Kakšna je vrednost? Določitev kapitala evropskih rek in praga hidroelektrarn

PETRA GSODAM & HEINRICH STIGLER

Povzetek Za osnovna sredstva elektroenergetskih podjetij sta značilna dolga življenjska doba in visoki investicijski stroški. Zgodovinsko gledano so osnovna sredstva prikazana v bilancah elektroenergetskih podjetjih s prenizko vrednostjo: realna vrednost osnovnih sredstev ni prikazana zaradi nominalnega višanja cen. Alternativo za prikaz realne vrednosti osnovnih sredstev predstavlja koncept kapitala, ki temelji na nadomestnih vrednostih zmanjšane amortizacije (neto kapitalska vrednost). Za izračun vrednosti osnovnih sredstev je potrebno poznati podatke o višini vložka v času gradnje v vsaki elektrarni (zgodovinska nabavna vrednost) kakor tudi skupno izhodiščno leto (nadomestne vrednosti). V članku je prikazano, kako oceniti ne-standardne naložbe v hidroelektrarne ter kako izračunati kapital pretoka reke in prag hidroelektrarne. Dolgoročna sredstva v obliki pretočnosti reke in pragu hidroelektrarne so primerjana na osnovi zgodovinskih stroškov in nadomestnih vrednosti. Ugotovljeno je, da je mogoče, glede na nominalno povišanje cen za nadomestne naložbe, kot je to primer z hidroelektrarnami z dolgo življenjsko dobo, zagotoviti ohranitev vrednosti premoženja družbe le z uporabo amortizacije na osnovi nadomestne vrednosti.

Ključne besede: • osnovna sredstva • elektroenergetska podjetja • bilanca stanja • kapitalska vrednost • amortizacija •

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What is it Worth? Determining the Capital Stock of European Hydropower Plants

PETRA GSODAM & HEINRICH STIGLER

Abstract High lifetimes and high capital intensities characterize fixed assets of electric utilities. The historical cost concept implicate that long-lasting fixed assets are shown too low in balance sheets of electric utilities: the real value of long-lasting assets is not shown because of nominal price increases. An alternative to show the real value of long-term assets represents the capital stock concept based on replacement values less depreciations (net capital stock). To calculate the capital stock, information regarding the level of investment in each power plant at the time of construction (historical acquisition values) and with regard to a common base year (replacement values) is necessary. This paper shows how the not-standardized investments in hydropower plants can be estimated and how the capital stock of run-of-river and threshold hydropower plants can be calculated. Long-term assets in the form of run-of-river and threshold hydropower plants are compared based on historic costs and replacement values. The paper concludes that given nominal price increases for replacement investments, as is the case with long-lasting hydropower plants, only depreciations based on replacement values can ensure preservation of the company's assets.

Keywords: • fixed assets • electric utilities • balance sheet • capital stock • depreciation •

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1 Introduction

One of the principles of proper accounting is the historical cost concept. On the basis of this principle, which is mandatory in the individual financial statements under commercial law, the cost of acquisition or production represent the upper limit for assets in the balance sheet (§ 203 para. 1 UGB). This aims at preserving a company's nominal capital, whereby monetary fluctuations and changes in replacement values over time are not considered [1]. The historical acquisition values as upper limit for the valuation lead to an undervaluation of long-lasting assets and hidden reserves are created within the company. As a consequence, the equity of a company appears too low than it is actually [2]. Ensuring a company's long-term viability as a superior corporate objective for capital-intensive companies with long-lasting assets is not possible with nominal capital preservation. Instead, such companies need to focus more on preserving a company's assets rather than a company's nominal capital. Therefore, the valuation of long-lasting assets in the balance sheet has to consider replacement values instead of historical acquisition values. The valuation based on replacement values was already taken up by Schmidt [3]. Schmidt's theory of the organic balance sheet includes price increases and, consequently, considers replacement values instead of historical acquisition values. The organic balance sheet is oriented towards preserving a company's assets. This theory was developed at times with high annual nominal price increases (hyperinflation in Germany). The International Financial Reporting Standards (IFRS) also addressed the issue of undervaluation (or overvaluation) of fixed assets. Therefore, there are two options for the valuation within the consolidated financial statements where companies can choose between the use of historical acquisition values and the fair value [1].

Depreciations consider impairments of fixed assets arising e.g. through use and aging. From an economic point of view, a constant depreciation based on historical acquisition values during the average useful life (straight-line depreciation) is common. Depreciations are part of the cash flow and should be used for replacement investments [2]. Depreciations based on historical acquisition values are – for long-lasting assets – due to nominal price increases too low to ensure adequate replacement investments at the end of a power plant's life. Long-lasting assets in capital-intensive industries, such as the electricity industry, require depreciations based on replacement values to preserve a company's assets. Preserving a company's assets is not possible with depreciations based on historical acquisition costs [3].

