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Regional Networks for the development of a Sustainable Market for Bioenergy in Europe

Case study: Installation of a flue gas condenser in district heating company “Limbažu siltums” boiler house, 31 Cēsu Street, Limbaži, Latvia

Supported by INTELLIGENT ENERGY EUROPE

Acknowledgements

This report has been produced as part of the project BioRegions. The logos of the partners cooperating in this project are shown below and more information about them and the project is available on www.bioregions.eu

The work for this report has been performed by Ekodoma, ltd (Latvia) and supported by VTT (Finland).

Title of the project

Installation of a flue gas condenser in district heating boiler house in Limbaži

Objectives of the project

Average moisture content of wood chips used in the boiler house is 40-60%. When combustion process starts, the fuel is heated up and water from the fuel starts to evaporate. Evaporation requires energy and this energy together with wet flue gases is released in atmosphere and is wasted. Part of this energy can be recovered if wet flue gasses are directed through a technical device called flue gas condenser. Installation of flue gas condenser allows recovering significant part of physical and latent heat from flue gases. Moreover, this technology reduces greenhouse gas and dust emissions in flue gases. The more heat energy can be recovered, the less amount of fuel will be needed to cover the same heat demand. Fuel savings are beneficial for both – for district heating company who can purchase less fuel and save on fuel costs and for energy end users who can benefit from more stable heat energy tariffs.

The objective of this project is to increase the efficiency of biomass use in Limbaži region by installation of flue gas condenser in municipality owned biomass boiler house.

Installation of a flue gas condenser allows increasing overall efficiency and reducing wood chips consumption by 15-20%. Flue gas condenser is installed in the flow of flue gases and allows partly recovering heat that is otherwise emitted into the atmosphere with flue gases and considered as heat loses. Additionally it allows improving air quality due to significant reduction of particulate matter emissions (up to 90%).

Project Timeline

Preparation of the project including application submission was done in September 2012. Implementation of the project is planned in 2014-2015.

The project can be implemented in 8 months.

No	Activity	Months							
		1	2	3	4	5	6	7	8
1.	Launch of the equipment procurement								
2.	Signing the contract								
3.	System design								
4.	Equipment manufacturing								
5.	Equipment supply and installation								
6.	Start-up and optimization								
7.	Training for operators								
8.	Putting into operation								

Description of local conditions

Project Operator:

Municipality owned district heating company 'Limbažu siltums' supplies district heat for consumers in Limbazi city. Among the heat users there are multi-apartment buildings, public buildings, commercial buildings and single family houses. The company owns and operates three boiler houses:

- 31 Cēsu Street, Limbaži town;
- 6 Jaunatnes Street, Limbaži town;
- Umurga village, Umurga municipality, Limbaži region.

Average efficiency of boiler houses is 85%.

During the winter season most of the heat is supplied from 31Cēsu Street boiler house (see in Figure 1). Therefore, installation of the flue gas condenser in this unit will give the most economical benefit.

Fig.1.Boiler house in 31Cēsu Street, Limbaži

Fig.2.Wood chips storage

In this boiler house there are three boilers with the total installed heat capacity 16.7 MW:

- DKVR 6.5–13 biomass boiler (5.19 MW),
- AK 5000P biomass boiler (6.10 MW),
- DKVR 6.5–13 diesel (light fuel oil) boiler (5.36 MW).

The DKVR biomass boiler is operated to cover peak loads. The DKVR diesel boiler is used only as back-up in case of emergency situations. The base load is covered by the AK 5000P biomass boiler. During the winter period the average heat load is 4.5 MW.

In Cēsu Street 31 boiler house wood fuel is delivered in logs. Wood logs are chipped and wood chips are prepared on the spot. Wood chips are stored in a shed under a roof (see in Figure 2). From there woodchips are fed in the furnace using moving floor transporters. Combustion process in AK 5000P boiler is completely automated; including providing continuous measuring of oxygen concentration levels. After combustion flue gases are mechanically treated in multi-cyclone ORIONS MC – 32 KA and then released in the atmosphere.

Site selection:

Limbaži town is a centre of the Latvian target region of the BioRegions project, which aims to get at least 1/3 of heating and electricity needs from local biomass sources. Most of the heating systems in the region are already wood based; however high potential to increase the biomass use efficiency exists.

Installation of the flue gas condenser will give significant contribution for reaching the fundamental target set in the Biomass Action Plan for Limbaži region - Improving efficiency of biomass use for at least 20% till 2022.

Technology analysis:

The process in the flue gas condenser is made in two steps. Flue gases through the inlet pipe are introduced in the condenser. First nozzle circuits are located in the pipe. In the first step flue gases are cooled to temperature that is acceptable to condense heat in the second part. Solid particles in fuel gases (still left after gas treatment in the multi-cyclone) are caught in the first nozzle circuit. The previously cooled flue gases are then injected in the second part of the condenser that contains with filling. Gases are moving from the bottom to the top through the second circuit filling and water that is injected at this step moves towards gas, creating counter flow. The purpose of the second step is to perform deep cooling of flue gases and steam condensing. Consequently the temperature of water injected through the second nozzles shall be as low as possible. The useful heat from the condenser is then returned back to district heating system.

For filling the condenser Tellerette rings are used. Those rings have large surface, low aerodynamic resistance and can be used in temperatures below 135°C. Tellerette rings support flue gas mixing with injected water and condensed water drops separation from flue gas flow. Due to deliquescent oxides in condensate and flue gasses, the condensate is acidic. In order to neutralize it, NaOH (sodium hydroxide) is used.

Above the condenser a stack pipe is located that takes fuel gases in the height of 20m and ensures proper flue gas dispersion in the atmosphere.

Proposed system consists of the following equipment:

- pump on nozzles 1
- pump on nozzles 2
- mud pump
- heat exchanger
- heat meter
- water meter
- pH/redox combination probe
- pH controller
- pH dosimeter pumps
- plastic rings

Since there is a limited space available in the boiler house (see layout plan in Annex 1), it is planned that flue gas condenser will replace the existing stack of the boiler house.

The condensing capacity and cross-sectional area of the exhaust pipe has been chosen based on assumption that for the heat generation mostly AK 5000P boiler will be used and that there is a possibility that new heat consumers will join the district heating system in next few years. In the current situation the average flue gas flow is 10 800 m^3/h.

Installation of a flue gas condenser in the boiler house will not require any additional permits or licenses. After installation of the condenser the pollution permit for boiler house might be a subject for changes with reference to reduced air pollution and fuel consumption.

