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CONFERENCE PAPER

Allowed Revenue of Network System Operators in the Croatian Energy Sector and Interest Rate Changes on the Croatian Capital Market

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Abstract: *The energy sector is characterized by market and monopoly activities. Monopoly activities include network activities, transmission and distribution of electricity, and transport and distribution of natural gas. For this reason, the revenue of the network activities is defined as allowed income, and it is under the control of the national energy regulator. In Croatia, this is the Croatian Energy Regulatory Agency. The allowed revenues of the network system operator in the Croatian energy sector are defined by the methodologies for individual network activities, which are based on the method of eligible costs. Network activities are usually capital-intensive activities. Capital cost is an element of the eligible cost method and is accounted for as a weighted average cost of capital (WACC). WACC affects the allowed revenue of the network system operator and the network tariff. It depends on the interest rates on debt capital, the risk-free rate, the market risk premium and the corporate tax rate. Changing the interest rate on the capital market, which also depends on the credit risk of the country, affects both the change in WACC and the change of tariffs for transport / transmission of energy. Amortization and operating expenses of the network operator, approved by the energy regulator, also have a significant impact on allowed revenues. The impact of the WACC change on the allowed revenue and network tariffs of network system operators has a different impact on the network tariffs, which depends on the structure of the eligible costs of a particular network system operator. Changing WACC affects the changes in tariffs of the network system operator. The aim of the paper is to determine how an interest rate change affects the WACC and how the change in WACC affects the change in the allowed revenue and the network tariff of the gas transport operator and the transmission of electricity in Croatia. The paper will analyse the tariffs of electricity transmission and natural gas transport in Croatia and compare them with those in the European Union.*

Keywords: WACC, interest rate; network system operator; allowed revenue; network tariff

JEL Classification: D42, G32, L51

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Introduction

Energy infrastructure operators are characterized by capital intensity and long periods of return on investment. In order for the price of use of the infrastructure to be within a reasonable frame, the regulatory framework should define appropriate and efficient methods of economic regulation. Thus, it should cover reasonable and justifiable cost of operations. The goal is to secure uninterrupted supply and quality of service and reasonable return on investment. At the same time, the regulatory framework also aims at the optimization of investment costs where the outcome is a moderate tariff for access and use of infrastructure, which balances interests of owners and users of infrastructure (Gelo et al., 2018). The EU decided to make a legal framework and operation conditions of natural monopolies in the energy sector. Thus, the regulation of energy activities was introduced with the goal to protect consumer and investor interests by protecting the invested capital, as well as obtaining the framework that is common in completely open market competition. At the same time, to obtain independency and transparency of the processes, the states organize regulatory bodies that define relationships among all participating parties in a non-discriminatory and transparent way (Gelo, Štritof, 2005). Through its legislation (directives), the EU initiated the process of opening its electricity and gas market to competition in 1996. The Directive consisted of common rules for the EU internal market in electricity and natural gas. The process was continued with new directives in 2003 and 2009. The aim of the directives was to create a competitive integrated market in electricity and natural gas in the EU. Further development of the market continued in 2016 with the adoption of a new package of various measures (Clean Energy for All Europeans), thereby completing the establishment of the integrated market and creating the Energy Union (Beus at al., 2018). The regulation of monopoly activities in electricity and gas sector in Croatia was introduced in 2001, when the first set of energy laws was passed, and furthermore in 2002, when the national regulatory authority was established. The national regulatory authority was in charge of regulating transmission and distribution activities in both sectors (Družić et al., 2012). Energy sector regulation is established with the aim to ensure the functioning and improvement of the energy sector, and it is based on the principles of independency, transparency and the protection of customers and investors in the energy sectors. The regulation of energy activities is implemented pursuant to the Act on the Regulation of Energy Activities, and it is in accordance with the EU directives.[1] The operating body for implementing the regulation in the energy sector is the national regulator – Croatian Energy Regulatory Agency (HERA). The directives determine the aims, and national laws determine the organization and responsibility for meeting the aims. Therefore, the regulators' roles are determined by national laws. The role of the regulator in the EU member states varies, taking into consideration market specificities and the initial state at the time when market principles were introduced.

HERA's roles and activities, according to the Act on the Regulation of Energy Activities, can be divided into:

- administrative (issuing previous orders for preferential energy producers, issuing orders on acquiring preferential producer status, issuing licenses for performing energy activities)
- advisory (providing opinions and proposals for improving acts which determine market functioning, consumer protection)
- regulatory (enacting methodologies, tariff items, tariff amounts for regulated activities, resolving complaints for connection conditions, analysing work of regulated energy companies, approving investment plans)

Basic tasks of the regulator are defining tariff systems which include the following:

1. the determination of the regulatory method which then leads to the determination and control of costs,
2. the determination of tariff items which are a result of allocation of costs to customers.

