1.1.14 Wood gasification power plant - Kočevje (SI)

Kočevje municipality adhered to the CoM initiative in February 2014. The SEAP development is currently in the final phase. The sustainable energy action "*Wood gasification power plant - Bio CHP Kočevje*" which is one of the cornerstones of the future development strategy of Municipality of Kočevje was assessed in terms of technical, financial, socio-economic and organisational aspects.

"BIO-CHP Kočevje" plant will be located 1,5 km away from the city centre of Kočevje town. It will be positioned close to the location of existing wood biomass combustion system used for district heating system of Kočevje town. Close to the location of the "BIO-CHP Kočevje" lies a chemical industry site Melamin d.d. Kočevje, milk industry Ljubljanske mlekarne and other industrial heat customers, which will assure heat consumption during the off-heating season and currently use fossil fuels. District heating system and industry represent reliable thermal heat consumption throughout the year. On the other side major wood processing industry and forestry industry is located nearby to the proposed location of the "BIO-CHP Kočevje" assuring reliable supply of wood based biomass feedstock materials. In BIO-CHP Kočevje project, the wood gasification technology was placed in epicentre of sustainable development:

- considering local advantages of Kočevje;
- which will raise the level of local energy self-supply considerable;
- and will have positive multiplicative effects in economic, environmental and social field.

Potential development effects of BIO-CHP project for the municipality of Kočevje:

- Important step towards sustainable energy self-sufficiency;
- Acceleration of economic development with higher added value;
- New working places in the region with one of the highest unemployment level in Slovenia;
- Reputation of Kočevje as a green municipality will attract new entrepreneurs and investors wishing to operate in a sustainable environment;
- Revenues from the energy self-supply will allow more investments in social infrastructure (culture, education, sports, care for the elderly, etc.);
- Faster development of (eco)tourism;
- Local food production (heated greenhouses);
- Establishment of a research, demonstration and dissemination centre for wood gas applications;
- An example for other municipalities in Slovenia and Europe;

- The pride of citizens to live in a green municipality and that they have chosen sustainable development.

Technical aspects

Biomass Gasification is a complex technological process, where a feeding stream is thermally decomposed and a product gas stream for electricity generation is produced as a result of the gasification reactions. The design of the FICFB (Fast Internally Circulating Fluidised Bed) CHP process has been demonstrated successfully in Güssing. The concept applied in the project is innovative within five main parts (gas cleaning, feeding system, fuel drying, fuel cells and syngas pipeline) to improve efficiency of the CHP plant, to further improve GHG balance, to enhance versatility of fuels used and to fulfil the heat demands. The standard operation of the plant is based on state of the art. On the other hand there will be some very important and innovative improvements integrated in the current project in order to push forward the gasification technology and to increase the overall efficiency. Complexity of innovations design is referring to strong interactions between gasification sub-processes, so any changes in the plant design must be very carefully performed and verified with other design parameters of the process.

Excess thermal heat produced in the FICFB plant will be consumed locally by industry users and by local district heating system during the heating season. In this way, cogeneration process of heat and power will have conditions for all-year operation, since constant demand for heat is assured. The main existing thermal heat distribution centre for industrial users and district heating system is located approximately 1300 m away from the FICFB plant location.

The total plant consists of the following main components:

- gasification
- gas cooling and gas cleaning (for the product gas and the flue gas)
- power conversion (engine and fuel cells)

and of the following auxiliary equipment: air compressor, nitrogen supply, bed - material and precoat - material supply, auxiliary fuel supply, gas burner, stack, transport systems, electrical equipment, and process control equipment.

Due to improvements and innovations proposed in the project, the following targets (Table 18) should be achieved in the project with FICFB gasifier and utilization of a gas engine and fuel cells for electricity production:

Table 17 Technical parameters and design values for the BIO-CHP Kočevje

Parameter	Design Value
Total fuel input power (wood biomass)	8000 kW
Fuel power producer gas	5600 kW
Power at generator output	2200 kW
Heat district heating	2000 kW
Heat steam generation	2500 kW

The produced gas is suitable for power generation, but due to its composition is also suitable for sustainable production of 2nd generation bio-fuels and green chemistry products e.g. green hydrogen, bio-methane, bio-diesel, bio-petrol, bio-formaldehyde, etc. depending on added value and transport and local industry needs.