Implementation of the project

In August 2012 Ekodoma started data collection in order to be able to elaborate technical specification of the desired system and to send request for proposals to potential flue gas suppliers. All together six flue gas condenser technology suppliers were contacted and in September 2012 technical descriptions and quotations from three potential flue gas condenser suppliers were received (see in Annex 2).

After that in cooperation with company 'Limbažu siltums', the best solution from the technical and economical point of view was selected and detailed economical calculations performed.

System design and technology provider:

Although the technical design of flue gas condensers may vary significantly, the basic principle remains the same. From the quotations that have been received, a condenser DK-5000 produced by Latvian company JSC Komforts and Riga Technical University has been selected and further evaluated in economical calculations.

JSC Komforts guarantees sufficient heat reduction efficiency and their technology is cheaper compared to other proposals. Condenser DK-5000 has been tested in another wood chips boiler house in Latvia (see Figure 3) by Riga Technical University researchers. Their testing results are showing confidence and reliability in this technology. The selected flue gas condenser is designed to treat flue gases with flow of 21 000 m^3/h.

Fig.3. Installation of flue gas condenser in Ludza biomass boiler house in Latvia

Limitations to the selected technical solution:

- For flue gas condensing the high moisture content in fuel is acceptable and even desirable; however for this technology it should not exceed 55%.
- The particulates (PM) concentration in flue gases entering condenser DK-5000 should not exceed 200 mg/m^3.

In current situation the moisture content in the fuel is between 40-60% and flue gas testing results indicate PM concentration of 69 mg/m^3.

Evaluation of savings:

The key figure for evaluation of project performance is energy recovery potential. Flue gas heat recovery potential depends on multiple factors. Heat recovery efficiency depends on fuel moisture, temperature of return water of heating network, combustion air ratio and humidity. The variation range corresponds to 10…45 % of the boiler output as shown in Figure 4.

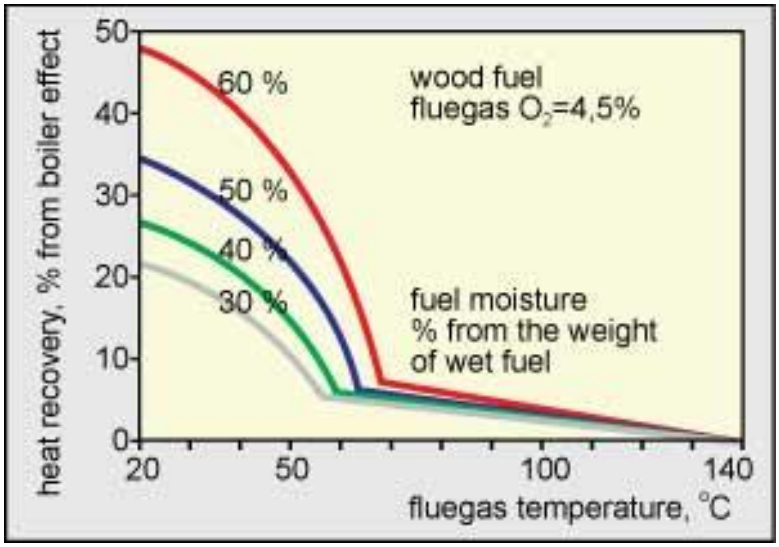


Fig.4. Heat recovery efficiency vs. flue gas temperature with different fuel moistures

Operating parameters of the 31 Cēsu Street boiler house that are affecting condenser productivity are the following:

- The temperature of return water is about 52°C;
- The moisture content in the fuel is between 40-60% (for further calculations the moisture content of wood chips were assumed 40%);
- Average flue gas temperature before installation of the condenser is 180°C.

According to the information given by the technology producer JSC Komforts, the expected energy recovery in 31 Cēsu Street boiler house is around 20%, however in economical calculations 10% energy savings was assumed.

Income (savings) from energy recovery is calculated based on the price for fuel. Fuel is purchased in a public tender procedure and payment is made according to produced heat amount. Since fuel supplier is paid for produced amount of energy, the supplier is interested in delivering wood chips with higher energy content (less moisture, sand and other impurities).

In 2012 the price for wood chips was 18.36 €/MWh. In average during one season the boiler house generates 18 000 MWh of heat that costs 330 480 €.

Evaluation of costs:

Investment costs were assumed based on the proposal received from JSC Komforts plus extra 10% for other investment costs were assumed.

In operation and maintenance costs the following cost categories were included:

- Cost for additional electricity consumption
- Purchase of NaOH

- Additional staff needed to operate the condenser
- Other costs

Flue gas condenser productivity is related to additional electricity consumption. To operate condensing unit, pumps will consume electricity that will be in addition to the current electricity consumption of the boiler house. The total electrical power of additional equipment is 35 kW, but exact work load depends on the productivity of flue gas condenser (see Figure 5). For further economical calculations the need of 20kW additional electrical power is assumed.

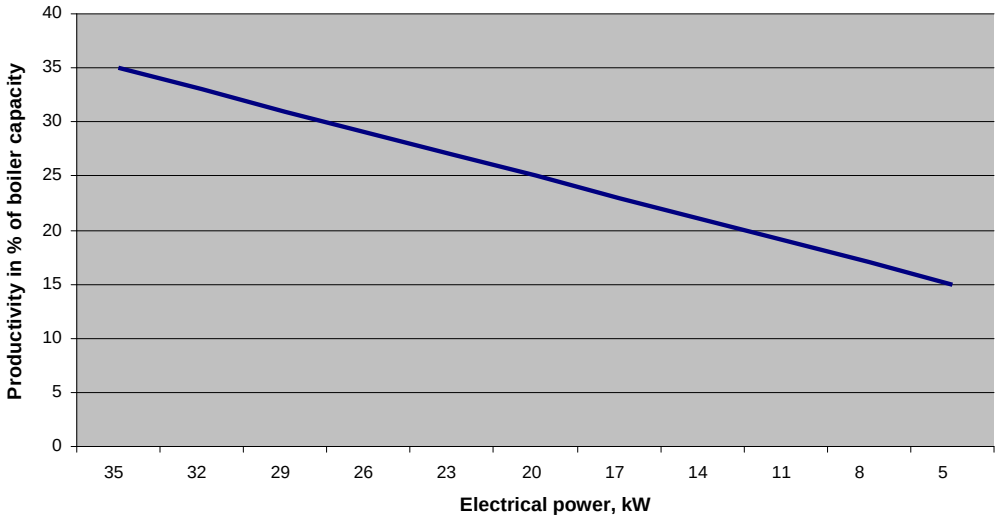


Fig.5.Additional electrical power needed depending on condenser productivity

In wood combustion the fly particles are alkaline and for this reason consumption of neutralization chemical NaOH is very low. In calculations it is assumed that around 2000 €/year will be needed to purchase the NaOH.

