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Markus Hirvonen (ed.)

Bioenergy feasibility study - Berzasca, Romania

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Bioenergy feasibility study - Berzasca, Romania

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1 Introduction

In CEE countries it has become essential to exploit local biomass resources more effectively to fight climate change and improve local economy. By providing good practices and proving the benefits of biomass utilization by calculations and case studies we can help these countries in reaching their goals for renewable energy utilization.

Heat production from biomass is one of the most effective ways to reduce one's carbon footprint when substituting fossil fuels with renewable alternatives in energy production. Even in warmer regions heating energy production has a big role in total energy consumption. It has to be carefully evaluated which is the most viable solution for renewable energy utilization in given area. With this report we are giving readers the possibility to familiarize themselves with basic assessment of forest resources and feasibility evaluation of centralized heat production in South-East Europe.

2 KIEMET-project

Central and Eastern European Forest Information Service (KIEMET) is a project that produces information on forestry, forest sector business environment, wood supply, forest enterprises and bioenergy markets in the CEE countries (Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Belarus, Ukraine and Romania).

As a part of the KIEMET-project University of Eastern Finland, Finnish Forest Research Institute and Karelia University of Applied Sciences conducted a case study on the feasibility of centralized heat production from biomass in Berzasca commune in Romania. KIEMET -project was funded by the European Social Fund 2010-2012.

3 Aims and objectives of the case study

In this case study we illustrate the basic steps for feasibility assessment of biomass based district heating system on the basis of what we have learnt in Finnish environment. This case study aims to produce useful information for decision makers in order to assess the possibilities of biomass based district heating systems and procurement chains needed.

First we describe the case study area and its properties and then we move on to discuss about forest resources and availability of biomass. Then we look at the wood procurement and wood chip production cost calculation. After these we move on to discuss about heat production from biomass in Berzasca commune with two different scenarios. Our aim is to produce as much as useful information as possible to promote the use of biomass in west-region of Romania and also on other CEE-countries.

4 Berzasca

Berzasca is a small village located on the West region, Caras-Severin county on the banks of Danube defile in the middle of Iron Gate Natural Park on the south-west part of Romania (Picture 1.). Berzasca has a bit more than 15 hundred inhabitants which create an active community seeking to invest in more sustainable solutions for the future wellbeing.

Some background info of Berzasca and its surroundings (Berari 2012):

- 1509 Inhabitants
- 536 houses and 4 multi-storey buildings
- Fresh water pipeline 3 km
- Sewage system 5,5 km
- No natural gas connection
- No district heating network (plant and network dismantled)
- Main source of heating energy buildings is wood heating boilers and stoves
- Temperate continental climate with pronounced Mediterranean influences
- Forests represent over 65% of vegetation in the area
- Hilly terrain of heights between 800-1200 m

Picture 1. *Location of Berzasca (Modified from Kiemet brochure)*

5 Current state of district heating in south-west Romania

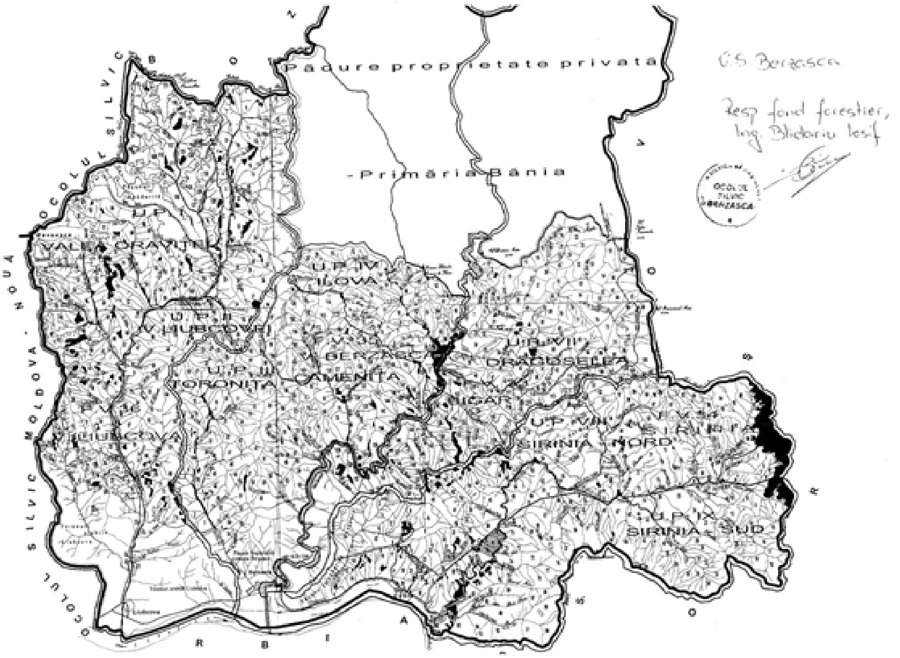
Centralized heating solutions were popular in south-west Romania during socialist era till the end of the eighties. Mostly coal and oil were used as a fuel for heat production and biomass based district heating systems haven't been reported. After the 1989 revolution many of these district heating systems were dismantled because lack of maintenance, unreliable heat distributing and rising prices. (Berari 2013) It is likely that one big contributing factor was also that district heating was seen as a part of socialist heritage and households therefore disconnected from the grid and started to produce their own heating energy.

Nowadays remote communes mainly use wood logs, coal or oil as their source of heating energy. Natural gas is used in the areas where it is available. District heating has gained interest lately mainly because of its energy efficient heat production and ease of use for the end user. In West-region of Romania bigger cities use district heating and heat is provided mainly by combined heat and power (CHP) plants. Smaller scale CHP-systems are absent in west-region at the moment. Centralized heat production from biomass especially in smaller communes could be beneficial for local economy and therefore heat production from biomass needs to be discussed further in order to promote district heating and sustainable energy solutions.

6 Forest resources information

Eugene Lopatin, University of Eastern Finland

For the wood procurement and wood chip production cost calculation the spatially explicit data layers were procured from the Regional Development Agency of West Romania. The characteristics of forest resources in Berzaska presented in Table 1. Forest stands were digitalized from georeferenced and scanned paper map (Picture 2).



Picture 2. *Forest management inventory map of Berzasca, 2004.*

Table 1. *Forest structure of Berzasca forest district according to Regional Development Agency of West Romania (2013)*

INDICATOR		**SPECIES**										
		TOTAL	**Beech**	**Oak (Quercus petrae)**	**Linden**	**Hornbeam**	**OAK - Quercus cerris**	**Fraxinus Ornus**	**Aspen**	**Diverse coniferous**	**Diverse hardwood**	**Diverse softwood**
Forests* (ha)	Group I	11144.7	6164.1	1764.5	782.3	774.1	251.0	49.4	319.5	397.3	478.3	164.2
	Group II	-	-	-	-	-	-	-	-	-	-	-
Total A1(gr.I+gr. II) (ha)		11144.7	6164.1	1764.5	782.3	774.1	251.0	49.4	319.5	397.3	478.3	164.2
Total U.P.(A1+A2) (ha)		22998.5	10729.5	3782.2	2426.4	1723.0	591.3	562.7	537.8	609.0	1815.7	220.9
Species proportion %	A1	100	55	16	7	7	2	1	3	4	4	1
	FD	100	47	16	11	7	3	2	2	3	8	1
Medium production grade	A1	III.2	III.2	III.3	III.1	IV.1	III.4	III.2	II.7	II.6	III.3	III.2
	FD	III.5	III.4	III.6	III.4	IV.3	III.8	IV.0	II.8	II.7	III.7	III.2
Medium consistency	A1	0.78	0.77	0.78	0.81	0.81	0.74	0.80	0.80	0.81	0.81	0.81
	FD	0.77	0.77	0.77	0.79	0.80	0.74	0.67	0.79	0.82	0.74	0.82
Medium age (years)	A1	65	71	72	59	53	78	50	43	31	51	31
	FD	72	76	79	66	60	91	75	46	31	66	30
Total wood (m^3)	A1	2127944	1263275	338984	181144	101123	45208	5959	49254	65758	63273	13966
	FD	4378558	2327034	736017	553246	229144	101728	42499	85050	94652	200450	17738
Wood volume m2/ha	A1	190	204	192	231	130	180	120	154	165	132	85
	FD	190	216	194	228	132	172	75	158	155	110	80
Current growth index (m^3/ year/ha	A1	5.8	6.0	4.6	7.5	5.3	4.1	0.9	4.1	8.6	5.1	4.2
	FD	5.1	5.6	4.2	5.4	4.7	3.1	0.2	3.9	8.1	4.1	4.8
Annual possibility of secondary products (m^3/year)*		23538*	18859	2107	811	215	823	6	37	58	452	170
Annual possibility of secondary products (m^3/year)*, of which:		3485	1164	272	653	354	39	3	274	359	162	205
Thinnings		3037	983	247	609	322	30	3	272	307	131	133
Harvest index (m^3/year/ha)		Main			Secondary				Total			
		1.0			0.2				1.2			

Forests for which it is reglementated the harvesting of main products.

Care and conservation work	Work	Clearances	Cleanings		Thinnings		Hygiene cuts		Conservation works	
		ha	ha	m^3	ha	m^3	ha	m^3	ha	m^3
	Total	250.2	790.9	4474	1264.3	30370	17370.7	150990	761.1	20389
	Annual	25.0	79.3	448	126.5	3037	17370.7	15100	76.1	2038

Afforestation work (ha)	Species	Total	Beech	Oak	Quercus cerris	Black alder	Acacia	Linden	Diverse coniferous	Diverse hardwood
		Hectars								
	Integral	213.0	90.2	17.1	5.8	13,3	0.8	0.2	7.4	78.2
	Addition	57.2	25.0	3.9	1.1	2.7	0.2	-	4.7	19.6
	Total	270.2	115.2	21.0	6.9	16.0	1,0	0.2	12.1	97.8

For each stand the stand characteristics were available. Example of stands characteristics database is presented in Table 2. Totally 2516 stands were in the database.

Table 2. *Example of stands structure characteristics database Romania (2013)*

Nr.	**Ocolul**	**U.P.**	**u.a**	**Surface**	**Compozitia/ composition**	**Varsta medie**	**Volume**
crt.	**Silvic**	**production units**	**forest planning units**	**ha**	**Proportion of tree species**	**the average age (years)**	**mc / u.a.**
1	Berzasca	I	1A	6,8	7FA 1GO 1TE 1DT	80	1884
2	Berzasca	I	1B	6,9	7GO 2CE 1DT	55	1284
3	Berzasca	I	1C	2	7PI 2CE 1DT	25	224
4	Berzasca	I	1D	2,3	5CE 4GO 1GI	65	362
5	Berzasca	I	1E	1,7	4GO 4CE 2GI	85	316
6	Berzasca	I	1F	2,3	5PI 2CE 2CA 1DT	25	200
7	Berzasca	I	2	0,2	7CE 3GI	70	34
8	Berzasca	I	3A	8,2	8FA 2CA	80	2001
9	Berzasca	I	3B	2,3	5GO 3CE 2GI	70	400
10	Berzasca	I	3C	2,1	9PI 1 DT	25	215

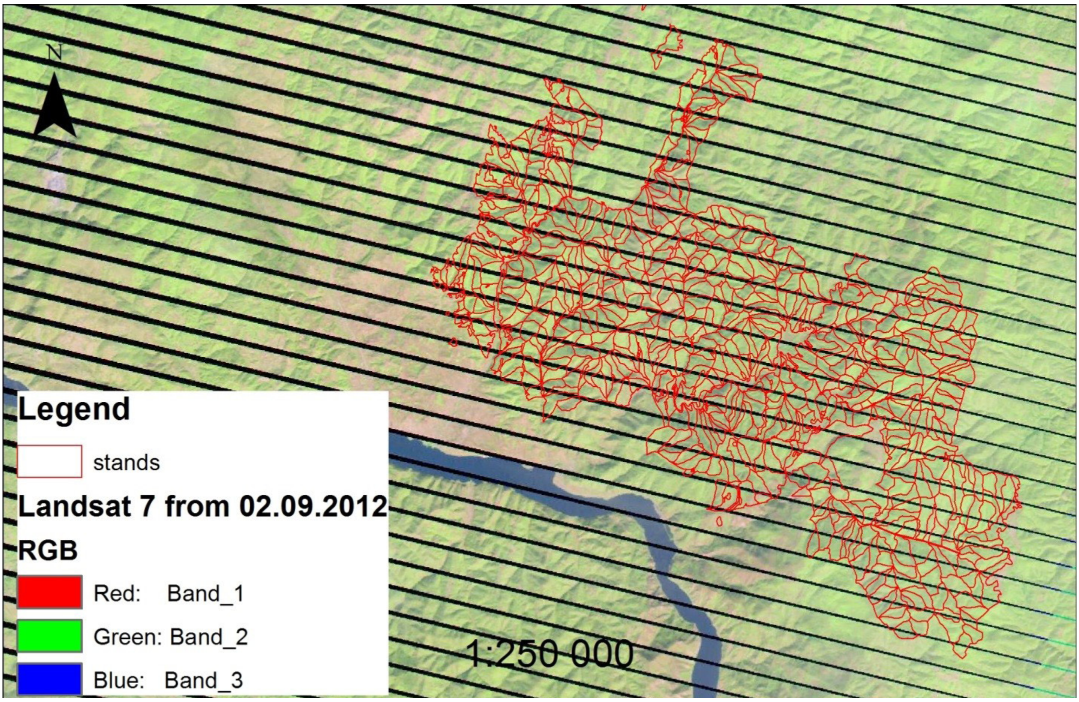
Species codes and abbreviations are presented in Table 3.

