M costs are 4.69 million euros per year for natural gas power plant, 8.19 million euros per year for biomass power plant, and 17.17 million euros per year for geothermal plant [49].

The purpose of adding monetary indicators in the form of health and environmental externalities is to provide a further integration between the techno-economic assessment and environmental dimension. A decrease of coal in the energy consumption would have a positive effect on the environment, thus avoiding the deterioration of health conditions of citizens that receive emissions. The Self-Governing Office of Trenčín recognizes that districts Partizánske and Prievidza are districts with the highest share of inhabitants living in distressed and heavily damaged environment—57.89% and 55.08%, respectively [36]. For this study, the economic benefit resulting from avoiding the environmental and health damage of closing the Nováky power plant is estimated for 149 million euros per year. The price considers the lowest value in the range reported in the European Environment Agency dataset under the Value of Life Year (VOLY) method [42].

Benefit cash-flows are calculated over an assumed life cycle of a power plant—a 30-year period—with a discount rate of 4%, contributing to the final value of the Net Present Value (NPV). The NPV is positive in all three alternative scenarios and reveals an estimate on what the society could gain when the brown coal usage phases out. Difference between Scenarios conversion to natural gas- or biomass-fueled plant is relatively small. Lower NPV in brown coal-to-biomass conversion is caused by a higher O&M costs in the biomass power plant. Yet, this position could change at higher CO_2 prices. The lowest NPV is for the geothermal plant option, driven mainly by the high investment costs for the new geothermal capacity. Although the NPV installation of the new geothermal plant drives the profitability of the geothermal technology down, it presents the highest CO_2 reduction in electricity generation in Slovakia, 34% less than the reference scenario. Moreover, the creation of the new industry can bring investment opportunities to the Slovakian region triggering overall positive socio-economic impacts, which is discussed in the following chapter.

3.3. Impacts on Business Activities

The mine closure affects different economic activities in different ways. In fact, the more diversified the business of the companies that are part of the value chain of the coal industry, and the wider the geographical perimeter of their activity, the lower the loss to be expected in terms of private and social benefits.

The ORBIS database provides the economic and financial information for 20 companies that are located in the Upper Nitra region and directly linked to the coal value chain (see Table A1). The performed analysis distinguishes between three categories of data: capital, where information on capital, cash flow, current liabilities, and total assets are included; the result of activity, which contains financial revenues, operating revenues (turnover), and P/L before tax; and the costs, represented by the depreciation and amortization of the capital, financial expenses, interest paid, long-term debts, costs for material, and costs for the employment and taxation. The analysis of the historical trends in the nine-year time frame by value chain segment are summarized in Appendix A.

The aggregated analysis for year 2016 shows that for what capital and result of activity are concerned, the companies belonging to segments inputs and mining of the value chain result to have the highest values, followed companies operating in transport and end user segment. For what is the third category concerned—the costs—the highest values are recorded by the companies active in the input sector, followed by those operating in the mining segment, while the companies in the transport and end-user segment are at similar levels.

A single company analysis on the HBP group were carried out as the company has its activities along the different segments of the value chain and it is the most important company in the region in terms of employment. In 2017, HBP sales of products, services, goods, and materials accounted for a volume of 193 million euros representing 99.4% of the total revenue. The largest volume of sales was achieved for the sale of coal (89%). Labor costs represented 39 million euros, which accounted for 20.4% of the total costs of the company. Historically, the average salaries in HBP increased from an average of 532 euros a month to 988 euros in correspondence of a reduction in the number of employees from 4630 in 2005 to 3260 in 2016 (Figure 6).

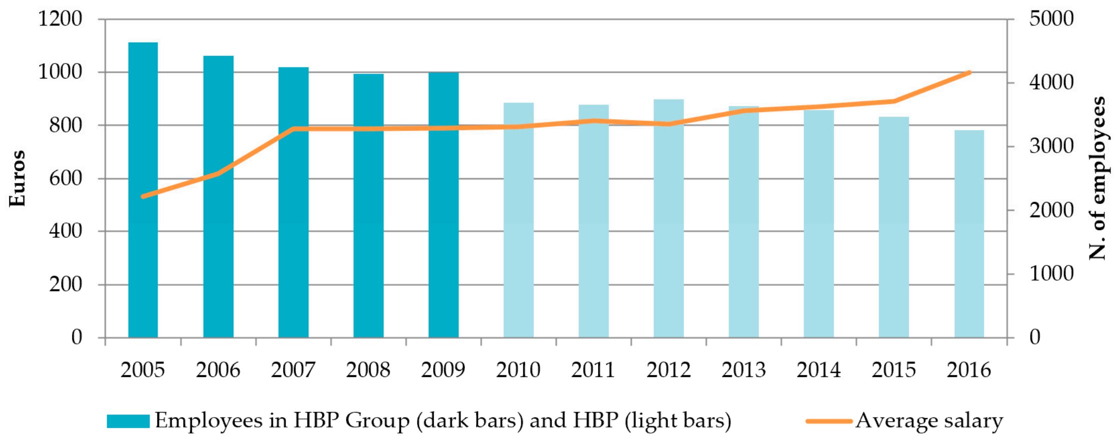

Figure 6. Employees in the Hornonitrianské báně Prievidza a.s. (HBP) Group and HBP and average salaries (2005–2016).