The fixed assets are particularly important for electric utilities due to the longevity of the power plants. The determination of the actual value of fixed assets is, however, difficult. In sectors with high asset turnover, the value of fixed assets is shown in the balance sheets of the companies. This is not the case in the electricity sector, since this sector faces a rather low asset turnover and nominal price increases, which have a great impact on long-lasting assets, are not considered. Therefore, an alternative method has to be used to determine the actual value of fixed assets [4]. One method is to determine the net capital stock, which shows the fair value of the fixed assets at a specified reference day. The net capital stock is calculated based on the gross capital stock (capital stock at replacement values) less cumulated depreciations [5]. Since the net capital stock is based on the gross capital stock and, therefore, on replacement values, it is important to determine accurate replacement values. Hydropower plants are specific regarding their investment costs. Thermal power plants are standardized and power plants of the same technology are similar to each other. The investment costs for a thermal power plant can be estimated based on other projects with known investments. On the contrary, hydropower plants vary from site to site and investment costs can only be estimated with uncertainty.

Investment costs depend on local environmental factors and geographic circumstances, such as gradient or average annual discharge of the river. Therefore, it is difficult to make generalizations regarding the investment costs of run-of-river and threshold hydropower plants.

Compared with other electricity generation technologies, run-of-river and threshold hydropower plants have a very high useful life. The comparatively old hydropower plants are shown in the balance sheets of the companies with their historical acquisition values. These values do not reflect the actual value of the power plants. A 40-year-old run-of-river hydropower plant produces too low depreciations due to annual nominal price increases, so that there is insufficient capital for replacement investments in the capital-intensive power plants available. An overview of the age structure of run-of-river and threshold hydropower plants of selected countries is shown in Figure 6.1. Figure 6.1 shows that a large part of hydropower plants was built between 1950 and 1990. Given an assumed economic useful life of 50 years, many of these power plants are already fully depreciated.

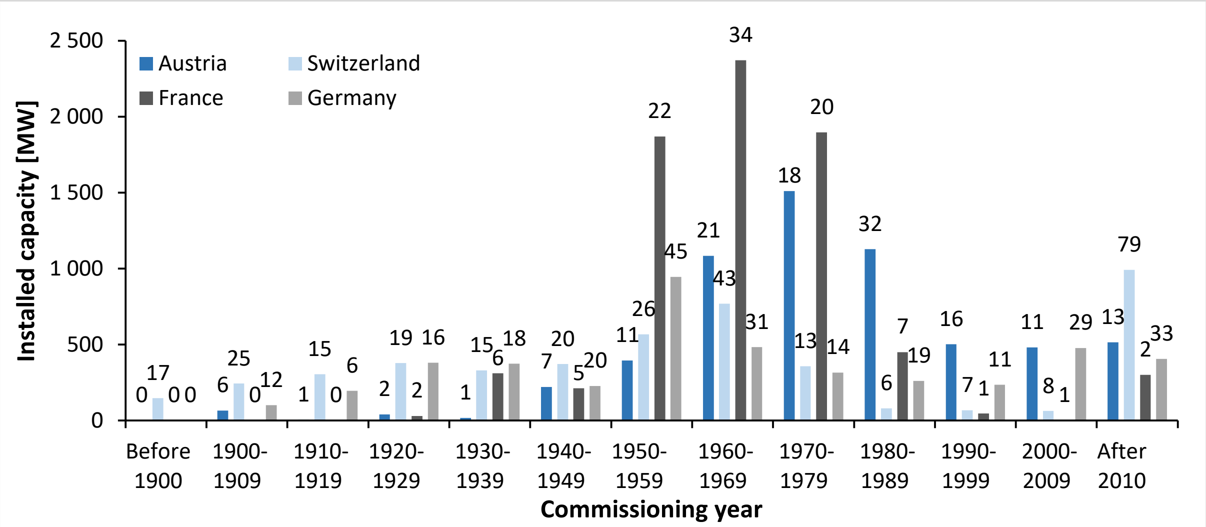

Figure 6.1. Age structure of run-of-river and threshold hydropower plants in selected countries (Source: own representation, based on the Institute's database).

Against this background, the following research questions arise:

- How can bandwidths for the specific investment costs of run-of-river and threshold hydropower plants be determined and how high are the resulting bandwidths?
- How do the fixed assets of electric utilities change if replacement values instead of historical acquisition values are used to determine the value of fixed assets?