Table 3. *Species codes and abbreviations.*

U.P.	production units	u.a.	forest planning units
ha	hectares	mc	cubic meters
mc/u.a.	cubic meters/forest planning unit		
Tree species/ abbreviations			
AN	White alder	ANN	Black alder
AR	Tartar maple	ARA	American maple
BR	fir	CA	hornbeam
CAP	horse chestnut	CAS	sweet chestnut
CD	wax cherry tree	CE	cerris, Turkey oak
CI	cherry tree	CR	hornbeam grove
CS	”cenusar”	DD	mulberry tree
DV	various softwood	DR	various resinous
DT	various hardwood	DU	douglas fir
EX	various exotic	FA	beech
FR	common ash tree	FRA	American ash tree
FRB	pond ash tree	FRP	”fluffy” ash tree
GI	Hungarian oak	GL	honey locust tree
GO	oak	JU	common maple
LA	larch tree	MA	apple tree
ME	birch	MJ	manna/flowering ash
MO	common spruce	NU	walnut tree
NUA	American walnut tree	OT	tanner’s sumach
PA	sycamore maple	PAM	mountain sycamore maple
PI	pine	PIC	”cembra” pine
PIN	black pine	PIS	”strob” pine
PLA	white poplar	PLC	gray poplar
PLN	black poplar	PLT	trembling plopar/aspen tree
PLX	poplar (3-5 sqm)	PLY	poplar (6-9 sqm)
PLZ	poplar (4x4 m)	PR	pear tree
PRN	plum tree	PTL	plane tree
SA	white willow	SAC	”capreasca” willow
SAP	osier	SB	wild service tree
SC	acacia/locust tree	SL	”small” willow
SR	service tree	ST	oak
STB	greysh oak	STP	”fluffy” oak
STR	red oak	TA	taxodium
TE	silver lime tree	TEM	”large leaf” lime tree
TEP	”smelly” lime tree	TI	yew tree
TU	white cedar	ULC	elm tree
ULM	mountain elm tree	ULV	elm tree
VIT	Turkey sour cherry tree		

Since the inventory was carried out in 2004, the database was updated by excluding harvested sites identified on the Landsat images from 02.09.2012 (Picture 3). For this purpose the Landsat images from September 2012 were combined to remove the effect of "scan line corrector off". The second image was from 2004, the year of forest inventory. The images were classified and clear cuts were mapped. The clear cuts were excluded from the stand inventory database. The areas and volumes were recalculated as a proportion between initial stand size and stand size after exclusion of the clearcuts.

For the accessibility analysis the digital elevation model (DEM) was provided by Regional Development Agency - West Romania. The spatial resolution of DEM was 90 m. The Spatial analyst module in ArcGIS the slope was used to calculate the slopes.

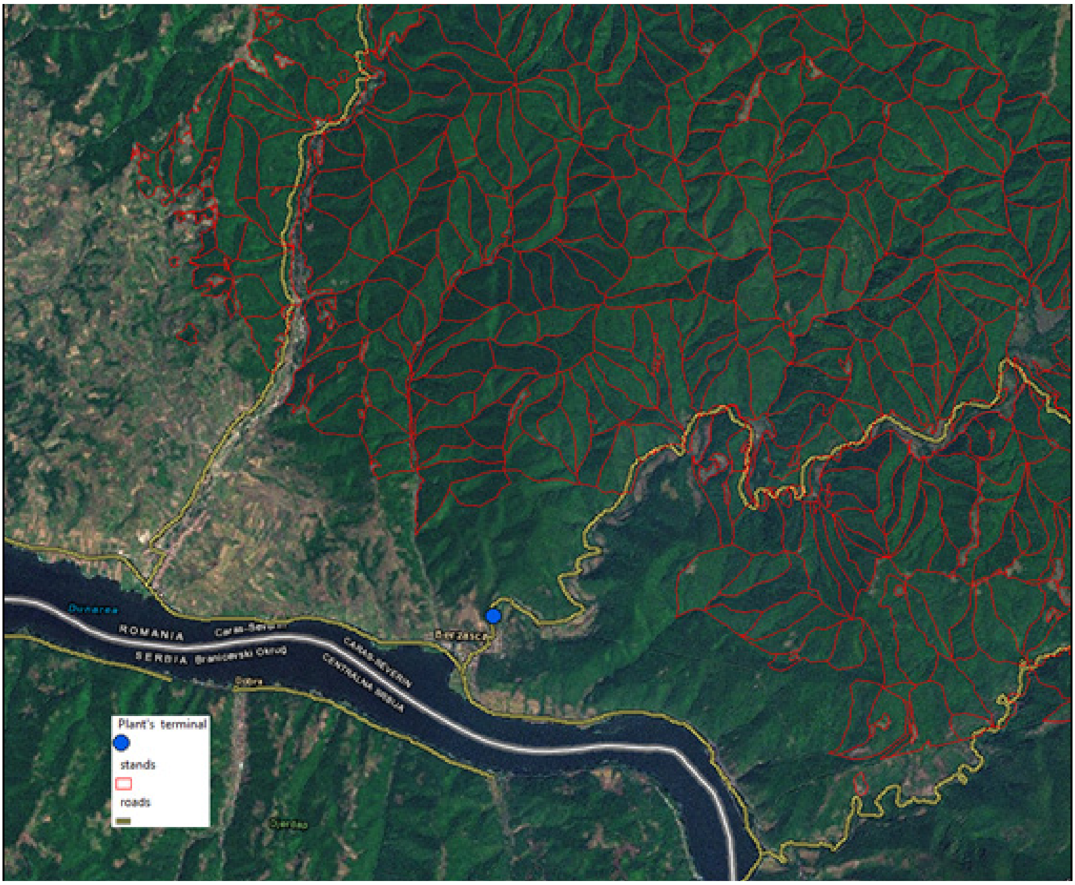


Picture 3. *Forest stands on the Landsat 7 image from 02.09.2012.*

7 Wood procurement and wood chip production cost calculation

Robert Printz & Mikko Nivala, Metla

Calculations have been made for a power plant which procurement need is around 2000 solid cubic meter yearly (1000 MWh). Calculation has been done by using ArcGIS network analysis and Microsoft excel. The commonly used machines and related costs in Romania were assumed as data material for the calculations based on the information obtained from the local partners (verbal communication). The assumed input parameters for the cost calculations are mentioned below followed by the outcome values for various scenarios. Cost calculators developed at Metla (Laitila 2004, Laitila 2006 etc.) were used for this cost estimation after modifying them to the salary level of Romania (World Salaries). The calculation has its limitation regarding the input parameters and definitions. The location of power plant's wood chip terminal is shown in picture 4.



Picture 4. *Power plant's wood chip terminal location (ArcGIS Map Service 2013, ArcGIS World Imagery 2013)*

The calculation area is quite mountainous so therefore we choose two different supply chains for the bioenergy wood procurement.

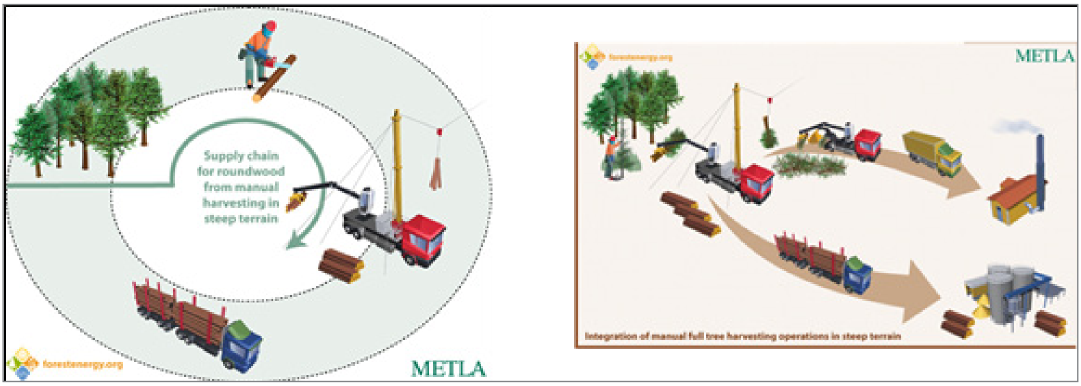
7.1 MANUAL LOGGING AND FARM SCALE FORWARDING

This calculation describes the manual harvesting by a lumberjack followed by a forwarding operation (farm trailer). The chipping operation is done at the roadside followed by chip transportation to the plant by trucks with a total weight of 30 tons (cargo weight 14 tons). See picture 5 for illustration on manual harvesting and farm scale forwarding.

Picture 5. *Manual harvesting of whole trees with chipping at the roadside and transportation of chips by truck. (Forest Energy Portal 2013)*

7.2 STEEP TERRAIN LOGGING

This calculation describes the manual harvesting by a lumberjack followed by a cable yarding operation. The chipping operation is done at the roadside followed by chip transportation to the plant by trucks with a total weight of 30 tons (cargo weight 14 tons). See picture 6 for illustration on manual harvesting and cable yarding operation.



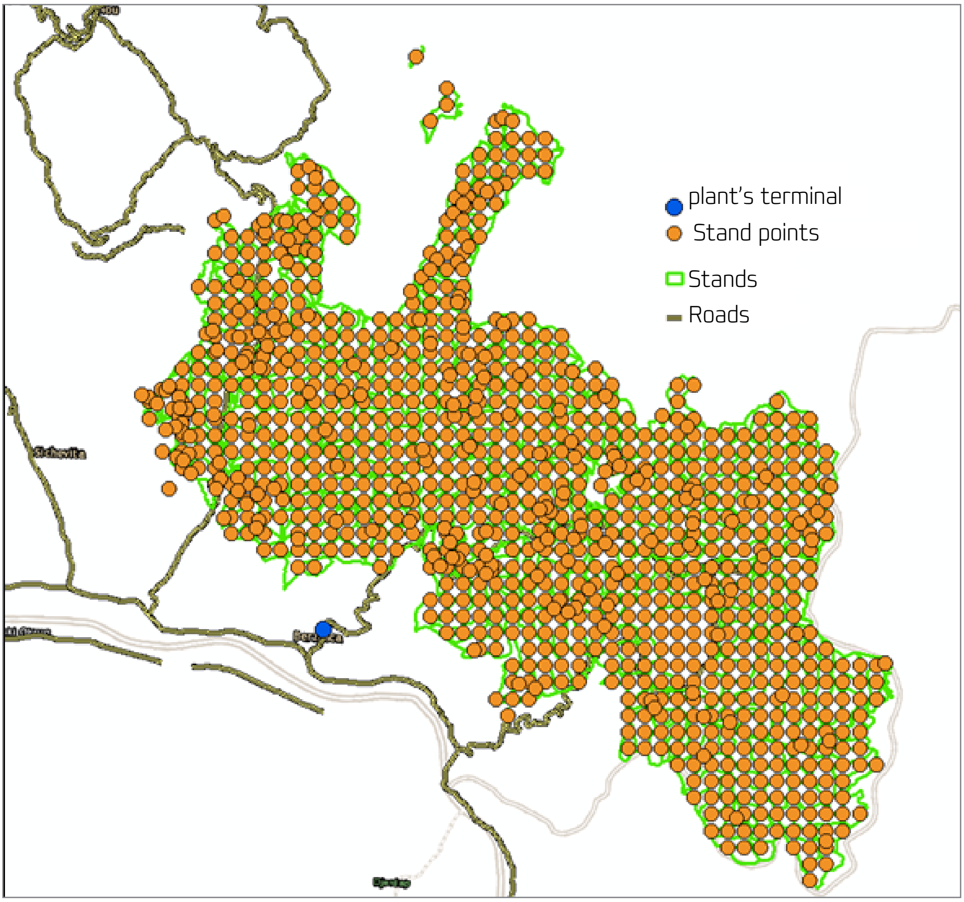
Picture 6. *Manual harvesting with cable yarding operation and chipping at the roadside and transportation of chips by truck. (Forest Energy Portal 2013)*