The overall socio-economic impacts of a mine closure may depend on how diversified the business strategies of companies in the value chain are. The Trenčín region stated that its priority is to support the creation and maintenance of jobs in the Upper Nitra, attract new investors and reinforce traditional industries. The potentials for economic growth cover different opportunities, such as free space for industrial parks and zones, the long tradition in geological exploration, electrical engineering, rubber and textile production, geothermal springs for spas and tourism, the space and capacity to build research and development centers, and enough high educated professionals in population [36,37,50].

While the final decision on future plan rests with the local stakeholders, Table 3 compares in a qualitative way the main pros and cons regarding the different alternative scenarios for the Nováky power plant.

Table 3. The main pros and cons of the proposed alternative scenarios.

Conversion to Natural Gas	Conversion to Biomass	New Geothermal
+ Low investment costs + Contribution in power balancing + Existing gas grid nearby	+ Low investment costs + Contribution in power balancing + Local energy source	+ Low running costs + Investment in innovative technology + Re-fitting mining skills
- Increased dependency on imported natural gas - Greenhouse gas emissions - Costs of connection to the existing gas grid - Losses of local jobs	- Environmental stress due to biomass harvesting - Local pollutant emissions	- High investment cost

Reconversion of the existing brown coal power plant to burn natural gas is a known process and is generally less expensive than building a new power plant. In addition, the proximity of the existing natural gas infrastructure keeps investment costs down. Slovakia lies on the main route for gas import pipeline from the Russian Federation and Ukraine. The main drawback of this scenario is the increased dependence on natural gas imports that is already relatively high. In 2018, natural gas contributed to 24.4% of the gross inland energy consumption in Slovakia, and almost 90% was imported [51]. Although less polluting than coal, under this scenario, the power plant continues burning fossil fuel and emitting CO_2 emissions. Moreover, it seems that the operation of the power plant connected to the existing natural gas pipeline is less job intensive in terms of number of employees required for the operation.

The fuel switch from brown coal to biomass may be as well a cost-efficient technical option, additionally creating employment from harvesting and logistics activities. Although fueled from a locally available energy source, a biomass-burning power plant brings substantial concern to the local authorities, mainly because of the environmental stress on local forests caused by excessive biomass harvest. The use of biomass also implies non-negligible air and ground emissions. The main advantage of reconversion of the current coal fired power plant to the natural gas or biomass feed is the re-utilization of the existing infrastructure of the site.

Geothermal technology is the least mature technology among the three scenarios. Slovakia is rich in low enthalpy resources of geothermal energy accessible by conventional technology but unsuitable for electricity production [52]. An innovative technological option for exploration of deep reservoirs accessing higher temperatures is essential for the electricity production [53]. A new technology for exploration and drilling is in its early development in Slovakia [54]. Although geothermal energy has low running costs, it still results as the most expensive due to the high capital cost. Yet it has the largest reduction of CO_2 emissions and can boost the economic activity in the region due to investment in innovative technologies. The strongest argument for the geothermal technology option is the creation of new industrial activities bringing more qualified jobs and investments in service companies for geological exploration, with some similarity to the mining sector [55]. Regarding the impact on the Slovakian power system, the generation pattern of the geothermal power plant may reduce generation flexibility. This can be seen as an advantage, planning the geothermal plant for the baseload generation. Thus, comparable to the existing coal power plant. Moreover, operating the geothermal power plant constantly at full available capacity ensures payback of the high investment. Gas and biomass-fueled power plants are more likely to contribute in the power balancing.

3.4. Impacts on Employment

The allocation of the employees per each segment of the value chain (Figure 3) indicates that the plan of closing the mine will affect, to a large extent, the mining segment of the value chain, corresponding to 80% of the HBP group employees. However, the group presents different professional profiles. Some of these professions, such as drivers, electricians, engineers, administrative workers could potentially be less affected by the closure of the mine. In fact, out of the 4017 employees of the HBP group, 56% work in activities directly linked to the subsurface mining. Figure 7 shows relative shares of job profiles within the portfolio of the HBP group [56].