Additional employees to operate the flue gas condensing unit will not be required. Costs for instructing and training existing boiler house operators are included in given quotation. Operation manual for condenser DK-5000 will be provided and it contains step by step instructions for start-up and stopping the equipment use.

Financing of the project:

Investment costs of the project were initially estimated about 105 000 LVL (149 000 €) excluding VAT. District heating company 'Limbažu siltums' is a limited company and investment costs will be covered from the budget of company.

Two options for project financing are considered:

1) Investment costs are covered by company 'Limbažu siltums' (25%) and using the bank loan (75%)
2) Part of the investments are covered with subsidy (30%), the remaining is financed by company 'Limbažu siltums' (17,5%) and bank loan (52,5%)

Financial evaluation of those options (with/without subsidy) is given in Annex 3 of this document.

For the second option Ekodoma evaluated availability of grants. Operational Programme "Infrastructure and Services" complement, Priority 3.5 "Environmental infrastructure and promotion of environmentally friendly energy", Measure 3.5.2 "Energy", Activity 3.5.2.1 "Measures for increasing energy efficiency of heat supply systems", Sub-activity 3.5.2.1.1 "Measures for increasing energy efficiency of district heating supply systems" supports district heating companies for significant increase in heat generation efficiency; reducing losses in heat transfer and distribution systems, and facilitating the switch from fossil fuels to renewable energy sources. Within this program 'Limbažu siltums' could get a subsidy up to 40% of the total eligible costs. At the moment the call for proposals is closed, however, it is expected that another call will be announced in 2013.

As for the bank loan, a meeting with Citadele banka was arranged where financing possibilities were discussed (see Annex 4 for the minutes of the meeting).

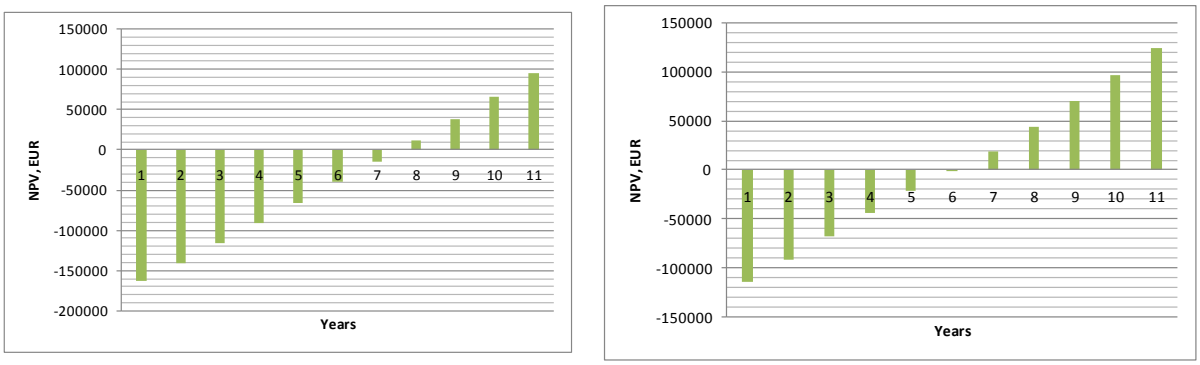
Financial evaluation of the project

The following table presents the costs, benefits and main assumptions used as input to the financial model built within the BioRegions project in order to evaluate the financial viability of this case study. Firstly, the capital and annual operation and maintenance costs after the project implementation are presented, whereas the incomes consist by avoided costs for energy as a comparison between before and after the implementation of the project. If a discount rate of 7% is assumed, without the subsidy the project's simple payback time is 7 years, with subsidy the project is paid back in 5 years.

			Without subsidy		With subsidy		
	Currency		LVL	EUR	LVL	EUR	0.7028 LVL/EUR
Capital costs	Investment costs		115 500	163 900	115 500	163 900	currency
	Assumed subsidy	Amount	0	0	34 650	49 170	currency
		Ratio	0		30		%
	Loan	Amount	86 625	122 925	60 475	86 048	currency
		Interest	6		6		%
		Payback time	10		10		Years
	Own funds		28 875	40 975	20 158	28 683	currency
O&M costs	Annual additional electricity costs		4 765	6 780	4 765	6 780	currency
	Annual NaOH purchase costs		1 405	2 000	1 405	2 000	currency
	Other annual costs		703	1 000	703	1 000	currency
Incomes	Annual heat sale		0	0	0	0	currency
	Annual electricity sale		0	0	0	0	currency
	Other (annual) income		0	0	0	0	currency
	Annual energy cost savings		23 226	33 048	23 226	33 048	currency
Evaluation criteria	Net present value	NPV	14 810	21 074	29 825	42 438	currency
	Internal rate of return	IRR	16		24		%
	Simple Payback Period	SPB	7		5		Years
	Year of implementation		2014				-
	Lifetime (evaluation)		10				Years
	Discount		7				%
	Potential energy savings		1 800				MWh/y
	Potential CO_2 savings*		0				t/y
*CO_2 emitted from biomass combustion is not considered							

Return of investments

The cumulative discounted cash flow is shown in the Figure 6. In both cases (with and without subsidy) payback times are very short.



Without subsidy With subsidy

Fig.6. Cumulative discounted cash flow

Sensitivity analysis

Sensitivity analysis were performed on three parameters for “without subsidy” scenario:

- Project investment costs,
- Achieved energy savings,
- Discount rate.

The result of the sensitivity analysis is given in Figure 7.