7.3 PROCUREMENT ANALYSIS

The procurement analysis has been done using following assumptions:

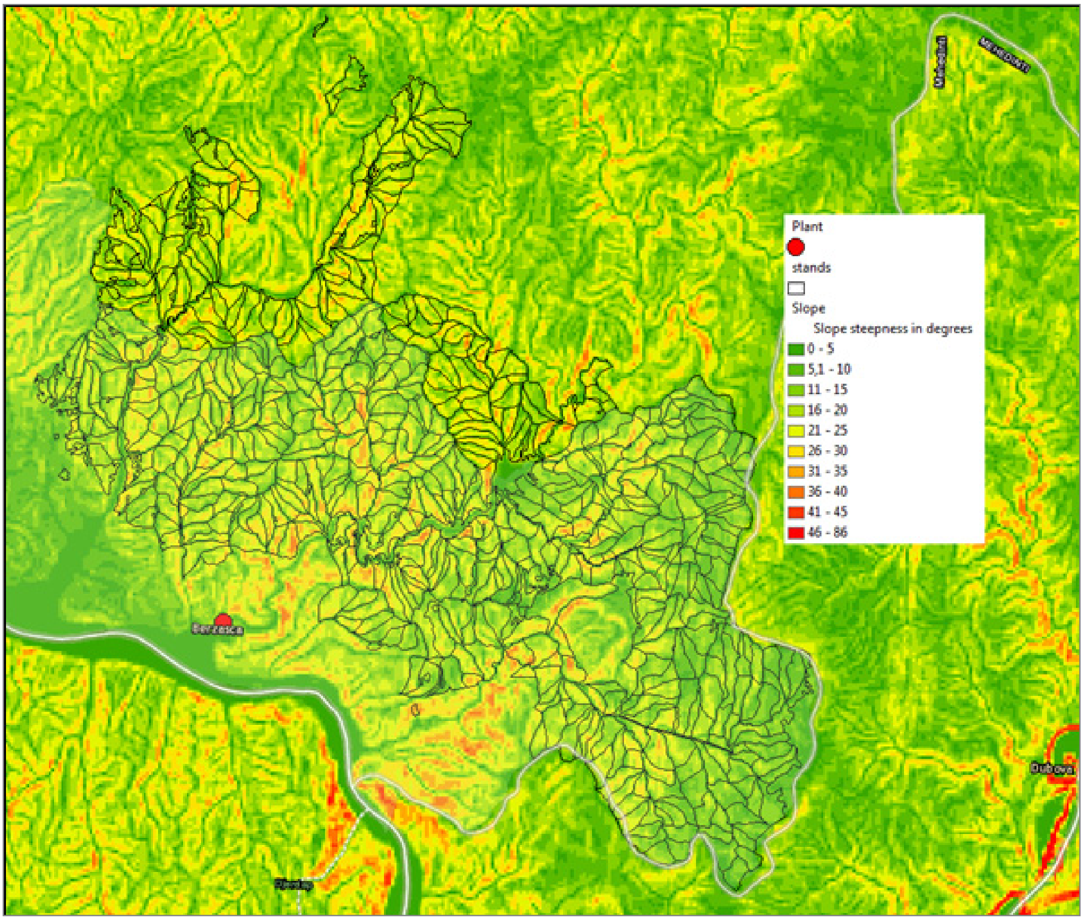
- It is not allow to harvest cherry dominating stands
- It is not allow to harvest stands which slope is more than 35 degrees steep
- The maximum cutting allowance is around 20 000 solid cubic meter (due to limitation within the National Park)
- Cutting from one production unit annually
- No clear cuts, minimum thinning depending on annual growth and total volume
- Maximum thinning for energy wood purposes is 15 % of the maximum volume of the stand (remaining volume is assumed for protection, log and pulp production and other purposes)
- No restriction regarding forwarding and transportation distances

A procurement analysis has been performed by building a lattice point network on the calculation area. The distance of each point is 500 meters, although manually points were added in the case that the stand size was very small. Each point has been joined with the stand information from the year 2004. For each point the transportation distance to a terminal has been calculated. The picture of lattice points can be seen from picture 7:



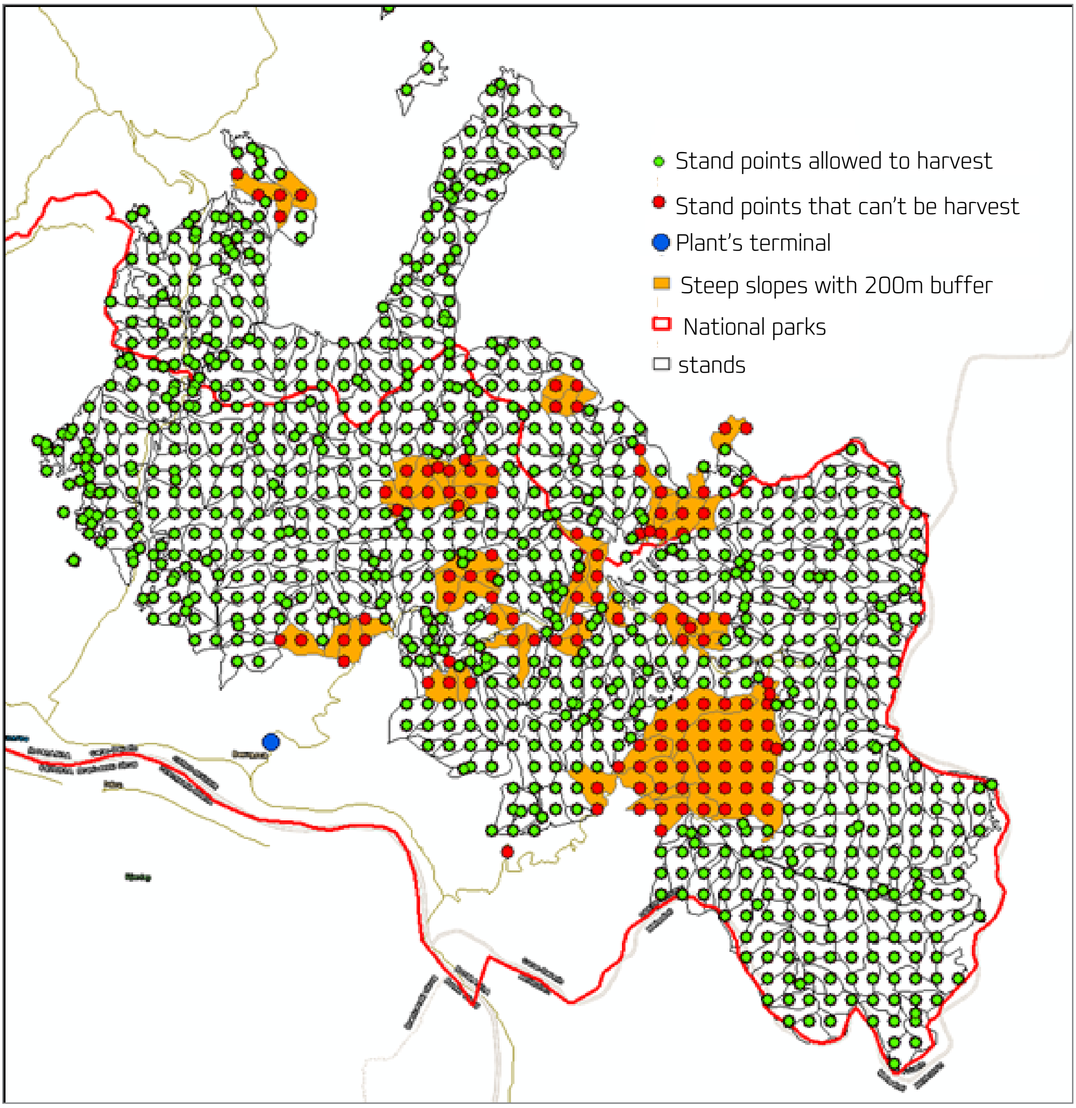
Picture 7. *Stand points in calculation area. (ArcGIS Map Services 2013)*

After calculating the transportation distances for each stand using lattice points, a slope analysis was performed in order to observe restricted cutting areas in steep terrain (picture 8).



Picture 8. *Slope analysis shows the steepness of slope in degrees. The redder, the more likely it is that the area cannot be harvested (ArcGIS Map Services 2013)*

Following the slope analysis, a 200 meter buffer zone around the steep slopes was created. Stands and stand points that were inside the buffer zone were excluded from the calculation (see picture 9).



Picture 9. *Cutting allowance based on slope steepness. A Bioenergy potential calculation has been done only slopes that are less than 35 degree steep (ArcGIS Map Services 2013)*

7.4 RESULTS

As a result of the availability calculation, the bioenergy potential varied from 2280 cubic meter to 21670 cubic meters annually, depending on the harvesting rate. When comparing the results with information from local specialists, the estimation for the current use was around 5000 cubic meters annually. A total of 149 stands were included in the calculation (one production unit) and the characteristic of an example stand can be seen from table 4.

Table 4 . *Characteristic of example stand according to our calculations.*

Area, ha	7,7			
Forwarding, m	2094			
Transporting, km	29			
Accumulation of small sized energywood, m^3/ha	25			
Stem volume of whole-tree (with branches), dm^3	164			
	Presumed value			
Moisture of fresh whole tree, %	55 %			
Moisture of seasoned whole tree, %	35 %			
Loss of seasoning, %	5 %			
Seasoning time at roadside storage, months	8			
Interest of capital, %	6 %			
Amount of energywood at stand	m^3	MWh	m^3/ha	MWh/ha
Fresh whole tree	190	326	25	42
At roadside storage dried whole-tree	180	342	23	44

Minimun Cutting allowance in Romania	*2 %*
Maximum cutting allowance of energy wood from stand	*15 %*

The cutting allowance is based on information provided by FAO forestry in Romania (FAO) and a presentation made by Nicolae Țucunel (Tucunel).

Further assumptions used within the calculation can be found from the table 5. The extra costs of yarding operation (yarder and processor) compared to conventional harvesting (harvester and forwarder) were calculated using estimation according to Grundin OHG (Grundin OHG 2013) and modified with the salary level of Romania. The calculations have limitations due to limited input parameters and definitions. The results can be considered as estimated, for a more realistic estimate further input data is needed.