1.1 The capital stock in the electricity sector

In this paper, the term capital stock refers to all non-financial assets that are used for more than one year for electricity production (i.e. power plants). The stock of fixed assets based on replacement values without consideration of depreciations at 2015 prices is referred to as gross capital stock; with consideration of depreciations the stock of fixed assets is referred to as net capital stock. The gross capital stock is based on replacement values. The price for all fixed assets is referred to a specific base year, resulting in constant prices for the replacement. The gross capital stock is the basis for the net capital stock – the cumulated depreciations are subtracted from the gross capital stock and the depreciated capital stock is shown [5]. The economic useful live used to calculate depreciations and residual book values in accounting is not equal to the technical lifetimes. Therefore, the net capital stock, which should represent the actual value of the fixed assets, is calculated based on the higher technical lifetimes.

The ratio of gross to net capital stock is called degree of modernity. This ratio provides information on how much of the historic investments are not yet depreciated; the ratio informs about the aging process of the fixed assets [6]. Another key performance indicator based on the capital stock is the capital intensity. This indicator represents the ratio between capital stock and number of employed people, whereby the average employment of capital per employee is measured. Both key performance indicators are quite high in the electricity sector compared to other sectors, e.g. the manufacturing sector [4, 7].

One method to determine the fixed assets of a sector is to sum up the fixed assets shown in balance sheets of individual companies. However, this is not very effective in sectors with long-lasting assets and high capital intensities. This would result in a distorted picture of reality; due to nominal price increases the value of fixed assets would be too low. The actual value of fixed assets cannot be determined from the balance sheets due to long technical lifetimes and depreciations based on historical acquisition values [4]. For all those reasons it is of particular importance to apply the capital stock concept to the electricity sector and to determine the gross capital stock and the net capital stock of this sector.

In order to determine the capital stock, time series of the investments in fixed assets as well as their economic useful live and technical lifetimes are necessary [6]. A part of the required information can be derived directly from the Institute’s simulation model ATLANTIS [8]. The missing element is investment in each power plant at the time of construction and based on a common base year for the replacement values. One possibility to determine the missing information for run-of-river and threshold hydropower plants is presented in the next section.

2 Methodology

The determination of the gross capital stock and the net capital stock requires information about the investment in each power plant. Data on investment costs of Austrian run-of-river and threshold hydropower plants are the basis for determining unknown investment costs. A large part of these data were taken from [9].

Investment costs in hydropower plants are highly depending on local environmental factors and geographic circumstances. Therefore, the Austrian power plants are grouped according to the river on which they were built. The considered power plants are located on the following rivers: Danube, Drava, Enns, Inn, Mur, Salzach, and Traun. The specific investment costs of the power plants, determined through extensive research, on the above mentioned rivers are shown in Figure 6.2. Figure 6.2 shows the entire bandwidth for each river as well as the bandwidth excluding minimum and maximum values. Within each box, the mean for each river is indicated. The specific investment costs are shown in constant prices for 2015 per annual kilowatt hour (kWh_a).

Based on the 10 % quantile as lower limit and the 90 % quantile as upper limit, the statistical bandwidths and the mean values of the adjusted specific investment costs in EUR_{2015} based on the annual production capacity (APC) are shown in Table for each river. The 10 % quantile and the 90 % quantile are used to eliminate minimum and maximum values.

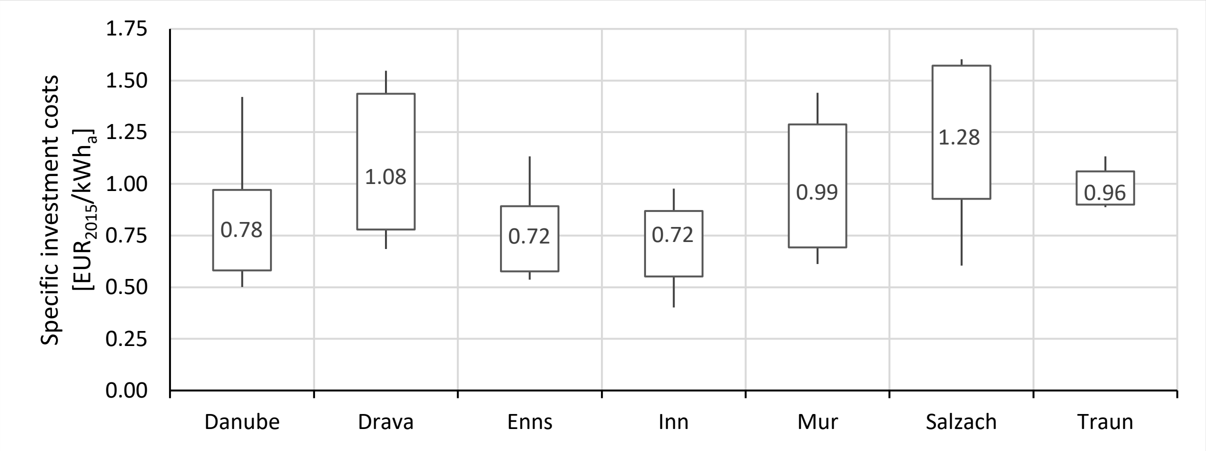

Figure 6.2. Boxplot of the specific investment costs based on the APC (Source: own representation).