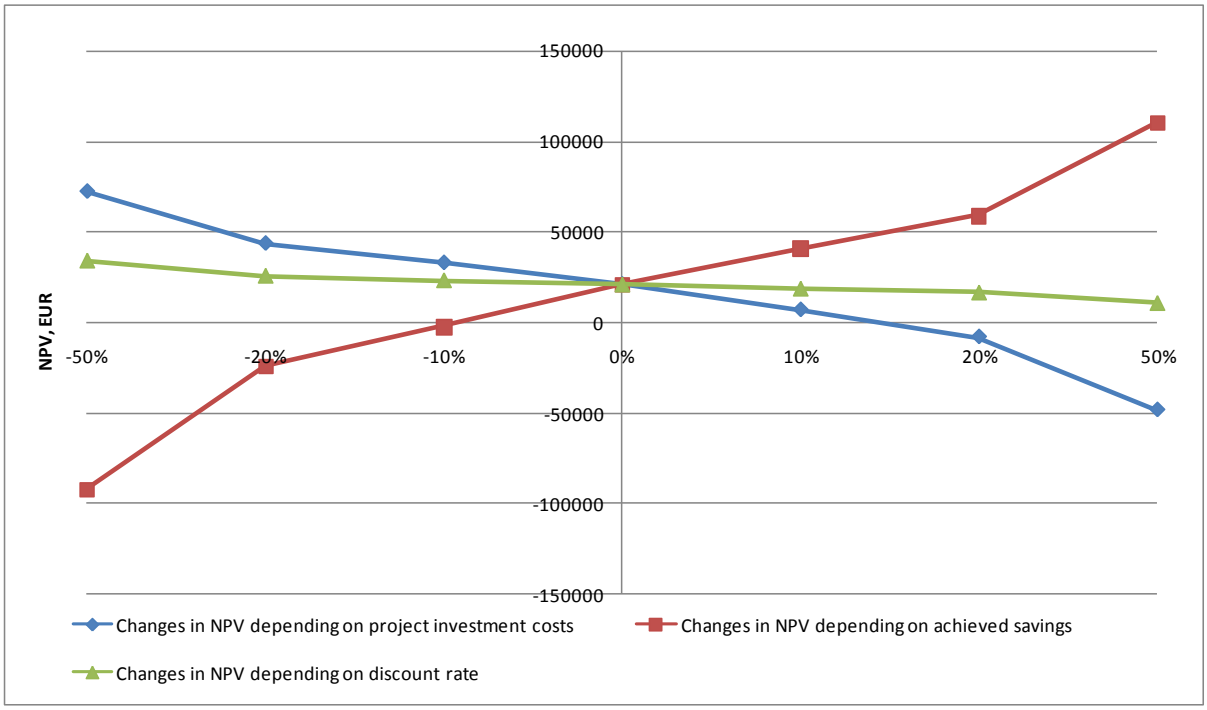


Fig.7. Sensitivity analysis of three parameters

If for some reason the total investment costs are rising, the NPV for 10 years period will get negative when increase in investment costs will be more than 15% compared to initially planned amount.

The higher risks are related to actual energy savings. If energy savings compared to base scenario are 10% less than expected, the project becomes economically not feasibile. Change in discount rate do not affect very significantly NPV values.

Conclusions

Implementation of the flue gas condenser installation project in Limbaži is in compliance with approved Biomass action plan designed within the BioRegions project.

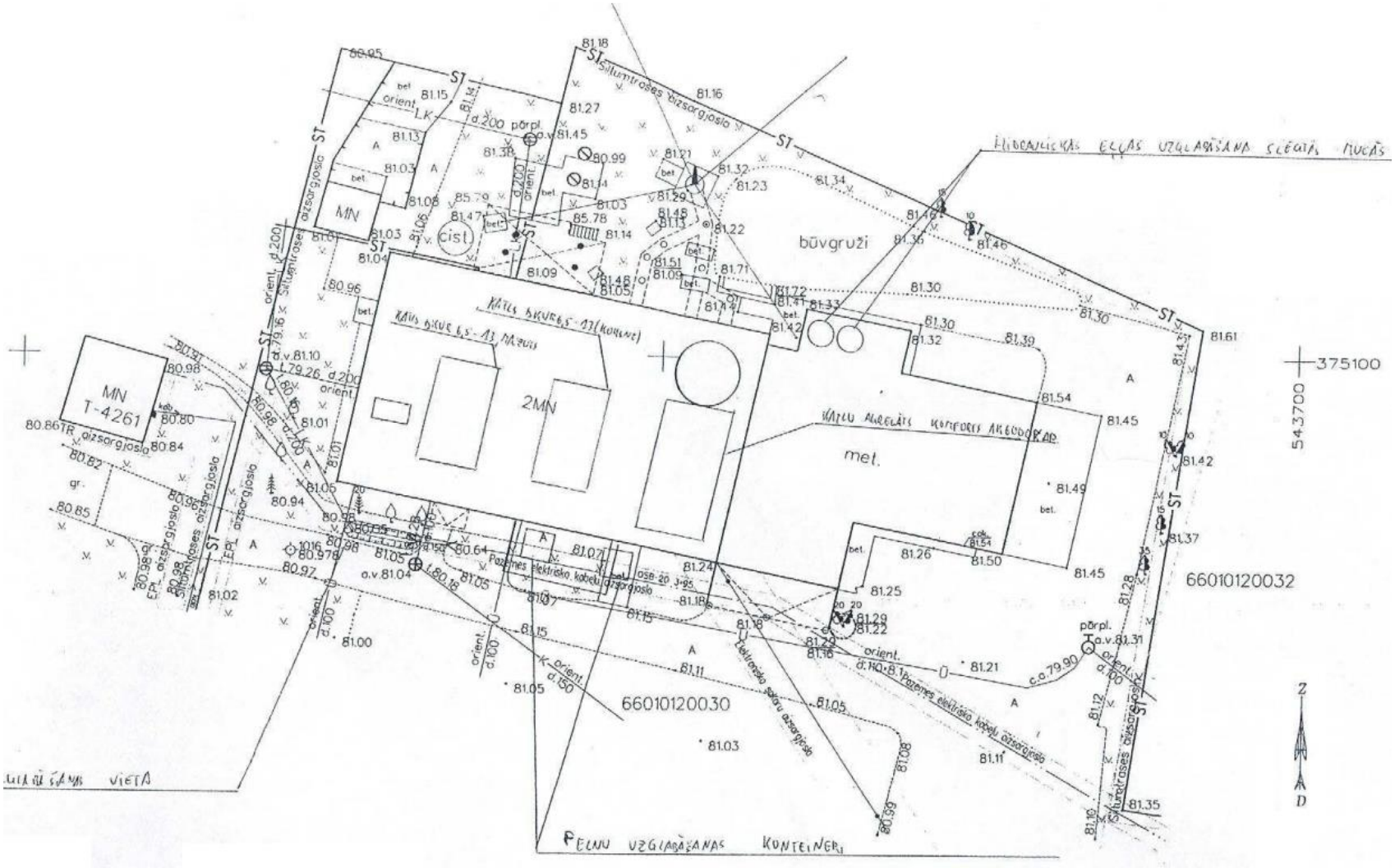
Installation of flue gas condenser will result in energy efficiency increase in heat generation and will save costs for fuel.