The process parameters are:

- Gross power at generator output (electricity): 1,2 MW
- Net power at generator output (electricity): 1,0 MW
- Heat generation (steam + hot water): 5,2 MW
- Wood biomass use: 20.500 t/a (45 EUR/t)
- Annual power generation: 15.840 MWh (143,17 EUR/MWh assuming 50% investment subsidy)
- Annual heat generation: 29.160 MWh (60 EUR/MWh)

Environmental aspects

The FICFB CHP plant is characterised by an excellent environmental performance, above all by low gaseous emissions, by no liquid emissions and by ash only from the combustion zone with a very low carbon content. In CO_2 savings calculation utilization of a gas engine of 2 MW and the fuel cells of 0,2 MW for electricity production is considered. Availability of the plant is expected to be 7200 hours per year (h/a).

Reduction of greenhouse gas emissions were determined using the standard GHG mix emission coefficient for electricity production in EU and the standard GHG emission coefficient for heavy fuel oil. The BIO-CHP Kočevje plant with a gas engine and fuel cells will reduce GHG emissions by **17.060 tCO_2eq per year.**

Due to the novel technology applied in this project the Directive 2009/28/EC does not provide sufficient input data to compute a complete CO2-balance. In general the GHG reduction is nearly 100% if system boundary doesn't include biomass harvesting or treatment since there are no additional GHG-emissions from the plant itself. A detailed LCA and computation of GHG emissions will be carried out in continuance of the project.

To comply with Directive 2009/28/EC, annex VB, there is a good estimation to use the GHG-reductions for the processes, which are utilizing syngas, which is in the range of 91-95% greenhouse gas emission savings. If we take into account, that the CHP utilization of syngas

is more efficient than the fuel production of it, the BIO-CHP Kočevje plant can be considered as nearly carbon neutral also from this point of view.

During construction, operation and decommissioning no significant environmental impacts are expected. The site is not located on the water protection area for drinking water protection, neither on the flooding area. The underground water emissions during the construction period are potentially possible because of the construction machinery and transport vehicles, potential fuel spills or propellants (mineral oils), but only in the case of extraordinary circumstances.

Financial aspects

Investment costs of the project "BIO-CHP KOČEVJE" that are predicted to be realized in construction period are attaining a value of **20.000.000 EUR**. Detailed investment plan is divided into six sub-categories:

- **Capital equipment**: 13.800.000 EUR
- **Site infrastructure**: 2.000.000 EUR
- **Development costs**: 1.500.000 EUR
- **Installation and commissioning**: 1.300.000 EUR
- **Design**: 1.400.000 EUR
- **Intangible assets**: 0 EUR

Municipality of Kočevje and private investor intend to raise funding money partly by raising funds externally and partly by internal reserves. Details of the municipality and private investor(s) funding are still not exactly known. Negotiations are in progress and it is anticipated, that in the due time the details will be defined. Majority of the requested funds will be provided by commercial loans. Project Sponsor is assuring that all conditions are met in respect of timing of funding and is minimizing the risk of appearance of any kind of contingency during the project delivery. Moreover, Project Sponsor will ensure overcoming a bridging of requested sources of funds within obliged amount and according to project's investment schedule.

Procurement procedures will be carried out by valid Slovene legislation which is in line with EU legislation. Foreseen procedure will include following steps:

- Invitation to submit applications (pre-selection)
- Negotiated procedure

The expected dates for: launching the tenders, signing the contracts and the contract execution schedule.

- Launching the tenders: August 2014
- Signing the contracts:

- Designing and supervision: March 2014
- Legal advisory: March 2014
- Main delivery and works contract: April 2015

Requirements and evaluation measures of each of the main contracts envisaged will be: experiences, references, guarantee period, appropriate bank guarantees, price and payment conditions.