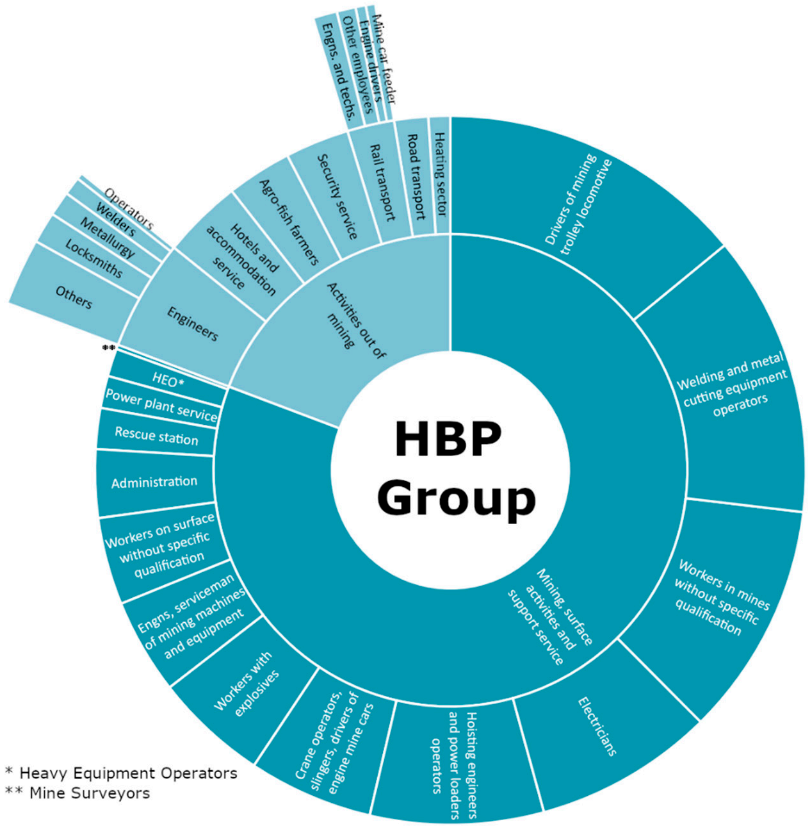

Figure 7. Shares of job profiles within the portfolio of the HBP group.

Another important factor is the age structure of the staff. In 2013, HBP reported that more than half of its employees are 45+ years old. Taking into account that the number of employees in HBP has been continuously decreasing and HBP has already started the diversification of its business portfolio and transforming the exiting jobs into a new prospective employment, the Office of Employment, Social Affairs, and Family may expect that a relatively small share of miners and employees directly linked to the mining activities will need to be absorbed by the labor market when the mines end its operation.

The second segment of the value where employees are more numerous is the end market. The planned closure of the mine will have a direct impact on employees working in the heat and electricity production, where the domestically mined coal is used as fuel. This specific group accounts for around 400 jobs (see Figure 3). The end market segment is followed by the segment providing the means of production, and finally the transport. A considerable amount of indirectly linked jobs is in the businesses associated to the mining, such as metallurgic industry, engineering industry, food industry, and housing or transport services. The indirect impact on the employment is a specific case and is not of the same magnitude due to the diversification potential of the business.

Within this context, the region prepared, in cooperation with local stakeholders, an Action Plan covering possible projects for creating new jobs in the region of Upper Nitra [57]. Although finding the final solution is a complex issue, the covered projects includes many opportunities mainly driven by the local job creation and preservation. Table 4 presents the most engaging plans together with their potential for job creation. According to this, more than 1600 new jobs could be created within the HBP group development projects. It is possible to observe that they stem from the existing infrastructure, for example the gas storage in the mine underground, or from the existing skills, for example, the innovative welding process using the existing skills of the daughter company of the HBP who provided the service and maintenance of the wagons transporting the coal. Other plans reinforce the traditional industries: for example, expansion of the chemical industry or engineering for the automotive parts. Moreover, the Action plan also specifies potential for the Research and Development (R&D) in the energy sector. It also focuses on energy areas reflecting our study, such as the deep geothermal technology, retrofit of the existing power plant, or a biomass logistic center.

Table 4. Examples of plans for regional development and their potential for job creation.

Plans	Job Creation
Within the HBP group:	
Innovative welding of machines	+800
Service for railway wagons	+160
Gas storage	+50
Greenhouse gas and fish breeding	+100
French fries and vegetable processing	+200
Logistic biomass center	+250
Manufacturing of plastics	+50
Total	1610
Others (existing companies and new investors):	
Chemical industry	+90
Manufacturing of car compounds	+2000
Retrofit of the power plant	+280
R&D deep geothermal	+40
R&D battery storage and electro mobility	+250
Manufacturing compounds for RES	+200
Industrial zone	+1700
Tourism and spa	+1600
Bottle filling station	+20
Total	6180

Additionally, the Office of Employment, Social Affairs and Family may find positions for some of the unemployed work force. Figure 8 presents the number of job seekers and open vacancies by category of profession aggregated for both studied districts. Most of the job seekers include graduates, women after maternity leave, and the voluntarily unemployed. Despite the large number of registered job seekers, there are vacancies that remain unoccupied. In 2017, there were in total 1680 registered open positions in Upper Nitra. Yet, companies register their job offers to the Office on voluntary basis. Many companies publish their open positions on their web sites. Most of the registered job vacancies are offered to qualified technicians, qualified craftsmen, and operators of machinery and equipment. This fact reflects the potential of the area for the development of industrial production and for attracting new investors. The regional authorities have already recognized the imbalance between the job vacancies and job seekers and focus especially on the young generation, promoting measures under which students follow more appropriate vocational courses.