The bandwidths shown in Table 6.1 are used to determine the unknown investment costs of run-of-river and threshold hydropower plants. For this purpose, the bandwidths for each river are distributed linearly over a period of 95 years, from 1920 to 2015, with the 10 % quantile reflecting the specific investment costs of 1920 and the 90 % quantile the specific investment costs of 2015. This is based on the assumption that first the particularly attractive hydropower plants were built on each river, followed by more expensive alternatives, so that at the end only comparatively expensive power plants remain. Potential cost savings resulting from technological progress in the construction of run-of-river and threshold hydropower plants are offset by the construction of power plants at unfavourable locations as well as increasing environmental requirements.

Table 6.1: Bandwidths of the specific investment costs based on the 10 % quantile and the 90 % quantile as lower and upper limit (Source: own representation).

River	Specific investment costs [EUR_{2015}/kWh_a]	Mean [EUR_{2015}/kWh_a]
Danube	0.581–0.971	0.75
Drava	0.779–1.436	1.08
Enns	0.577–0.892	0.72
Inn	0.552–0.869	0.72
Mur	0.692–1.288	0.99
Salzach	0.927–1.572	1.28
Traun	0.900–1.060	0.93

The lower limit for the specific investment costs for all power plants on a river is the 10 % quantile. Specific investment costs in constant prices cannot be below this limit. The year 1920 as lower limit is chosen since only few European countries built hydropower plants before this year. This is illustrated in Figure 6.3. Among the continental European countries, Switzerland has the most (large) run-of-river and threshold hydropower plants with a commissioning year before 1920 (59), followed by Germany (19) and Italy (13).

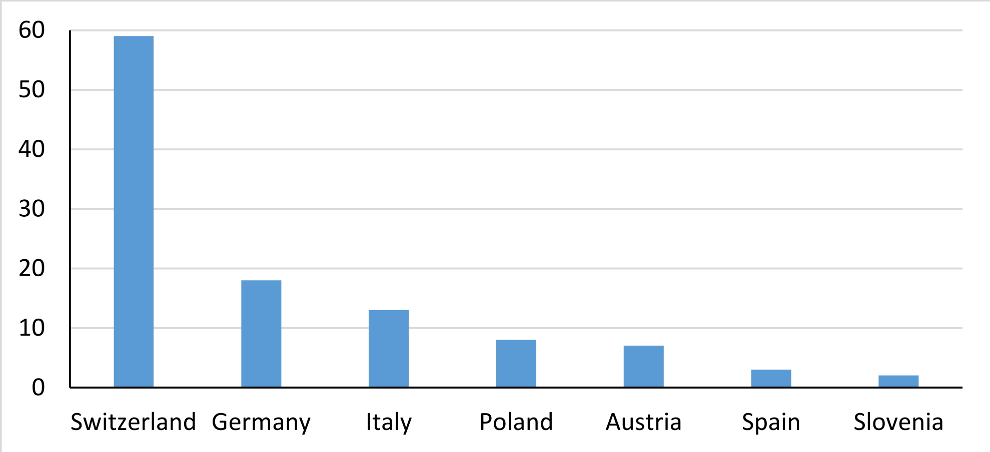

Figure 6.3. Run-of-river and threshold hydropower plants with a commissioning year before 1920 in selected European countries (Source: own representation, based on the Institute's database).

In order to calculate the total investment costs in constant prices ($TIC_{COP\ 2015}$) based on specific investment costs ($SIC_{COP\ 2015}$), it is necessary to relate the specific investment costs to the APC of the power plant. This is shown in (1).

$$TIC_{COP\ 2015}\ [EUR] = SIC_{COP\ 2015} \left[\frac{EUR}{kWh_a}\right] \times APC\ [kWh_a] \quad (1)$$

Next, the $TIC_{COP\ 2015}$ are converted into current prices (TIC_{CUP}) – i.e. prices at the time of construction – using an index for price increases, in order to determine the actual historical acquisition values that had to be paid in the commissioning year, see (2). This is the value of the power plants of which depreciations and the depreciated book values are calculated. Data on average annual inflation in Austria (consumer price index, CPI) are provided by [10]. The CPI is chosen because it presents – among all European countries – the longest available time series to measure price increases. For calculating historical acquisition values of very old run-of-river and threshold hydropower plants (commissioning year before 1948), an average annual price increase of 2 % is assumed. Before 1948 no data on CPI in Austria is available. 2 % is chosen because this represents the ideal annual inflation according to European Central Bank, the Federal Reserve and many others.

