BAY OF PLENTY REGIONAL COUNCIL
TOI MOANA

Submission Form

Send your submission to reach us by **4.00 pm** on **Wednesday, 18 April 2018**

Submission Number
Office use only
029

Post: The Chief Executive Bay of Plenty Regional Council PO Box 364 Whakatāne 3158	**or Fax:** 0800 884 882	**or email:** air@boprc.govt.nz

Submitter Name:

This is a submission on **Proposed Plan Change 13 (Air Quality) to the Regional Natural Resources Plan**

I **could/~~could not~~** gain an advantage in trade competition through this submission. *[Delete as required.]*

(a) I ~~am/~~**am not** directly affected by an effect of the subject matter of the submission that adversely affects the environment; and

(b) My submission **does/~~does not~~** relate to trade competition or the effects of trade competition.

[Delete the entire paragraph if you could not gain an advantage in trade competition through this submission.]

2 The details of my submission are in the attached table. There are additional information attached for clarification

3 I wish/~~do not~~ wish to be heard in support of my submission. *[Delete as required]*

4 ~~If others make a similar submission, I will consider presenting a joint case with them at a hearing~~. *[Delete if you would not consider presenting a joint case.]*

[Signature of person making submission or person authorised to sign on behalf of person making submission.]
[NOTE: A signature is ***not*** *required if you make your submission by electronic means.]*

16/4/2018
Date

Address for Service of Submitter: Rene Haeberli, 133 Ohahune Rd, RD3 Whangan.

Telephone: **Daytime:** 021 24 24 211 **After Hours:** 021 24 29 211

Email: rene.haeberli@xtra.co.nz **Fax:**

BOPRC ID: A2802144

Contact person*: [Name and Designation is applicable]* **Dr Rene Haeberli, Owner and Director of EnviroSolve Ltd**

Page No	Reference (e.g.Policy,rule, Method or Objective number)	Support/Oppose	Decision Sought Say what changes to the plan you would like	Give Reasons
3	AQ P7 (a)	Oppose, Amend	...replacement low emission wood burners and Ultra Low Emission Burners (ULEBs)	ULEBs are tested under Canterbury Method one (CM1) and that is a real-life test and it is much more stringent than Low Emission burner under AU/NZS 4012/4013.
4	Table AQ1	Amend	Low Emission burners and Ultra Low Emission Burners should be added to table	It would make the table complete
8	AQ R12 (a) (i),(ii)	Oppose/Amend	(i), (ii) is only a permitted activity if these fires are equipped with secondary emission reducing devices approved by the Bay of Plenty Regional Council or the Minister of Environment within a certain transition period	High sophisticated secondary reducing devices are available for dwelling houses and industrial application.
8	AQ R12 (d) (ii)	Oppose/Amend	... less or equal 0.6 g/kg fuel under AU/NZS 4012/4013 or is a Ultra Low Emission Burner (ULEB) less or equal 0.5 g/kg fuel tested under Canterbury Method 1 (CM1)	The Low Emission burners approved under AU/NZS 4012/4013 are not allowed to be sold into the Environment Canterbury area (from 1. January 2019) due to their much stringent CM1 test. CM1 test measure the most important start up and end phase while under AU/NZS 4012/4013 only hot phases are measured and low emission fires are tuned for the hot phase and ignore start up and end phase. Low Emission Burner do not pass the CM1 test despite the fact they are 0.6 g/kg equal or less.
8	AQ R13 (c)	Oppose/Amend	... less or equal 0.6 g/kg fuel under AU/NZS 4012/4013 or is a Ultra Low Emission Burner (ULEB) less or equal 0.5 g/kg fuel tested under Canterbury Method 1 (CM1)	Please see above.
9	AQ R14 (a)	Oppose/Amend	) is only a permitted activity if these fires are equipped with secondary emission reducing devices approved by the Bay of Plenty Regional Council or the Minister of Environment until 1 February 2020.	As I mentioned above there are high sophisticated secondary reducing devices available on the world market which has been extensively tested in Lab and Field trials over the last eight years and are in certain countries partly or fully subsidized by these various governments.
13	AQ R18 (2) (b) B.	Format/Amend	the discharge is a permitted activity provided: (i) All emission stack	The same format should be used like under (c) and (d) for (i) and (ii) two and requirement amended.

			(ii) The emission stack is designed .... at full load is ??? metres per second (has to be determined). (iii) The concentration of particulates shall not exceed ??? milligram per cubic metre corrected to 0 degrees Celsius dry gas basis, 1 atmosphere pressure and 8 % oxygen	The velocity has to be set like under (c) and (d) Under (iii) the concentration of particulates should be put in there for the range of boilers between 40 kW – 500 kW (i.e. in Dunedin are limits for wood boilers of 50mg/m3 or in certain air zones 25 mg/m3 respectively)
13	AQ R18 (2) (c) B.	Format/Amend	(iii) The concentration of particulates shall not exceed ??? milligram per cubic metre corrected to 0 degrees Celsius dry gas basis, 1 atmosphere pressure and 8 % oxygen	Under (iii) the concentration of particulates should be put in there for the range of boilers between 500 kW – 2 MW (please see example for Dunedin).

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

IANZ ACCREDITED LABORATORY Accreditation No. 962

SPECTRUM LABORATORIES

Spectrum Laboratories Ltd is accredited by International Accreditation New Zealand (formerly Telarc). The tests reported herein have been performed in accordance with the terms of our accreditation. This accreditation does not extend to any opinions or any interpretations of test results contained in this report.

(This report is endorsed)

Test Report Number:	0457.
Item Under Test (IUT):	
Make:	RAIS.
Model:	Bionic Fire.
Type:	Freestanding – Downdraft.
Client Details:	
Attention:	Mr. Rene Haeberli.
Company Name:	EnviroSolve Ltd.
Company Address:	Ohakune Road, R D 3, Wanganui.
Phone:	+64 (0)6 385 4871.
Manufacturer:	Rais A/S, Industrivej 20, 9900 Frederikshavn, Danmark.

Standard Specification:
AS/NZS 4012:2014 - Method for determination of power output and efficiency.
AS/NZS 4013:2014 - Method for determination of flue gas emission.

Client Instructions:
The client requested the item be tested to the above standard(s).

Report Record:

Report Preformat	CD-00263 revision 2.0.
Worksheet Spreadsheet	CD-00195 revision 1.3.
Test Runs Record Sheet	CD-10229 revision 1.1.