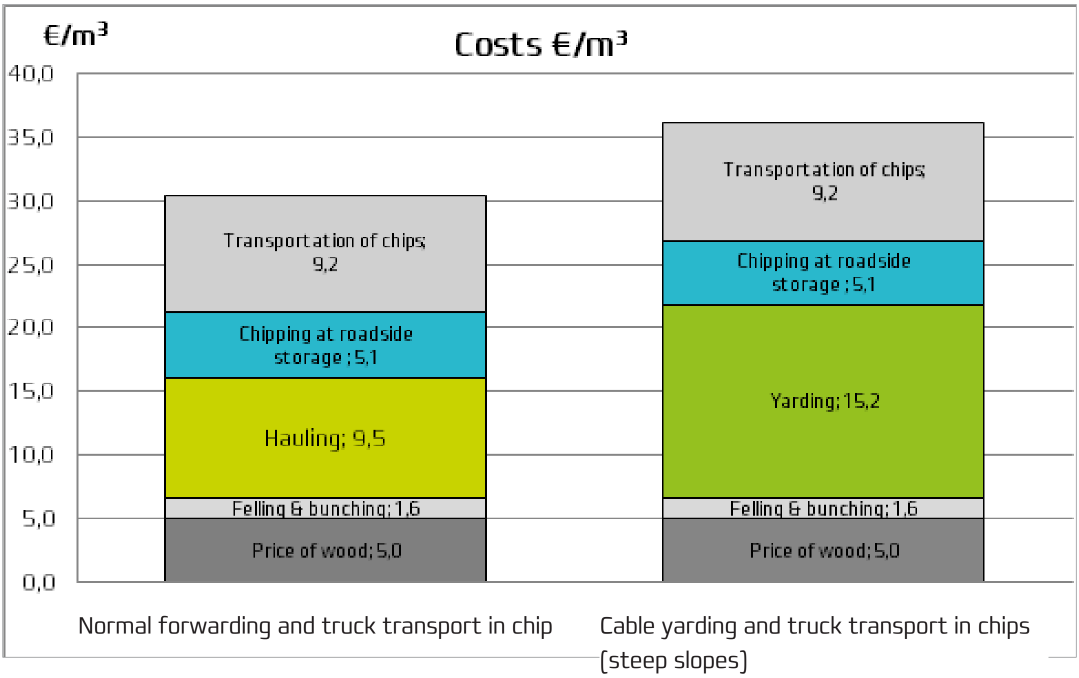
Table 5. *Calculation assumptions, Manual felling & bunching**

Other costs		**Set value**	**Presumed value**	**Model uses**
Stumpage of energywood, €/ m^3		3	0	3
Overhead costs, €/ m^3		0	2	0
Covering costs, €/ m^3		2	0,9	2,0
	Fresh whole-tree, €/m^3	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Other costs	5,0	2,9	5,3	2,8
Felling & bunching		**Set value**	**Presumed value**	**Model uses**
Lumberjack's salary costs, €/day		50	153	50
	Fresh whole-tree, €/m^3	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Felling & bunching	1,6	0,9	1,7	0,9
Hauling		**Set value**	**Presumed value**	**Model uses**
Load capasity of forwarder, m^3		6	6,2	6,0
Gross effective / effective time ratio		1,2	1,20	1,20
Hourly cost of forwarder, €/h		20	47	20
Transferring cost of forwarder €/ turn		20	47	20
Productivity (m^3/h)		2	3	2
	Fresh whole-tree, €/m^3	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Hauling	9,5	5,5	10,0	5,3
Cable Yarding		**Set value**	**Presumed value**	**Model uses**
Hourly cost of cable yarding, €/h		30	47	30
Transferring cost of yarding €/turn		30	47	30
Productivity of yarding (m^3/h)		2		2
	Fresh whole-tree, €/m^3	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Cable Yarding	15,2	8,8	16,0	8,4
Chipping at roadside storage		**Set value**	**Presumed value**	**Model uses**
Chipper's productivity on operational hour, loose-m^3		85	85	85
Lowering of chippers' productivity, stored/dried whole-tree		0,2	15 %	20 %
Chipping cost at roadsidestorage, €/ m^3 (solid)		5,0	5,3	5,0
Transferring cost of chipper, €/turn		20	45	20
	Fresh whole-tree, €/m^3	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Chipping at roadside storage	5,1	3,0	6,0	3,2

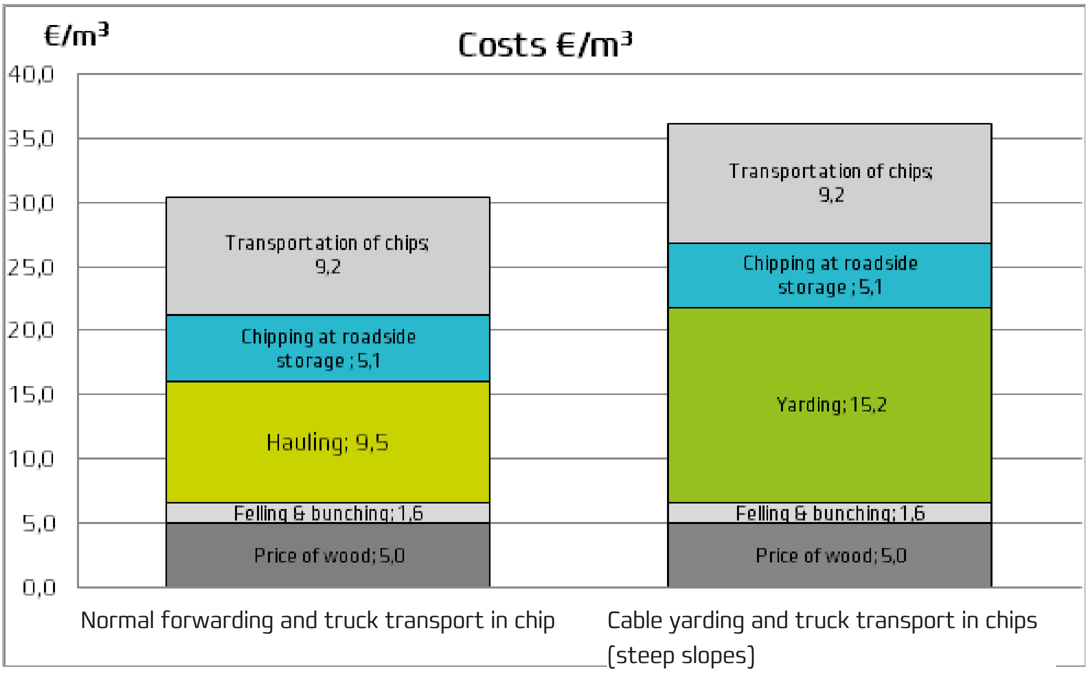
Transportation of chips		**Set value**	**Presumed value**	**Model uses**
Load size, loose-m^3		44	110	44
Loading- and unloading cost, €/h		50	53	50
Hourly driving cost, €/h		80	76	80
Unloading time, h		0,5	0,5	0,5
Auxiliary time, h		0,3	0,3	0,3
	€/m^3	€/MWh	€/m^3	€/MWh
Transportation of chips	9,2	5,4	9,6	5,1
Cost at the heating plant	**Fresh whole-tree, €/m^3**	**Fresh whole-tree, €/MWh**	**Stored whole-tree, €/m^3**	**Stored whole-tree, €/MWh**
Chipped at roadside storage+normal forwarding	30,4	17,7	32,5	17,2
Chipped at roadside storage+Cable yard forwarding	36,1	21,0	38,5	20,3

**(manual felling bunching's productivity is based on labour agreement)*

A chart highlighting the differences of two selected supply chains, shows the costs in €/m^3 (Picture 10) and €/MWh (Picture 11). The total costs from the forest to a plant's terminal when using the example stand were 30,4 €/m^3 (17,7 €/MWh) in normal terrain conditions and 36,1 €/m^3 (21 €/MWh) for steep terrain. With a delivery cost to the plant this is at the lower end compared to the figures of local experts (exploitation costs + transport + manpower was estimated at an interval between 34,30 Euros and 38,90 Euros) after storage at the roadside.

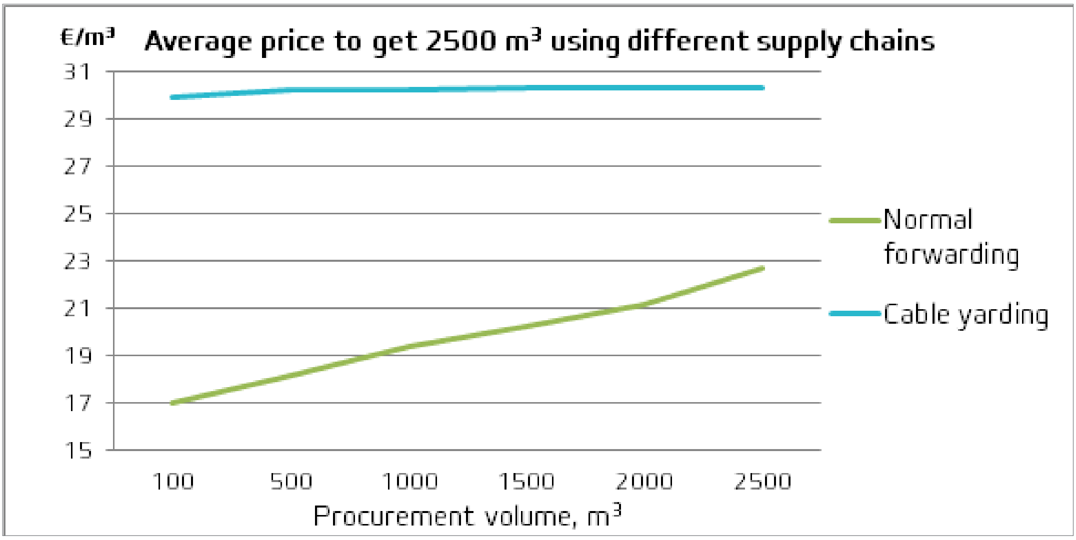


Picture 10. *Comparison of selected supply chains [€/m^3]. In steep terrain the use of more costly cable yarding systems is required.*



Picture 11. *Comparison of selected supply chains [€/MWh]. In steep terrain the use of more costly cable yarding systems is required.*

The availability of wood for bioenergy at a certain price level is shown in Picture 12. The calculation is based on stand data and a transportation calculation.



Picture 12. *Average price of wood from forest to terminal.*

As a conclusion, the road network is not sufficient and is causing a bias for the calculation. Calculated average forwarding distances (approximately 2 km in the case Berzasca) are very long and other calculation parameters might be biased with those long distances. Therefore, the performed calculations have limitations due to limited input parameters and definitions. The results can be considered as an estimate, a more realistic estimation can be achieved using further input data.

8 Biomass based district heating system feasibility study

Markus Hirvonen, Karelia University of Applied Sciences

In this chapter we are discussing the feasibility of biomass based district heating plant in the case of Berzasca. With this case-study, we'll go through all the key points of preliminary district heating system design in order to give a clear view of the different things affecting to district heating system viability.

Two different scenarios will be calculated based on the area characteristics. Basic sensitivity analysis is being used to assess the sensitivity of the results.

8.1 AREA AND BUILDING CHARACTERISTICS

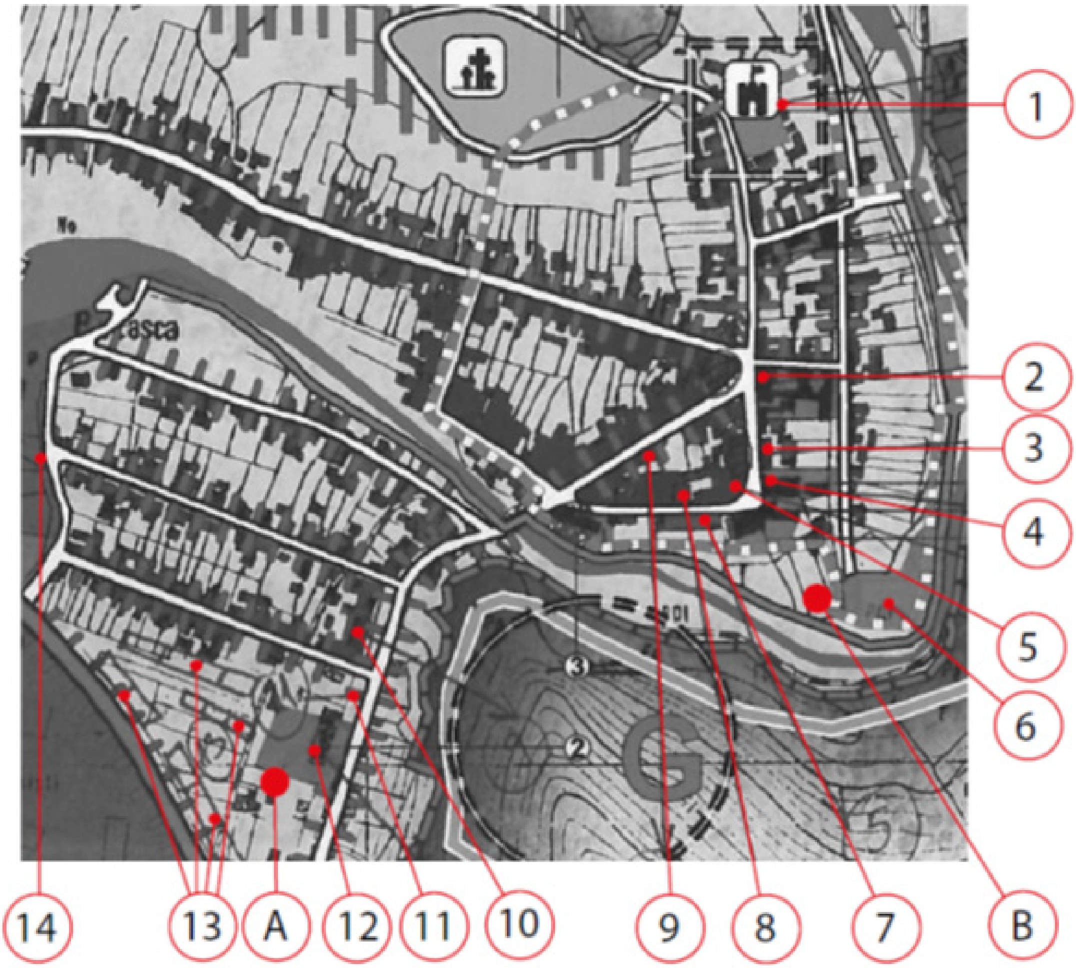
Berzasca is a small village located in the West region, Caras-Severin county on the banks of Danube defile in the middle of Iron Gate Natural Park on the south-west part of Romania. Berzasca has a bit more than 15 hundred inhabitants as described earlier in chapter 4 of this paper. Map of central Berzasca is shown in picture 13.