As can be seen from the financial evaluation of the project it is very attractive for investors, since the return on investments is very short.

In order to secure funding for the project, one meeting in a bank was organised. Minutes of the meeting are enclosed in Annex 4.

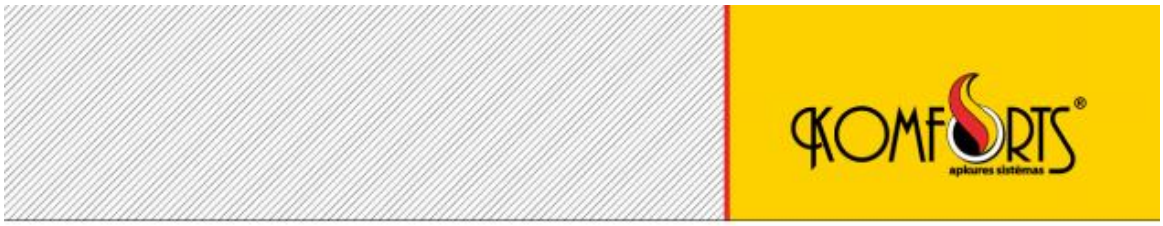
Technical details of the project were assessed by experts from VTT. They have developed recommendations and estimations of the fuel saving potential. Technical specification for tendering procedure and recommendation report is enclosed in Annex 5.

Annex 1: 31 Cēsu Street boiler house layout plan



Annex 2: Quotations received

JSC "Komforts" – 105 000 LVL (149 402 €) without VAT



CENU PIEDĀVĀJUMS Nr. IL/LV-12/149

Tukumā, 27.09.2012.

Pasūtītājs:	**SIA „EKODOMA"**
Adrese:	**Noliktavs 3-3, Rīga**
Kontaktpersona:	**Projektu asistents Jānis Ikaunieks**
Kontakti:	**26349224; janis.ikaunieks@ekodoma.lv**

Piegādātājs:	**AS KOMFORTS**
Objekts:	**Dūmgāzu kondensators DK-5000 SIA „Limbažu Siltums" katlu mājai Cēsu ielā 31**
Kontaktpersona:	**AS „KOMFORTS" valdes loceklis Ivars Liepiņš**
Kontakti:	**6 3125057, 29113965; ivars.liepins@komforts.lv**

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Fakss +371 3181203
e-pasts: komforts@comfort.lv
www.comfort.lv

KOMFORTS® apkures sistēmas

1. Dūmgāzu kondensators

Daudzums – 1 k-ts
Ražotājs – AS KOMFORTS, Latvija

- Dūmgāzu kondensators paredzēts enerģijas ražošanai no katla-kurtuves izejošajām dūmgāzēm
- Dūmgāzu kondensēšanas procesā tiek saražots siltais ūdens ar 60-70°C temperatūru
- Dūmgāzu kondensēšanas procesā atgūstamā enerģija ir 10-30% no kopējās katla jaudas
- Izmešu samazinājums vairāk kā 90%
- Samazina dūmgāzu piesārņojošo piemaisījumu nokļūšanu atmosfērā, kā:
  - sēra savienojumus;
  - hlorīdus;
  - smagā metāla daļiņas;
  - putekļus.
- Dūmgāzu temperatūra 180°C (ieplūde dūmgāzu kondensatorā)
- Dūmgāzu temperatūra 50...60°C (izplūde no dūmgāzu kondensatora)
- Maksimālais elektropatēriņš 35 kW
- Kurināmais – šķelda, skaidas, kūdra
- Kurināmā mitrums – līdz 55%
- Izmēri: diametrs 2.3 m, platums 3.6 m, augstums 21 m
- Dūmgāzu kondensatora svars bez ūdens 25 t

Cena LVL, bez PVN: 105,000.00

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www.comfort.lv

Condens Heat Recovery Oy – 250 000 €

Janis Ikaunieks

From: Ilkka Haavisto [ilkka.haavisto@condens.fi]
Sent: piektdiena, 2012. gada . 21. Sep 10:04
To: Janis Ikaunieks
Cc: Hannu Filen
Subject: VS: Your enquiry

Dear Mr Ikaunieks,

Thank you for the information. In case you need a short stack (exhaust 15 – 20 m from the earth level) and you will be able to place the sensitive components near-by indoors(heat exchanger, pumps etc), I think, for budgetary purposes, you should use a price of 250 000 €. There you should be able to build the automation/electricity yourself, but it would be included in the price as well as small service platforms and ladder for the service of the scrubber. The price does not include any building activities, so, you should consider the foundation at least. The price does not include any activity on the district heating piping, so you should take care of the black steel piping.

On annual basis, considering the return temperature of 52 C, which is a little too high, I would use 14 – 16 % heat recovery, calculated from the actual boiler effect. If you put in your budget a consumption of electricity, 2.5 % of the received heat recovery, you are not too far from the truth – this includes also the increased consumption of your flue gas fan. Operation and maintenance of the plant, max 2 manmonths a year. As you use wood fuel, the consumption of chemicals will be negligible, for budget maybe 3000 € a year.

So, we hope to have helped you with the calculations. It would be a pleasure to quote, in case you see an economical change in the investment. But, it might be, you should first invest in lowering the return temperature. Max 45 C return would surely give you 5 % more annual heat recovery, also calculated from the actual boiler capacity.

Terveisin/Best Regards,

Ilkka Haavisto
Condens Heat Recovery Oy
mob. +358 400 843 844| tel. +358 3 65 33 111
fax +358 3 65 33 110
Luukkaankatu 8, 13110 Hämeenlinna
Finland
www.condens.fi

Lähettäjä: Janis Ikaunieks [mailto:janis.ikaunieks@ekodoma.lv]
Lähetetty: 21. syyskuuta 2012 8:05
Vastaanottaja: Ilkka Haavisto
Aihe: RE: Your enquiry

Dear Ilkka,

The boiler house is in Limbaži city in Latvia with water heated boiler.

Our idea is to take of the old stack and in the same place build the new one.
For now we are preparing buisuness plan therefore we need to understand costs for such operation.