Checked by
Mr. P. Sparrow
Authorized Signatory

Tested by
Mr. P. Chen
Compliance Engineer

Issue Date 12/12/2016

Unit 1/25 Highbrook Drive, East Tamaki, Auckland.
PO Box 204-252 Highbrook, Manukau Auckland, 2161.
Telephone +64 9 271 1616, Fax +64 9 271 1615.

Section 1: Description

Overall external dimensions:
The heater had the following overall external dimensions.

Height	1252 mm	*- measured to the highest point of the heater*
Width	403 mm	*- measured at the widest points of the heater*
Depth	410 mm	*- measured from the rear most panel to the glass door*

Refer to design drawings for detailed dimensions.

Firebox internal dimensions:
The fire box had the following basic internal dimensions;

Height	295 mm	*- measured between floor and leading edge of the ceiling baffle.*
Width	280 mm	*- measured between the interior side walls.*
Depth	200 mm	*- measured between the rear interior wall and inner edge of fuel retaining glass.*

Refer to design drawings for detailed dimensions.

Removable grilles and cook tops:
The heater did not have any removable grille or cook tops.

Fuel loading doors:
The door consisted of a one piece of a rectangular glass window with round corners.
Overall dimensions of the door were:

Height	1030 mm
Width:	405 mm

The lowest edge of the glass was located 225 mm above the floor.

Refer to design drawings for detailed dimensions.

Refractory materials and gaskets:
The heater contained six vermiculite fire bricks in the upper combustion chamber, four vermiculite bricks in the lower combustion chamber; covering side walls, rear wall, ceiling and floor.

The door frame was fitted with a fire resistant rope to seal the gap between the door and the firebox aperture.

Refer to design drawings for material dimensions and specifications.

Water heating device:
The heater was not fitted with a water heating device.

Air circulation Fan:
This heater was not fitted with an air circulation fan.

Catalytic combustor:
This heater was not fitted with a catalytic combustor.

Bypass damper:
The heater was fitted with a bypass damper to switch between conventional and downdraft mode.
The bypass damper was controlled automatically.
Refer to design drawings for detailed dimensions.

Section 2: Air inlets and outlet

All combustion air entered via a 94 mm diameter air supply inlet centrally located in the base of the heater.

Primary air:
Thermally controlled variable primary air entered the heater from the bottom of the base and was channeled up that back of the heater into the upper combustion chamber from below the door seal the gap between the door glass and metal was 7.5 mm.

The primary air was controlled by a bimetal lever coupled to a rotating air slide; three additional air holes set the minimum air supply when the slide was fully closed.

Maximum Primary Air 1992 mm^2
Minimum Primary Air 359 mm^2

Secondary Air:
Uncontrolled secondary air entered the firebox through a 20 mm by 15 mm opening.

Secondary Air 300 mm^2

Pilot Air:
Uncontrolled pilot air entered the firebox through two 11.5 mm holes.

Pilot Air 201 mm^2

Refer to design drawings for detailed dimensions.

Flue gas outlet:
The flue gas outlet spigot was positioned centrally when viewed from the front of the firebox and the spigot's axial centre was 106 mm from the rear edge of the appliance's top panel.

The flue spigot had an internal diameter of 132 mm.

Refer to design drawings for detailed dimensions.

Cross sectional area:
The flue spigot outlet aperture was calculated to be 13685 mm^2

Refer to design drawings for detailed dimensions.

Section 3: Procedure

Testing was carried out in accordance with AS/NZS 4012:2014 and AS/NZS 4013:2014 as per the client's instructions.
During testing the air controls were set as required to achieve the appropriate burn rates.
The ember bed and fuel loads were calculated in accordance with AS/NZS 4012:2014.

Section 4: Results

During these tests conducted in accordance with the standard AS/NZS 4012:2014 the efficiency was calculated as an average overall efficiency.

The fuel consumption rate for any given burn cycle was calculated by dividing the oven-dry mass of the test fuel by burn cycle time and expressed at a rate of kilograms per hour kg/h (oven-dry).

The heaters particulate emission factor was calculated by averaging the particulate emission factors for all three test runs.

Fuel data:

Type of Fuel used:	Hard Wood.
Species of Firewood:	Grey Ironbark.
Fueling Rate:	As per AS/NZS 4012:2014.
Usable volume of firebox:	10.5 L.
Longest dimension of firebox:	280 mm (Side to Side).
Fuel Loading Orientation:	280 mm (Side to Side).
Firewood test load mass:	1.71 kg.
Theoretical number of fuel load:	1.50 pcs.
Actual number of pieces per load:	2 pcs.
Firewood piece length range in mm:	196 mm minimum. 224 mm maximum .
Embers bed:	0.42 kg (Allowed range 0.41 –0.44 kg).
Average Moisture Content:	13 %.
Average Calorific Value:	20.13 MJ/kg.
Average Ash content:	0.12 %.
Average Burn Time:	123 minutes.

Efficiency:
72.2 %.

Fuel consumption rate:
0.73 kg/h.

Emission factor:
0.43 g/kg.

Compliance with standard
Australia:
The AS/NZS 4012:2014 standard required that the appliance shall have an overall average efficiency of not less than 60%, the overall efficiency result of 72.2% for the tested appliance complied with the AS/NZS 4012:2014 standard

The AS/NZS 4013:2014 standard required that the particulate emission factor be not greater than 1.5 g/kg for any appliance without a catalytic converter, the emission factor result of 0.43 g/kg for the tested appliance complied with the AS/NZS 4013:2014 standard.

Conditioning Burn Results:
In accordance with the AS/NZS 4012:2014 the heater under test was subjected to the required post conditioning and the post burn air flow test flow rates, in cubic metres per minute (corrected to 20°C and 101.3 kPa).

