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An Analysis of the Profitability of Investments in Biomass Power Plants within the Current System of Incentives in the Federation of BiH

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1 FOREWORD

The USAID EIA project is working to promote biomass use for energy purposes in the agriculture and wood-processing industries. To this end, one of the planned activities is the provision of technical assistance to small and medium-sized enterprises (SMEs) from these sectors in the preparation of projects for the construction of plants for the Combined production of Heat and Power – CHP or cogeneration using waste from production (biomass). Through these activities, EIA wants to increase the utilization of the available biomass potential, increase the share of renewable energy in electricity generation and provide additional income for the companies and thereby improve their businesses.

An additional objective of the EIA project is to review the adequacy of the existing legal framework and the system of incentives for biomass use for the production of electricity and heat. In order to improve the existing system of incentives, this report has been prepared and presented the Regulatory Commission for Energy in the Federation of Bosnia and Herzegovina (FBiH), Operator of Renewable Energy Sources and Efficient Cogeneration in FBIH and the Federal Ministry of Energy, Mining and Industry.

2 INTRODUCTION

In this report the current system of incentives in FBiH will be analyzed to determine if the incentives make the investment into biomass CHP plants attractive for SMEs from the wood-processing sector and agriculture. In agriculture we will focus on the biogas from livestock farming, since residues from crop farms have a much smaller usable biomass potential. See the EIA reports on Biomass potential on www.usaideia.ba.

In FBIH the only existing incentive for investing in biomass CHP plants is the guaranteed purchase price for electricity – the feed-in tariff (FIT). The FIT is also the only incentive for investing in power plants using other renewable energy sources (RES). The difference between biomass and other RES, except for geothermal energy, which is not included in the current system of incentives, is that biomass power plants can produce simultaneously both heat and electricity (CHP), while other RES power plants can only produce electricity. However, in the current system in FBIH, there is no incentive to produce and use heat from biomass plants.

In this report, we will show that the FIT for biomass power plants is too low for such an investment to be attractive to private investors, except for 150 kW biogas power plants. The situation on the field confirms this conclusion, as there is not a single operational biogas or biomass power plant in FBiH and the only ongoing project is a 1.2 MW biomass plant in Livno.

In this report, first the FBiH Action Plan and Incentive System is explained and illustrated, followed by an analysis of the profitability of biomass power plants in FBiH, ending with recommendations on how to improve the current system of incentives in FBiH to motivate private companies to invest in biomass CHP plants. As a result, even the modest goal of 30 GWh of electricity (approximately equivalent to 4MW capacity) produced from biomass in FBiH in 2020 will not be reached.

3 Action Plan and Incentive System in FBIH

The FBiH Action Plan for the use of renewable energy sources was published in May 2014, by the Federal Ministry of Energy, Mining and Industry (FMERI). In the Action Plan, the planned share of renewable energy sources (RES) was defined as the total final consumption of energy from RES in heating and cooling, electricity and transport. In order to realize the planned consumption of electricity from RES, the dynamic quotas of electricity produced from RES that will be incentivized up to the year 2020, were determined and are shown in the following tables.

Table 1 Overview of Incentivized Electricity Generation from RES 2012-2015 in FBiH

	hours annually	2012		2013		2014		2015	
		MW	GWh	MW	GWh	MW	GWh	MW	GWh
HYDROENERGY	4100	**20,729**	**86,120**	**20,729**	**86,120**	**23,918**	**98,062**	**28,747**	**117,862**
‹ 1 MW	4100	7,830	35,330	7,830	35,330	8,371	34,322	8,624	35,359
MEDIUM from 1 to 10 MW	4100	12,899	50,790	12,899	50,790	15,546	63,740	20,123	82,503
LARGE › 10 MW		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
GEOTHERMAL ENERGY:		**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**
SOLAR ENERGY	1500	**1,265**	**1,856**	**1,265**	**1,856**	**3,900**	**5,850**	**5,230**	**7,850**
PHOTOVOLTAIC		1,265	1,856	1,265	1,856	3,897	5,845	5,230	7,845
micro from 0,002 to 0,023 MW		0,081	0,011	0,081	0,011	1,169	1,754	1,569	2,354
mini from 0,023 to 0,150 MW		1,185	1,845	1,185	1,845	1,559	2,338	2,092	3,138
small from0,150 to 1 MW		0,000	0,000	0,000	0,000	1,169	1,754	1,569	0,000
CONCENTRATED		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TIDAL ENERGY		**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**
WIND ENERGY	2500	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**
ON LAND		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
AT SEA		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
ENERGY FROM BIOMASS	6500	**0,000**	**0,000**	**0,000**	**0,000**	**0,923**	**6,000**	**1,846**	**12,000**
solid		0,000	0,000	0,000	0,000	0,923	6,000	1,846	12,000
biogas		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
bio-liquids		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL		**21,994**	**87,976**	**21,994**	**87,976**	**28,741**	**109,912**	**35,823**	**137,712**