In order to respond to the requirements in an optimal way, a quality assurance system will be established. Quality control will comply with the effective Slovenian standards and take guidance from the international standards ISO 9001 and ISO 14001. Active participation will be committed in making the quality assurance procedures of the different sub-contractors close to and harmonizing with one another during the advancement of the design and performance of the works.

Table 18 Project investment dynamics

YEAR		2014	2015	2016	2017	2018	2019	2020	2021
YEAR		0ii	0i	0	1	2	3	4	5
Investment Schedule	%	10	80	10					
	EUR	2.000.000	14.000.000	4.000.000					
Municipality	%	5	10	5					
	EUR	1.000.000	2.000.000	1.000.000					
Private investor	%	5	20	5					
	EUR	1.000.000	2.000.000	3.000.000					
NER300 Grant	%		50						
	EUR		10.000.000						
Operation				Commissioning / Performance testing	80%	90%	100%	100%	100%

Entry into operation

The project cash flow projection of the project is shown in Annex II (in the detailed SEAP action assessment study). Project cash flow projections have been made in real and nominal terms and enable calculation of pre - tax and post tax internal rate of return (IRR). Table 20 below shows project cash flow projection in real terms, including calculation of post - tax IRR. A financial plan anticipates straight line method of depreciation, which refers to reduction of the value as per a constant rate. The depreciation value is calculated by taking the original purchase (CAPEX), and dividing it by an economic period of 15 years. The rate of depreciation remains constant as a fixed expense throughout the years.

Table 19 Dynamic indicators derived from the cash flow of the project BIO-CHP Kočevje after funding in real terms

Dynamic Economic Indicators		
NPV	3.241.407	€
IRR	4,97	%

RELATIVE IRR	16,25	%
RECOVERY PERIOD	11	YEARS

The minimum pre - tax Internal IRR that the Project Sponsor normally requires in order to approve its projects (Hurdle Rate) is 7%. The same rate is determined as a hurdle rate or general discount rate by the Republic of Slovenia (Decree on the uniform methodology for the preparation and treatment of investment documentation in the field of public finance; Official Gazette of the Republic of Slovenia, number 60/2006, 54/2010). The project BIO-CHP Kočevje IRR (real terms, after tax) of 4,97%. IRR of the project in Kočevje is less than a hurdle rate.

The project shows relatively high volatility of modification of model inputs according to running sensitivities (Table 21). Four factors have been determined as being most critical in terms of forecasting of other type of contingency events. Those factors are heat price, biomass price, electricity price and annual production. The sensitivity analysis shows that modifying critical model parameters by 10%, dynamic indicators of the project would show less efficient economic dynamic indicators in the terms of ceteris paribus.

Table 20 Sensitivity analysis

CALCULATIONS FOR SENSITIVITY ANALYSIS	
PARAMETERS	**VALUES OF PARAMETERS BASED ON A MODEL INPUTS**
NPV	4.795.009
IRR	4,02%

SENSITIVITY ANALYSIS (absolute value)			
PARAMETERS	**MODIFICATION**	**NPV**	**IRR**
HEAT PRICE	↓ 10 %	2.591.792	2,93%
BIOMASS PRICE	↑ 10 %	3.607.049	3,44%
ELECTRICITY PRICE	↓ 10 %	1.939.223	2,59%
PRODUCTION	↓ 10 %	- 263.993	1,42%

SENSITIVITY ANALYSIS (relative value)			
PARAMETERS	**MODIFICATION**	**NPV**	**IRR**
HEAT PRICE	↓ 10 %	-45,9%	-27,1%
BIOMASS PRICE	↑ 10 %	-24,8%	-14,4%
ELECTRICITY PRICE	↓ 10 %	-59,6%	-35,6%
PRODUCTION	↓ 10 %	-105,5%	-64,7%

Socio-economic aspects

Socio-economic impacts of the project are expected to be very positive for the Municipality of Kočevje, creating new working places, supporting local suppliers and enhancing the energy self sufficiency of the local community. Regional added value will rise because of less amount of money for externally produced energy, which will remain in the region. The local community

will take over the leading role in reducing greenhouse gas emissions in Slovenia and will be a best practice example for further replication of green technologies.