$$TIC_{\ CUP}\ [EUR] = TIC_{COP\ 2015}[EUR] \times \frac{CPI_{Commissioning\ year}}{CPI_{2015}} \quad (2)$$

Based on the data of the Austrian run-of-river and threshold hydropower plants, the unknown investment costs of run-of-river and threshold hydropower plants built in other European countries are determined. It is assumed that rivers with similar geographic circumstances, like gradient and water volume, have similar specific investment costs and differ only regarding the price level of the countries. In order to represent the price levels correctly, data from [11] are used. In this work, price levels for 2015 are used because the common base year for the replacement values in constant prices is the year 2015. Information like length, gradient, average annual discharge and others, are collected for each river or river section on which run-of-river and threshold hydropower plants were built according to the Institute’s database. Furthermore, the geographic situation (river in the mountains, lowlands) is taken into account via Google Earth. Based on this information, the rivers are compared and an Austrian "reference river" is assigned to each river. If a river does not show significant similarities with any of the Austrian rivers, the mean of all analysed Austrian rivers for the commissioning year of the considered power plant is used. The conversion from constant to current prices is based on the CPI for the respective country, to calculate the historical acquisition values, see (2). The CPI of a country is provided by national statistical offices and the OECD statistics database. For some countries, such as most Balkan countries, it is not possible to find complete historical time series back to 1948 and before 1948. Missing data are filled with the "2 %-assumption", same as for Austria before 1948. Many countries had to cope with runaway inflation (10–50 %) or even hyperinflation (> 50 %) in the past. After periods with runaway inflation or hyperinflation, a monetary reform is usually unavoidable. Therefore, it is assumed that the index after this period is just slightly above the index before. These high price increases are adjusted and the assumption is made that the average annual inflation rate during these years was 2 %.

3 Results

Based on the method presented in Section 2, the capital stock (replacement values) and the value of fixed assets shown in the balance sheets of the companies (historical acquisition values) were calculated for 28 continental European countries (excluding Scandinavia, Ukraine, Moldova, Belarus and Russia). Data are shown in Table. The depreciated values (net capital stock and depreciated book values) were calculated using the economic useful life and the technical lifetimes, respectively. The net capital stock is based on the technical lifetime (assumption: 80 years), while the depreciated book values are based on the economic useful life (assumption: 50 years). At the end of 2015, the considered countries show a gross capital stock at replacement values of 158.5 bn EUR for electricity production out of run-of-river and threshold hydropower plants. Gross capital stock less depreciations with a technical lifetime of 80 years results in 70.8 bn EUR for the net capital stock at replacement values. On the basis of the historical acquisition values – the prices that had to be paid in the commissioning year – the fixed assets of the companies amount to 57 bn EUR. Less depreciations with an economic useful life of 50 years the depreciated book values shown in the balance sheets of companies amount to 26.7 bn EUR. At the end of 2015, the considered countries have in total about 1 600 run-of-river and threshold hydropower plants (microgeneration units were combined to aggregates for each country) with an installed capacity of about 50 GW.

It can be seen from Table 6.2 that the net capital stock based on depreciated replacement values is higher than the fixed assets without depreciations based on historical acquisition values. The degree of modernity shows the ratio between the gross capital stock and the net capital stock and provides information on how much of the investments are not yet depreciated. The degree of modernity for the above-mentioned capital stock is 45 %. This means that 45 % of the capital stock based on replacement values are not yet depreciated through use and aging with an assumed technical lifetime of 80 years. Considering historical acquisition values and an economic useful life of 50 years, the degree of modernity for the fixed assets is 47 %. The degree of modernity for the investigated countries was high in Estonia (88 % and 82 %, respectively) and Greece (87 % and 84 %, respectively), while this indicator was low in Bulgaria (29 % and 14 %, respectively) and Lithuania (36 % and 15 %, respectively). The degree of modernity in Slovenia is 43 % and 51 %, respectively.

Table 6.2: Capital stock (replacement values) and fixed assets (historic acquisiton values) of run-of-river and threshold hydropower plants (Source: own representation).