The paper analyses the Methodology for determining the amounts of tariff items for gas transport and the Methodology for determining amounts of tariff items for electricity transmission. The methodology for determining the amounts of tariff items for gas transport refers to the energy company in charge of gas transport, which is Plinacro. The methodology for determining the amounts of tariff items for electricity transmission refers to the energy company in charge of energy transmission, which is the Croatian Transmission System Operator (HOPS). Natural gas transport is a regulated energy-related activity performed as a public service. PLINACRO Zagreb is the transport system operator in Croatia, and it is owned by the Croatian state. Plinacro is in charge of the monitoring, maintenance, development and construction of the entire gas transmission system, and of other activities necessary for the technical functioning of the system. Plinacro operates 2700 km of high-pressure gas pipelines (HERA, 2016). Electricity transmission is a regulated energy activity performed as a public service. In Croatia, Croatian Transmission System Operator (abbreviated HOPS) provides the public service of electricity transmission and is responsible for the operation, management, maintenance, development and construction of the transmission network and cross-border transmission lines, as well as for ensuring the long-term capability of the network to satisfy reasonable requirements for the transmission of electricity. HOPS is the sole electricity transmission system operator in the Republic of Croatia and the owner of the entire Croatian transmission network. It is owned by Hrvatska elektroprivreda, national energy company, which deals with the generation, distribution and supply of electricity. HOPS operates 7700 km of transmission network (HERA, 2016).

Regulation methodology of network system operators

With the aim to ensure energy market functioning, national regulators establish and implement regulatory policies through their activities, i.e. through enacting methodologies and tariffs. The methodologies determine the regulation model, i.e. the model of allocating costs and revenues to the network operator. Methodologies are based on a regulatory approach, i.e. the method, and they can be (Gelo and Štritof, 2005):

- rate of return regulation (Cost plus / Rate of return)
- incentive regulation (which can have three forms):
  - o maximum price (Price cap)
  - o maximum revenue (Revenue cap)
  - o hybrid model (Price cap / Revenue cap)

With the rate-of-return method, the system operator is allowed all eligible operating expenses increased by the margin which reflects the corresponding return on invested capital. This method is also called cost-of-service or cost-plus regulation. The allowed revenue of the operator consists of eligible operating expenses (OPEX) and eligible capital expenditure (CAPEX). Allowed revenues and tariffs are determined for a regulation period which, as a rule, is one, or sometimes two years, after which an audit is carried out, and all elements for the following year are determined. Taking into consideration certain flaws of this method, a new method (Joskow, 2007) was developed – incentive regulation. The primary advantage of the incentive regulation with regard to the rate-of-return regulation is incentivising more efficient business performance of regulated companies, whereby the regulator seeks to approximate the price of use of infrastructure to optimal operating expenses in the long run. With the price cap method, the basic modern method of the incentive regulation is the revenue cap method. The price cap method determines the maximum price, i.e. the tariff, which the operator is allowed to apply during the regulation period which most commonly lasts from three to five years, and sometimes even longer. The revenue cap method determines the maximum revenue which the operator is allowed to generate during the regulation period. In addition to the mentioned methods, a series of hybrid models which combine basic regulation models is also applied in the regulatory practice. Apart from the mentioned regulation methods, there are many various instruments for service quality regulation which regulators also apply (Pérez-Arriaga, 2013), but this is not the subject of this analysis.

Selecting the regulation method is based on the regulatory approach which takes into consideration specificities and the development level of the energy market in a regulatory area. Therefore, the methods vary from country to country in the EU. The cost-plus method is used for energy transmission in Belgium. The incentive-based method is used by the Czech Republic, France, Germany and the Netherlands. The revenue cap or price cap method is mostly used by eastern EU countries, Poland, Romania, Slovakia, but also Sweden. A method combination is used by Finland,

Greece, Italy, Spain, Switzerland and the UK, whereas the cost-plus method is used in Croatia. For gas transport, the revenue cap method is used by the Czech Republic, Finland, Hungary, Luxembourg, the Netherlands, SE and Slovenia, whereas the price cap method is used by Latvia and Lithuania. The rate-of-return method is used by Greece and Estonia, whereas other countries use a combination of methods. Croatia uses a revenue cap method based on incentive regulation.

This paper analyses two similar energy network activities, gas transport and electricity transmission, i.e. the allowed revenue of the gas transport system operator (Plinacro) and the electricity transmission system operator (HOPS). The analysis is based on the adopted methodologies which are the base for determining the allowed revenue and tariff. Taking into account the complexity of methodologies, as well as numerous elements defined with them, the analysis is directed at a very important element where energy companies have no impact. These are interest rates which are a result of trends and conditions on the capital market of the Republic of Croatia, i.e. the credit rating of the Republic of Croatia, and which are a reflection of the Croatian economy. Since network energy activities are capital intensive, the impact of the change in interest rates on the financial market is significant.

Regulation methodology of gas transport system

The methodology for determining the amounts of tariff items for gas transport is based on the incentive regulation model. The planned allowed revenue AR^P_t is determined for a year according to the formula:

$$DP^P_t = OPEX^P_t + A^P_t + PRO^P_t + PV\delta_t - (P_{PRIK}{}^P_t + P_{NU}{}^P_t + P_{OST}{}^P_t)$$

where:

DP^P_t – is the planned allowed revenue in a regulation year t (HRK),

$OPEX^P_t$ – are the planned operating expenses in a regulation year t (HRK),

A^P_t – is the planned amortisation of regulated funds in a regulation year t (HRK),

PRO^P_t – is the planned return on regulated funds in a regulation year t (HRK),

$PV\delta_t$ – is a part of the difference between the revised allowed revenues and the generated revenues in the year T-1 and in the previous years of the regulation period expressed in a regulation year t (HRK),

$P_{PRIK}{}^P_t$ – is the planned revenue from the connection fee and the increase in connection capacity in a regulation year t (HRK),

$P_{NU}{}^P_t$ – is the planned revenue from non-standard services in a regulation year t (HRK),

$P_{OST}{}^P_t$ – is the planned other operating revenue which does not refer to the core business of the transport system operator (hereinafter: planned other operating revenue), in a regulation year t (HRK).