Picture 13. *Map of Berzasca (Berzasca Mayors office 2013)*

Buildings in Berzasca are mainly single buildings which are on the both sides of the main streets. Most of the public buildings are situated on the eastern part of the area and flat blocks are situated on the southern side of the center village. View on the main street is shown in picture 14. Picture 14 also illustrates clearly the hilly terrain of Berzasca surroundings.

Picture 14. *View on the Berzasca main street. Photo: Markus Hirvonen.*

More detailed look into the building location and types in Berzasca are illustrated in the following picture 15.



Picture 15. *Buildings in Berzasca (Modified from Berzasca Mayors office 2013)*

Numbers identify the buildings and are as follows (Table 6):

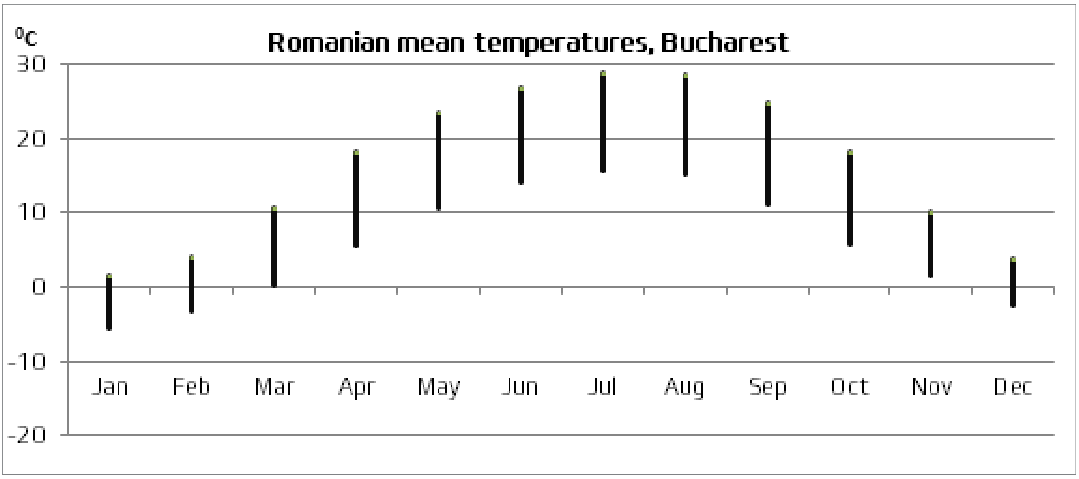
Table 6. *Buildings in Berzasca*

1	Orthodox Church	8	Police
2	City Hall	9	Healthcare Unit
3	Forest Management Area HQ	10	School
4	Cultural Center	11	Catholic Church
5	Tourist Information Center	12	Border Police
6	Sports Hall	13	Flats Blocks I-IV
7	Kindergarten	14	Locker Room / Stadium

As one can see, there is a lot of public buildings in Berzasca which could be connected to possible district heating network. There are two different building clusters, one in the north bank of the river and the other one more south. This is not optimal arrangement since there will be a need for excessive heat transfer network without connecting buildings. All of the buildings except buildings no 12-13 (Border police and Flats Blocks I-IV) are classified as public buildings. It is unsure whether the Border Police and Flat Blocks could be connected to the district heating network. As mentioned earlier, two different scenarios will be calculated to evaluate the effect of these non-public buildings for district heating network feasibility. This is discussed in more detail in the following chapters.

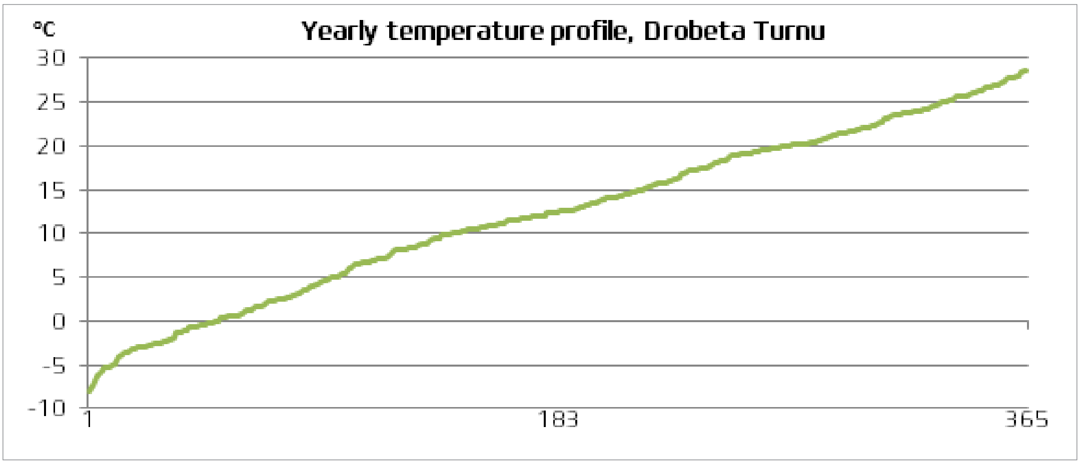
8.2 CLIMATE DATA

Climate of Berzasca can be descibed as temperate continental climate with Mediterranean influences. This means that usually summers are relatively hot and winters can be rather cold at times. Usually snow covers the land in winter time for a few weeks. Outside temperatures of Bucharest are illustrated in picture 16.



Picture 16. *Romanian mean temperatures in Bucharest (World Meteorological Organization)*

For a more detailed description of temperature profile in Berzasca area, we are using daily outside temperatures from Drobeta Turnu Sever weather station, which is located 55km east of Berzasca on the banks of Danube.



Picture 17. *Outside temperature profile of Drobeta Turnu Sever (Degree Days)*

From picture 17, one can read the exact yearly time that temperature is below certain level. For example, daily average temperature is below 12 °C for 180 days of the year. This information is vital for correct dimensioning of the heating plants and the network.

8.3 ENERGY BALANCE AND HEATING POWER DEMAND

Exact heating energy consumption of Berzasca buildings is unknown. Amount of wood logs to produce heating energy for public buildings is known and therefore we can estimate the amount of energy consumed in each building taking account the total volume of the building and its hot water consumption. All public buildings (13 total) consume 600 solid cubic meters of hardwood. Heating energy is generated by modern automated woodlog boilers. Border Police building (no. 12) and Flat Blocks (no. 13) are not included in provided wood consumption (Furdui 2013). Following assumptions are made to calculate public buildings energy balance:

- Density of the wood logs is 670 kg/m^3(solid)
- Lower heating value is 4 kWh/kg (Alakangas 2000, 73)
- Boiler average yearly efficiency is 80%
- Production of hot dwelling water [HDW] consumes energy 58 kWh/m^3 of hot water used (Ministry of the Environment 2007, 26)

Total gross energy demand for heating energy production is therefore 1608 MWh/a and net consumption of the buildings is 1286,4 MWh/a for both space heating and hot dwelling water production.

We can estimate the amount of heat consumed by each building by taking account the total volume of the buildings and subdividing the total amount of heat to each building in relation to its volume. Volume of the buildings, hot water consumption and currently installed boiler capacity are shown in the following table 7.

Table 7. *Building volumes and energy balance of Berzasca*

No	Building	Volume [m^3]	Hot Dwelling Water, HDW [m^3/ Month]	Installed Boiler Capacity [kW]	Heating energy, Space heating [kWh/a]	Heating energy HDW [kWh/a]
1	Orthodox Church	1400	0	40	56017	0
2	City Hall	1213	4	80	48519	2784
3	Forest Management Area HQ	710	2	60	28409	1392
4	Cultural Center	3044	5	100	121797	3480
5	Tourist Information Center	636	0	25	25464	0
6	Sports Hall	14500	10	80	580179	6960
7	Kindergarten	1440	0	60	57618	0
8	Police	531	0	25	21247	0
9	Healthcare Unit	700	2	60	28009	1392
10	School	4646	0	160	185897	0
11	Catholic Church	366	0	40	14629	0
12	Border Police	2160	2	-	86427	1392
13	Flats Blocks I-IV*	51706	160	-	2068880	111360
14	Locker Room / Stadium	479	13	30	19159	9048
	Total	**83531**	**198**	**760**	**3342250**	**137808**

* Total energy consumption in public buildings is 600 solid-m^3 of wood --> 40,01 kWh/m^3(space)
**Calculated from nominal kWh/m^3

Public buildings, excluding Border Police, consume 1212 MWh/a of net heating energy. Border Police and Flat Blocks consume additional 2268 MWh/a of net heating energy. This leads to assumption that Flat Blocks and Border Police equals 65 % of total net heating energy consumption of Berzasca.

Heating power demand profile varies in straight relation to outside temperature and hot dwelling water demand. Heating degree days are used to evaluate the needed maximum heating power demand on the coldest day of the year. Following assumptions are made to calculate maximum heating power demand.

- Base temperature is 17 °C (when outside temperature reaches 17 or above, no more heating is needed to maintain required indoor temperatures)
- Hot dwelling water consumption is assumed to be constant throughout a year
- Drobeta Turnu Sever weather data is used to simulate Berzasca weather conditions (HDD 17 is 2296 °Cd)

Maximum heating power demand for each building is illustrated in the following table 8.

Table 8. *Power demand for space heating and average power consumption of HDW production*

Num	Building	Heating Power, Space heating [kW]	Heating Power (avg.), HDW [kW]
1	Orthodox Church	28,9	0,00
2	City Hall	25,1	0,32
3	Forest Management Area HQ	14,7	0,16
4	Cultural Center	62,9	0,40
5	Tourist Information Center	13,1	0,00
6	Sports Hall	299,6	0,79
7	Kindergarten	29,8	0,00
8	Police	11,0	0,00
9	Healthcare Unit	14,5	0,16
10	School	96,0	0,00
11	Catholic Church	7,6	0,00
12	Border Police	44,6	0,16
13	Flats Blocks I-IV*	1068,3	12,71
14	Locker Room / Stadium	9,9	1,03
	Total	**1725,9**	**15,73**

Flats Blocks' peak power demand is over 1 MW during the coldest days and it is by far the biggest possible customer in the Berzasca area.

8.4 ASSESSED SCENARIOS

As briefly described earlier in chapter 7.1, buildings are situated in rather vast area within Berzasca. Most of the public buildings are situated to northern part of the centre and Flat Blocks and Border Police are close to each other a bit more south from public buildings.

From district heating point of view, it is always more beneficial to provide maximum amount of heat through as short heating network as possible, The more compact the heating network is, the less there will be heat losses to the ground. Also investment, maintenance and running costs will be lower.