Table 2 Overview of Incentivized Electricity Generation from RES 2016-2020 in FBIH

	hours annually	2016		2017.		2018.		2019.		2020.	
		MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh
HYDROENERGY:	4100	**30,052**	**123,212**	**36,585**	**150,000**	**39,024**	**160,000**	**40,244**	**165,000**	**50,000**	**205,000**
‹ 1 MW	4100	9,016	36,964	10,976	45,000	11,707	48,000	12,073	49,500	15,000	61,500
MEDIUM FROM 1 TO 10 MW	4100	19,534	86,248	25,610	105,000	27,317	112,000	28,171	115,500	35,000	143,500
LARGE › 10 MW		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
GEOTHERMAL ENERGY:		**0,000**	**0,000**	**0,000**	**0,000**						
SOLAR ENERGY	1500	**5,900**	**8,850**	**8,000**	**12,000**	**9,330**	**14,000**	**9,670**	**15,000**	**12,000**	**18,000**
PHOTOVOLTAIC		5,900	8,850	8,000	12,000	9,333	14,000	9,667	14,500	12,000	18,000
micro from 0,002 to 0,023 MW		1,770	2,655	2,400	3,600	2,800	4,200	2,900	4,350	3,600	5,400
mini from 0,023 to 0,150 MW		2,360	3,540	3,200	4,800	3,733	5,600	3,867	5,800	4,800	7,200
small from0,150 to 1 MW		1,770	2,655	2,400	3,600	2,800	4,200	2,900	4,350	3,600	5,400
CONCENTRATED		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TIDAL ENERGY		**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**	**0,000**
WIND ENERGY	2500	**0,000**	**0,000**	**24,000**	**60,000**	**30,000**	**75,000**	**38,000**	**95,000**	**42,800**	**107,000**
ON LAND		0,000	0,000	24,000	60,000	30,000	75,000	38,000	95,000	42,800	107,000
AT SEA		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
ENERGY FROM BIOMASS	6500	**2,154**	**14,000**	**2,769**	**18,000**	**3,385**	**22,000**	**3,846**	**25,000**	**4,615**	**30,000**
solid		2,154	14,000	2,769	18,000	3,385	22,000	3,846	25,000	4,615	30,000
biogas		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
bio-liquids		0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
TOTAL		**38,106**	**146,062**	**71,355**	**240,000**	**81,739**	**271,000**	**91,760**	**300,000**	**109,415**	**360,000**

The table above shows that in year 2016, the planned electricity from biomass was 14 GWh from solid biomass, without the planned participation of biogas and bio-liquids. The reason for not planning dynamic quotas for biogas and bio-liquid was that there was no interest in projects for construction of biogas and bio-liquid electricity generation plants. Since, up to now, no biomass power plant has been built in FBiH, the total dynamic quota of 14 GWh is available, which corresponds to the installed capacity of 2.15 MW with 6,500 hours per year at full capacity. **In the year 2020, the electricity generated from biomass should be 30 GWh (4,615 MW installed capacity).**

3.1 Guaranteed purchase prices in FBiH

The Federation Energy Regulatory Commission (FERC) issued a Decision on the adoption of the guaranteed purchase prices calculation for generation from RES plants, No. 01-07-1052-05/15, December 18, 2015 (the Decision) in which it ordered guaranteed purchase prices (feed-in-tariffs) for electricity from RES, given in the following table. The contract on purchase of electricity at guaranteed purchase prices is signed with the Operator for Renewable Energy Sources and Efficient Cogeneration (Operator for RES) for a period of 12 years. The table shows that the price varies, depending on the installed electrical capacity of the biomass plants. Plants are divided into four groups:

1) up to 23 kW
2) 23 - 50 kW
3) 10 - 1,000 kW, and
4) 1,000 kW - 10,000 kW

For electric power plants over 10,000 kW that use solid biomass, the electricity is not purchased at the guaranteed purchase price, while the maximum allowed capacity is 1,000 kW for biogas plants. It should be noted that it is necessary to fulfil the conditions prescribed by FERC and Operator for RES in order to qualify for purchase at the guaranteed purchase price: one of the conditions is that the **key plant equipment must be new.**

Table 3 Feed-in tariffs for RES generated electricity in the Federation of BiH

REGULATORNA KOMISIJA ZA ENERGIJU U FEDERACIJI BOSNE I HERCEGOVINE - F E R K

РЕГУЛАТОРНА КОМИСИЈА ЗА ЕНЕРГИЈУ У ФЕДЕРАЦИЈИ БОСНЕ И ХЕРЦЕГОВИНЕ – Ф Е Р К

Attachment 1.