For the purpose of this analysis, the variables which vary from year to year, i.e. $PV\delta_t$, $P_{PRIK}{}^{P}{}_{t}$, $P_{NU}{}^{P}{}_{t}$ and $P_{OST}{}^{P}{}_{t}$, are zero. These variables do not have a significant impact on the allowed revenue, and the change in interest rates does not affect their change. Thus, we obtain a simplified model for further analysis.

The planned revenue from regulated funds is:

$$PRO^{P}{}_{t} = ROpros^{P}{}_{t} \times WACC$$

where:

$PRO^{P}{}_{t}$ - is the planned return on regulated funds in a regulation year t (HRK),

$RO_{pros}{}^{P}{}_{t}$ - is the planned average amount of regulated funds in a regulation year t (HRK),

WACC - is the WACC amount for the regulation period (%).

WACC is a variable which affects the planned allowed revenue of the transport system operator.

For the purpose of calculating tariff items, a simplified equation will be used for the reference tariff item of working energy for all customers which uses the total revenue in the ratio with the total transmitted energy in the system operator. Thus, we avoid the tariff item breakdown for each customer category, and the simplified model illustrates the average reference item:

$$TS_p = \frac{DP_t^P}{E}$$

where:

$DP^{P}{}_{t}$ – is the planned allowed revenue in a regulation year t (HRK),

E – is the parameter which will be shown, in this simplified model, as the energy transmitted through the system (MWh)

Regulation methodology of electricity transmission system

The methodology for determining the amounts of tariff items for electricity transmission is based on the basic principle that the revenue should cover total expenses which are based on total eligible expenses and generated revenue.

The total expenses UTP are determined for a year according to the formula:

$$UTP = TP_{pos} + TP_{kap} - TR_{nsu} - TR_{ppk}$$

where:

TP_{pos} – are the operating expenses (OPEX)

TP_{kap} – are the capital expenditure (CAPEX)

TR_{nsu} – are the expenses of providing non-standard services
TR_{ppk} – are the revenues from allocating cross-border capacities

For the purpose of this analysis, the variables which vary from year to year, i.e. TRnsu and TRppk, are zero. These variables do not have a significant impact on the total operating expenses. Thus, we obtain a simplified model for further analysis.

Capital expenditure equal to:

$$TP_{kap}=PR_{im}+A$$

where:
PR_{im} – is the return on regulatory assets
A – is the amortisation

The return on regulatory assets PR_{im} equals to:

$$PR_{im}=\frac{WACC}{100}*RI$$

where:
WACC – is the weighted average cost of capital
RI – is the average value of the regulatory assets

From the methodology elements, it is noticeable that WACC is a variable which affects the level of operating expenses, as well as the revenue, i.e. tariffs, of the transmission system operator.

For the purpose of calculating tariff items, a simplified equation is used for the reference tariff item of working energy for all customers which uses the total revenue in the ratio with the total transmitted energy in the system operator. A simplified model illustrates the average reference item:

$$Ts=\frac{UTP}{E}$$

where:
UTP – are the total operating expenses
E – is the parameter which will be shown, in this simplified model, as the energy transmitted through the system (MWh)

Weighted average cost of capital – WACC

The most widely used approach for estimating the cost of equity is the Capital Asset Pricing Model (CAPM) (Frontier Economics). CAPM revolutionized modern fi-

nance. Developed in the early 1960s by William Sharpe, Jack Treynor, John Lintner and Jan Mossin, the model provided the first coherent framework for relating the required return on an investment to the risk of that investment (Perold, 2004). It displays the relationship between risk and expected return for a company's assets. The capital asset pricing model provides a theoretical structure for the pricing of assets with uncertain returns (Bollerslev at al., 1988). This model is used throughout financing for calculating expected returns for assets while including risk and cost of capital. The attraction of CAPM is that it offers powerful and intuitively pleasing predictions about how to measure risk and the relation between expected return and risk (Fama and French, 2004). The CAPM model is based on the assumption of a perfect and fully efficient market, which, of course, does not exist in practice. However, CAPM is still widely used in applications, such as estimating the cost of equity capital for (energy) companies and evaluating the performance of managed portfolios.

The cost of capital is one of the most important factors that energy regulators, and companies, have to estimate. With the regulatory assets values of the Croatian transmission and gas networks approaching 1 billion EUR, even small changes in the allowed return on asset base can have a significant impact on customers' bills. Estimating the overall cost of capital using CAPM involves the following steps (Crew and Parker, 2006): first, the risk-free interest rate is estimated. The second step involves estimating the company-specific debt premium. The third step then involves estimating the markets' valuation of equity risk – the equity risk premium. The fourth step is to estimate the risk associated with the specific regulated activity. The fifth step involves weighting together the cost of debt and the cost of equity to produce an overall weighted average cost of capital (WACC). Finally, it is necessary to decide whether to set the cost of capital on pre-tax or capital gains taxes.