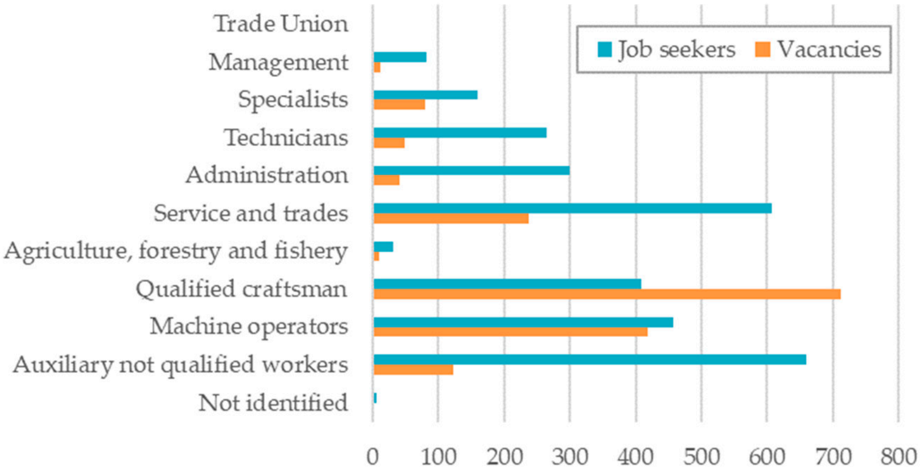

Figure 8. Number of unemployed and registered open positions in the Office of Employment, Social Affairs, and Family (2017).

This diagnostic evidence allowed quantifying possible losses and opportunities in terms of jobs in the region due to the phasing out of the mining activities. The alternative technological options foreseen from the energy transition presented earlier may help to understand the skills needed, both in a short and long term, in order to match embedded skill competences and define opportunities for re-skilling and up-skilling.

As an example, the value chain approach can be used to analyze the impacts of a geothermal power plant as an alternative to the coal mining plant and to find possible correspondences between the profiles and number of employees of the coal mine value chain and those of the geothermal technology. According to the Geothermal Energy Association, the geothermal energy creates 1.7 direct and 4.25 indirect full-time positions per installed MW [58]. In our case study, this derives to 367 and 939 local positions, respectively. Moreover, the construction phase accounts for another 1414 positions per year. It can be expected that further strategic growth would allow for a possible enlargement of this innovative business activity and thus bringing more qualified employees into the region. The geothermal is one of the most local sources and employs different workers for each phase of the development. The main professional profiles are summarized in Figure 9 according to each segment of the development chain.

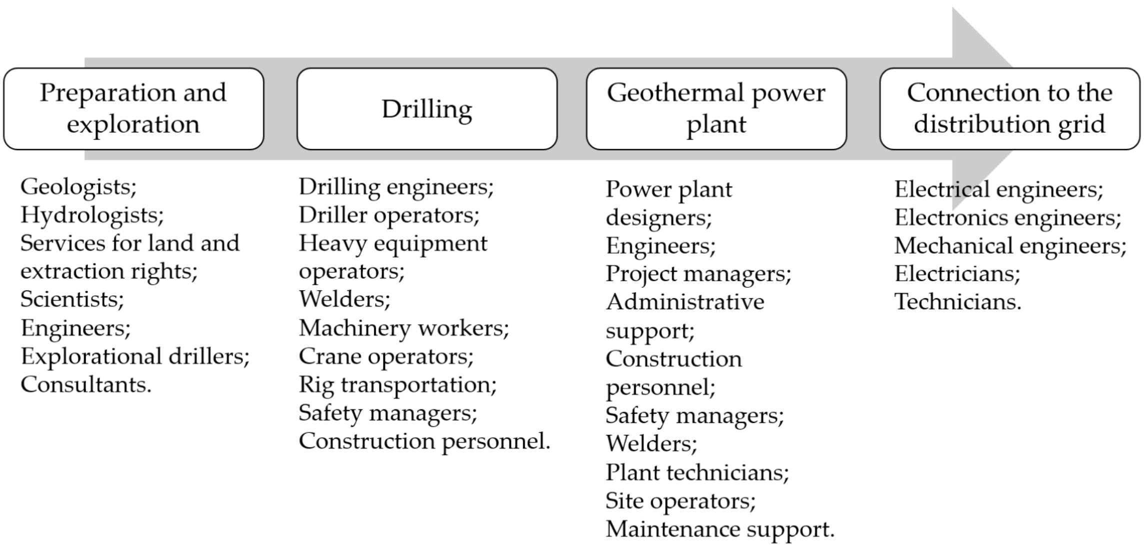

Figure 9. Example of personnel required for each phase of the geothermal plant development.

For many occupations, the experience from the coal mining industry can be applied and thus preserve the local professional knowledge. The exploratory and drilling phase requires, for example, engineers, welders, rig drivers, drilling machinists, crane operators, and safety managers. All these are existing skills in HBP. Additionally, operators of the heavy equipment are necessary to remove the soil and disposal from the excavations. The construction of the power plant employs engineers, construction personnel, and construction equipment operators. A large network of the pipeline infrastructure involves specialization in welding. Later, for the plant operation and monitoring of the site, electricians, site operators, and administrative support are needed, similarly as for the operation of the exiting power plant. Just for comparison, the O&M of the geothermal power plant generates 1.7 job per MW, while natural gas power plant only 0.1 job per MW [58].

3.5. Impacts on Public Revenues

The mining company stimulates the business in a big part of the economy in the region creating direct and indirect economic benefits also at national level. The calculation estimates the public revenues gained by the national government from the income taxes paid on the yearly income of employees and from the sales of the 20 companies operating in the coal value chain identified in the analysis. From the ORBIS database we extracted the figures on total salaries paid to employees and taxation on sales to assess the public income from working activities of the selected companies. The total taxes on sales from the business activity of the 20 companies over the period from 2007 to 2015 corresponded to 36.7 million euros, while the total income taxes in the same period is estimated at 5.3 million euros.