Plant as per primary source of energy type	Capacity	Hours of operation	Unit value of investment C_{inv}	Operation and maintenance cost $C_{m\&o}$	Fuel Cost C_{fuel}	Compensation factor of invested capital ($F_{z.n}$)	Production cost per electricity unit CP_c	Referent price (R_c)	Tarif coefficient (C)	Guaranteed price (G_c)
	kW	h/god	KM/kW	KM/kW	KM/kWh	%	KM/kWh	KM/kWh		KM/kWh
	1	2	3	4	5	6	7=5+4/2 +(3*6)/2	8	9=7/8	10=8*9
Hydro Power Plant										
a) **micro**	23	4,100	3,500	705	0	13.90	0.29036	0.099458	**2.9194**	0.29036
b) **mini**	150	4,100	3,500	260	0	13.90	0.18192	0.099458	**1.8291**	0.18192
c) **small**	1,000	4,100	3,100	134	0	13.90	0.13751	0.099458	**1.3826**	0.13751
d) **medium**	10,900	4,100	2,900	105	0	13.90	0.12373	0.099458	**1.2440**	0.12373
e) **large**	-	-	-	-	-	-	-	-	-	-
Wind plant										
a) **micro**	23	2 500	3100	498	0	13.90	0.37124	0.099458	**3.7326**	0.37124
b) **mini**	150	2 500	3 100	124	0	13.90	0.22140	0.099458	**2.2261**	0.22140
c) **small**	1 000	2 500	2 900	71	0	13.90	0.18917	0.099458	**1.9020**	0.18917
d) **medium**	10 000	2 500	2 550	47	0	13.90	0.16033	0.099458	**1.6121**	0.16033
e) **large**	15 000	2 500	2 350	43	0	13.90	0.14766	0.099458	**1.4847**	0.14766
Solar plant										
a) **micro**	23	1 500	3 150	376	0	13.90	0.54190	0.099458	**5.4486**	0.54190
b) **mini**	150	1 500	2 850	142	0	13.90	0.35806	0.099458	**3.6001**	0.35806
c) **small**	1 000	1 500	2 750	82	0	13.90	0.30866	0.099458	**3.1034**	0.30866
d) **medium**	-	-	-	-	-	-	-	-	-	-
e) **large**	-	-	-	-	-	-	-	-	-	-
Geothermal plant										
a) **micro**	-	-	-	-	-	-	-	-	-	-
b) **mini**	-	-	-	-	-	-	-	-	-	-
c) **small**	-	-	-	-	-	-	-	-	-	-
d) **medium**	-	-	-	-	-	-	-	-	-	-
e) **large**	-	-	-	-	-	-	-	-	-	-
Biomass plant										
a) **micro**	23	6 500	7 000	708	0.055	13.90	0.31292	0.099458	**3.1462**	0.31292
b) **mini**	150	6 500	6 800	326	0.055	13.90	0.24987	0.099458	**2.5123**	0.24987
c) **small**	1 000	6 500	6 600	294	0.055	13.90	0.24067	0.099458	**2.4198**	0.24067

d)	**medium**	10 000	6 500	6 600	206	0.055	13.90	0.22706	0.099458	**2.2829**	0.22706
e)	**large**	-	-	-	-	-	-	-	-	-	-
	Biogas plant										
a)	**micro**	23	8 000	5 800	263	0.039	13.90	0.71160	0.099458	**7.1547**	0.71160
b)	**mini**	150	8 000	5 800	195	0.039	13.90	0.66637	0.099458	**6.7000**	0.66637
c)	**small**	1 000	7 000	7 800	376	0.039	13.90	0.27891	0.099458	**2.8043**	0.27891
d)	**medium**	-	-	-	-	-	-	-	-	-	-
e)	**large**	-	-	-	-	-	-	-	-	-	-
	Power plant using the energy from the sea										
a)	**micro**	-	-	-	-	-	-	-	-	-	-
b)	**mini**	-	-	-	-	-	--	-	-	-	-
c)	**small**	--	-	-	-	-	-	-	-	-	-
d)	**medium**	-	-	-	-	-	-	-	-	-	-
e)	**large**	-	-	-	-	-	-	-	-	-	-
	Power plant using the municipal waste										
a)	**micro**	-	-	-	-	-	-	-	-	-	-
b)	**mini**	-	-	-	-	-	-	-	-	-	-
c)	**small**	-	-	-	-	-	-	-	-	-	-
d)	**medium**	-	-	-	-	-	-	-	-	-	-
e)	**large**	-	-	-	-	-	-	-	-	-	-
	Power plant with efficient cogeneration *										
a)	**micro**	-	-	-	-	-	-	0.15419	0.099458	**1.5503**	0.15419
b)	**mini**	-	-	-	-	-	-	0.15419	0.099458	**1.5503**	0.15419
c)	**small**	-	-	-	-	-	-	0.15419	0.099458	**1.5503**	0.15419
d)	**medium**	5 000	5 750	2 600	90	0.068	13.90	0.15419	0.099458	**1.5503**	0.15419
e)	**large**	-	-	-	-	-	-	-	-	-	-