WACC calculation

For calculating the cost of equity, the most widely used regulatory approach is chosen, as elaborated in (Brounen et al., 2004). In the methodologies, WACC is calculated according to the formula:

$$\text{WACC}=\frac{r_e}{(1-p_d)} * \frac{E}{E+D} + r_d * \frac{D}{E+D}$$

where:
D – is the total debt
E – is the total equity
r_e – is the cost of equity (%)
r_d – is the cost of debt (%), and
p_d – is the corporate tax rate (%)

The cost of debt is defined as the average interest rate on liabilities. However, a very common approach in estimating the cost of debt is estimating the risk-free rate on which country-specific debt premium is added (Ajodhia and Hakvoort, 2005). A Croatian methodology defines the post-tax WACC.

The cost of equity or yield on equity after taxation is determined:

$$r_e = r_f + (r_m - r_f) \cdot \beta$$

where:

r_f – is the risk-free rate
r_m – is the expected return on the market
$(r_m - r_f)$ – is the market risk premium
β – is the measure of the relative (or non-diversifiable) risk of the company or industry

The risk-free investments and the return obtained from them exist only as a theoretical abstraction. In practice, such investments with minimum risks are investments in government securities. The market risk premium implies that any additional risk taken by an investor should be rewarded with an interest rate higher than the risk-free rate. The difference between the market return and the risk-free rate of return is a risk premium. Risk premiums may be calculated for a particular security, a class of securities, or a market. The equity β (beta) coefficient is essentially a measure of price volatility of a company's shares in comparison to the market index. In case of a high beta, the company's share prices will tend to oscillate more than the market index (β is greater than 1), and in case of a low beta, the company's share prices will tend to oscillate less than the market index (β is lower than 1). A standard procedure for estimating betas is to regress share returns against market returns. The slope of the regression corresponds to the beta of the share and measures the riskiness of the share (Štritof et al., 2009). The beta is very often estimated by using relatively straightforward statistical parameters:

$$\beta = (\mathrm{cov}_{s,m})/(var_m)$$

where $\mathrm{cov}_{s,m}$ is the covariance of the company's share prices with the market prices and var_m is the variance of the market prices.

In essence, funding through the owner's capital would be possible in case when the profitability of a regulated entity is sufficient to cover risk-free rates of return and the individual risk premium based on the market risk. This is secured by using CAPM. However, when a regulated comapny is not listed on a liquid market, direct estimation of the β coefficient is not possible. Thus, regulators often use comparisons to similar companies in other markets and other regulatory regimes. For example,

in Argentina this is recognized through the legal framework, which defines the rate of return on regulatory assets. The estimation has to be based on comparison with other sectors with similar risk within the country and internationally. In addition, in regulatory practice, the β coefficient and other WACC elements are determined in a reverse procedure, as a result of an acceptable WACC level. (Pardina at al., 2008; Družić et al., 2012)

The weighted average cost of capital is a variable which depends on the interest rates on the capital market, variability coefficient of shares and regulatory approach related to the equity and debt capital. Interest rates are different for each state, debt-to-equity ratios are different for each regulatory area, variability coefficient of shares depends on the company activity type, i.e. the risk, so the β is different for the gas transport system operator and the electricity transmission system operator. From the elements of WACC calculation, a different WACC amount can be expected for different states and different activities.

A comparative review of WACC calculation elements and the WACC amount for gas transport system operators of chosen EU member states is shown in Table 1.

Table 1 WACC comparison for different EU natural gas transporters

Parameter	Croatia	Germany	Poland	Finland	Czech R.	France	Slovakia	average
Risk-free rate r_f	2.75%	3.80%	5.42%	1.82%	4.60%	2.00%	4.01%	3.49%
Market risk premium $(r_m - r_f)$	4.80%	4.55%	4.80%	5.00%	6.40%	5.00%	3.00%	4.79%
Variability coefficient of energy company shares*b*	0.54	0.32	0.4	0.3	0.4	0.58	0.3	0.41
Cost of equity r_e	5.34%	9.05%	8.73%	6.80%	8.54%	10.40%	6.00%	7.84%
Cost of debt capital r_d	3.92%	3.80%	6.42%	3.62%	4.91%	2.60%	5.13%	4.34%
Equity in total capital *E/(E+D)*	50.00%	40.00%	58.00%	80.00%	60.00%	50.00%	40.00%	54.00%
Debt in total capital *D/(E+D)*	50.00%	60.00%	42.00%	20.00%	40.00%	50.00%	60.00%	46.00%
Corporate tax rate p_d	18.00%	15.82%	19.00%	26.00%	19.00%	34.43%	20.00%	21.75%
WACC Weighted average cost of capital before tax	**5.22%**	**5.90%**	**8.95%**	**5.99%**	**8.29%**	**6.50%**	**6.04%**	6.70%

Source: Mapping power and utilities regulation in Europe; HERA 2018.