The number of employees in each segment of the coal value chain, their salaries and the Personal Income Tax Rate (PITR) in Slovakia is considered to estimate the contribution to the public revenues of income taxes from the coal industry. Considering that the national average income is much below the first income bracket of 35 million euros, the associated PITR equal to 19%—instead of the 25% associated to the last income bracket is used [59]. Moreover, the average salaries in the coal sector seem to be lower than the national average. The overall benefit to the public revenues in form of income taxes will also depend on other revenues coming from the fact that the money earned by these workers is re-injected into the local economy, for example, buying of real estate.

4. Discussion

The strength of our framework derives from the fact that it delivers tailored technical support to the region. A tight collaboration with involved stakeholders plays a fundamental role in the research. On the one hand, the interaction enables collecting regional data, which is the biggest limitation of spatially detail analysis. On the other hand, the stakeholders' feedback is important for the validation of results.

The main dimensions associated with the structural energy planning at the local level are economic, technical, environmental, social, and political [60]. The following paragraphs discuss these aspects of the energy transition in coal dependent regions.

Socio-economic impacts: Existing companies in this sector will need to evaluate the possibilities of diversifying their business. This will reduce possible economic losses and accelerate the energy transition. In order to anticipate serious risks of the job losses, the most critical age groups and professions need to be identified. In this respect, the most affected may be employees approaching the retirement and those less experienced who entered the labor market. Transversal professions could potentially be less affected by the closure of the mine, and the available specialized knowledge and expertise have a great potential to be transferred into emerging activities. An effective incentive for employers and employees is to support targeted training on green skills and upskilling opportunities.

Technical challenges and opportunities: The reduction of domestic fossil fuel extraction has a direct effect on end users, especially in the heat and electricity generation fields but also, if that is the case, in industries where the coal is used in the production process and the substitution is challenging (for example steel industry). The companies involved in these activities are most likely continue their activities; however, they need to switch to an alternative source of energy or convert their production process to an alternative source, both with a high investment. The local companies have a considerable interest to reuse/retrofit the existing infrastructure when developing the coping strategies. Nevertheless, the significance of the technological change is an integral part of the energy transition. Specialization, knowledge sharing, and innovation are key factors in this domain.

Environmental impacts: There is a consensus on the environmental consequence of industrial facilities that emit greenhouse gas emissions and thus causing deterioration of health conditions of citizens that receive these emissions. In addition, the communities that live near mines face reduced life expectancies and increased rates of cardio or respiratory diseases. This is especially true for the workers in the underground mines, as they are exposed to coal dust. Miners also face a great physical risk due to accidents, explosions, and mine collapses. Therefore, it is clear that phasing out the coal mining will reduce the external health costs. Besides, the mining activities contributes to soil degradation, destruction of wildlife habitat, and contamination of water systems in the area. The coal mines will be successfully closed only after the decommissioning, reuse, and recycle of all used components and reclamation of the degraded soil, which can take decades.

Governance: The transition is a multidimensional process that needs to be managed in an integrated manner that balances the negatively perceived economic short-term impacts on jobs (and society in the traditional industry) and the long-term perspective of a climate neutral economy and sustainable growth. The Government will play a key role in this and therefore needs to be coherent at different levels—local, regional, and national—and set in coordination the right policy mix. The local authorities have the opportunity to interact directly with the businesses involved. Specific information on industry plans for alternative technologies would support the local decision-making process when deciding on the implementation of measures to support the regional entrepreneurship and the development of new businesses. In addition, the local authorities are aware of local conditions and expertise that can help map and monitor the rising opportunities and manage local citizens' engagement.

5. Conclusions

This study presents a comprehensive analytical framework that contributes to a better understanding of the implications of the energy transition, while considering development priorities of the region. The framework is applied to the Slovakian region of the Upper Nitra and explores the main challenges and opportunities emerging from the closure of the local coal mines. Despite the fact that most of the used elements for the analysis are specifically tailored to the case study, the analytical framework can be applied to any other region facing a similar energy transition. The following results may be of interest for the lessons sharing.

To understand the magnitude of the business around the mining sector, the number of jobs per each segment of the value chain are collected as well as the relevant financial data of companies linked to the coal mining activity. The assessment also covers indirectly linked business activities, such as the petrochemical industry, the food industry, and collateral services, although the impact of the coal mines closure may not be the same. The analysis shows that almost 50% from the total number of employees is allocated to the mining segment of the value chain. However, the group presents various professional profiles, including cross-sectorial professions such as drivers, electricians, engineers, and administrative workers, which have a relatively high potential to be absorbed elsewhere. The analysis confirms that the existing companies have already started to diversify their business, which can alleviate the overall negative socio-economic impacts.

