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New approach in production of heat and electricity from wood biomass – good enginering practice of Bioenergy Point

The United Nations Development Programme (UNDP), acting as an implementing agency of the Global Environment Facility (GEF), is supporting the Ministry of Environmental Protection (MoEP) to implement the five-year "Climate Smart Urban Development Challenge" project, jointly financed by the GEF, MoEP and municipalities. The objective of the project is to promote climate-smart urban development. By a challenge prize approach it seeks to actively engage the civil society, public and business communities to come up with new and innovative ideas on how to contribute to this in practice and to jointly develop, finance and implement these ideas further. Broader and more effective use of new information and communication technologies (ICT) to enable and spearhead innovation and productivity gains, optimization of the resource use (e.g. by improved energy efficiency and resource sharing), reduction of physical mobility needs, more attractive public and non-motorized transport, increased use of renewable energy sources, climate smart waste management (improved recycling schemes and waste to energy) and other measures contributing to climate change mitigation are among the topics to be considered in this context. All activities and measures undertaken by the project will need to result in tangible GHG emissions reduction and are to be considered from the perspective of climate smart planning.

The project idea offers innovative business model and technology which will have impact on GHG reduction, ecological problems, employment and gender equality trough conversion of wood waste to energy in combined heat and electricity plant (CHP), trough expansion of production of biomass - pellets with highest EnPlusA1 quality produced form green energy and way of collecting, preparing and transport inputs for production processes. Bio Energy Point (BEP) completed closed system which will produce and consume all heat energy and made leverage in inputs for their products. Objectives of the project are: reduction of GHG emissions, employment of 1% of population in Boljevac, creation of efficient wood waste market in Serbia and building of innovative sustainable business model in wood waste management. The project has been implemented mainly in Serbia with impact at national level.

DESCRIPTION OF PROJECT ACTIVITIES

BEP Company built diverse wood waste supply: woody packages from industry, residual after harvesting, waste wood from River Danube at Hydroelectric power plant Đerdap. BEP will collect waste, grind with shredder at the site depending of quantity, putting into containers and transport to CHP. Wood waste are chipped with special machines (Figure 1.) and collected at seller place, loaded to ab-roll containers and transported to Boljevac, where CHP plant operate, and the produced heat energy will be used for production of pellet at the Bio Energy Point plant which is 200 m away, with parallel electricity production that will be sold to EPS at feed-in-tariffss.

Figure 1: BEP's shredder machine processing waste wood from Danube river

Transport services of all inputs (wood and wood waste) and final products previously have been outsourced and now BEP created its own fleet comprised of 3 roll-off tippers with diesel EURO 5 engines with trailers and 10 ab-roll containers. Logistic is organized as it follows: engage above mentioned fleet to transport pellets and pallets in ab-roll containers (33m3 volume and 11 pallet places each container) from Boljevac to customers and to transport wood waste to Boljevac with no empty runs and without delays in delivery due to to a truck breakdown and poor maintenance. Each truck will have average yearly mileage between 75.000 km and average fuel consumption of 36 l/100km. New fleet will replace outsourced transportation services with relatively old trucks.

Plant, which as a fuel uses non-hazardous waste wood, started production of electric and heat power in 2019. CHP (Figure 2.) is designed by URBAS and has installed capacity of 2.38 MWel. Projected BEP's electricity production of 19.992 MWh per a year will be reached in 2020. Projected power production covers average yearly electric power consumption of 4.700 households in Serbia. When Serbian households reach European average of 250 kWh of average monthly electric power consumption per household, 6.580 households in Serbia will use green electric energy produced in CHP plant in Boljevac. All produced electric power has been sold to state-owned company ''JP EPS'' at feed-in tariff prices and all heat power of 57.739 MWh will be used for sawdust drying system and for pallets drying system. Hot water from CHP, goes through pipes to dryers which is 200 meters far from plant. After the innovative sawdust drying system complete the process, the material for pellets of highest quality is ready to continue the production process.

Figure 2: BEP's CHP plant Boljevac

BEP will replace existing sawdust drying technology in pellets production and implement innovative drying system. Currently uses 4 dryers, 2 rotary and 2 fluid which consume 3000 t of wood waste per a year in heating processes and operate with emissions which do not fit EU regulations. All 4 have capacity to dry sawdust for production of 70000 t of pellets per a year (it is bottleneck in production) and have high electric power consumption.