The average WACC for gas transport system is 6.7%, and it varies from country to country. Croatia has the lowest WACC (5.22%), and Poland (8.95%) has the highest. WACC calculation is determined by various parameters shown in the table. Parameters which are defined with financial characteristics of a certain financial market have different ranges. Interest rates on loans vary from 3.62% to 6.42%, the risk-free interest rate varies from 1.82% to 5.42%, and the market risk premium from 3.00% to 6.40%. The variability coefficient of shares is in the range between 0.3 and 0.58,

and the corporate tax rate between 15.82% and 34.43%. The parameter which is determined by the regulator is the debt-to-equity ratio. The ratio is in the range between 80% : 20% and 40% : 60%.

If the debt capital could also change with respect to a decrease in interest rates, which depends on the indebtedness of the energy company, the weighted average cost of capital would also change, and the return on the allowed revenue would decrease as well, which would eventually lead to a decreased allowed revenue and the average tariff item.

The same analysis was carried out for calculating WACC and the WACC amount for electricity transmission system operators in the same countries (Table 2).

Table 2 WACC comparison for different EU electricity transmission system operators

Parameter	Croatia	Germany	Poland	Finland	Czech R.	France	Slovakia	average
Risk-free rate r_f	2.75%	3.80%	5.42%	1.82%	4.60%	4.20%	4.01%	3.80%
Market risk premium $(r_m - r_f)$	3.75%	4.55%	4.80%	5.00%	6.40%	4.50%	3.00%	4.57%
Variability coefficient of energy company shares β	0.38	0.32	0.4	0.4	0.35	0.33	0.3	0.35
Cost of equity r_e	4.13%	9.05%	8.73%	5.59%	8.05%	10.92%	6.00%	7.50%
Cost of debt capital r_d	3.36%	3.80%	6.42%	1.82%	4.91%	4.80%	5.13%	4.32%
Equity in total capital $E/(E+D)$	40.00%	40.00%	58.00%	40.00%	60.00%	40.00%	40.00%	45.43%
Debt in total capital $D/(E+D)$	60.00%	60.00%	42.00%	60.00%	40.00%	60.00%	60.00%	54.57%
Corporate tax rate p_d	18.00%	15.82%	19.00%	24.50%	19.00%	34.43%	20.00%	21.54%
WACC Weighted average cost of capital before tax	**4.03%**	**5.90%**	**8.95%**	**3.06%**	**7.92%**	**7.25%**	**6.04%**	6.16%

Source: Mapping power and utilities regulation in Europe; HERA 2018b.

WACC for electricity transmission system ranges from 3.06% to 8.95%. The parameters vary from country to country. Interest rates on loans vary from 1.82% (Finland) to 5.42% (Poland). The risk-free interest rate varies from 1.82% to 5.42%, and the market risk premium from 3.00% to 6.40%. The variability coefficient of shares ranges between 0.3 and 0.38, and the corporate tax rate between 15.82% and 34,43%. The debt-to-equity ratio allowed by the regulator ranges between 60% : 40% and 40% : 60%.

WACC varies depending on the activity and the characteristics of the regulatory area, i.e. the state, and influencing parameters are from financial markets and regulatory.

The analysis of the impact of the financial market condition on the WACC change

The condition on financial markets affects the changes in interest rates. In addition, it can be expected that Croatia's entrance into the European Monetary Union (EMU) and the acceptance of euro as a single currency will reduce the interest rate because

the risk premium is one of the basic determinants of interest rates. With the entrance into the EMU, a country's risk is inevitably reduced due to the country's increased credibility because it is now supported by the European Central Bank (ECB) (Gospodarstvo Hrvatske, 2016). The change in interest rates affects the expected return on the market, i.e. the cost of equity and the debt interest, i.e. the cost of debt capital, which are elements for calculating WACC. Since the expected return on the market is the basis for calculating equity, and the interest at which companies were indebted is the basis for calculating debt capital, the assumption is that they change in the same proportions as the changes in interest rates on a capital market. The impact of the change in the expected return on the market and the cost of debt capital on WACC will be analysed in continuation, as a consequence of changes in interest rates on the Croatian financial market.

The impact of the expected return on the market changes on WACC

The impact of the change in the expected return on the market on equity is observed with the assumption that the change in the expected return on the market has no influence on the debt capital, i.e. that the company has no new debts, that it does not refinance its existing bank debts, and that it has debts with a fixed interest rate. The analysis was carried out with the change impact in the range of +/- 10%, i.e. +/- 20%. The gas transport analysis was carried out first (Table 3).

Table 3 The impact of the expected return on the market changes on WACC for gas transport

Parameter	WACC -20	WACC -10	**Value**	WACC +10	WACC +20
Risk-free rate r_f	2.75%	2.75%	**2.75%**	2.75%	2.75%
Expected return on the market r_m	6.04%	6.80%	**7.55%**	8.31%	9.06%
Market risk premium $(r_m - r_f)$	3.29%	4.05%	**4.80%**	5.56%	6.31%
Variability coefficient of energy company shares β	0.54	0.54	**0.54**	0.54	0.54
Cost of equity r_e	4.53%	4.93%	**5.34%**	5.75%	6.16%
Cost of debt capital r_d	3.92%	3.92%	**3.92%**	3.92%	3.92%
Equity in total capital $E/(E+D)$	50.00%	50.00%	**50.00%**	50.00%	50.00%
Debt in total capital $D/(E+D)$	50.00%	50.00%	**50.00%**	50.00%	50.00%
Corporate tax rate p_d	18.00%	18.00%	**18.00%**	18.00%	18.00%
WACC Weighted average cost of capital before tax	**4.72%**	**4.97%**	**5.22%**	**5.47%**	**5.71%**

Source: authors' calculation

The increase in the expected return on the market of 10% and 20%, results in the increase in WACC for gas transport from 5.22% to 5.47%, and 5.71%, whereas the de-

crease in the expected return on the market of 10% and 20%, results in the decrease in WACC for gas transport from 5.22% to 4.97%, and 4.72%, i.e. the relative increase/decrease in the expected return on the market of 10% and 20% results in the increase/decrease in WACC of 4.7%, i.e. 9.5%.