As determined by the VCA, closing the coal mines would strongly affect end market companies whose business depends mainly on coal supply. In this particular case, it is the nearby located power plant that consumes 94% of the domestically mined coal. Three different alternatives to the existing coal power plant are proposed: (1) conversion natural gas combustion, (2) conversion to biomass combustion, or (3) replacement with a new geothermal power plant of the same capacity; and evaluated in terms of cost-benefits. These alternative scenarios have been designed to meet the constraints of security of energy supply and their selection is driven by the existing infrastructure, existing knowledge and job preservation. The main advantages and disadvantages of each scenario are also discussed. The lowest NPV is for the geothermal plant option as influenced by the high investment costs for new geothermal capacity. Yet, this scenario presents the highest CO_2 reduction in electricity generation in Slovakia—34% less than in the case continues operation of the existing coal power plant.

The strongest argument for the potential of geothermal technology is the creation of new industrial activities that attract new investors and bring more qualified jobs to the region. In addition, service companies for geological exploration and drilling require similarly professions as the coal mining sector such as engineers, welders, rig drivers, drilling machinists, crane operators, and safety managers. Further analysis of the main projects included in the Slovakian Action plan presents many other opportunities for the development of new business lines in the region, which offers the potential for job creation in larger quantities than those related to the coal value chain.

This study shows that the implementation of the European and national policies happens at regional level. The ongoing energy transition in the Slovakian region contributes to reach the objectives of the European Green Deal, especially a zero-pollution Europe, achieving climate neutrality and clean, reliable, and affordable energy while putting particular care on the implementation of dedicated measures to protect the weaker segments of the society. Regional policies for a successful transition should facilitate the industrial sector to achieve economy of scale and aim at building a solid basis for regional specialization, inter-regional, and inter-sectoral cooperation. The local authorities should support the creation and development of new expertise and support those categories of workers that are the most exposed to unemployment or needs of re-skilling.

Author Contributions: Conceptualization and methodology: H.G., A.S., and S.G.; resources and investigation: H.G., formal analysis: A.S. and S.G.; data curation: H.G., A.S., and S.G.; writing—original draft preparation, H.G.; writing—review and editing, A.S. and S.G.; visualization, H.G. and A.S. All authors have read and agreed to the published version of the manuscript.

Funding: The research received no external funding.

Acknowledgments: We would like to specially thank our colleagues from the JRC. Silvia Salanska for the liaison with the representatives of the Trenčín region, Mircea Ardelean for preparing Figure 2, Wouter Nijs and Pablo Ruiz Castello for the insights on the base case scenario of the JRC-EU-TIMES, Arturs Purvins for carrying out the PLEXOS runs, Alessandro Fiorini for extracting data from the ORBIS database, and Marcello Barboni and Ulrik Von Estorff for reviewing the script and supervision.

Conflicts of Interest: The authors declare no conflict of interest.**Disclaimer:** The views expressed here are purely those of the authors and may not, under any circumstances, be regarded as an official position of the European Commission.

Appendix A

To have an idea of the evolution of the financial situation of the selected 20 companies (Table A1), historical data on capital, working capital, cash flow, current liabilities, and total assets from the year 2007 to year 2016 are analyzed. The result of the activity is represented by elaborating data on financial revenues, operating revenues (turnover), and P/L before tax, while the costs is represented by the depreciation and amortization of the capital, financial expenses, interest paid, long-term debts, costs for material, costs for the employment, and taxation. Historical information on the level of employment in the nine-year time frame are also added as an indication of the trend of the activity. The data for this analysis are extracted from the ORBIS database. The figures bellow can be read as follows: A—financial performance; B—result of the activity; C—costs; D—employment.

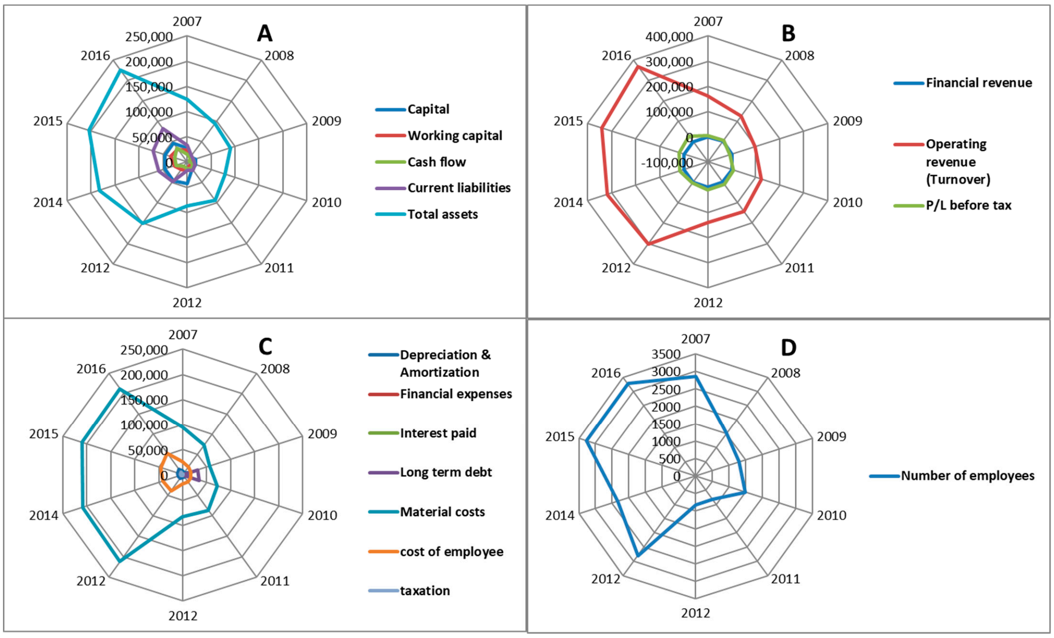

Figure A1. Historical financial results of the companies: Input segment of the coal value chain. (**A**)—financial performance; (**B**)—result of the activity; (**C**)—costs; (**D**)—employment.