Post Conditioning Air flow	0.60 m^3 / min
Post Burn Air Flow	0.61 m^3 / min

Raw data:

CALORIMETER TEST DATA SHEET	Records			
Reference file	0457			
Test date	21/10/2016			
Start Time	10:43	12 23	14:13	16:25
Heater model	Bionic			
Test run number	Pre	1	2	3
CV of fuel, MJ/kg DAF	20.13	20.13	20.13	20.13
Weight of Wood charge, kg	1.72	1.72	1.74	1.68
Moisture of Wood, % Sample Label	12	13	13	13
Ash content of Wood, % dry	0.12	0.12	0.12	0.12
Weight of Wood (Dry mass) kg	1.5136	1 4964	1.5138	1.4616
Main filter label	TA	1A	2A	3A
Backup filter label	TB	1B	2B	3B
Main filter Start, g	0.09326	0.09453	0.09217	0.09492
Backup filter Start, g	0.09125	0.09449	0.09476	0.09413
Main filter Stop, g	0.09435	0.09529	0.09333	0.09603
Backup filter Stop, g	0.09148	0.09463	0.09482	0.09435
Dry gas meter START, cu.m.	1951.756	1952.757	1953.837	1955.116
Dry gas meter STOP, cu.m.	1952.757	1953.837	1955.116	1956.372
Start power, kW	4.47	3.38	3.06	2.67
Stop power, kW	3	3.05	2.98	2.72
Average Power, kW	3.5	3.232	2.8	2.8
Dilution tunnel temperature	25.91	26.83	28.19	26.78
Dry Gas Meter Average Temperature, °C	20.53	22.5	23.95	24.91
Total Cycle Time (mins)	105	111	130.4	128.26
Average cycle Barometric Pressure, mB	1017	1016	1016	1014
Dilution Tunnel volume, cu.m.	500.012	560.122	657.233	647.63
Peak Power, kW	4.61	3.56	3.22	3.1
Calculated Efficiency	72.37	71.46	71.89	73.24
Emission Factor	0.4348	0.3312	0.4357	0.5341
Fuel consumption rate, kg/h	0.86	0.81	0.70	0.68
Gas Meter Sample flow rate, L/min.	9.55	9.67	9.70	9.64

Notes: This is a single setting wood burner.

Brunner T., Wuercher G., Obernberger I., 2016: 2-year field operation monitoring of electrostatic precipitators for residential wood heating systems. To be published in the proceedings of the 24th European Biomass Conference & Exhibition, June 2016, Amsterdam, Netherlands, ETA-Renewable Energies (Ed.), Italy

2-YEAR FIELD OPERATION MONITORING OF ELECTROSTATIC PRECIPITATORS FOR RESIDENTIAL WOOD HEATING SYSTEMS

Thomas Brunner, tel: +43 316 48130013; fax: +43 316 4813004; email: brunner@bios-bioenergy.at
Gerald Würcher, tel: +43 316 48130058; email: wuercher@bios-bioenergy.at
Ingwald Obernberger, tel: +43 316 48130012; email: obernberger@bios-bioenergy.at
BIOS BIOENERGIESYSTEME GmbH, Hedwig-Katschinka-Straße 4, A-8020 Graz, Austria

ABSTRACT: To assess the applicability of ESPs for particulate matter emission reduction in old residential wood heating appliances comprehensive field tests with accompanying ESP operation monitoring and dedicated emission measurement campaigns have been performed in the region of Graz (AT). Three OekoTube ESPs were thereby tested during the heating seasons 2014/2015 and 2015/2016 at different sites with rather old respectively high-PM-emission wood burning devices. Before installing the ESPs at the field testing sites they were checked in the lab regarding functionality and precipitation efficiency. The evaluation of the plant monitoring data collected during the field tests revealed high seasonal ESP availabilities between 80.2% and 97.7%. Dedicated test runs with emission measurements at the different testing sites showed high precipitation efficiencies which were well comparable with those gained during preceding lab-tests. Based on these results it can be concluded, that ESP models like the OekoTube are suitable as retrofit units in old appliances and have due to their high availability and particle precipitation efficiency the potential to contribute to a significant reduction of particulate matter emissions from old residential wood burning systems.
Keywords: gas cleaning, particle emission, small scale application

1 INTRODUCTION AND OBJECTIVES

According to the European Biomass Association (AEBIOM) more than 50% of the bioheat produced in the EU28 is related to residential heating [1]. Logwood stoves, logwood boilers, pellet boilers and wood chip boilers are thereby the most common heating technologies. However, biomass burning in stoves and outdated boiler systems is increasingly criticized as a major source of particulate matter (PM) emissions. With the introduction of the EU directive 1999/30/EC, which limits among others PM_{10} concentrations in the ambient air, it had to be recognised that in many European regions the related limit value is more frequently exceeded than allowed. As the main sources for PM emissions traffic, industry and domestic heating have been identified. It has furthermore been shown that the contribution of residential biomass combustion to the total PM emissions of the residential heating sector exceeds 80% in some European regions.

Previous research projects dealing with this problem have revealed that especially old wood burning appliances are responsible for the high PM emissions of the residential heating sector [2, 3, 4]. An appropriate solution to the problem would be to exchange old appliances by modern low-emission systems. However, since owners of outdated heating systems cannot be forced to shift to newer ones and since also incentives for replacing old boilers did up to now often not show the desired effect, the application of precipitators for PM emission reduction seems to be the economically most feasible short-term approach.

The city of Graz (AT) is located in a typical basin-shaped region with a low exchange of air especially during winter time. This leads to accumulation of PM in the ambient air and consequently to more frequent exceedances of the PM concentrations allowed. A broad application of particle precipitators in old wood burning appliances could therefore, among others, be one appropriate countermeasure against air pollution. Recent work has shown that especially electrostatic precipitators (ESPs) are suitable for PM emission reduction from residential biomass combustion appliances [5]. However, former research projects such as the ERA-NET Bioenergy project FutureBioTec have also revealed that many ESPs presently available are not designed for a long-term operation at the harsh operation conditions prevailing in old logwood boilers and stoves which are characterized by a flue gas with insufficient burnout as well as high soot and organic aerosol emissions. The reason therefor is that presently ESPs are mainly developed with the aim to safeguard the keeping of the stringent dust emission limits for pellet and wood chip combustion defined in the 1. BImSchV in Germany. Consequently, they are designed for much better burnout conditions than prevailing in old appliances. Moreover, no reliable long-term performance data regarding ESP operation are available.

Thus, the overall objectives of the project presented has been to identify an ESP technology suitable for the application with old high-emission wood burning appliances and to test it over two heating seasons within field tests in the region of Graz. These field tests should be accompanied by a comprehensive monitoring and measurement program.

2 APPROACH

2.1 Selection and description of the ESP technology

At first, an appropriate ESP technology, which is capable to operate at the harsh conditions of old biomass burning appliances had to be identified. Test runs with four different ESPs performed within a former Austrian R&D project have shown that the availability and precipitation efficiency of ESPs may significantly suffer from high concentrations of organic aerosols and soot in the raw gas which lead to problems and failures with ESP operation. In this project, the ESP OekoTube of the company OekoSolve (CH) has been identified as reliable ESP, which can operate at poor burnout conditions of the biomass boiler resp. stove to which it is connected and achieves very good precipitation efficiencies. Therefore, the OekoTube technology was selected for the field tests.