Figure 3: Old rotary dryer

Rotary dryers (Figure 3.) work at 200-300°C. High temperatures damage (partially burn) material for pellets and more wood is required for production of 1 t of pellets. BEP acquired new belt dryer (Figure 4.) which will be connected to GEPs heating system, dry sawdust at 70-90°C and have annual drying capacity for production of 90.000 t of pellets of ENPlusA1 quality. Electricity consumption of new belt dryer for 90000 t of pellets is around 50% less (198 kWel) than consumption of 4 existing dryers (412 kWel) for production of 70000 t.

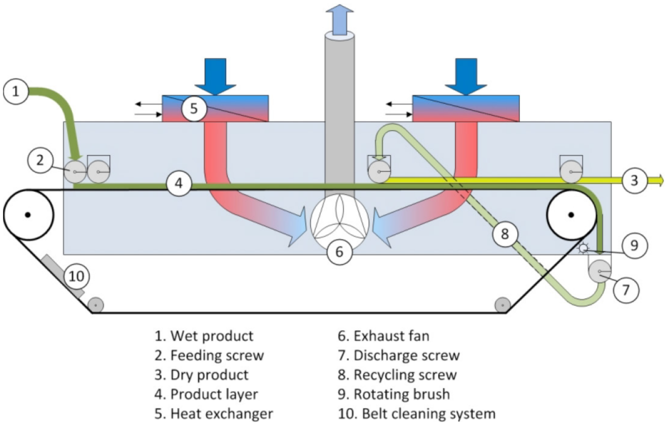

Figure 4: New belt rotary dryer [1]

After connection to CHP heating system and new dryer, the yearly production of pallets will be 114,28% higher. BEP will expand yearly production from 84000 to 180000 pieces. Over 21000 pieces of pallets will be delivered to pellets packing and loading point (200m faraway) without transportation and it will save 5250 km and 2100 l of diesel (35 loaded trucks, each with 600-700 loaded pallets, 150 km per load which is equal to 5250 km, and truck fuel consumption 40l/100km equal to 2100 l of diesel).

Focus to domestic market and plan to sell 20000 t of pellets in Serbian market instead of European will save 3.676.320 l of diesel in period of 20 years (20000 t will be sold in places within 150 km far from Boljevac instead of Italy 750 km far; each truck can load 23 pallets which is 24.15 t; 200000 t/24.15 t=828 trucks which will transport pellets 150 km instead of 750 km and save 496800 km per a year and 3.676.320 l in a period of 20 years.

CALCULATION OF GHG EMISSIONS REDUCTION

Reduction of GHG emissions will be reached through implementation of innovative business model, technology and reorganization of current processes.

Reduction due change in biomass supply transport

Situation before Project implementation - Outsourced transportation

- Total annual mileage of all outsourced trucks: n_{km}=1600000 km
- Average fuel consumption: c_f = 40l/100km
- Net calorific value, Emission factors for diesel [2] and Global worming Potential (GWP) [3]:

H_d = 43000 kJ/kg (density ρ_d=840 kg/m³)
EF_{CO2} = 74100 kgCO2/TJ
EF_{CH4} = 3.9 kgCO2/TJ and GWP $_{CH4}$=25
EFN2O = 3.9 kgCO2/TJ and GWP $_{N2O}$=298

- Total annual $CO2_{eq}$ emissions:

$$E_{OF} = n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot \cdot EF_{CH4} \cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

E_{OF} = 1742.08 $tCO_{2\,eq}$/year

New situation – Own new fleet

- Total annual mileage of all trucks: n_{km}=225000 km
- Average diesel consumption: c_f =36l/100km
- Total annual CO_{2eq} emissions:

$$E_{NF} = n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot \cdot EF_{CH4} \cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

E_{NF}=220.48 $tCO_{2\,eq}$ /year

Annual reduction potential due change in biomass supply transport:

$R_{ST} = E_{OF} - E_{NF}$
R_{ST} = 1521.59 $tCO_{2\,eq}$/year

CHP characteristics and GHG savings

- Installed electrical capacity: Q_{el} = 2.38 MWel
- Total annual full load hours: n_{wh} = 8400 h

Since Serbian electricity production is based on coal thermal power plants, savings are calculated based on substitution of coal (domestic Serbian lignite) produced electricity.