The same analysis for electricity transmission was carried out in the continuation, with the same sensitivity analysis of the change (Table 4)

Table 4 The impact of the expected return on the market changes on WACC for electricity transmission system operators

Parameter	WACC -20	WACC -10	**Value**	WACC +10	WACC +20
Risk-free rate r_f	2.70%	2.70%	**2.70%**	2.70%	2.70%
Expected return on the market r_m	5.16%	5.81%	**6.45%**	7.10%	7.74%
Market risk premium $(r_m - r_f)$	2.46%	3.11%	**3.75%**	4.40%	5.04%
Variability coefficient of energy company shares β	0.38	0.38	**0.38**	0.38	0.38
Cost of equity r_e	3.63%	3.88%	**4.13%**	4.37%	4.62%
Cost of debt capital r_d	3.36%	3.36%	**3.36%**	3.36%	3.36%
Equity in total capital $E/(E+D)$	40.00%	40.00%	**40.00%**	40.00%	40.00%
Debt in total capital $D/(E+D)$	60.00%	60.00%	**60.00%**	60.00%	60.00%
Corporate tax rate p_d	18.00%	18.00%	**18.00%**	18.00%	18.00%
WACC Weighted average cost of capital before tax	**3.79%**	**3.91%**	**4.03%**	**4.15%**	**4.27%**

Source: authors' calculation

The increase in the expected return on the market of 10% and 20%, results in the increase in WACC for electricity transmission from 4.03% to 4.15%, and 4.27%, whereas the decrease in the expected return on the market of 10% and 20%, results in the decrease in WACC for electricity transmission from 4.03% to 3.91%, and 3.79%, i.e. the relative increase/decrease in the expected return on the market of 10% and 20% results in the increase/decrease in WACC of 2.9%, i.e. 5.8%.

The impact of the change in the cost of debt capital on WACC

The impact of the change in the cost of debt capital will be observed with the assumption that the changes in interest rates on the market have no impact on equity, i.e. the analysis is carried out only with the aim to determine the partial impact of the change in the cost of debt capital on WACC. The analysis was carried out with the change impact in the range of +/- 10%, i.e. +/- 20%. The gas transport analysis was carried out first (Table 5).

Table 5 The impact of the change in the cost of debt capital on WACC for gas transport

Parameter	WACC -20	WACC -10	**Value**	WACC +10	WACC +20
Risk-free rate r_f	2.75%	2.75%	**2.75%**	2.75%	2.75%
Expected return on the market r_m	7.55%	7.55%	**7.55%**	7.55%	7.55%
Market risk premium $(r_m - r_f)$	4.80%	4.80%	**4.80%**	4.80%	4.80%
Variability coefficient of energy company shares β	0.54	0.54	**0.54**	0.54	0.54
Cost of equity r_e	5.34%	5.34%	**5.34%**	5.34%	5.34%
Cost of debt capital r_d	3.14%	3.53%	**3.92%**	4.31%	4.70%
Equity in total capital $E/(E+D)$	50.00%	50.00%	**50.00%**	50.00%	50.00%
Debt in total capital $D/(E+D)$	50.00%	50.00%	**50.00%**	50.00%	50.00%
Corporate tax rate p_d	18.00%	18.00%	**18.00%**	18.00%	18.00%
WACC Weighted average cost of capital before tax	**4.83%**	**5.02%**	**5.22%**	**5.41%**	**5.61%**

Source: authors' calculation

The increase in the cost of debt capital of 10%, i.e. 20%, results in the increase in WACC for gas transport from 5.22% to 5.41%, and 5.61%, whereas the decrease in the cost of debt capital of 10% and 20% results in the decrease in WACC for gas transport from 5.22% to 5.02%, and 4.83%, the relative increase/decrease in the cost of debt capital of 10% and 20% results in the increase/decrease in WACC of 3.8% and 7.5%.

The same analysis for electricity transmission was carried out in the continuation, with the same sensitivity analysis of the changes (Table 6).