The OekoTube is a typical tube-type electrostatic precipitator. The unit consist of a T-fitting (9 in Figure 1) and a metal tube which are mounted on top of the chimney (chimney-top application). It uses the inner surface of the chimney or in case of a non-metallic chimney an extended metal tube (as shown in Figure 1) as precipitation electrode. A 1.6 m long electrode (10) thereby extends downwards in the chimney and is connected with an insulator (5) positioned outside the flue gas stream. The electronic circuit and the control unit (2) are mounted outside and protected with a cover (4) against weathering. The power consumption of the ESP amounts to 20-30 W during operation and the high-voltage power applied is usually in the range of 15-30 kV. The OekoTube is applicable for biomass combustion systems up to 40 kW.

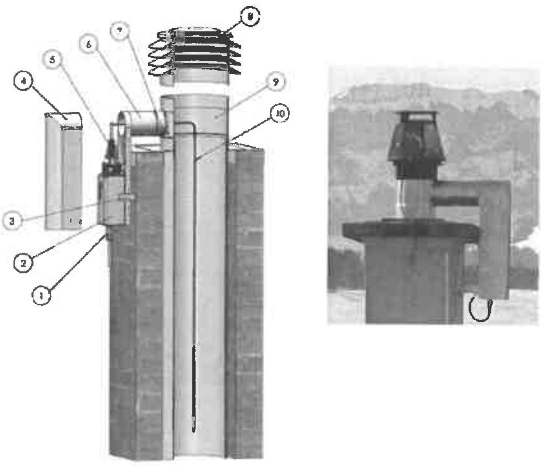

Figure 1: Scheme (left) and installation example (right) of the ESP OekoTube
Explanations: 1 ... power plug; 2 ... control unit; 3 ... mounting angle; 4 ... protective cover; 5 ... high voltage insulator; 6 ... connecting tube; 7 ... temperature sensor; 8... chimney crest (optional); 9 ... T-fitting; 10 ... electrode; source: www.oekosolve.ch

The OekoTube is equipped with a temperature sensor (7 in Figure 1) which measures the flue gas temperature. Based on the exceedance of a predefined temperature the control system identifies the start-up phase of the heating system and automatically activates the ESP. In turn, when the flue gas temperature drops below a certain predefined limit, the ESP is turned off again. These temperature set-values are configured in the control software before the first ESP start with respect to the expected flue gas temperatures and can be modified also during operation. Also the installation situation of the thermocouple is thereby considered since its readings may be influenced by cold radiation from the metal tube which is exposed to the ambient.

One advantage of the system, especially for integration in existing heating systems, is its positioning at the top of the chimney which demands for no additional space inside the building. As the precipitator has no automated cleaning system, ESP cleaning is carried out by the chimney sweep during his visits. The cleaning interval thereby depends on operating time and type of furnace. However, as a rule of thumb one additional chimney cleaning per year compared to operation without the OekoTube has to be considered.

Within the project presented also one so-called OekoTube inside has been tested. The ESP technology is the same as for the chimney-top model but the OekoTube inside is designed for an installation in between the heating device and the chimney. The only restriction that has to be taken into account is a maximum flue gas temperature of 200°C during permanent operation.

2.1 Selection of appropriate field testing sites

Identically constructed ESPs have been delivered by OekoSolve and have at first been tested at the testing facilities of BIOS BIOENERGIESYSTEME GmbH to check their principal functionality and to gain benchmark values for the dust precipitation efficiency.

These ESPs should then be applied during a comprehensive field testing campaign in the heating season 2014/2015. For the second field testing campaign (heating season 2015/2016) one ESP has been replaced by an OekoTube inside.

Candidates for the field testing campaign have been screened and the most suitable testing sites have been selected. The aim was to select appliances which are suspected to show high particulate emissions and which are typical for the Graz region. Moreover, easy accessibility of the chimney for field measurements was a relevant requirement. Finally, private buildings with the following heating devices have been chosen:

Site 1: logwood boiler; year of manufacture: 2010; nominal boiler capacity: 25 kW. During the field test season 1 it was equipped with the OekoTube and during field test season 2 with the OekoTube inside technology. Figure 2 shows the OekoTube and the OekoTube inside installed at site 1.

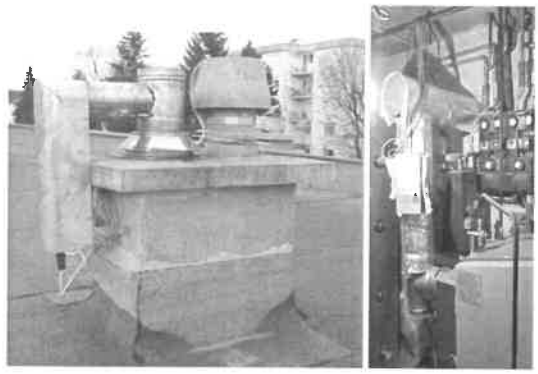

Figure 2: OekoTube (left) and OekoTube inside (right) mounted at site 1

Figure 3: OekoTube mounted at site 2

Site 2: logwood boiler, year of manufacture: 1997; nominal boiler capacity: 18 kW (tested during field test year 1). The ESP tested at this plant was moved to site 3 during the second testing season.

Site 3: logwood stove, year of manufacture: 2009; nominal capacity 8.4 kW.

As an example for these installations the OekoTube mounted at the top of the chimney at site 2 is presented in Figure 3.

2.1 Performance of field testing and operation monitoring

At these testing sites the ESPs have been continuously operated over the whole heating seasons and relevant ESP operation data have been recorded and evaluated at least once a week. Moreover, two emission measurement (gaseous and particulate emissions) campaigns have been performed per testing site and per heating season.

At the end of the first heating season (2014/2015) the results have been evaluated and possible measures for adaptations respectively optimisations have been communicated to the manufacturer OekoSolve. The modifications have then been implemented for the field testing phase 2 during the heating season 2015/2016.

3 METHODOLOGY

3.2 Performance of pre-tests in the lab

In order to check the performance of the three ESPs delivered and to gain reference values regarding their precipitation efficiencies for TSP (total suspended particulate matter = total dust) and PM_1 (particulate matter with a diameter smaller than 1 µm = fine PM), at first the ESPs have been tested in the lab under controlled operation conditions of the boiler applied. Therefore, a state-of-the-art pellet boiler (Windhager BioWIN 210, nominal boiler capacity: 21 kW) has been connected to the ESPs.