* **When calculating tariff coefficient for efficient cogeneration plants, formula from the Rule Book is used where the amoung of $P_{toplota}$ is 68KM/MWh$_{th}$**

3.1.1 An overview of feed-in tariffs for biomass power plants in BiH, Croatia and Serbia

The foregoing tables include all types of RES and are offered to provide a better insight into *APOEF* (*Akcioni plan Federacije BiH za korištenje obnovljivih izvora energije, English: FBiH Action Plan for the Use of RES*). This report deals with the use of biomass for electricity generation; to this end, it is important to compare feed-in tariffs for electricity generated from solid biomass and biogas with prices in the region. The price difference is more evident when presented in a form of a graph, so they are shown graphically and in tables.

Table 4 Feed-in tariffs for solid biomass power plants in the region

Installed capacity (kW)	FBIH (EUR/MWh)	RS (EUR/MWh)	Serbia (EUR/MWh)	Croatia (EUR/MWh)	Croatia for CHP >50% efficiency (EUR/MWh)
Up to 23	159.99	123.37	132.6	173.33	208.00
23-150	127.76	123.37	132.6	173.33	208.00
150-200	123.05	123.37	132.6	173.33	208.00
200-300	123.05	123.37	132.6	173.33	208.00
300-700	123.05	123.37	132.6	166.67	200.00
700-1000	123.05	123.37	132.6	166.67	200.00
1.000-2000	116.09	115.60	127	166.67	200.00
2.000-10.000	116.09	115.60	127	160.00	192.00

The value of feed-in tariffs and the duration of the guaranteed purchase of electricity at that value should be calculated so that the investor can operate profitably during this period and pay back its bank loan. By the time the contract for guaranteed purchase of electricity expires (currently 12 years), the investor should have paid off the bank loan; and the power plants should be able to be competitive on the electricity market. The longer the duration of the contract for guaranteed purchase of electricity, the lower the feed-in tariff should be and vice versa.

Figure 1 Feed-in tariffs for solid biomass power plants in the region

Table 5 Feed-in tariffs for biogas power plants in the region

Installed capacity (kW)	FBIH (EUR/MWh)	RS (EUR/MWh)	Serbia (EUR/MWh)	Croatia (EUR/MWh)
Up to 23	363.84	122.81	156.6	178.67
23-150	340.71	122.81	156.6	178.67
150-200	142.60	122.81	156.6	178.67
200-300	142.60	122.81	152.4	178.67
300-700	142.60	122.81	135.7	168.00
700-1,000	142.60	122.81	123.1	168.00