- Equivalent thermal capacity: 7.21 MWth (at average eficieance of Serbian coal power plants η_{el}=33 %).
- Emission factors for lignite [2] and Global worming Potential (GWP) [3]:

EF_{CO2} = 101000 kgCO2/TJ
EF_{CH4} = 1 kgCO2/TJ and GWP $_{CH4}$=25
EF_{N2O} = 1.5 kgCO2/TJ and GWP $_{N2O}$=298

- Total annual CO_{2eq} savings:

$$R_{CHP} = \frac{Q_{el}}{\eta_{el}} \cdot n_{wh} \cdot 3600 \cdot EF_{CO2} + \frac{Q_{el}}{\eta_{el}} \cdot n_{wh} \cdot 3600 \cdot EF_{CH4} \cdot \cdot GWP_{CH4} + \frac{Q_{el}}{\eta_{el}} \cdot n_{wh} \cdot 3600 \cdot EF_{N2O} \cdot GWP_{N2O}$$

R_{CHP} = 22127 $tCO_{2\,eq}$ /year

GHG emissions from shredding machine

Shredding machine is driven by truck diesel engine.

- Estimated annual diesel consumption: q_d = 5500 l/year
- Total annual CO2eq emissions:

$$E_{SM} = q_d \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CH4} \cdot \cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

E_{SM}=14.95 $tCO_{2\,eq}$ /year

GHG emissions and reductions from drying process

Situation before Project implementation:

- Installed electrical capacity: Q_{OD} = 412 kWel
- Total annual operating hours: n_{wh} = 8400 h
- Grid emission factor for Serbia: GEF = 1.099 tCO2/MWh [4]
- Total annual CO_2 emissions from drying process:

$$E_{OD} = Q_{OD} \cdot n_{wh} \cdot GEF$$

E_{OD} = 3803.4 tCO_2/year

Situation with Project proposed new drying process:

- Installed electrical capacity: Q_{OD} = 198 kWel
- Total annual operating hours: n_{wh} = 8400 h
- Total annual CO_2 emissions from drying process:

$$E_{ND} = Q_{ND} \cdot n_{wh} \cdot GEF$$

E_{ND} = 1827.9 tCO_2/year

Annual reduction potential for drying process:

$R_D = E_{OD} - E_{ND}$
R_D = 1975.5 tCO2/year

Reduction of GHG emissions due changes of pallets transport

- Total annual mileage savings due to Project implementation: n_{km}= 5250 km
- Average diesel consumption: c_f = 40 l/100km
- Total annual CO_{2eq} reduction:

$$R_{TP} = n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CH4} \cdot \cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

R_{TP} = 5.72 tCO2 eq /year

Reduction of GHG emissions due market changes

European market

- Total annual mileage of all outsourced trucks: n_{km} = 621000 km
- Average deisel consumption: c_f = 37 l/100km
- Total annual CO_{2eq} emissions:

$$E_{EM} = n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CH4} \cdot \cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

E_{EM} = 625.43 $tCO_{2\,eq}$ /year

Serbian market

- Total annual mileage of all outsourced trucks: n_{km} = 124200 km
- Average diesel consumption: c_f = 37 l/100km
- Total annual CO_{2eq} emissions:

Figure 5: Interface of GHG emissions and reduction tool

$$E_{SM} = n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CO2} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{CH4} \cdot$$
$$\cdot GWP_{CH4} + n_{km} \cdot c_f \cdot \rho_d \cdot H_d \cdot EF_{N2O} \cdot GWP_{N2O}$$

E_{SM} = 125.09 $tCO_{2\,eq}$ /year

Annual reduction potential due changing market:

$$R_M = E_{EM} - E_{SM}$$

R_M = 500.35 $tCO_{2\,eq}$ /year

Overall annual Project reduction potential:

$$R_{total} = R_{ST} + R_{CHP} - E_{SM} + R_D + R_{TP} + R_M$$

R_{total} = 26115.21 tCO2 eq

MONITORING PLAN

According to "Climate Smart Urban Development Challenge" Project terms GHG emission reduction potential is calculating on 20 years base, so it is necessary to follow the activity data of GHG emissions and based on them and presented calculations get the real anaul and overall 20 year reduction. According given calculation, maximal 20 year reduction potential is 522304 tCO2 eq. Following calculations for each of activities in BEP's project plan, and in order to monitor and calculate GHG emissions and reductions, comparing to situation before Project implementation, in future years simple calculation tool is developed (Figure 5.).

CONCLUSION

BEP's project "New approach in production of heat and electricity from wood biomass" supported by UNDP's "Climate Smart Urban Development Challenge" project is an example of good practice, that presents innovative business model which will have impact on GHG reduction, ecological problems, employment and gender equality. Based on analysis of GHG emissions for situation before and after project implementation, overall annual reduction potential due to project activities implementation is 26115.21 tCO2 eq. Installation of CHP presents project activity with the most potential for GHG reduction since it covers almost 85% of total reduction.

In order to calculate and monitor annual GHG emissions a simplified tool has been developed.

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