Best regards,

Jānis Ikaunieks
Ekodoma LTD
Project assistant
Tel.: +371 67323212
Mob.: +371 26349224
E-mail: janis.ikaunieks@ekodoma.lv
http://www.ekodoma.lv

From: Ilkka Haavisto [mailto:ilkka.haavisto@condens.fi]
Sent: Thursday, September 20, 2012 8:06 AM
To: Janis Ikaunieks
Cc: Hannu Filen
Subject: Your enquiry

Dear Mr Ikaunieks,

Thank you for the enquiry. Sure, it is possible to get a quotation. However,
in order to prepare one, we need some more background information about the project, like location, boiler type, customer information, more than only the name and how do you see the plant erection. Also the planned erection schedule would be interesting. We, as a company, do not have any installation/manufacturing activity in the Baltic countries. Also, in our opinion, if the boiler is the typical, which is used in Baltic countries, the return 52 C sounds a little high for providing a good operation economy.

We are looking forward for further information from you.

Terveisin/Best Regards,

Ilkka Haavisto
Condens Heat Recovery Oy
mob. +358 400 843 844| tel. +358 3 65 33 111
fax +358 3 65 33 110
Luukkaankatu 8, 13110 Hämeenlinna
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www.condens.fi

ER&RS – 261 000 €

[SIA"ER&RS"]
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Reģ. Nr.: 40003703630, PVN Reģ. kods: LV40003703630
AS SEB Banka, kods:UNLALV2X, konts: LV71 UNLA 0050 0050 8460 4

Rīga
Nr. 1.5/12-092

27.09.2012

QUOTATION: Flue gas wet cleaning and condensing heat recovery

Contents of the quotation:	The quotation includes the deliveries described in the attached technical description.
Price:	Equipment and deliveries in the technical description POS 1 - 10: **261.000,00€** The prices do not contain any VAT
Terms of payment:	30 % when ordered 40 % when all components have been delivered 30 % after final acceptance of the delivery, not later than 90 days from the delivery of the components Payments against invoice 14 days, net, interest for late payment 15%
Terms of delivery:	DAP Latvia
Other terms:	6 months from a clear and binding order
Validity:	This quotation is valid 8 weeks from the date

We hope, that You are interested in our quotation and we can continue the project with You.

Elīna Bule
Tālr. +371 67724092
e-mail: Elina.Bule@errs.lv

Annex 3: Financial evaluation results

With subsidies

Investments	EURO
Total Investment	163 900
Subsidy	-49 170
Investment (minus) **subsidy**	**114 730**

Post-Financing	EURO
Debt Capital 75.0%	86 048
Equity Capital 25.0%	28 683
Total	**114 730**

Debt term (years)	**10**
Interest rate:	**6%**

Energy
Savings
W. chips
Electricity

Cash Flow Model, EUR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Year of contract in exploitation		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Heat sale											
Energy price inflation, %			*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*
General price inflation, %			*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Heat energy savings		**33 048**	**34 039**	**35 061**	**36 112**	**37 196**	**38 312**	**39 461**	**40 645**	**41 864**	**43 120**
Electricity		-6 780	-6 983	-7 193	-7 409	-7 631	-7 860	-8 096	-8 339	-8 589	-8 846
Heating Gross Profit		**26 268**	**27 056**	**27 868**	**28 704**	**29 565**	**30 452**	**31 365**	**32 306**	**33 276**	**34 274**
Process water (NaOH)		-2 000	-2 040	-2 081	-2 122	-2 165	-2 208	-2 252	-2 297	-2 343	-2 390
Annual maintenance/admin costs/other		-1 000	-1 020	-1 040	-1 061	-1 082	-1 104	-1 126	-1 149	-1 172	-1 195
Corporate income tax 15.0%		0	0	-1 449	-3 267	-5 269	-7 463	-2 393	-2 600	-2 815	-3 039
Operational Cashflow		**23 268**	**23 996**	**23 297**	**22 253**	**21 048**	**19 677**	**25 594**	**26 260**	**26 945**	**27 650**
Investment and Financing											
Investment	-163 900										
Debt financing	122 925										
Subsidy		49 170									
Pre-subsidy debt cost		-3 380									
Return of subsidy to bank		-36 878									
Debt service		-11 416	-11 416	-11 416	-11 416	-11 416	-11 416	-11 416	-11 416	-11 416	-11 416
Own financing	40 975	-12 293									
FREE CASH FLOW	**0**	**8 472**	**12 580**	**11 881**	**10 837**	**9 633**	**8 261**	**14 178**	**14 845**	**15 530**	**16 234**
Cumulative Cash Flow	-114730	-91462	-67466	-44169	-21916	-868	18809	44403	70664	97609	125259
Oper. Cash Flow/ Debt payment:		**2.04**	**2.10**	**2.04**	**1.95**	**1.84**	**1.72**	**2.24**	**2.30**	**2.36**	**2.42**
ROI		20.3%	20.9%	20.3%	19.4%	18.3%	17.2%	22.3%	22.9%	23.5%	24.1%
NPV - 10 years @7%	€ 42 438.51										
IRR	24%										

Debt Capital payments	1	2	3	4	5	6	7	8	9	10
Annual loan repayment	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**	**11 416**
Interest payment	*4 733*	*4 365*	*3 977*	*3 568*	*3 137*	*2 681*	*2 201*	*1 694*	*1 159*	*595*
Payment on principal	*6 683*	*7 051*	*7 438*	*7 848*	*8 279*	*8 735*	*9 215*	*9 722*	*10 256*	*10 821*
Balance	79 364	72 314	64 875	57 028	48 748	40 014	30 799	21 077	10 821	0

Corporate Income tax	1	2	3	4	5	6	7	8	9	10
Part of Investment Expensed in Year 1, %	10%									
Part of Investment Depreciated over years	90%									
Taxable income	15 155	19 631	20 769	21 952	23 181	24 458	25 786	27 166	28 601	30 093
Investment expensed	-16 390									
Investment depreciated	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751
Subsidy	4 917	4 917	4 917	4 917	4 917	4 917	4 917	4 917	4 917	4 917
Accumultated Taxable income	-11 069	-1 272	9 663	21 781	35 128	49 753	15 952	17 332	18 767	20 259
Corporate income tax 15.0%	0	0	-1 449	-3 267	-5 269	-7 463	-2 393	-2 600	-2 815	-3 039

Without subsidies

Investments	EURO
Total Investment	163 900
Subsidy	0
Investment (minus) **subsidy**	**163 900**

Post-Financing	EURO
Debt Capital 75.0%	122 925
Equity Capital 25.0%	40 975
Total	**163 900**