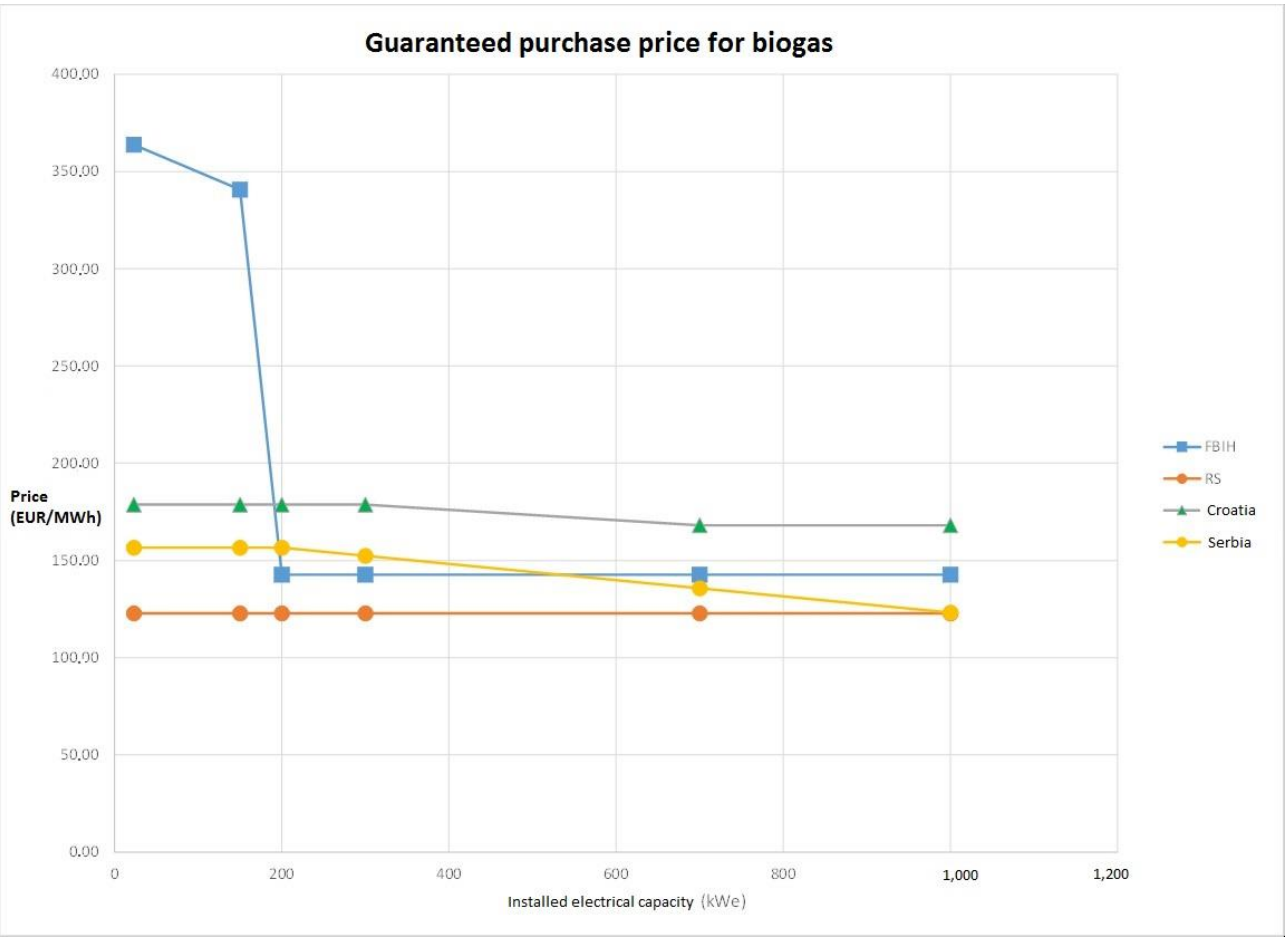

Figure 2 Feed-in tariffs for biogas power plants in the region

4 Preliminary analysis of biomass cogeneration plants

Unlike other renewable energy sources for which dynamic quotas are planned under the APOEF (water, solar and wind energy), commercial technologies for generation of electricity from biomass also include the generation of thermal energy. Therefore, for more efficient use of biomass, one should consider the simultaneous generation and use of electricity and heat – cogeneration. **Commercial biomass CHP technologies** suitable for use in BiH include:[1]

1. Direct combustion with a steam cycle
2. Gasification and gas engines
3. Direct combustion with Organic Rankin Cycle (ORC)
4. Biogas and gas engines

Using Excel software developed by USAID EIA to analyze the profitability of investment in biomass-fueled CHP plants, one can calculate the simple payback period. The software will be made user-friendly (adjusted for use by third parties) and available on the project website (www.usaideia.ba) in January 2017. To facilitate the tariff comparison in the region (Tables 4 and 5), the software uses the local currency, BAM (convertible mark), instead of EUR. In the profitability analysis for the Federation of BiH, the parameters specified in the aforementioned Decision as well as those measured by USAID EIA on the basis of market research were used.

The analysis covered power plants of 150 kW to 1,000 kW, as these capacities can be sufficiently supplied with biomass by agricultural and wood processing companies in BiH, increasing the qualification for financing for the plants through loans from commercial banks and lowering the risk for the investor. According to information collected, the interest rates of commercial banks for financing of these projects vary from 5.5% to 8.5%; and for the project to be viable, the internal rate of return (IRR) must be higher than the interest rate. If we assume that the interest rate is under 7%, then the IRR should be 7%, which corresponds to a simple payback period of 8 years.

PARAMETERS FOR PROFITABILITY ANALYSIS OF SOLID BIOMASS-FUELED POWER PLANTS

In this analysis, some parameters were taken from the Decision, and some were set by the USAID EIA project.

FERC parameters

- Feed-in tariff for electricity (150-1,000 kW) – EUR 123.05/MWh
- **No revenue from thermal energy considered (market value or incentivized)**
- Price of moist woodchips EUR 7.16/MWh (14 KM/MWh)
    - The price of biomass is to be entered into the software in EUR/t to calculate the appropriate value, as follows:

$$V_{woodchips}\left[\frac{EUR}{kWh}\right] = \frac{price\ of woodchips\left[\frac{EUR}{bulk\ m^3}\right]}{density\ of\ woodchips\left[\frac{kg}{bulk\ m^3}\right] * thermal\ power\left[\frac{kWh}{kg}\right]} \quad (1)$$

[1] Biomass CHP Catalogue of technologies, USAID EIA, 2016.