In order to simulate the later field operation on top of the chimney, a tube with controlled electric trace heating was installed between the boiler and the ESP, so that a flue gas temperature of about 100°C has been achieved at ESP inlet. This tube also contained an isothermal sampling section right at ESP inlet, where TSP and PM_1 measurements upstream the ESP have been performed. At ESP outlet a second tube was installed for measurements downstream the ESP and for connection to the chimney. This tube has also been equipped with electric trace heating in order to keep the temperatures constant and to avoid possible influences by the condensation of organic vapours on the measurement results. In Figure 4 the experimental setup is schematically described.

The boiler was operated with A1-quality wood pellets (according to EN ISO 17225-2) at three different operation modes, which have been adjusted by appropriate manipulation of the process control settings.

- Normal operation
- Operation at conditions causing high emissions of organic aerosols to simulate the behaviour of an old logwood boiler
- Operation at sooty conditions to simulate the behaviour of a logwood stove.

The contents of O_2 (paramagnetic sensor), CO, CO_2 (ND-IR) and organic gaseous compounds (FID) in the flue gas were measured and on-line recorded. The particulate emissions have been measured in parallel upstream and downstream the ESP. A total dust measurement equipment according to VDI2066 and a Berner-type low-pressure impactor to determine the PM_1 emissions where therefore applied. From these parallel measurements the total dust and the PM_1 precipitation efficiencies were calculated. Moreover, relevant ESP and boiler operation data have been recorded on-line and evaluated.

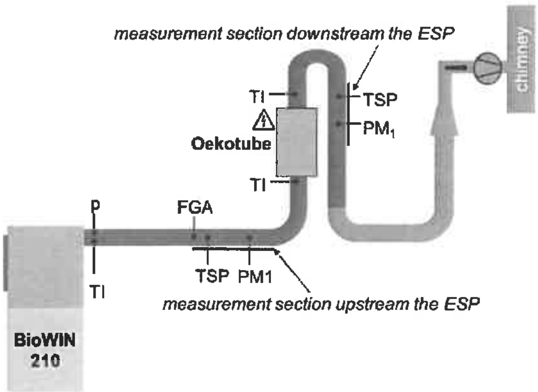

Figure 4: Scheme of the test stand setup
Explanations: Red colored tubes are equipped with electric trace heating; PM_1 ... Berner-type low-pressure impactor measurement; TSP ... total dust measurement; FGA ... flue gas analysers (O_2, CO, OGC); TI ... flue gas temperature measurements; P ... draft measurement

3.2 Field monitoring

To facilitate a continuous observation of the ESP performance during the field tests, relevant operation data were logged by data acquisition systems installed at each site in 5 second intervals. Each day the data were automatically submitted via GSM to the office of BIOS BIOENERGIESYSTEME GmbH. The data received were evaluated at least once a week in order to detect possible system failures and to decide if appropriate countermeasures have to be taken. The data recorded and evaluated were:

- Operating state of the ESP [ON/OFF]
- ESP voltage [kV]
- ESP current [µA]
- Flue gas temperature at ESP outlet [°C]
- Temperature in the ESP control box [°C]
- Error messages regarding the control hardware
- Error messages indicating operation failures

3.2 Dedicated measurement campaigns

At each ESP at least two dedicated testing campaigns have been performed – one at the beginning and one in the second half of the heating season. Thereby the gaseous and particulate emissions downstream the ESP were determined with the same equipment as applied during the lab tests. To enable a correct measurement downstream the ESP, a "measurement section", which is a tube with appropriate sampling ports, was connected on top of the ESP. In Figure 5 the measurement setup is presented.

As there has been no possibility to measure the PM emissions upstream the ESP, the PM precipitation efficiency was determined with downstream measurements at two successive days; one day with and one day without ESP operation. It has been taken care that the framework conditions during these two days regarding outside temperatures, operation cycles of the biomass combustion systems and duration of the test runs were comparable.

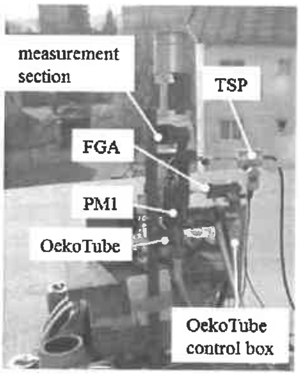

Figure 5: Measurement setup during the dedicated field measurement campaigns

At the logwood boilers (site 1 and 2) consecutive TSP measurements have been performed in order to cover the whole operation cycle of the boiler including the ignition phase, the main combustion phase and the charcoal burnout phase. At least three short-term impactor measurements (duration of some minutes) have been carried out during the distinct combustion phases to determine the PM_1 emissions. At the stove (site 3) one TSP measurement per batch has been performed and at least 3 impactor measurements were made within one test run day during the main combustion phases of selected batches.

From these data the particle precipitation efficiencies were calculated. However, the main aim of these measurements was to check if relevant changes regarding the precipitation efficiencies in comparison with the lab tests and over the heating seasons occur rather than to get exact data on particle precipitation.

4 RESULTS

4.1 Results of the lab tests performed

The aim of the preliminary lab tests has been to check the ESPs before installing them in the field and to gain data regarding particle precipitation efficiencies under well-controlled lab conditions which can be compared with results from the field tests.

The ESPs generally could be taken into operation without problems. During the two test weeks performed with each ESP also no relevant failures occurred.

At boiler standard operation conditions, which were characterized by a good gas phase burnout with CO emissions below 60 mg/MJ (related to the NCV of the fuel) and low PM emissions at ESP inlet (total dust emissions below 10 mg/MJ_{NCV}) all ESPs showed precipitation efficiencies of 88 to 93% for total dust and of 88 to 97% for PM_1. The ESP voltage was slightly below 30 kV and the ESP power between 10 and 16 W. Based on experience from former projects and on literature data this has been an expected result.

The boiler operation which aimed at a high amount of organic aerosol emissions was characterized by very high CO emissions (around 4,000 mg/MJ_{NCV}) and high oxygen contents the flue gas (up to 18 vol% d.b.). Total dust emissions at ESP inlet were in the range between 35 and 50 mg/MJ_{NCV}. At these conditions precipitation ratios of about 90% could be achieved for total dust and PM_1. The ESP voltage was at about 30 kV and the ESP power between 4 and 10 W. Compared with former experience these values regarding PM precipitation must be assessed as very good.