It is unsure whether the Flat Blocks and Border Police could be connected to the heating network so therefore two different scenarios needs to assessed. Two different scenarios will be calculated to evaluate whether shorter, more compact network with only the public buildings connected to it (no 2-11), or bigger, and longer network in which all the buildings (no 2-13) are connected, would suit Berzasca better. Scenarios are described in more detail in following chapters. Heating plant in Big network -scenario is located in point A as illustrated in picture 13 and in Compact network -scenario the heating plant would be situated in point B as illustrated in the same picture.

8.4.1 Key factors explained

There are many things that contribute to the feasibility of district heating network. In the following, some of the key factors explained and some general numerical limits for profitability are illustrated.

- Heat density of the network: The amount of heat sold to clients per meter of installed district heating network. Generally if ratio between sold heat vs. network length is above 1 MWh/m, network's heat density is considered high enough for feasible heat distribution

- Capasity factor: The time to produce the amount of energy in a year with boilers nominal output compared to actual production figures is often described with boilers capacity factor. If one 1000 kW boiler would produce 4000 MWh of heat, it's capacity factor would be 4000 h/a -> in theory the time the boiler would be running on nominal power to produce the yearly energy. With biomass base load boilers, capacity factor should be above 4000 h/a in order to decrease investment payback time.

- Network heat losses: Generally network heat losses are in loose counter commensurate relation to heat density. In smaller networks, heat losses can be as high as 20 % of the total heat production and in bigger networks the usual figure is less than 10 %. The amount of heat loss depends on the temperature levels, amount of insulation, length of the network and soil properties. In preliminary studies it is often sufficient to use values between 15 – 25 W/m depending on the sizing of the network.

- Heat production profile: With sufficient knowledge of the yearly temperature profile, heat consumption for space heating and for hot dwelling water and also taking account the heat losses, we can form the heat demand profile for the given area. With this generated and numerically modeled heat demand profile we can assess the heat production profile for any imaginable boiler combination in the given area with precision.

8.4.2 Big network

Big network would provide heating energy for all buildings (no 2-13) in Berzasca centre. This includes Flat Blocks and Border Police. Stadium locker room (no 14) is located far away from other buildings as is also Orthodox Church (no 1). Therefore Stadium locker room and Orthodox Church are excluded from this scenario without further analysis.

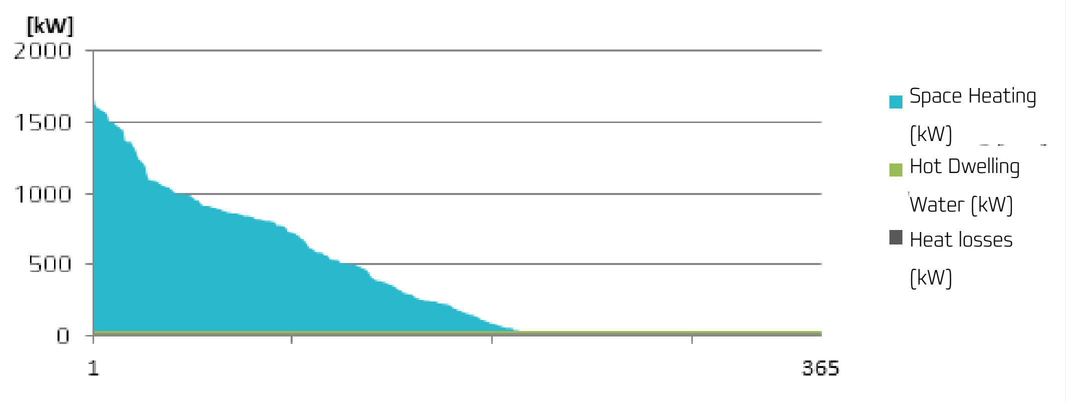
Total length of the network in Big network -scenario will be 950 meters measured from provided maps. Energy balance and peak power demand are illustrated in the following table 9.

Table 9. *Big network –scenario energy and peak power balance*

No	Building	Heating energy, Space heating [kWh/a]	Heating energy HDW [kWh/a]	Heating Power, Space heating [kW]	Heating Power (avg.), HDW [kW]
2	City Hall	48519,3	2784,0	25,1	0,3
3	Forest Management Area HQ	28408,7	1392,0	14,7	0,2
4	Cultural Center	121797,5	3480,0	62,9	0,4
5	Tourist Information Center	25463,8	0,0	13,1	0,0
6	Sports Hall	580178,5	6960,0	299,6	0,8
7	Kindergarten	57617,7	0,0	29,8	0,0
8	Police	21246,9	0,0	11,0	0,0
9	Healthcare Unit	28008,6	1392,0	14,5	0,2
10	School	185897,2	0,0	96,0	0,0
11	Catholic Church	14629,3	0,0	7,6	0,0
12	Border Police	86426,6	1392,0	44,6	0,2
13	Flats Blocks I-IV*	2068879,8	111360,0	1068,3	12,7
	Total	**3267074,0**	**128760,0**	**1687,1**	**14,7**

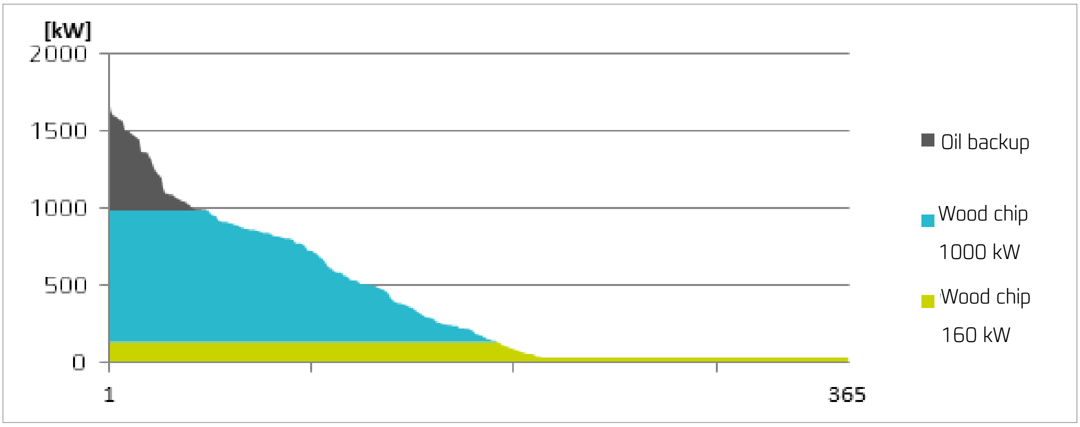
Heat density of the network will be 3,5 MWh/m/a. It is calculated by dividing the amount of heat transferred to the heated buildings with the length of the district heating network. Heat losses to the ground from district heating pipelines are 167 MWh/a (20 W/m), which equals to 19 kW of constant heat loss power. This is the amount of heat that radiates through insulation layers of pipelines. Heat losses account for 5 % of total heat consumed in this scenario. Heat loss needs to be taken account when calculating the total energy balance of the scenario.

Power demand profile of the Big network -scenario is illustrated in the following picture 18.



Picture 18. *Heat demand profile of the Big network -scenario*

As seen from the picture 14, hot dwelling water consumption is neglible as are the heat losses. Peak power demand at -12 °C outdoor temperature is 1720 kW and for 150 days a year the power demand will be less than 34 kW. These extremes poses a great dilemma in regards to boiler dimensioning, since both the highs and the lows cannot be produced with single biomass boiler. Therefore two different sized biomass boilers will be used, one boiler with 160 kW nominal heating power output for warmer periods and the other boiler with 1000 kW nominal heating power output for colder periods. There will be also backup oilboiler to produce the needed peak thermal power. Production profile of this system is illustrated in picture 19.



Picture 19. *Heat production profile on the Big network -scenario*

The following heating energy production shares were calculated for this scenario as illustrated in the following table 10.

Table 10. *Heating energy production profile in Big network -scenario*

	Nominal power [kW]	Lower limit [kW]	Efficiency [%]	Energy produced [MWh/a]	Capacity factor [h/a]	Share [%]	Fuel consumption [MWh/a]
Wood chip 160 kW	160	40	0,85	792	5824	22 %	932
Wood chip 1000 kW	1000	250	0,85	2447	2879	69 %	2879
Oil backup	1500	375	0,9	324	240	9 %	360
Total				**3563**		**100 %**	**4171**

With chosen two biomass-boiler setup we can produce 91 % of the total heat energy demand with biomass. Oil boiler needs to be run on the coldest days of the year and therefore its capacity factor is very low at 240 h/a. On the one hand larger biomass boiler (1000 kW) suffers a bit from long summer break with slightly below 3000 h/a capacity factor but on the other hand smaller biomass boiler (160 kW) has an excellent capacity factor at 5824 h/a.

8.4.3 Compact network

Compact network would provide heating energy for all public buildings (no 2-11) in Berzasca centre. This excludes Flat Blocks (no 12) and Border Police (no 13) oppose to Big network -scenario. Stadium locker room (no 14) is located far away from other buildings as is also Orthodox Church (no 1). Therefore Stadium locker room and Orthodox Church are excluded also from this scenario without further analysis.

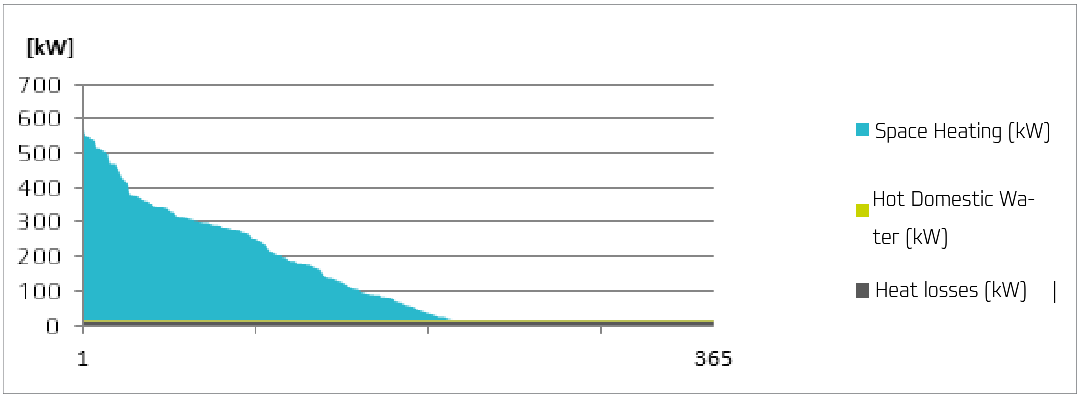
Total length of the network in Compact network -scenario will be 750 meters measured from provided maps using point B (picture 13) as a location for the heating plant. Energy balance and peak power demand are illustrated in the following table 11.

Table 11. *Compact network –scenario energy and peak power balance*

No	Building	Heating energy, Space heating [kWh/a]	Heating energy HDW [kWh/a]	Heating Power, Space heating [kW]	Heating Power (avg.), HDW [kW]
2	City Hall	48519,33	2784	25,0	0,32
3	Forest Management Area HQ	28408,74	1392	14,7	0,16
4	Cultural Center	121797,5	3480	62,9	0,4
5	Tourist Information Center	25463,83	0	13,1	0
6	Sports Hall	580178,5	6960	299,6	0,8
7	Kindergarten	57617,73	0	29,8	0
8	Police	21246,94	0	10,9	0
9	Healthcare Unit	28008,62	1392	14,5	0,16
10	School	185897,2	0	96,0	0
11	Catholic Church	14629,3	0	7,6	0
	Total	**1111768**	**16008**	**574,1**	**1,8**

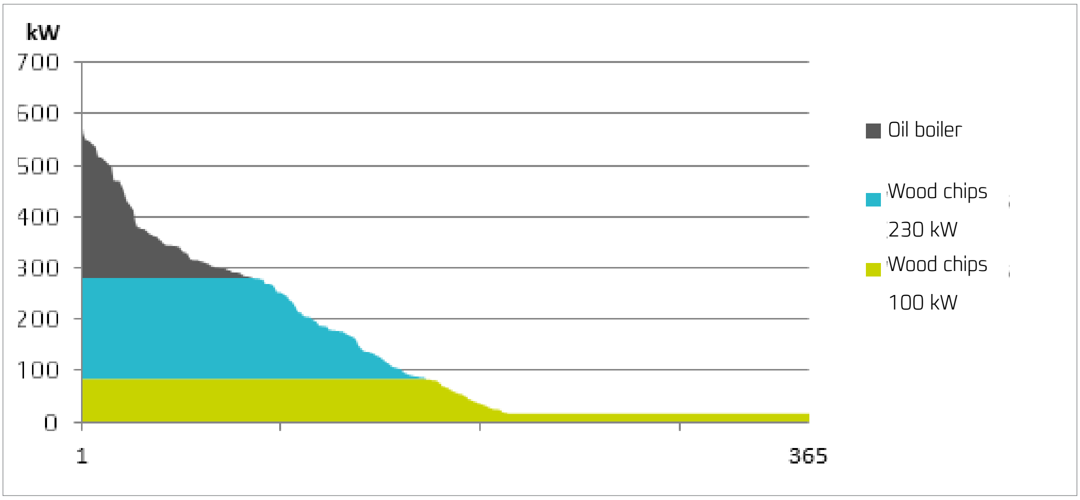
Heat density of the network will be 1,5 MWh/m/a. It is calculated by dividing the amount of heat transferred to the heated buildings with the length of the district heating network. Heat losses to the ground from district heating pipelines are 131,8 MWh/a (20 W/m), which means an 15 kW heat loss on average. This is the amount of heat that radiates through insulation layers of pipelines. Heat losses account for 10,4 % of total heat consumed in this scenario. Heat loss needs to be taken account when calculating the total energy balance of the scenario.