The companies operating in the Input segment seem to have recorded their highest performance during year 2016, except for what is the employment concerned that registered one of the lowest levels of the previous 10 years of activity.

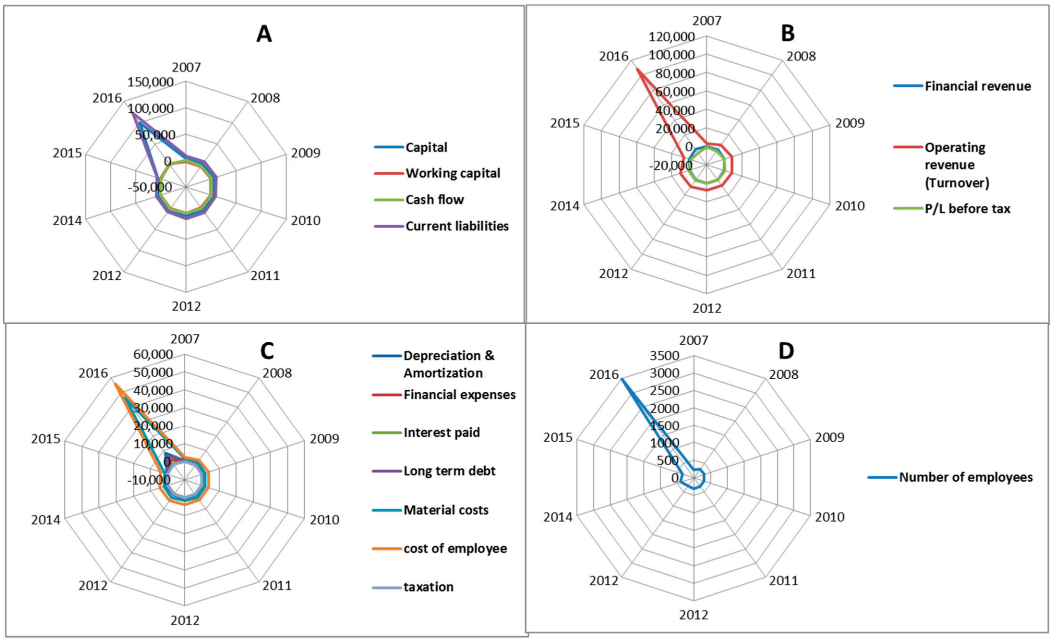

Figure A2. Historical financial results of the companies: Mining segment of the coal value chain. (**A**)—financial performance; (**B**)—result of the activity; (**C**)—costs; (**D**)—employment.

The data collected for the companies operating in the Mining segment of the value chain show a similar trend with respect to the four variables taken into account in this analysis. The highest performance has been registered again for year 2016—in this case, also for what is the number of employees concerned. It is worth noting that the ORBIS database, despite being one of the largest and more comprehensive and updated databases on private companies available on the market, can be incomplete with respect to some sectors and/or years when the geographical coverage of the analysis is limited to a small region, as in the case of this study.

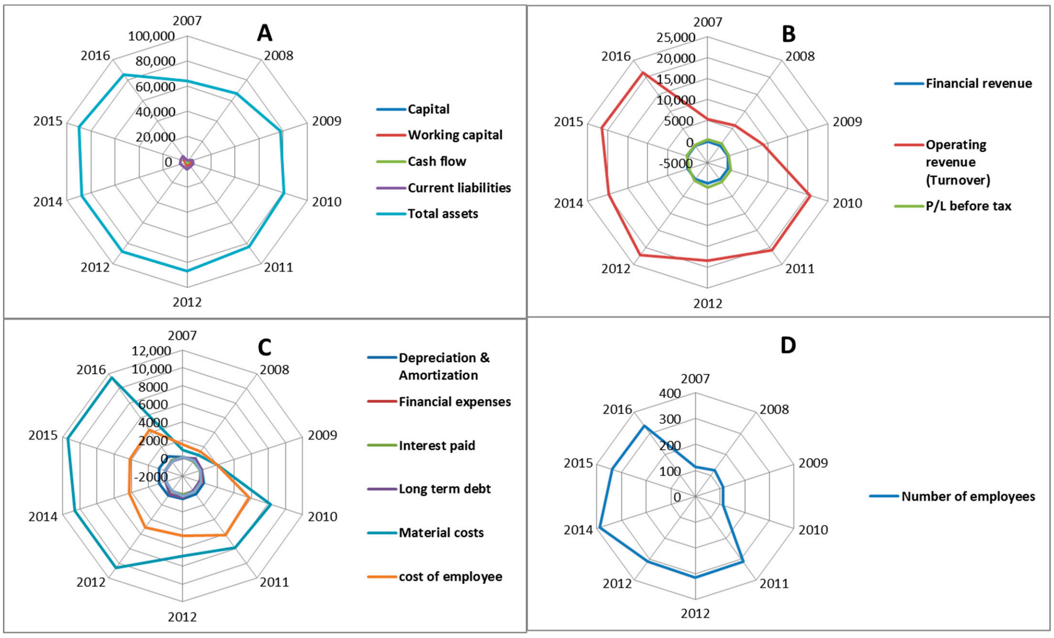

Figure A3. Historical financial results of the companies: Transport segment of the coal value chain. (**A**)—financial performance; (**B**)—result of the activity; (**C**)—costs; (**D**)—employment.