During the sooty operation the pellet boiler was operated at very low excess air ratios (about 4 vol% O_2 in the dry flue gas) resulting in increased CO emissions (up to in average 2,000 mg/MJ_{NCV}) and high total dust emissions of up to 50 mg/MJ_{NCV}. The ESP voltage was at about 30 kV and the ESP power between 3.4 and 8.0 W. For PM_1 a very good precipitation efficiency of up to 96% could be determined. However, regarding total dust at some measurements the emissions downstream the ESP were even higher than upstream the ESP which can be explained by the high soot emissions. Soot particles form rather loose dendritic agglomerates on the electrodes and the filter walls which can easily be re-entrained with the flue gas and cause emissions of rather big (even some millimeter in diameter) soot flakes. After the flue gas exits the chimney these flakes are immediately precipitated by gravitational forces and do not remain in the ambient air.

Summing up, from the lab tests it could be concluded that the ESPs were functional and showed the expected particle precipitation efficiencies. Moreover, the data acquisition systems have been tested and finally the ESPs were released for the field testing.

4.2 Results of the ESP monitoring at the field testing sites

Field monitoring took place over two heating seasons (2014/2015 and 2015/2016). The data gained have been continuously evaluated in order to regularly check the ESP performance.

As an example in Figure 6 a typical ESP operation cycle from one day at site 1 is presented. Due to the increase of the flue gas temperature above 35°C the ESP control identifies the ignition phase of the logwood boiler and turns on the ESP. Immediately, the ESP voltage and power increase. In the following the ESP control tries to maximize the ESP power by increasing the voltage. In the case presented the targeted power of 15 W is reached after 15 seconds. If the voltage is increased too much, sparkovers can occur. In this case the power is reduced and then increased again and a failure message is sent. The occurrence of such sparkovers is accepted in order to achieve a high average ESP power and therefore a high precipitation efficiency.

The precipitation efficiency of the ESP depends, besides the voltage and power also on the flue gas temperature and the particle load at ESP inlet. From Figure 6 it can be derived that during the ignition and the main combustion phase (can be identified by the higher flue gas temperatures) voltage and power remain at about the same level of about 25 kV and up to 16 W respectively. The temperature decrease in the second half of the operation cycle indicates the charcoal burnout phase. As soon as the temperature drops below a certain level, the ESP power decreases. This is related to the decrease of the electric conductivity of the flue gas with decreasing temperatures. At a flue gas temperature of 30°C (set value for this ESP) the ESP control desires the end of the heating cycle and turns off the ESP.

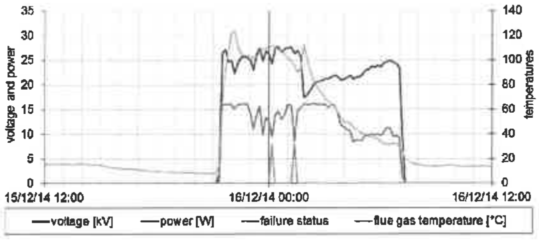

Figure 6: Typical daily operation cycle of the ESP at field test site 1

In Figure 7 the trends regarding the ESP operation parameters during January and February 2015 at site 1 are presented. The logwood boiler at site 1 was typically operated once a day for in average 7 hours, usually starting the operation cycle in the late evening to load the buffer storage of the heating system during nighttime. From Figure 7 it can be revealed that the voltage (black line) always reaches maximum values between 25 and 30 kV which indicates a good precipitation performance.

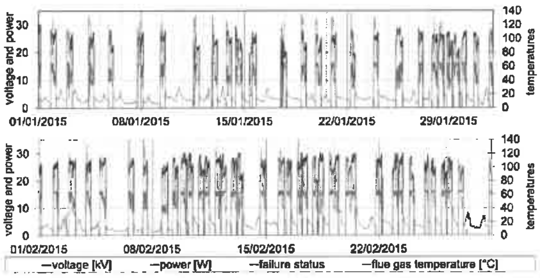

Figure 7: Operation data of the ESP at field testing site 1 during January and February 2015

At site 2 also a logwood boiler was operated and therefore, about the same operation cycles and operation behaviour as for site 1 were observed. However, at this installation very harsh operating conditions prevailed with flue gas temperatures at ESP inlet of more than 300°C and, as the dedicated test runs have shown, high CO, OGC and PM emissions. This was one reason why at this plant the highest number of sparkovers and the lowest average voltage were detected (see Table II). Moreover, the high flue gas temperatures after some weeks of operation led to the deformation of the electrode due to thermal tensions and the electrode had therefore to be replaced a by a more robust one. This was the only failure occurring over the field testing periods with all ESPs which demanded for a revision by the manufacturer.

All data collected during the two heating seasons have finally been evaluated in order to determine the availability of the ESPs as well as the average ESP voltage and power. Therefore, the maximum possible operation hours have been calculated from the periods where the ESP signal indicated operation ("ESP ON"), i.e. the period at which the flue gas temperatures were above the operation threshold values. The availability is calculated by the operation hours of the ESP divided by the maximum possible operating hours. The mean values and standard deviations of the ESP voltage and the ESP power were calculated over all operation cycles (periods between turning on and off the ESP). Moreover, the number of ESP operation cycles and the average duration of an operation cycle has been evaluated. The respective data are presented in Table I and Table II.

In Table I relevant data collected for the ESP operated at site 1 are summarised. During the first heating season the chimney-top version of the OekoTube has been tested. The detailed evaluation of the data has revealed that at each time when the boiler was taken into operation also the ESP was turned on. Due to a low number of operation failures (sparkovers), which led to short-term shut downs of the ESP, a high availability of 97.7% could be reached. The average voltage (24.3 V) is quite close to the maximum voltage of 30 kV and the average power (13.5 W) is within the range determined during the lab-tests (10-16 W). It has been noticed that dust deposits on the electrode and the walls caused a slight but gradual decline of the voltage and the current, however, after an intermediate cleaning by the chimney sweep at the end of February 2015 the initial values could be reached again.

Due to the stable performance, the acceptable precipitation efficiency achieved, and because of the moderate flue gas temperatures at site 1 it was decided to replace the chimney-top OekoTube by an OekoTube inside for the second monitoring season. The idea was to gain additional experience with this model, which is in terms of precipitation technology identical with the chimney-top version but can be installed inside the building. The advantage are the lower installation costs (no crane is needed and no cable has to be laid to the roof top) provided that there is enough space for mounting the ESP between the boiler and the chimney.