Debt term (years)	**10**
Interest rate:	**6%**

Energy
Savings
W. chips
Electricity

Cash Flow Model, EUR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Year of contract in exploitation		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Heat sale											
Energy price inflation, %			*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*	*3.0%*
General price inflation, %			*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*	*2.0%*
Heat energy savings		**33 048**	**34 039**	**35 061**	**36 112**	**37 196**	**38 312**	**39 461**	**40 645**	**41 864**	**43 120**
Electricity		-6 780	-6 983	-7 193	-7 409	-7 631	-7 860	-8 096	-8 339	-8 589	-8 846
Heating Gross Profit		**26 268**	**27 056**	**27 868**	**28 704**	**29 565**	**30 452**	**31 365**	**32 306**	**33 276**	**34 274**
Process water (NaOH)		-2 000	-2 040	-2 081	-2 122	-2 165	-2 208	-2 252	-2 297	-2 343	-2 390
Annual maintenance/admin costs/other		-1 000	-1 020	-1 040	-1 061	-1 082	-1 104	-1 126	-1 149	-1 172	-1 195
Corporate income tax 15.0%		0	0	0	0	-310	-1 594	-1 514	-1 753	-2 003	-2 263
Operational Cashflow		**23 268**	**23 996**	**24 747**	**25 520**	**26 008**	**25 546**	**26 473**	**27 107**	**27 758**	**28 425**
Investment and Financing											
Investment	-163 900										
Debt financing	122 925										
Subsidy		0									
Pre-subsidy debt cost		-3 380									
Return of subsidy to bank		0									
Debt service		-16 308	-16 308	-16 308	-16 308	-16 308	-16 308	-16 308	-16 308	-16 308	-16 308
Own financing	40 975	0									
FREE CASH FLOW	**0**	**3 579**	**7 688**	**8 438**	**9 212**	**9 699**	**9 238**	**10 165**	**10 799**	**11 449**	**12 117**
Cumulative Cash Flow	-163900	-140632	-116636	-91889	-66369	-40362	-14816	11657	38764	66522	94947
Oper. Cash Flow/ Debt payment:		**1.43**	**1.47**	**1.52**	**1.56**	**1.59**	**1.57**	**1.62**	**1.66**	**1.70**	**1.74**
ROI		14.2%	14.6%	15.1%	15.6%	15.9%	15.6%	16.2%	16.5%	16.9%	17.3%
NPV - 10 years @7%	€ 21 074.63										
IRR	16%										

Debt Capital payments	1	2	3	4	5	6	7	8	9	10
Annual loan repayment	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**	**16 308**
Interest payment	*6 761*	*6 236*	*5 682*	*5 097*	*4 481*	*3 830*	*3 144*	*2 420*	*1 656*	*850*
Payment on principal	*9 547*	*10 072*	*10 626*	*11 211*	*11 827*	*12 478*	*13 164*	*13 888*	*14 652*	*15 458*
Balance	113 378	103 305	92 679	81 468	69 641	57 163	43 998	30 110	15 458	0

Corporate Income tax	1	2	3	4	5	6	7	8	9	10
Part of Investment Expensed in Year 1, %	10%									
Part of Investment Depreciated over years	90%									
Taxable income	13 127	17 760	19 065	20 423	21 837	23 309	24 843	26 440	28 104	29 838
Investment expensed	-16 390									
Investment depreciated	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751	-14 751
Subsidy	0	0	0	0	0	0	0	0	0	0
Accumultated Taxable income	-18 014	-15 005	-10 691	-5 020	2 066	10 625	10 092	11 689	13 353	15 087
Corporate income tax 15.0%	0	0	0	0	-310	-1 594	-1 514	-1 753	-2 003	-2 263

Annex 4: Minutes of the Meeting in Bank

Meeting at „Citadele banka" about financing a flue gas condenser installation project in „Limbažu siltums" heating plant in 31 Cēsu Street, Limbaži

Date and time: 09/04/2013; 1:00 PM – 2:00 PM

Place: "Citadele banka" headquarters, Republikas square 2A, Riga, LV-1010

Participants:

- „Ekodoma", Claudio Rochas
- „Ekodoma", Jānis Ikaunieks
- „Citadeles banka", Ieva Vērzemniece

At the beginning of the meeting Claudio Rochas introduced a "Citadele bank" representative Ieva Vērzmeniece to the idea and economic calculations of flue gas condenser installation project prepared by "Ekodoma", Ltd.

1. The working principles and main benefits of flue gas condenser were presented to the representative of "Citadele banka". The presentation is provided in the annex of the minutes of meeting.

2. Currently in the heating plant owned by heating company "Limbažu siltums" in 31 Cēsu Street, Limbaži three boilers are installed:
    a. DKVR 6.5-13 with the thermal input of 5.19 MW_{th} (fuel – wood chips) is used to cover the peak load;
    b. AK 5000P with the thermal input of 6.10 MW_{th} (fuel – wood chips) is used to cover the base load;
    c. DKVR 6.5-13 with the thermal input of 5.36 MW_{th} (fuel – diesel oil) is used as a backup boiler.

3. The average moisture content of the wood fuel used in the heating plant is 45-60%. For the 2012/2013 heating season wood fuel has been purchased for 18.36 EUR/MWh_{th}. It is expected that in 2013 the price of the woodchips will increase by 5-10%. The overall efficiency of the heating plant is around 75%.

4. In order to identify the potential flue gas condenser technology suppliers, a market research was made by sending request for quotations to 7 potential equipment suppliers (Valmiera-Andren, Agrosilva, ER&RS, JSC Komforts, Condens Heat Recovery Oy, Ehox Tuote Oy). Three offers were received:
    a. JSC Komforts – 149 402 EUR (a turnkey project)
    b. Condens Heat Recovery Oy – 250 000 EUR (only equipment)
    c. ER&RS – 261 000 EUR (only equipment)

5. According to the preliminary economical analysis, the main economic figures for the project are:
    a. NPV – 42 000 Euro

b. IRR – 16%

6. The representative of the “Citadele banka” informed that the interest rate used in the calculations corresponds to the actual situation. If the loan holder is a municipal company (as it is in the case of “Limbažu siltums”), the required own funding might be only 5-10% from the total project costs, however, if project is implemented by a private company, then company will have to provide about 30% of the own funding. The interest rate given by the bank to the municipal company is 4-5%, for private companies – around 5-6%.

It is important for the bank to understand, whether the installed flue gas condenser might be used in another heating plant in case the company is not able to pay back the loan. If the same condenser can be installed in different heating plants, then the equipment itself can be used as a deposit otherwise, additional collateral must be provided. The bank would need some approval for the actual lifespan of a flue gas condenser technology.