The companies operating in the Transport segment of the value chain show a different trend compared to the previous two segments. Here, the performance of the sector seems to be constant during the last 5–7 years. Again, the completeness of the data collected for the four groups of variables seem to be nonhomogeneous, as some variables (i.e., working capital) record very low levels all through the time horizon of the analysis.

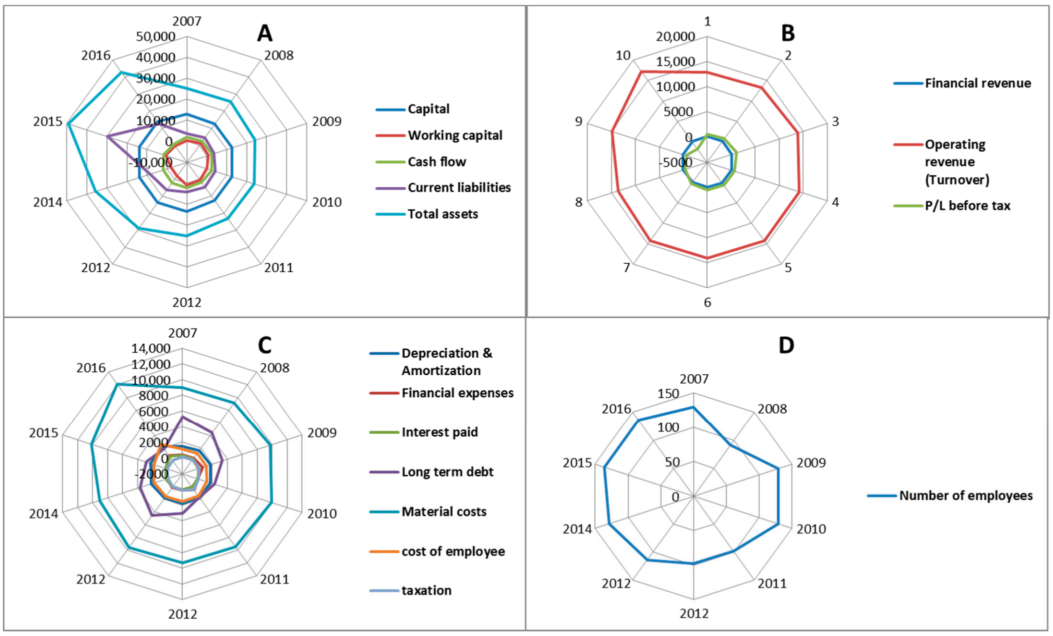

Figure A4. Historical financial results of the companies: End Market segment of the coal value chain. (**A**)—financial performance; (**B**)—result of the activity; (**C**)—costs; (**D**)—employment.

For the End Market, the historical trend of the four variables show all a similar a quite constant trend all through the time horizon of the analysis. The companies belonging to this segment of the coal value chain seem to have experienced a more stable operation, in terms of performance and presence in the market during the previous 10 years.

Table A1. The list of companies included in the financial analysis.

Company	Type of Activity	Value Chain Segment
Contitech vibration control Slovakia s.r.o.	Manufacture of other rubber products	Input
Fortischem a.s.	Manufacture of plastics in primary forms	Input
Saargummi slovakia s.r.o.	Manufacture of other rubber products	Input
Slovaktual s.r.o.	Manufacture of builders' ware of plastic	Input
Vegum a.s.	Manufacture of other rubber products	Input
Bana Cary a.s.	Coal mining	Mining
Bana Dolina a.s.	Coal mining	Mining
BIC Prievidza s.r.o.	Other education	Mining
HBP security s.r.o.	Private security activities	Mining
Hornonitrianske Bane Prievidza a.s	Coal mining	Mining
Ekosystemy s.r.o.	Machining	Transport
Evots s.r.o. *	Freight transport, excavations, demolitions and waste management	Transport
Hornonitrianske bane zamestnanecka a.s. **	Manufacture of machinery for mining quarrying and construction	Transport
Hornonitrianske bane a.s. ***	Manufacture of machinery for mining quarrying and construction	Transport
Agro GTV s.r.o.	Greenhouse agriculture	End Market
Agro rybia farma s.r.o.	Freshwater aquaculture	End Market
Handlovska energetika s.r.o.	Steam and air conditioning supply	End Market
Paliva a stavebniny a.s.	Other retail sale in non-specialised stores	End Market
Priamos a.s. Prievidza	Agents involved in the sale of a variety of goods	End Market
Prievidzske tepelne hospodarstvo a.s.	Steam and air conditioning supply	End Market

* active also in End Market; ** active also in Input—Mining; *** active also in Input—Mining—End Market.

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