Table I: Results of the evaluation of the ESP operation data at site 1
Explanations: M … mean value; s … standard deviation

	2014/2015 OekoTube	2015/2016 OekoTube inside
Field test period	12/11/2014 - 29/03/2015 3,288 h	02/11/2015 - 31/03/2016 3,624 h
Maximum possible operating hours	915.2 h	777.7 h
Number of operation cycles	121	133
Average duration of an operation cycle	452 min	346 min
ESP availability:	97.7 %	81.2 %
Average voltage:	M: 24.3 kV *s: 4.3 kV*	M: 21.4 kV *s: 5.2 kV*
Average power:	M: 13.5 W *s: 3.8 W*	M: 8.2 W *s: 6.5 W*

The heating season 2015/2016 was characterized by a rather calm weather and therefore the maximum possible operating hours decreased from 915.2 in the preceding heating season to 777.7 hours although ESP operation started earlier. Also the average duration of one operation cycle was lower. Compared with the chimney-top version of the OekoTube the availability of the OekoTube inside was with 81.2% lower but still acceptable. The main reason for the lower availability was that the maximum flue gas temperature of 200°C was unexpectedly often exceeded which led to failures and short shutdowns. Also with the OekoTube inside one intermediate cleaning in the mid of February 2016 was sufficient to maintain a stable ESP operation throughout the whole heating season.

In Table II the results for the ESP installed at site 2 and site 3 are presented. During the first heating season it had been installed at site 2 but problems with the owner regarding access for the dedicated measurement campaigns have led to the decision to change to site 3 during the second heating season.

At site 2 an outdated logwood boiler was operated. Typical features of this boiler were very high flue gas temperatures at boiler outlet leading to temperatures up to more than 300°C in the ESP and very sooty emissions. Analyses of dust samples taken after cleaning by the chimney sweep have revealed elemental carbon contents of 30 to 45 wt% (d.b.). Especially the high temperatures caused thermal deformations of the electrode and as a consequence of that massive sparkovers. Therefore, before the electrode was replaced by a more robust one, it sometimes took more than one attempt of the control system to reach stable operation. These effects are also the reasons for the lower availability (81.7%) and the comparably low average voltage that could be reached in comparison with site 1. However, as measured by these framework conditions, the availability achieved can still be assessed as acceptable. As already noticed at site 1 also at site 2 a gradual decrease of the ESP voltage and the ESP current over time occurred and one intermediate cleaning of the ESP by the chimney sweep was needed.

Table II: Results of the evaluation of the ESP operation data at site 2 and 3
Explanations: M … mean value; s … standard deviation

	2014/2015 OekoTube site 2	2015/2016 OekoTube site 3
Field test period:	01/12/2014 - 12/04/2015 3,168 h	21/10/2015 - 17/04/2016 4,320 h
Maximum possible operating hours	573 h	1,360 h
Number of operation cycles	137	368
Average duration of an operation cycle	249 min	222 min
ESP availability:	81.7 %	80.2 %
Average voltage:	M: 18.1 kV *s: 5.9 kV*	M: 26.1 kV *s: 8.8 kV*
Average power:	M: 10.0 W *s: 6.6 W*	M: 6.6 W *s: 4.9 W*

Before the heating season 2015/2016 the ESP has been moved from site 2 to site 3. There, a wood stove is operated as primary heating system, and as the data regarding the duration of an average operation cycle and the number of heating cycles confirm, the system was even more in operation than the logwood boiler in the year before. Logwood stoves typically show relatively high soot emissions and the average voltage (26.1 kV) and the average ESP power (6.6 W) reflect the results of the lab-tests at sooty conditions (30 kV and 3.4 to 8 W). High amounts of soot deposits on the ESP surfaces caused some problems during continuous operation and therefore the availability of the ESP at site 3 was with 80.2% in the same range as at site 2. Two intermediate cleanings by the chimney sweep were demanded at this site.

4.3 Results of the dedicated field measurement campaigns

At each testing site two dedicated measurement campaigns per heating season have been carried out to check the precipitation efficiencies of the ESPs. Therefore, measurements have been performed at two successive days, one with and one for comparison without ESP operation. It has been taken care that the framework conditions regarding the operation of the wood heating devices have been comparable during both days. The flue gas temperatures, the duration of the operation cycle and the O_2, CO and OGC contents of the flue gas have therefore been evaluated.

As an example for such a measurement campaign a test run performed at site 1 is presented in the following. In Figure 8 the oxygen contents of the flue gas and the flue gas temperatures for two successive testing days are presented whereby the start of the test runs has been synchronised to gain a better comparability of the results. The average oxygen content of the flue gas over the whole test run amounted to 16.7 vol% (with ESP operation) respectively 17.3 vol% d.b. The average flue gas temperatures at ESP were with 98.6°C (with ESP operation) and 106.8°C (without ESP operation) also in about the same range. The CO emissions were with in average 4,750 mg/Nm³ during operation with ESP higher than during operation without ESP (3,930 mg/Nm³). The same is true for the OGC emissions (328 resp. 138 mg/Nm³ - all emissions related to dry flue gas and 13 vol% O_2). Consequently, during operation of the ESP slightly worse burnout conditions prevailed than during the measurements without ESP operation.

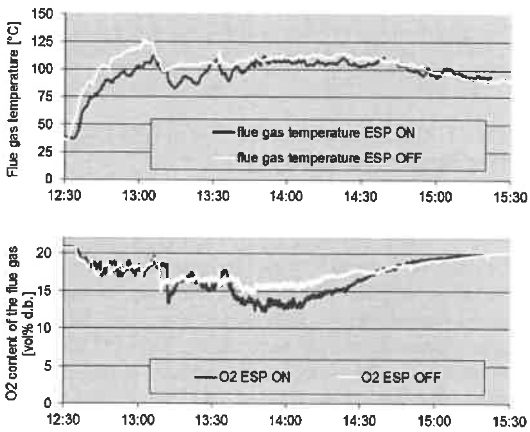

Figure 8: Comparison of the trends of the O_2 concentrations in the dry flue gas and the flue gas temperatures during test runs at site 1 on two successive days

Three consecutive total dust emission measurements have been performed. The total dust emissions varied during operation without ESP between 234.4 mg/Nm³ (during the ignition phase), 45.7 mg/Nm³ (main combustion phase) and 47.8 mg/Nm³ (during the charcoal burnout phase). During ESP operation total dust emissions of 48.0 (ignition phase), 7.2 mg/Nm³ (main combustion phase) and 15.9 mg/Nm³ (charcoal burnout phase) have been measured (all emissions related to dry flue gas and 13 vol% O_2). From these single measurements total dust precipitation efficiencies of 80%, 84% and 67% could be calculated for the different combustion phases. Four short term measurements with the Berner-type low-pressure impactor per day revealed PM_1 precipitation efficiencies of 86 to 87.5% whereby the PM_1 contents in the flue gas amounted from 19.4 to 44.8 mg/Nm³ (without ESP operation) and 2.0 to 7.4 mg/Nm³ (with ESP operation). When evaluating these data it has to be considered that the total dust measurements covered the whole operation period while the PM_1 measurements are only related to rather short (some minutes) operation phases during which impactor measurements have been performed.