Power demand profile of the Compact network -scenario is illustrated in the following picture 20.



Picture 20. *Heat demand profile of the Compact network –scenario*

As seen from the picture 20, hot dwelling water consumption is extremely low at constant 1,8 kW heat load. Network heat losses accounted for 15 kW constant average heat load which means that almost half of the year we are losing 89 % of the heating energy produced to the network. Peak power demand at -12 °C outdoor temperature is 590 kW and for 150 days a year the power demand will be less than 17 kW. These extremes poses a great dilemma regards to boiler dimensioning, as it also did in the Big network -scenario. Two different sized biomass boilers will be used, one boiler with 100 kW nominal heating power output for warmer periods and the other boiler with 230 kW nominal heating power output for colder periods. There will be also backup oil-boiler to produce the needed peak thermal power. Production profile of this system is illustrated in picture 21.



Picture 21. *Heat production profile on the Compact network –scenario*

The following heating energy production shares were calculated for this scenario as illustrated in the following table 12.

Table 12. *Heating energy production profile in Compact network -scenario*

	Nominal power [kW]	**Lower limit [kW]**	**Efficiency [%]**	**Energy produced [MWh/a]**	**Capacity factor [h/a]**	**Share [%]**	**Fuel consumption [MWh/a]**
Wood chip 100 kW	100	20	0,85	463	5450	37 %	545
Wood chip 230 kW	230	57,5	0,85	594	3037	47 %	699
Oil backup boiler	500	25	0,9	203	450	16 %	225
Total				**1260**		**100 %**	**1469**

With selected boiler sizes we can produce biomass based heating energy up to 84 % of the total heating energy production. Extremely low domestic hot water production is a major problem and especially its relation to network heat losses during warmer periods. Capacity factors for both biomass boilers are sufficient enough for proper operation.

8.5 COST CALCULATION

Two scenarios in previous chapters described the technical energy balance and the dimensioning of the heating plants. Both scenarios had their own drawbacks but in the end they would be both feasible from technical point of view. Further cost calculation helps decision makers to evaluate different options to reach the optimal solution both economically and technically. In this chapter we describe the basic cost calculation procedure normally used to evaluate the total cost of heating energy production in centralized systems.

Following is assumed in this cost calculation

- Investments are divided to yearly costs by using annuity approach for a given payback period and given interest rate
- Payback time for boilers is 10 years and for the network 20 years
- Interest rate is 3 % and inflation is neglected
- Residual value of current in house wood log boilers is neglected
- In house works and modifications to connect to the network is neglected
- Price for wood chips is 17,7 €/MWh for Compact network scenario and 21 €/MWh for Big network –scenario (see chapter 6.3)
- Labour costs are assumed to be 10 €/h

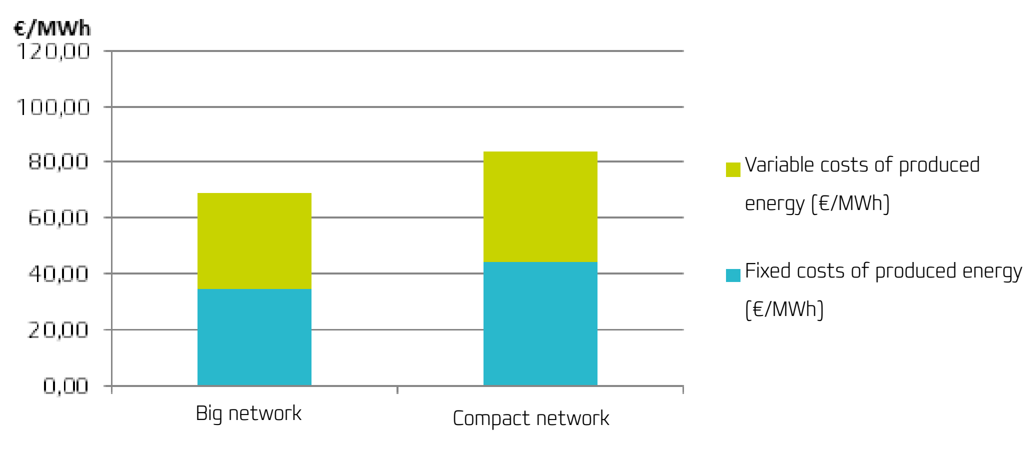
Summary of the cost calculation is provided in the table 13.

Table 13. *Summary of the cost calculation*

	Big network	**Compact network**
Produced heating energy [MWh/a]	3563	1260
Network losses [MWh/a]	167	132
Wood Chip boilers efficiency [%]	0,85	0,85
Oil backup boilers efficiency [%]	0,9	0,9
Wood chips consumption [MWh/a]	3811	1243
Light fuel oil consumption [MWh/a]	360	225
Payback time, boilers etc [a]	10	10
Payback time, network [a]	20	20
Interest rate [%]	3,0	3,0
Oil price, [€/MWh]	100	100
Wood chips price at the plant [€/MWh]	21	17,7
Personell costs, €/h	10	
Investmen costs	**Big network**	**Compact network**
Residual value [€]	0	0
Boiler + auxillaries investment [€]	684 000	248 000
Installation + ground work [€]	80 000	50 000
DH-Network [€]	104 500	75 000
Total investment [€]	868 500	373 000

Fixed costs		
Annuity boilers + installation [€/a]	89 564	34 935
Annuity DH network [€/a]	7 024	5 041
Heating and maintenance work [h/a]	500	400
Heating and maintenance work [€/a]	5 000	4 000
Electricity etc. [€/a]	6 000	2 000
Spare parts [€/a] (1,5 % / inv.)	10 260	3 720
Total	117 848	49 696
Running costs		
Wood Chips consumption [MWh/a]	3 811	1 243
Oil consumption [MWh/a]	360	225
Wood Chips costs [€/a]	80 025	22 010
Oil costs [€/a]	35 998	22 514
Total [€/a]	116 023	44 523
Indicators		
Fixed costs of produced energy [€/MWh]	34,70 €	44,07 €
Variable costs of produced energy [€/MWh]	34,16 €	39,49 €
Total costs of produced energy [€/MWh]	**68,87 €**	**83,56 €**

Big network -scenario seems to be economically more feasible. Main reason for this is that the Flats Block's excessive heat consumption, which creates efficient network with lower heat losses compared to Compact network -scenario. See picture 22 for a graphical illustration of the cost calculations.



Picture 22. *Cost calculation results*

Main differences in total costs come from fixed costs which consist mainly of network and boiler investments. Although the overall investment level is a lot lower in Compact network scenario compared to Big network -scenario, Compact network -scenario is still overall economically not as good as Big network -scenario. Further sensitivity analysis will be needed to assess the significance of different variables.

8.6 SENSITIVITY ANALYSIS

Dependency of the overall costs in relation to given variable can be assessed with basic sensitivity analysis. Even with basic sensitivity analysis, one can gain useful information of the district heating system economics.

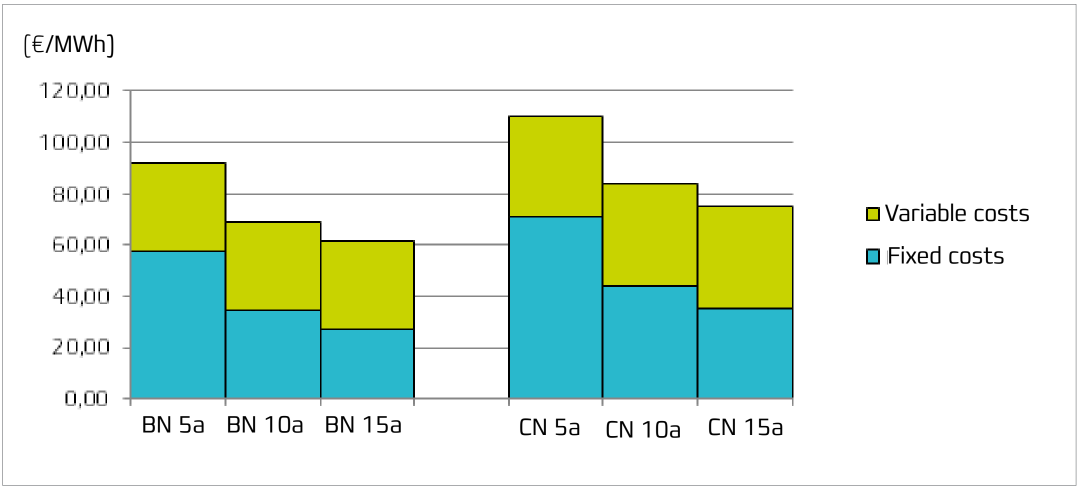
In this chapter we evaluate the significance of payback times, interest rate, investment costs and fuel prices.

8.6.1 Boilers and auxiliaries payback time

Payback time of the boilers and auxiliary installations is one of the most important factors in overall profitability. Risk investors seek for a very short loan payback time where public sector can cope with longer loan payback time. Boiler and auxiliaries are calculated with 5, 10 and 15 years payback times to illustrate the significance of payback time (table 14 and picture 23).

Table 14. *Significance of boilers auxiliaries payback time to the overall costs*

	Big network (BN)			**Compact network (CN)**		
	5 years	10 years	15 years	5 years	10 years	15 years
Fixed costs of produced energy [€/MWh]	57,45	34,70	27,17	70,80	44,07	35,23
Variable costs of produced energy [€/MWh]	34,17	34,17	34,17	39,47	39,47	39,47



Picture 23. *Significance of boilers and auxiliaries payback time for the overall costs*

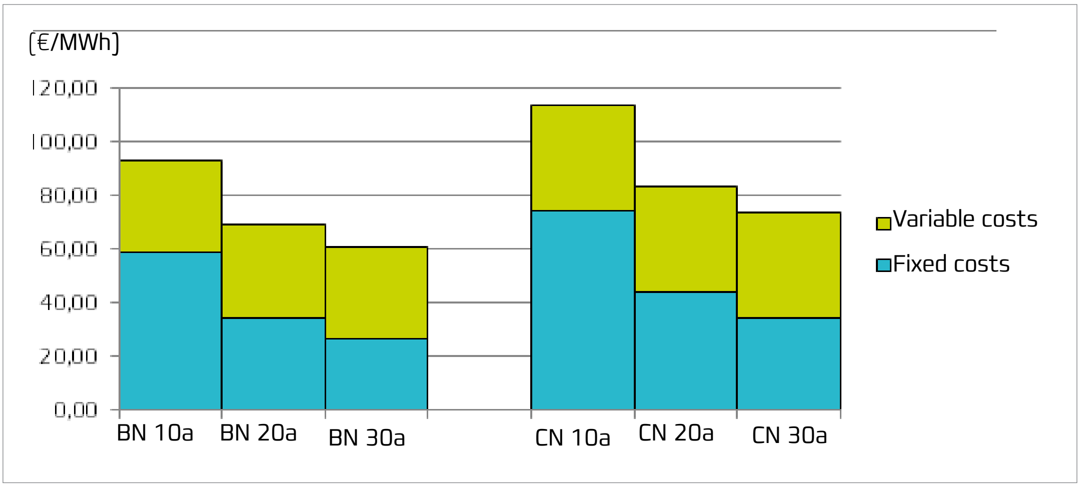
Regarding the total investments, boilers and auxiliaries have the biggest share of all. Therefore payback time affects the total costs heavily in both scenarios. Payback time has greater effect on the profitability of the Compact network -scenario.