Country	Gross capital stock (RV[1])	Net capital stock (RV[1])	Fixed assets (hist. AV[2])	Depreciated book values (hist. AV[2])
Albania	757 162 913	436 403 076	392 820 643	201 677 087
Austria	25 804 920 759	13 915 808 433	10 798 748 392	5 168 883 020
Belgium	233 962 135	103 176 333	74 116 424	22 107 525
Bosnia and Herzegovina	1 218 549 134	888 083 921	863 203 273	635 159 890
Bulgaria	360 196 605	103 803 122	94 172 806	13 415 958
Croatia	1 762 895 487	855 416 617	643 186 293	172 163 339
Czech Republic	991 561 465	435 505 894	352 220 967	54 950 337
Denmark	11 095 804	1 803 068	1 128 676	–
Estonia	13 535 401	11 953 955	10 461 580	8 582 995
France	32 344 531 744	12 474 351 151	8 502 937 629	2 347 318 857
Germany	16 483 897 919	6 891 692 608	6 836 624 590	3 348 803 966
Greece	673 600 549	583 961 232	546 196 215	459 229 570
Hungary	90 497 153	37 474 718	17 277 922	2 499 998
Italy	19 319 917 659	7 668 547 347	6 537 097 141	3 465 777 568
Latvia	862 787 482	380 454 644	292 023 805	36 465 132
Lithuania	262 172 125	94 791 775	91 285 235	13 473 818
Luxembourg	106 325 828	44 630 530	28 322 769	7 850 439
Macedonia	75 925 097	38 388 742	36 174 501	14 974 122
Montenegro	130 534 258	118 160 891	118 195 347	111 144 718
Netherlands	132 685 493	89 653 346	80 789 381	38 929 487
Poland	489 865 918	198 152 752	143 593 843	28 609 846
Portugal	9 140 474 058	5 589 838 649	4 739 452 161	3 172 744 354
Rumania	5 740 163 974	3 365 748 785	2 469 970 897	1 103 089 093
Serbia	3 330 417 842	1 786 833 943	1 243 327 443	534 865 489
Slovakia	4 345 973 004	2 785 747 568	1 207 506 927	683 797 681
Slovenia	3 493 633 101	1 508 623 873	922 735 976	470 722 255
Spain	6 439 903 796	3 353 746 340	2 465 744 039	1 322 216 834
Switzerland	23 889 455 797	6 992 514 096	7 614 920 640	3 213 682 084
Total	**158 506 672 502**	**70 755 267 409**	**57 124 235 515**	**26 653 135 462**

[1] Replacement values
[2] Historical acquisition values

Due to nominal price increases the differences between historical acquisition values and replacement values is highest for rather old hydropower plants. Figure 6.4 and Figure 6.5 present a comparison of the investment costs of hydropower plants on the Drava and Sava river. The oldest hydropower plant is Fala on the Drava river with a commissioning year of 1918. In contrast, the youngest hydropower plant is Krško on the Sava river with a commissioning year of 2012. Figure 6.4 and Figure 6.5 show the historical acquisition values and the replacement values as well as the respective depreciated values. All values are referred to the replacement value of 2015 for each power plant. The historical acquisition values only account for a small portion of the replacement values due to nominal price increases. This is illustrated best for the rather old hydropower plants, like Fala, Medvode or Dravograd. Those power plants are also already above their economic useful life of 50 years. Considering the historical acquisition values, they are already fully depreciated. In the balance sheets of the companies such power plants are represented with a value of 1 EUR, so that they are still visible and listed but without any economic value. Considering the replacement value and the technical lifetime of 80 years, all power plants – despite Fala – still show a depreciated replacement value.

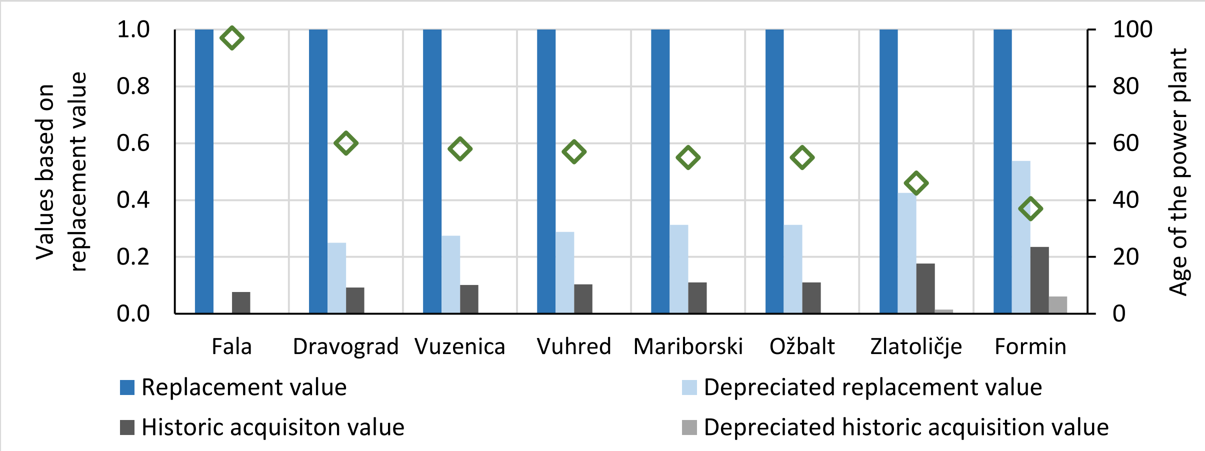

Figure 6.4. Comparison of the investment costs of hydropower plants on the Drava river. Values are referred to the replacement value (Source: own representation).