Internal Rate of Return (IRR) are unfavourable, mainly because of high investment cost of the novel technology, and are lower than that the Municipality normally requires in order to approve its projects.

However, the main motivation of the BIO-CHP Project is sustainable development in the less developed region and municipality with high level of unemployment, with emphasise on local energy self-supply and decentralised energy production. Albeit the economic effectiveness of the sustainable development is very important, the natural environment for wood gasification plant and expected positive multiplicative effects of the BIO-CHP Kočevje project on social and environmental area outweigh unfavourable economic indicators.

Abundance of wood is great, yet unexploited development potential of Slovenia - especially of as wooded municipality as is Kočevje, which has to be used for sustainable growth, new working places and economy competitiveness improvement. This is also basis for large repeatability potential of the BIO-CHP Kočevje project. New working places, added value, which remains in municipality/region, simultaneously development of eco-tourism and other sustainable plans of the Project sponsor to improve the overall situation in municipality/ region are based on the BIO-CHP Kočevje project. The goal of municipality Kočevje is to become a sustainable and energy self-sufficient municipality and the BIO-CHP project represents a crucial step in path towards this objective. It is expected and already demonstrated by good examples in Europe, that cumulative effects, especially economic, of such approach to sustainable development is by far better than that of the project solely.

The economic analysis of the project estimates contribution to the economic development of society. It is made on behalf of the entire society and not just in terms of infrastructure owner/ operator. In the economic analysis, the assessment of the added value of the project on the quality of life has been taken into account. Added value can also be represented by impact on healthy lifestyles and human health. The assessed investment will add value through a positive impact on the economy as well. In the economic analysis, the following impacts were considered:

- tax adjustments;
- corrections for externalities;
- adjustments due to indirect effects;
- transformation market price to clearing price;
- discounting.

Possible additional economic benefits, defined in the methodology of costs and benefits (CBA) would be:

- increase the welfare of the citizens;
- social costs that would result from the sub-optimal investment by not used the best alternative;
- externalities, for example increase in revenue due to additional activities (eco-tourism, etc.).

Table 21 Summary sheet with key financial/economic metrics

Indicators	Value	Unit
NPVe	4.795.009	€
NPVf	3.241.407	€
NPVf	13.850.254	€
NPVe	12.296.652	€
IRRf in real terms, before tax	4,02	%
IRRf in real terms, after tax	4,97	%
IRRe in nominal terms, before tax	7,57	%
IRRe in nominal terms, after tax	7,02	%
REQUESTED GRANT NER 300	10.000.000	€
Credit 1	3.000.000	€
Credit 2	5.000.000	€
Interest rate	1,01725	%
Annual depreciation	1.333.333	€
Depreciation rate	6,67	%
f stands for financial and e for economic		

Socio-economic internal rate of return is positive and after tax amounts to 7.02 % (for the default period of 15 years). Investment therefore gives a positive social and financial performance.

Organisational assessment

Investment is planned to be carried out between years 2014 and 2017 (Table 23).

Table 22 Time schedule of the project

Task	Duration	Start	End
BIO-CHP Kočevje	36 months	January 1 2014	January 1 2017
Main subcontracts	3 months	January 1 2014	March 1 2014
FEED, key investment decision, funding	4 months	March 2 2014	June 30 2014
Award decision		June 30 2014	
Consenting	5 months	June 1 2014	December 1 2014
Design/Engineering	16 months	April 2 2014	July 30 2015
Procurement	6 months	August 1 2014	February 1 2015
Site enabling works	3 months	February 2 2015	May 3 2015
Civil construction	5 months	April 4 2015	September 4 2015
Mechanical erection	6 months	September 5 2015	March 5 2016
Electrical, control and instrumentation	5 months	November 1 2015	April 1 2016
Commissioning	6 months	April 2 2016	October 2 2016
Compliance/ Performance testing	7 months	June 3 2016	December 31 2016
Entry into operation		January 1 2017	

The design work has been prepared on the conceptual design level. This means that the general technological approach has been defined; however specific technological

components and equipment are still open. This has been done intentionally in order to have the flexibility of deciding on the supplier of the equipment and therefore obtaining the best price for the required supply rather than being “held hostage” by the pre-chosen supplier.