  - Woodchips humidity of 45% is 347 kg/bulk m3 (spruce 286 kg/bulk m3 and beech 408 kg/bulk m3)2.
  - Thermal power of wood humidity of 45% is 2.52 kWh/kg.
  - **When the values are entered into equation (1), the resulting price of woodchips is EUR 18/t**
- Number of operating hours: 6,500 h/year

[2] Wood fuels handbook – Priručnik o gorivima iz drvne biomase (prevod na hrvatski), AIEL – Italian Agroforestry Energy Association, Regionalna energetska agencija sjeverozapadne Hrvatske, 2008.

USAID EIA parameters

- Total costs of salaries and administration EUR 32,000/year
- Woodchip humidity 45%
- Annual maintenance costs - 3% of investment
- Amounts of investments from the projects in the region and literature

PARAMETERS FOR PROFITABILITY ANALYSIS OF BIOGAS POWER PLANTS

FERC parameters

- Feed-in tariff for electricity
  - 23 kW to 150 kW – EUR 340.7/MWh
  - 150 kW to 1,000 kW – EUR 142.6/MWh
- **No revenue from thermal energy**
- Number of operating hours: 7,000 h/year

USAID EIA parameters

- Total costs of salaries and administration EUR 32,000/year
- For 150 kW of raw material – manure only – handling costs EUR 0.02/m^3
- For 150 kW of raw material – manure and corn silage at price of EUR 30/t
- Annual maintenance costs - 3% of investment
- Amounts of investments from the projects in the region and literature

4.1 Results of profitability calculation taking no account of thermal energy share

Results of profitability calculations are shown in the table below:

Table 6 Simple payback period for investment, without a thermal energy share

Technology	Electricity (kW)	Thermal capacity (kW)	Total investment	Specific investment (EUR/kW)	Simple payback (years)
Steam turbine	145	3,000	1,615,000	11,138	Losses
Gasification	150	185	950,000	6,333	34.8
	850	1,060	3,774,000	4,440	10.7
ORC	729	3,146	4,191,750	5,750	25.4
	300	1,505	1,860,000	6,200	58.2
Biogas	150	180	1,027,260	6,848	3.6
	500	500	2,500,000	5,000	8.8

As evident from the table above and calculation made based on the aforementioned parameters, the only profitable investment would be one into a biogas-fueled power plant with capacity of up to 150 kW. The reason for this is an extremely high feed-in tariff for electricity with installed capacity of 23 kW to 150 kW – EUR 340.7/MWh. From Figure 1 Feed-in tariffs for solid biomass power plants in the region

Table 5 we see that the feed-in tariff is significantly higher than in the region.

The main reason behind such long payback periods for other biomass/biogas plants is the fact that revenue from thermal energy is not considered at all. Namely, the applicable Decision does not consider biomass plants as CHP plants and thus it does not specify the price of thermal energy. The same Decision, however, specifies the value of thermal energy of 68 BAM/MWth, i.e., EUR 34.8/MWth for efficient CHP plants with capacity of up to 5 MW. Yet, the efficient cogeneration in the Decision applies only to fossil fuel-powered plants.

The longest payback period was calculated for an ORC plant with capacity of 300 kW. The key parameters of the calculation were:

- Thermal power 1,505 kW
- Revenue = 0.300 MW*6,500* EUR 123 /MWh = EUR 239,850
- Expenditures EUR 207,912
    - Annual maintenance costs - 3% of investment EUR 55,800
    - Total costs of salaries and administration EUR 32,000
    - Fuel costs = 6,294 ton*18 EUR/t EUR 113,287
    - Operating costs of auxiliary devices EUR 6,825
- Profit EUR 31,938
- Simple payback period 1,860.000 / 31,938 = 58.2 years

Since the profit is very low, small changes in the revenue estimate significantly affect the amount of profit, and thus profitability. If the total expenditures are about 15% lower than estimated (approx. EUR 30,000), the profit will be nearly double, i.e., EUR 61,938. In this case, the simple payback period is 30 years, which is much more than the plausible 8 years, yet much less than the original 58.2 years. Calculation in this case is more susceptible to estimated expenditure error than other cases due to the low profit rate.