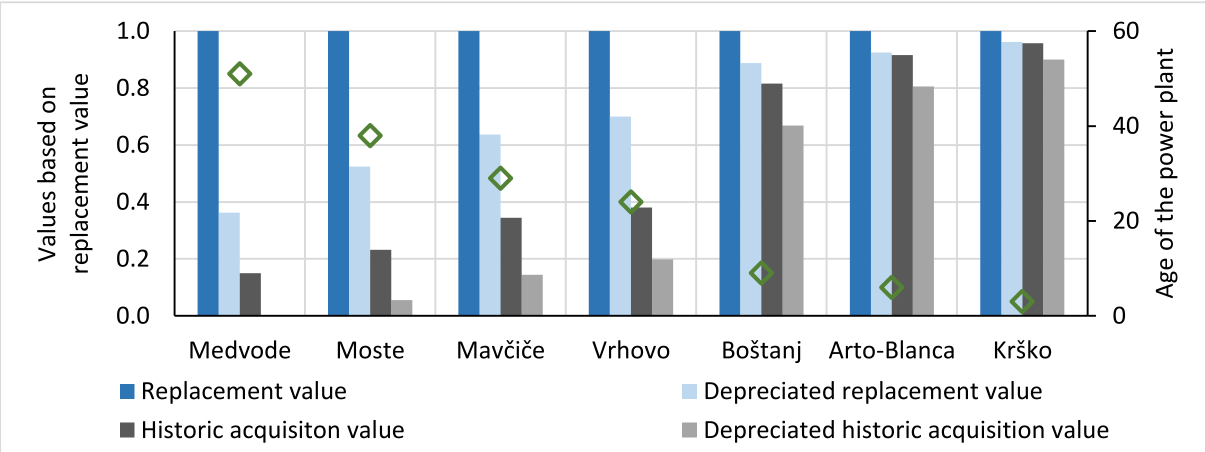

Figure 6.5. Comparison of the investment costs of hydropower plants on the Sava river. Values are referred to the replacement value (Source: own representation).

Figure 6.6 illustrates the investment costs in absolute numbers of the three youngest large hydropower plants in Slovenia, all of them located on the lower Sava river. Also these rather young hydropower plants already show some differences between the replacement values and the historical acquisition values due to nominal price increases. For all three power plants, the depreciated replacement value is higher than the historic acquisition value.

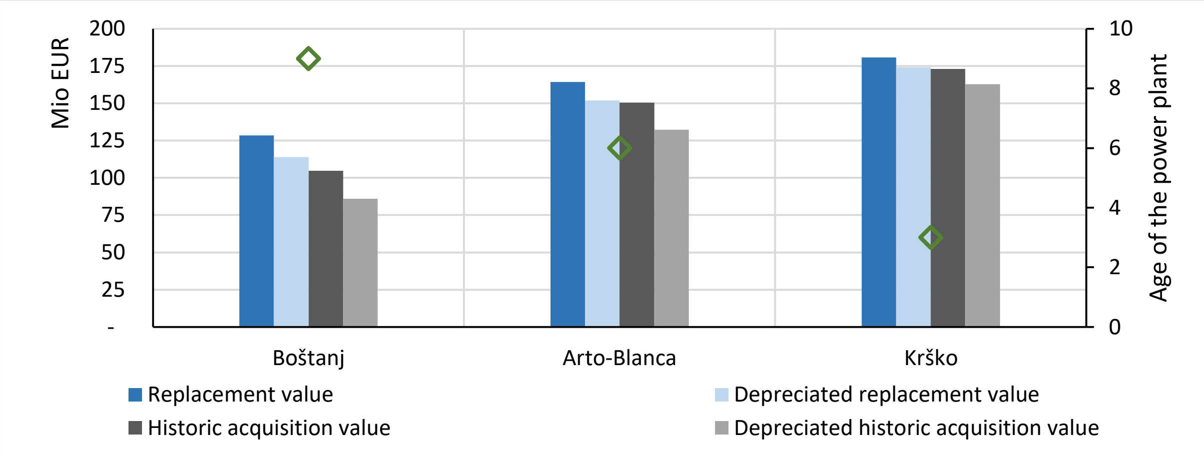

Figure 6.6. Comparison of the investment costs of the three youngest large hydropower plants. The secondary axis shows the age of the power plant (Source: own representation).