Stakeholder management plan

Partners will use stakeholder management plan (Table 24) in order to support future partners in achieving its strategic objectives by interpreting and influencing both the external and internal environments and by creating positive relationships with future partnershttp://en.wikipedia.org/wiki/Stakeholder_%28corporate%29 through the appropriate management of their expectations and agreed objectives. Key stakeholder will be the Municipality of Kočevje, together with Komunala Kočevje d.o.o.

Table 23 Stakeholder plan

Position/Title	Department/Organisation	Interests
Mayor	Občina Kočevje	Main-owner of the process. Ensure that the project is managed effectively. Provide direction and make business decisions.
Director of administration	Občina Kočevje	Provide direction and make legal decisions.
Financial manager	Občina Kočevje	Provide direction and make financial decisions.
General Manager	Komunala Kočevje d.o.o	Co-owner of the process. Provide direction and make business decisions.
Manager	Ljubljanske Mlekarne, d.d.	Provide direction and make business decisions.
General Manager	Melamin d.d. Kočevje	Provide direction and make business decisions.
Technical Manager	Melamin d.d. Kočevje	Provide direction and make technical decisions.
General Manager	Gozdarstvo Grča d.d. Kočevje	Provide direction and make business decisions.

Kočevje municipality signed a twinning agreement with Huétor Tajar. The importance of experiences exchange regarding the district heating system in Huétor Tájar was significant, since the district heating in Kočevje is planned to be upgraded with similar system. The expert’s presentation on the 750 kW cogeneration plant was impressive and very interesting for Slovenian delegation. It was demonstrated, how olive pits, otherwise waste at oil production process, can be used for heating the swimming pool, sport area, primary school buildings and hot domestic water. In addition to the district heating system, the mayor of Kočevje discussed with its colleague about the efficient public lighting experiences in Huétor Tájar, as well as about different possibilities of cooperation between their municipalities not only in the framework, but also beyond the end of Green Twinning project.

Figure 3 Visit to the biomass district heating of Huétor Tájar

Findings and Recommendations

Annual net incomes of the project after tax are estimated to be about 2.000.000 EUR. This money will be used for used for social, education, sport infrastructure and transfers. The project is orientated purely towards sustainable development of the local community and is therefore recommended in form as planned without any hesitations for Municipality of Kočevje.

Table 25 below summarises the results of the technical, financial, socio-economic and organisational analysis of the action entitled "Wood gasification power plant "Bio CHP Kočevje"".

Table 24 Summary of the findings of the assessment study of the action "Wood gasification power plant "Bio CHP Kočevje"

Technical/ Environmental Assessment	**Title**	Wood gasification power plant "Bio CHP Kočevje"
	Baseline scenario data (kWh, tCO_2, €)	SEAP not approved yet
	Technology employed	FICFB - steam - gasification - process for heat and power cogeneration (gas engine + fuel cells)
	Technology providers	Not specified yet
	Technical specifications	Total fuel input power: 8000 kW Fuel power produced gas: 5600 kW Power at generator output: 2200 kW Heat district heating: 2000 kW Heat steam generation: 2500 kW
	Energy savings	Carbon near-neutral production of: Electricity: 15.840.000 kWh/year Heat: 29.160.000 kWh/year
	CO_2 savings	17.060 tCO2/year
	Primary energy savings	71.676.000 kWh/year
Financial assessment	**Financing scheme**	PPP (municipality + private partners) funds (50 %) NER300 grant (50 %)
	Project cost	20.000.000 €
	Annual maintenance	~ 2.700.000 €

	costs	
	Annual project revenues	~ 4.700.000 €
	Discount rate	1,56 %
	IRR (%)	4,97 %
	NPV (€)	3.250.448 €
	Payback period (years)	11 years
Socio-economic assessment	**IRR**	7,02 %
	NPV	4.795.009 €
Organisational assessment	**Time-schedule**	1/1/2014-1/1/2017