Table 6 The impact of the change in the cost of debt capital on WACC for electricity transmission

Parameter	WACC -20	WACC -10	**Value**	WACC +10	WACC +20
Risk-free rate r_f	2.70%	2.70%	**2.70%**	2.70%	2.70%
Expected return on the market r_m	6.45%	6.45%	**6.45%**	6.45%	6.45%
Market risk premium $(r_m - r_f)$	3.75%	3.75%	**3.75%**	3.75%	3.75%
Variability coefficient of energy company shares β	0.38	0.38	**0.38**	0.38	0.38
Cost of equity r_e	4.13%	4.13%	**4.13%**	4.13%	4.13%
Cost of debt capital r_d	2.69%	3.02%	**3.36%**	3.70%	4.03%
Equity in total capital $E/(E+D)$	40.00%	40.00%	**40.00%**	40.00%	40.00%
Debt in total capital $D/(E+D)$	60.00%	60.00%	**60.00%**	60.00%	60.00%
Corporate tax rate p_d	18.00%	18.00%	**18.00%**	18.00%	18.00%
WACC Weighted average cost of capital before tax	**3.62%**	**3.83%**	**4.03%**	**4.23%**	**4.43%**

Source: authors' calculation

The increase in the cost of debt capital, i.e. the reference interest rate on CNB loans of 10% and 20%, results in the increase in WACC for electricity transmission from 4.03% to 4.23%, and 4.43%, whereas the decrease in the cost of debt capital of 10% and 20% results in the decrease in WACC for electricity transmission from 4.03% to 3.83%, and 3.62%, the relative increase/decrease in the cost of debt capital of 10% and 20% results in the increase/decrease in WACC of 4.9% and 9.8%.

It is evident that the changes in expected return on the market, as well as the cost of debt capital in the same amount of +/-10%, i.e. +/-20%, result in different changes of WACC for the gas transport system and the electricity transmission system. The impact of the change in the expected return on the market is larger on the gas system operator, whereas the change in the cost of debt capital is larger on the electricity system operator.

The differences in WACC change arise from economic and regulatory differences in parameters for calculating tariffs for gas transport and electricity transmission.

The differences in economic parameters arise from the differences in the times when the tariffs were established because the tariffs were not established at the same time, and financial markets had different conditions at the moments when the tariffs were established. Regulatory differences are a consequence of regulatory approach for gas transport and electricity distribution in the amount of the interest rate at which the companies were indebted and debt-to-equity ratio. The debt-to-equity ratio of 50% : 50% was accepted for the gas transport system, whereas the debt-to-equity ratio of 40% : 60% was accepted for electricity transmission.

By analysing the amounts of the impact of the changes in the expected return on the market, as well as the cost of debt capital on WACC, it is evident that the impact of the change in the cost of debt capital is more significant in comparison to the impact of the change in the expected return on the market.

The change in the cost of debt capital simultaneously affects both equity and debt capital, i.e. the expected return on the market and the cost of debt capital, therefore, they should be observed together.

If the interest rates on the financial market are decreasing, the regulator should react and decrease the expected return on the market which decreases the return on equity. The cost of debt capital is a result either of the real interest rate on a loan, or the reference interest rates on the Croatian National Bank (CNB) debts in case if the energy company has a higher interest rate on debts than the CNB reference rate. This motivates the energy company to become indebted under the most favourable conditions on the financial market. If the interest rates on the financial market are increasing, energy companies should react and ask for the increase in the expected return on the market, i.e. the return on equity, and the increase in the interest rate on debts referring to the increase in the reference interest rate on the CNB debts.

The simultaneous impact of the change in the expected return on the market, as well as in the cost of debt capital on total (equity and debt) capital results in:

- The increase in the expected return on the market, as well as in the cost of debt capital of 10% and 20% results in the increase in WACC for gas transport from 5.22% to 5.66%, and 6,11%, whereas the decrease in the expected return on the market, as well as in the cost of debt capital of 10% and 20% results in the decrease in WACC for gas transport from 5.22% to 4.77%, and 4.33%.
- The increase in the expected return on the market, as well as in the cost of debt capital of 10% and 20% results in the increase in WACC for electricity transmission from 4.03% to 4.35%, and 4.67%, whereas the decrease in the expected return on the market, as well as in the cost of debt capital of 10% and 20%, results in the decrease in WACC for electricity transmission from 4.03% to 3,71%, and 3,39%.

Comparative analysis of the allowed revenue

The change in the expected return on the market and in the cost of debt capital caused the change in WACC on the total capital, and the change in WACC caused the change in the revenue on regulatory assets, i.e. capital expenses and allowed revenues for the gas transport system and total operating expenses for electricity transmission, i.e. the change in average tariff items.

The impact of the change in the expected return on the market and in the cost of debt capital of +/-10%, i.e. +/-20% on WACC, the return on regulatory assets (PRI= $A^P_t + PRO^P_t$), allowed revenues and the average tariff item for gas transport is shown in Table 7.

Table 7 The impact of WACC changes on allowed revenues and the average gas transport tariff (mil HRK)

$\Delta r_m + \Delta r_d$	$OPEX^P_t$	A^P_t	$ROpros^P_t$	WACC	ΔWACC	PRI	ΔPRI	DP^P_t	ΔDP^P_t	TS	ΔTS
-20%	158,058	112,256	2,327,471	4.33%	-17.04%	212,992	-8.86%	483,306	-4.11%	0.01790	-4.11%
-10%	158,058	112,256	2,327,471	4.77%	-8.52%	223,340	-4.43%	493,654	-2.05%	0.01828	-2.05%
Value	**158,058**	**112,256**	**2,327,471**	**5.22%**	**0.00%**	**233,688**	**0.00%**	**504,002**	**0.00%**	**0.01867**	**0.00%**
+10%	158,058	112,256	2,327,471	5.66%	8.52%	244,035	4.43%	514,349	2.05%	0.01905	2.05%
+20%	158,058	112,256	2,327,471	6.11%	17.04%	254,383	8.86%	524,697	4.11%	0.01943	4.11%

Source: authors' calculation (HERA, 2018)

The change in the expected return on the market and in the cost of debt capital of -20% and -10%, i.e. 10% and 20% on the capital market results in the change in WACC for gas transport of -17.04%, -8.52%, 8.52% and 17.04%, with the change in the revenue on regulatory assets of -8.86, -4.43%, 4.43% and 8.86% of allowed revenues and average tariff items of -4.11%, -2.05%, 2.05% and 4.11.