4 Discussion and conclusion

The net capital stock based on replacement values is about 2.75 times higher than the depreciated historical acquisition values. When looking at the gross capital stock and the historical acquisition values, the same picture can be observed. In companies with low asset turnover, high capital-intensities and long-lasting assets, the fixed assets are undervalued in the balance sheets of the companies due to historical acquisition values as upper limit for the valuation and nominal price increases. The actual value of fixed assets (capital stock) is higher as shown in the balance sheets. Furthermore, the economic useful life is not equal to the technical lifetime. The net capital stock based on replacement values is perceived to be a suitable method to show the real value of electric utilities' fixed assets. Due to nominal price increases, it is not possible to finance new power plants by using the part of the cash flow which consists of depreciations. Depreciations resulting from the historical acquisition values are not sufficient for preserving a company's fixed assets and provide insufficient financial resources for investments. The determination of the gross capital stock and the net capital stock based on replacement values as well as the determination of the (depreciated) historical acquisition values shown in the balance sheets of the companies provide relevant information on a sector. On the one hand, the actual value of the fixed assets of the companies is shown (capital stock). On the other hand, there are various key performance indicators for productivity analysis, such as capital productivity, capital intensity or degree of modernity.

Investments in run-of-river and threshold hydropower plants are difficult to determine due to plant-specific features and location-specific costs. The method shown in Section 2 is a possibility for the determination of the non-standardised investment costs in run-of-river and threshold hydropower plants. A large part of the investment costs of these hydropower plants consist of the costs for dykes and the dam. These costs depend on the gradient and water volume of the river. Therefore, those characteristics of a river can be used to determine the investment costs in hydropower plants. The calculated investment costs represent an estimate in order to determine the actual value of the electric utilities' fixed assets. Plant-specific features that lead to a reduction in investments during construction cannot be taken into account accurately.

Finally, we can draw the following conclusion. Preservation of a company's fixed assets can only be ensured by deprecations based on replacement values. Depreciations based on historic acquisition values lead to a lack of capital for replacement investments in capital-intensive and long-lasting assets. Furthermore, a valuation based on the historical cost concept does not show the actual value of long-lasting assets due to nominal price increases. The capital stock concept can be used to determine the actual value of long-term fixed assets.

References

[1] R. Heno, Jahresabschluss nach Handelsrecht, Steuerrecht und international Standards (IFRS). 7. Auflage, Berlin Heidelberg: Springer-Verlag, 2011.
[2] G. Wöhe und U. Döring, Einführung in die Allgemeine Betriebswirtschaftslehre. 25. Auflage, München: Verlag Franz Vahlen GmbH, 2013.
[3] F. Schmidt, Die organische Bilanz im Rahmen der Wirtschaft, Leipzig, 1921.
[4] P. Gsodam, G. Feichtinger und H. Stigler, „Ansätze zur Ermittlung des Kapitalstocks der europäischen Elektrizitätswirtschaft," in 14. Symposium Energieinnovation: Energie für unser Europa, Graz, TU Graz Press, 2016, pp. 1-17.
[5] G. Rais und P. Sollberger, „Nichtfinanzieller Kapitalstock - Methodenbericht. Arbeitsdokument," Bundesamt für Statistik BFS, Neuchâtel, 2009.
[6] Statistisches Bundesamt Deutschland, „Gesamtwirtschaft & Umwelt - Vermögensrechnung - Kumulationsmethode," 2017. [Online]. Available: https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VGR/Vermoegensrechnung/Glossar/Kummulationsmethode.html. [Zugriff am 13 Jänner 2017].
[7] A. Schüppel, Wertigkeit von Windkraft, Photovoltaik und Spitzenlastkraftwerken als Teil des gesamten Elektrizitätssystems, Technische Universität Graz: Dissertation, 2014.
[8] H. Stigler, U. Bachhiesl, G. Nischler und G. Feichtinger, „ATLANTIS: techno-economic model of the European electricity sector," Central European Journal of Operations Research, 24: 965 2015.
[9] ÖZE, Jahrgang 1 bis 46, Wien: Springer, 1948-1993.
[10] Statistik Austria, „Kleinhandelspreisindex (Basis: März 1938)," 2016a. [Online]. Available: http://www.statistik.at/web_de/statistiken/wirtschaft/preise/verkraucherpreisindex_vpi_hvpi/zeitriehen_und_verkettungen/022814.html. [Zugriff am 18 August 2016].
[11] Eurostat, „Vergleichende Preisniveaus," 2017. [Online]. Available: e.europa.eu/eurostat/web/products-datasets/-/tec00120. [Zugriff am 4 Jänner 2017].
[12] C. Marchetti, „Primary Enery Substitution Models: On the Interaction between Energy and Society," Technological forecasting and social change 10, pp. 345-356, 1977.
[13] A. Greiner, L. Grüne und W. Semller, „Economic growth and the transition form non-renewable to renewable energy," Environment and Development Economics, Cambridge University Press (CUP), p. 34, 2013.