Annex 5. Recommendations from technical experts of VTT

Recommendations and estimation of the fuel saving potential

1. Technical data

To size and price a scrubber and condenser the following basic data is needed for specifying the equipment:

Boiler and heating plant

- Boiler type (stoker, grate, fluidized bed…)
- Nominal, maximum and minimum capacity output (MW)
- Water pressure and temperature
- Annual energy produced (MWh/a)
- Annual running time (h/a)
- (Durability curve of energy demand, if available)
- Efficiency of the boiler
- Return water temperature (minimum, maximum, average)
- Automation system (name of a supplier)
- Ambient air temperature and humidity (not essential)

Flue gases

- Type of fly ash pre-separator (cyclone, ESP…)
- Particulate concentration after pre-separator (mg/m^3)
- Oxygen content of flue gases (dry or wet gas, needed to specify)
- Temperature of flue gases

Fuels (can be classified according to EN 14961-1 standard)

- Type of fuels (wood chips from thinning, logging residue chips, hog fuel from stumps etc.)
- Elemental analysis of fuel (Carbon, Hydrogen, Nitrogen, Sulphur (CHNS), Cl, F)
- Net calorific value as received
- Ash content on dry basis
- Moisture on wet basis

2. Call for offers

It is recommended to include the technical data mentioned above and an additional data (initiated or requested) defined by the purchaser, like:

- Particle separation efficiency, limit value of concentration
- Time of delivery
- Maintenance intervals and costs
- Consumptions and prices of chemicals (type of chemicals) and electricity consumption

- Optional offer: Humidification of combustion air is included
- Comparison basis of the purchase: Best offer in terms of total economy (criteria recommended to detail, e.g. price 35%, heat recovery rate 30%, maintenance costs and usability 20%, materials 10% and time of delivery 5%)

3. The offer

The offer needs to include

- Total price and terms of payment (in € and in Latvian currency)
- Guarantee of the performance:
    - Heat recovery capacity, particulate concentration in flue gas after condenser, electricity consumption…
    - Terms of guarantees (fuel quality requirements, oxygen content of flue gas…)
    - Conditions of guarantee tests (fuel quality, actual boiler capacity, oxygen content of flue gas, quantities to be measured, measurement standards to be applied…)
- Labour needed, h/a
- Usability guarantee, h/a or %
- Guarantee period, years
- Maintenance at guarantee period and later maintenance contract
- Commissioning and training of staff
- Availability of spare parts
- Technical specifications of components (materials, manufacturers of main components (like fans and pumps), automation...)
- References
- Optional offer (to be calculated separately): Humidification of combustion air is included
    - Price, performance values and other technical data as above
    - Additionally combustion air temperature and humidity and air duct material

Comparison of the offers is recommended to do according to the criteria described in part 2 (last bullet). Purchaser will write short and comprehensible minutes of the procedure of the choice to avoid possible later misunderstandings.

4. Heat recovery capacity of the condenser

Heat recovery capacity depends strongly on the oxygen content in flue gases, see figure 1. The calculations are based on the following initial data:

- nominal capacity of the boiler 6 MW_{th},
- actual capacity of the boiler is 70% from nominal capacity,

- fuel: wood chips, moisture 40%,
- return water temperature 52°C,
- flue gas temperature 180°C,
- no combustion air humidification is applied.

To increase the heat output capacity some measures to lower the return water temperature are recommended (e.g. renewing or repairing heat exchanger in the buildings connected to the district heating). Temperature drop from 52°C to 45°C would increase fuel savings at least by 5%-units.

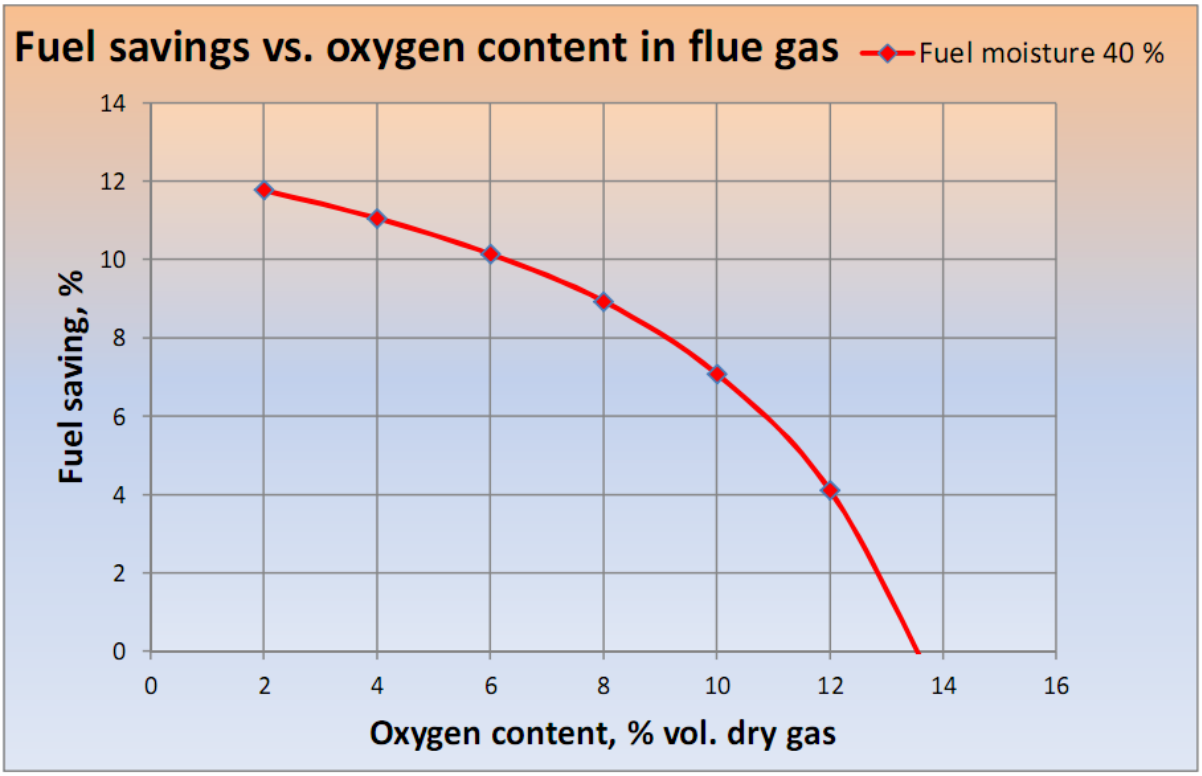

Figure 1. Heat recovery capacity of flue gas condenser compared to actual fuel energy with varying oxygen content.