The impact of the change in the expected return on the market and in the cost of debt capital of +/-10% and +/-20% on WACC, the return on regulatory assets, allowed

operating expenses and the average tariff item for electricity transmission is shown in Table 8.

Table 8 The impact of WACC changes on allowed revenues and the average electricity transmission tariff (mil HRK)

$\Delta r_m + \Delta r_d$	TPpos	Amort.	regulatory assets	WACC	ΔWACC	TPkap	ΔTPkap	UTP	ΔUTP	TS	ΔTS
-20%	1,215,536	345,167	4,840,000	3.39%	-15.95%	509,043	-5.76%	1,724,579	-1.77%	0.10145	-1.77%
-10%	1,215,536	345,167	4,840,000	3.71%	-7.97%	524,587	-2.88%	1,740,123	-0.89%	0.10236	-0.89%
Value	**1,215,536**	**345,167**	**4,840,000**	**4.03%**	**0.00%**	**540,132**	**0.00%**	**1,755,668**	**0.00%**	**0.10327**	**0.00%**
+10%	1,215,536	345,167	4,840,000	4.35%	7.97%	555,676	2.88%	1,771,212	0.89%	0.10419	0.89%
+20%	1,215,536	345,167	4,840,000	4.67%	15.95%	571,220	5.76%	1,786,756	1.77%	0.10510	1.77%

Source: authors' calculation (HERA, 2018b)

The change in the expected return on the market and in the cost of debt capital of -20% and -10%, i.e. 10% and 20% on the capital market results in the change in WACC for energy transmission of -15.95%, -7.79%, 7.79% and 15.95%, with the decrease in capital expenditure (return on regulatory assets) of -5.76%, -2.88%, 2.88% and 5.76%, and allowed operating expenses and average tariff items of -1.77%, -0.89%, 0.89% and 1.77%.

The impact of the change in the expected return on the market and in the cost of debt capital on WACC is different for the gas transport system and the electricity transmission because the debt-to-asset ratio and the cost of debt capital are different due to the difference in times at which the companies were indebted and in the moments when the tariff items were established by the regulator. The impact is larger on the gas system operator (Plinacro). Therefore, we conclude that the change in the interest rate has a more dominant impact on the change in the equity for observed operators.

The WACC change is not proportional to the change in the allowed revenue on regulatory assets / capital expenditure for the gas transport system and electricity transmission, with is a consequence of a different proportion in the return on regulatory assets and amortisation in the allowed revenue on regulatory assets /capital expenditure for the gas transports system and electricity transmission. A larger impact is on the system operator with a smaller amortisation proportion, and a larger return proportion in the allowed revenue on regulatory assets / capital expenditure.

The change in the allowed revenue on regulatory assets /capital expenditure and the total allowed revenue / average tariff item are not proportional for the gas transport system and electricity transmission due to a different proportion of operating expenses for the gas transport system and the electricity transmission system. A larger impact is on the system operator with a larger proportion of capital expenditure in the allowed revenue / total operating expenses.

Conclusion

The changes in the expected return on the market and in the cost of debt capital affect the change in WACC, and the WACC amount depends on the debt-to-equity ratio of each system operator analysed. A larger impact is seen in larger equity proportions.

The change in WACC results in the change in the return on regulatory assets / the cost of capital, and the change amount depends on the proportion of amortisation in regulatory assets. The impact is larger when the amortisation and regulatory assets ratio is smaller.

The change in the return on regulatory assets / the cost of capital results in the change in the allowed revenue / total operating expenses and average tariff items, and the change amount depends on the proportion of capital expenditure in the allowed revenue / total operating expenses. The impact is larger when the proportion of capital expenditures in the allowed revenue / total operating expenses is larger.

The change in the interest rates on the capital market will have a different impact on the expected return on the market and the cost of debt capital, which will have a different impact on the regulated companies because the change impact depends on the capital structure of the companies and the level of capital expenditure in the total cost.

The gas transport system operator and the electricity transmission operator have different debt-to-equity ratios, a different amortisation rate and capital expenditure shares in the allowed revenue / total operating costs, thus they have different effects of the changes in the expected return on the market and the cost of debt capital on the allowed revenue / total operating costs and average tariff items.

ENDNOTES

[1] Directive 2009/72/EC of the European Parliament and of the Council concerning common rules for the internal market in electricity (SL. L 211, 14. 8. 2009.), Directive 2009/73/EC of the European Parliament and of the Council concerning common rules for the internal market in natural gas (SL. L 211, 14. 8. 2009.).

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