8.6.2 Network paypack time

Although district heating network investment costs are not as high boiler and auxiliaries investments they have their own role in the big picture. Network is a very long term investment and therefore it needs to be accounted differently from boiler and auxiliaries investments. In normal situation technical life of heating network can exceed 50 years with proper maintenance. Therefore we use 10 -, 20 - and 30 –years as a payback times. Results are shown in table 15 and picture 24.

Table 15. *Significance of network payback time to the overall costs*

	Big network (BN)			**Compact network (CN)**		
	10 years	20 years	30 years	10 years	20 years	30 years
Fixed costs of produced energy [€/MWh]	58,99	34,70	26,68	74,13	44,07	34,15
Variable costs of produced energy [€/MWh]	34,17	34,17	34,17	39,47	39,47	39,47



Picture 24. *Significance of network payback time to the overall costs*

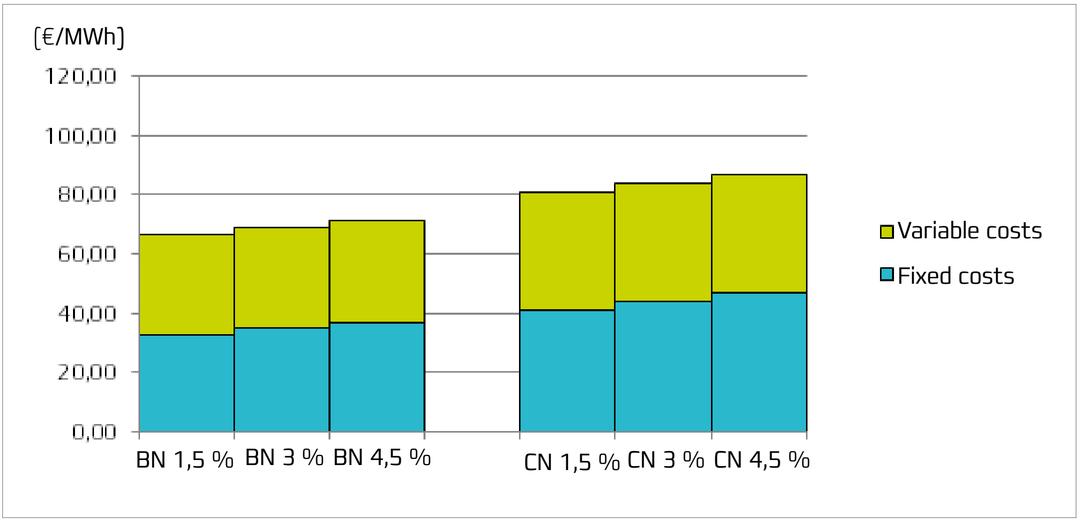
As already noted with the boilers and auxiliaries payback time analysis, Compact network is much more sensitive for the change of payback time. With 10 year payback period total costs increases close to 115 €/MWh.

8.6.3 Interest rate

Basic interest rate in this case study was 3 % and sensitivity analysis is conducted using interest rates between 1,5 – 4,5 %. Results of the calculations are illustrated in table 16 and picture 25.

Table 16. *Significance of the interest rate to the overall costs*

	Big network (BN)			**Compact network (CN)**		
	1,5 %	3 %	4,5 %	1,5 %	3 %	4,5 %
Fixed costs of produced energy [€/MWh]	32,45	34,70	37,06	41,15	44,07	47,13
Variable costs of produced energy [€/MWh]	34,17	34,17	34,17	39,47	39,47	39,47



Picture 25. *Significance of the interest rate to the overall costs*

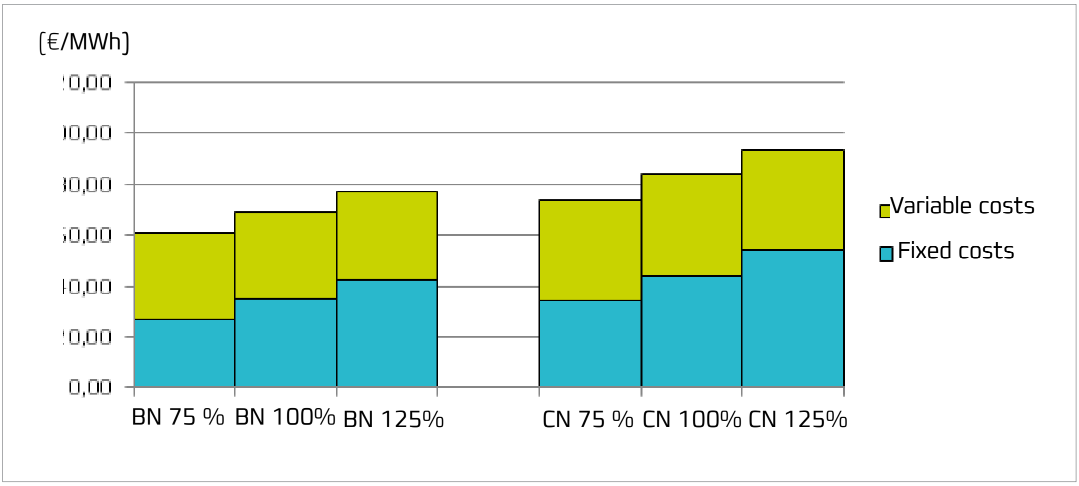
Used interest rates seem to have only little significance to the overall costs. It needs to be stated that interest rates used in this sensitivity analysis were rather low and higher interest rates needs to be calculated separately.

8.6.4 Investment sensitivity

Sensitivity to investment level is analyzed between 75 – 125 % from the originally used investment level. This includes the boiler, auxiliaries and network investments. Results are illustrated in table 17 and picture 26.

Table 17. *Significance of investment level to the overall costs*

	Big network (BN)			**Compact network (CN)**		
	75 %	100 %	125 %	75 %	100 %	125 %
Fixed costs of produced energy [€/MWh]	26,84	34,70	42,57	34,39	44,07	53,76
Variable costs of produced energy [€/MWh]	34,17	34,17	34,17	39,47	39,47	39,47



Picture 26. *Significance of investment level to the overall costs*

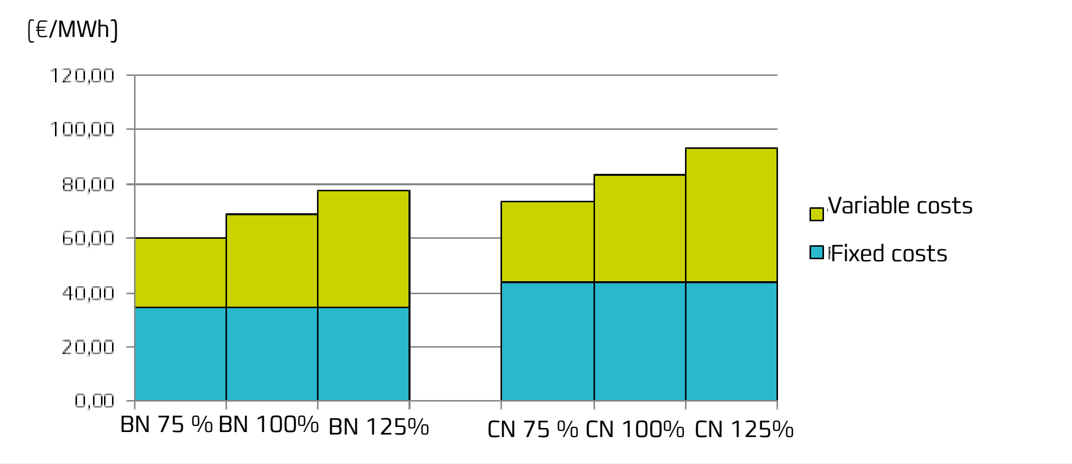
Investment level naturally has a strong impact on the total costs of heat production. Change in the investment level has a bit stronger influence on the Compact network -scenario but it also affects heavily on Big network -scenario. Changes are still somewhat parallel between the two scenarios.

8.6.5 Sensitivity to fuel prices

Effect of fuel prices is modeled between 75 - 125 % price scenarios. This means that in Big network -scenario the wood chip price varies between 15,75 to 26,25 €/MWh and in Compact network –scenario between 13,275 to 22,125 €/MWh. Oil price varies between 75 – 125 €/MWh in both scenarios. Results are illustrated in table 18 and picture 27.

Table 18. *Significance of fuel prices to the overall costs*

	Big network (BN)			**Compact network CN)**		
	75 %	100 %	125 %	75 %	100 %	125 %
Fixed costs of produced energy [€/MWh]	34,70	34,70	34,70	44,07	44,07	44,07
Variable costs of produced energy [€/MWh]	25,63	34,17	42,71	29,60	39,47	49,33



Picture 27. *Significance of fuel prices to the overall costs*

Fuel prices have a strong impact on running costs as it was to be expected. Once again the Compact network -scenario is a bit more sensitive to the change.

9 Conclusions, discussion and suggestions

Berzasca commune has a good possibility to build a district heating system which could be run technically without major problems. Both assessed scenarios filled the basic requirements for heat distribution via district heating network. Fuel logistics can be a bit of a challenge mainly because of the lack of road network. As mentioned in the procurement study, the results can be biased because of that and this needs to be taken account when reading the case study results. With high share of manual procurement the needed amount of wood could still be gathered.

Lack of summer time heat load is still some sort of a problem at least on the Compact network -scenario, where public buildings use minimal amount of hot dwelling water. This increases the price of produced heating energy, since network losses are close to 90 % of total heat production in the summertime.

Although the Big network –scenario seems more beneficial in almost every aspect it is hard to evaluate what would be the chances for it to realize in real world. Numbers displayed in this case study assume that all the apartments in Flats Blocks would be connected to district heating system. This goal might be hard to reach since people have a right to choose their own method of heating their apartments. Since there are no centralized heating systems in the Flats Blocks it would require massive renovation operations to make centralized heating possible in the first place. This needs to be taken into account before rushing into conclusions.

Sensitivity analysis didn't bring any ground breaking differences between the two assessed scenarios. Compact network scenario suffers from smaller heating energy consumption and therefore it is more sensitive to the increases in different costs. Boiler and auxiliaries investment costs may vary drastically in regards to the desired automation level. This is something to be considered as well. Investment figures used in the calculation represents modern day automation. If more manual labor and less efficient combustion is desired, the investment level will even less than 75 % of the original investment level regarding boilers and auxiliaries.

In order to make heating of public buildings more profitable and economically viable some sort of summer time heat load would be required. This could be anything from heat consuming industrial plant to a spa center or anything in between. Sole purpose of such a heat sink would be to provide “thicker” base load for warmer periods.

Further it needs to be discussed that at the moment public buildings are already heated with biomass so conversion to district heating based heating system wouldn’t bring any major environmental gains in bigger picture. When evaluating the feasibility of centralized systems, alternative heat production methods need to be taken into account. In this case the alternative is the current wood log-based in-house biomass-boilers. It is rather unlikely that conversion to district heating system would bring any real benefits, especially in a 10-20 year period, until the wood log-boilers reaches the end of their technical life-cycle.

Building of district heating network could be seen as an investment for the future since it could host a small scale combined heat & power plant if more constant summer time heat load should occur. At the moment heat load without Flat Blocks is close to being insufficient even for traditional heating plant.

Overall biomass based district heating systems can be economically feasible even in southernmost CEE-countries if area characteristics are carefully taken into account. Keeping in mind the outdoor temperature profile, it is suggested that special attention is given to summer time heat loads.

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Karelia

Central and Eastern European Forest Information Service (KIEMET) is a project that produces information on forestry, forest sector business environment, wood supply, forest enterprises and bioenergy markets in the CEE countries (Estonia, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Belarus, Ukraine and Romania).

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