If we compare the costs from the calculation with those shown in Table 3, the resulting values are as follows:

- Cfuel = EUR 113,287/1,950 MWh = BAM 0.1136 /kWh
  Cfuel (
  Table 3) = BAM 0.055/kWh
- Co&m = (55,800+38,825) EUR/1,950 MWh = BAM 0.0949/kWh
- Co&m (
- Table 3) = 294/6,500 = BAM 0.0452/kWh
- Cuvi = EUR 146,508/1,950 MWh = BAM 0.147/kWh (70% investment, 12 years, 6%)
- Cuvi (
- Table 3) = (6,600*13.9/100)/6,500 = BAM 0.141/kWh
- CPc = Cfuel + Co&m + Cuvi = BAM 0.3555/kWh
- CPc (
- Table 3) = Cfuel + Co&m + Cuvi = BAM 0.24067/kWh

Where:

- Cfuel – fuel costs
- Co&m – operating and maintenance costs
- Cuvi – investment costs
- CPc – Total costs of production per unit of generated electricity

As can be seen, there is a significant difference in the calculated value of fuel, and operating and maintenance costs. The investment costs are similar to those in the Decision (Table 3), although in the Decision a specific investment value of BAM 6,600 (EUR 3,375 per kW) was used, whereas in this calculation the investment value is nearly double at EUR 6,200 per kW. This is due to the fact that in this calculation, a lower interest rate on the loan accounting for 70% of the investment was used, instead of 80%, which is used in the Decision; also, the value from the Decision took into account the yield on interest-earning assets.

As can be seen from the above, in order for an ORC plant with capacity of 300 kW to be profitable over a period of 12 years, the feed-in tariff for electricity should be BAM 0.3555/kWh.

4.2 Results of profitability calculation that takes into account a thermal energy share

In this calculation the same parameters were used, except for:

- Price of moist woodchip EUR 35/ton
- 70% of thermal energy was used, the value of which is EUR 27/MWh
- Number of operating hours 8,000 h/year

These values are based on information USAID EIA collected from wood-processing companies in 2016. Market value of moist woodchips ranged from BAM 50 to 90/t, depending on the quality and transportation distance; but the most frequently quoted value was BAM 60-70 a ton. Due to an expected increase in demand for woodchips, the value used in the calculation was BAM 70/t, i.e., EUR 35/t.

Assuming that an average annual efficiency rate of the existing boilers is 75% and costs of investments, operating and maintenance costs are 50% of the value of fuel,[3] we get the value of thermal energy used in the generation process of EUR 27/MWh. This amount greatly depends on the value, type and age of the boiler and ancillary equipment as well as on the level and quality of automated control; however, the rough estimate presented here is appropriate for this purpose.

It is estimated that about 70% of thermal energy can be utilized. This estimate indirectly sets the total efficiency to be achieved for a power plant to be viable. In a detailed analysis of incentives one should consider the option of setting a minimum total efficiency rate in order to qualify for the feed-in tariff (premium) for electricity and/or thermal energy. As shown in Table 4, Croatia currently provides additional incentives for CHP plants with an efficiency rate over 50%.

Larger wood-processing companies require thermal energy throughout the year (over 8,000 h/year), so the capacity of a power plant should be selected based on thermal energy input required. Accordingly, the number of operating hours is estimated at 8,000 h/year, which is close to the maximum value that can be

[3] Holzwärme für Hotels und Gewerbe, Österreichischer Biomasse-Verband, 2016.

achieved if we take into account the regular maintenance of the system. Results of the profitability calculation are shown in table below:

Table 7 Simple payback period for investment, with a thermal energy share

Technology	Electricity (kW)	Thermal capacity (kW)	Total investment	Specific investment (EUR/kW)	Simple payback (years)
Steam	145	3,000	1,615,000	11,138	12.6
Gasification	150	185	950,000	6,333	22.4
	850	1,060	3,774,000	4,440	8.6
ORC	729	3,146	4,191,750	5,750	9.7
	300	1,505	1,860,000	6,200	11.9
Biogas	150	180	1,027,260	6,848	2.9
	500	500	2,500,000	5,000	7.1

From table above we see that **investments in solid biomass-fueled power plants are not viable**, i.e., given the current feed-in tariffs, the investors will not be able to repay loans with an interest rate of 7% and make a return on investment. In other words, even if the investor accepts 0% interest on the money put into the plant, the investor will still not be able to make payments on a loan with 7% interest.

The simple payback period is particularly long for small-capacity plants. This is particularly unfavorable for the promotion of solid biomass power plants because higher capacity means higher investment but also higher risk for the investors. On the other hand, investment into biogas CHP plants with a capacity of 150 kW is very favorable and will indeed attract investors.

5 Conclusions and recommendations

This report shows that, according to the values of parameters USAID EIA assessed based on a market research in 2016, **investments into solid biomass power plants are not financially viable**. In Croatia, feed-in tariffs for power plants with the capacity of 150–1,000 kW are EUR 200-208/MWh and are 62%-70% higher than in the Federation of BiH. Tariffs in Croatia only confirm the results of this analysis. In fact, Croatia has 10 solid biomass power plants with a total installed capacity of 24,585 kW, while FBiH and Serbia, which have very similar feed-in tariffs to those in FBIH, do not have even one solid biomass CHP plant. In the Federation of BiH, there is only one cogeneration using solid biomass under development– an ORC plant with the capacity of 1.2 MW, which is a part of a thermal plant in Livno.

On the other hand, the feed-in tariff for biogas-fueled plants with capacity of 23-150 kW is very high, which will certainly attract investors. However, a slump in feed-in tariffs for capacities over 150 kW makes such plants unprofitable. Feed-in tariffs for biogas-fueled plants with a capacity over 150 kW should be aligned with the tariffs for plants with a capacity of up to 150 kW, and this can be made by a linear reduction of tariffs with increasing plant capacity. This principle has already been applied in Serbia and is applicable to all capacity ranges, including solid biomass. Currently the feed-in tariff changes in a stepwise manner meaning it is constant for a range of plant capacities and that favors the power plants with capacity at the end of the range. This is particularly noticeable in FBiH, where the feed-in tariff for biogas-fueled plants with a capacity 23-150kW is 0.66637 KM/kWh and for plants with a capacity 151-1,000 kW is 0.27891/kWh, which means that the feed-in tariff drops from 0.66637 to 0.27891 KM/kWh when a plant capacity increases by 1kW from 150kW to 151kW. Clearly, no investor would then build a biogas plant with a capacity larger than 150kW unless they can build a plant with a capacity close to 1,000 kW.

In a detailed analysis of incentives, one could consider the option of setting a minimum total efficiency rate to qualify for a feed-in tariff (premium) for electricity and/or thermal energy. Croatia currently provides additional incentives for CHP plants with an efficiency rate over 50%.

Contracts for purchase of electricity at a feed-in tariff are valid for the period of 12 years, but banks and investors prefer shorter loan repayment periods – 5 to 8 years. Accordingly, shorter periods of validity of feed-in tariffs should be considered, with an appropriate tariff increase. To finance the increase of the feed-in tariff, the surcharge on the electricity price must be increased. When deciding on the contract duration and the feed-in tariff, a balance must be found between the interest of the private investor, the interests of banks and the ability of the electricity consumer to pay for the increased cost of electricity to finance the feed-in tariff. In FBIH the current surcharge on the electricity to finance the feed-in tariffs is only 0.001 KM/kWh or about 1% of the electricity price for households. In Republika Srpska the current surcharge on the electricity to finance the feed-in tariffs is 2.5 times larger, which proves that in the FBiH there is room for increasing the surcharge and the feed-in tariffs for biomass.

In addition, it is recommended to set the value of referent tariff (tariff paid out after the expiry of FIT) for biomass- and biogas-fueled power plants higher than for other RES plants. Currently, the referent tariff is the same for all RES plants, but biomass- and biogas-fueled power plants have significantly higher operating costs than water, wind and solar plants, as they must get their fuel supply on the market. For this reason, they should be considered separately.

Under the *FBiH Action Plan for the Use of RES* (APOEF), the plan was to generate 14 GWh of electricity from biomass in 2016 (dynamic quota for biomass for 2016), and all of it from solid biomass, without any share of biogas and bio-liquids. Since feed-in tariffs for biogas-fueled power plants of up to 150 kW are very favorable, one can expect greater interest in building biogas-fueled power plants. **Generation of electricity from biogas should be supported through feed-in tariffs in the APOEF**.

Having in mind the potential of biomass in the Federation, the existing dynamic quotas are small; nevertheless, they are not being reached. The APOEF should be re-considered, taking into account the developmental goals and potentials of RES in the FBiH. USAID EIA and GIZ are willing provide support to this task. In addition, certain provisions of the Law on Renewable Energy Sources of the Federation of BiH should be re-considered, in particular the possibility of shifting unused quotas from one RES to another (Article 19-3). Such practice may exhaust all available funds for electricity from RES, which may result in a very small or no support at all to some RES, such as biomass, that are of great importance for BiH.

In summary, the recommendations of this Report are:

1. The feed-in tariffs for biomass plants must be increased to make investment in them viable (except for biogas plants in the range 23-150kW).
2. The feed-in tariff should not change in stepwise manner but linearly decrease with increasing capacity**.**
3. The production and usage of heat as well as electricity should be considered in the setting of FITs for biomass plants.
4. The contract for purchase of electricity for biogas and biomass should be shortened with an associated FIT increase.
5. The surcharge on the electricity to finance the subsidies for electricity generation from RES can be set higher, without presenting an excessive burden to electricity customers, to be able to finance the increase FITs for biomass.
6. The referent tariff for biomass plants needs to be higher than for other RES plants because of higher operational costs (biomass is not free like sun, water and wind).
7. FBiH Action Plan for Use of RES should be revised to include a quota for generation of electricity from biogas.
8. FBiH Action Plan for Use of RES should be revised to increase the quotas for biomass.