In Table III and Table IV the PM emission data and the precipitation efficiencies achieved at the different testing sites are summarised. The broad variation of the single TSP measurements at the logwood boilers (site 1 and 2) mainly results from the different combustion phases during which the single measurements were performed (ignition phase, main combustion phase, charcoal burnout). It has to be mentioned that during some measurements flaking (re-entrainment of agglomerates of already precipitated soot particles from the precipitator surfaces) occurred. In some cases this caused higher total dust emissions during ESP operation than during operation without ESP. These results have not been considered in Table III and IV.

Moreover, the comparability of the combustion conditions during the different combustion phases between the measurement days with and without ESP operation always is limited which also contributes to the scattering of the data regarding particle precipitation efficiency.

Table III: Results of the dedicated testing campaigns with emission measurements at site 1
Explanations: emissions in mg/Nm³ related to dry flue gas and 13 vol% O_2; TSP … total suspended particulate matter = total dust; PM_1 … particles <1 µm aerodynamic diameter

	2014/2015 OekoTube	2015/2016 OekoTube inside
TSP emissions without ESP operation	33 – 274	15 – 220
TSP emissions with ESP operation	4 - 174	2 – 100
TSP precipitation efficiency	30 - 93%	54 – 90%
PM_1 precipitation efficiency	55 - 96%	46 – 98%

The data regarding site 1 show, that the TSP emissions without ESP operation were in the same range for both heating seasons. For both, the chimney-top and the inside version of the OekoTube acceptable precipitation efficiencies were determined (Table III). The lower values regarding the TSP precipitation efficiency at this boiler are most probably due to re-entrainment of already precipitated soot particles (flaking). The highest precipitation efficiencies (93% rep. 90% for the OekoTube and the Oekotube inside) are well comparable with results gained from the lab tests. The average TSP emissions during operation with filter amounted to 39 mg/Nm³ resp. 22 mg/Nm³ (related to dry flue gas and 13 vol% O_2)

The maximum precipitation efficiencies regarding PM_1 show values of up to 96% respectively 98%, which are well comparable with the results of the lab-test performed. However, since impactor measurements are short term measurements (some minutes). Slightly changing combustion conditions at the two testing days which are compared can have a certain impact on the resulting precipitation efficiencies and therefore, the range mentioned in Table III has to be evaluated with care.

At site 2 (Table IV) the highest PM emissions upstream the ESP of all testing sites have been determined (up to 736 mg/Nm³). Moreover, as chemical analyses of selected TSP samples have shown, the contribution of soot to the TSP emissions was very high (elemental carbon content of the TSP of up to 85 wt%). The latter explains the low minimum value of the TSP precipitation efficiency, which is assumed to be due to re-entrainment of already precipitated soot particles. In fact soot flakes have been found in the vicinity of the chimney which confirms the occurrence of the flaking effect. The maximum precipitation efficiencies for TSP (83%) and PM_1 (93%) however confirm the expectations from the lab-test. The average TSP emission for ESP operation amounted to 84 mg/Nm³ (related to dry flue gas and 13 vol% O_2).

Table IV: Results of the dedicated testing campaigns with emission measurements at site 2 and 3
Explanations: emissions in mg/Nm³ related to dry flue gas and 13 vol% O_2; TSP … total suspended particulate matter = total dust; PM_1 … particles <1 µm aerodynamic diameter

	2014/2015 OekoTube site 2	2015/2016 OekoTube site 3
TSP emissions without ESP operation	74 – 736	98 – 321
TSP emissions with ESP operation	22 – 154	14 – 46
TSP precipitation efficiency	35 – 83%	57 – 93%
PM_1 precipitation efficiency	44 – 93%	50 – 97%

Also at site 3 very good maximum precipitation efficiencies for TSP (93%) and PM_1 (97%) have been determined. The average TSP emissions for ESP operation amounted to 28 mg/Nm³ (related to dry flue gas and 13 vol% O_2).

Summing up, the dedicated field measurement campaigns have shown that the ESPs worked well and that also in field operation precipitation efficiencies comparable with those gained during lab-tests can be achieved. Moreover, no significant differences between the two measurement campaigns at the beginning of the heating season and in its second half could be found.

5 SUMMARY AND CONCLUSIONS

To assess the applicability of ESPs for particulate matter emission reduction in residential wood heating appliances field tests with accompanying ESP operation monitoring and dedicated emission measurement campaigns have been performed in the region of Graz (AT). Three OekoTube ESPs (two chimney-top and one inside version) where thereby tested over the heating seasons 2014/2015 and 2015/2016 at three different sites, two with logwood boilers and one with a logwood stove.

Before being released for the field tests the ESPs were checked within lab-tests regarding functionality and particle precipitation efficiency.

At the field testing sites the ESPs could be installed and taken into operation without major problems. Also during the operation over the heating seasons no severe problems occurred at site 1 and site 3. Site 2 however distinguished its self by very high flue gas temperatures of up to 300°C at the ESP which led to a deformation of the electrode. After replacement with a more robust electrode, which was less sensitive regarding thermal tensions, no further problems occurred.

ESP operation periods in the range of 630 to 1088 hours per season were determined. One (site 1) and two (site 2 and 3) additional cleanings by the chimney sweep were needed to maintain the ESP performance over the whole heating season. The cleaning demand could thereby be identified from slightly decreasing ESP voltage and ESP power with increasing operation time.

The evaluation of the plant monitoring data revealed acceptable respectively high ESP availabilities for the chimney-top version of 81.7% and 80.2% (at site 2 and 3) and 97.7% at site 1. The availability of the OekoTube inside was evaluated with 81.2%. These availabilities are all above the target value of 80% which has been defined by the manufacturer OekoSolve for this product.

Dedicated test runs with emission measurements at the different testing sites showed scattering results regarding the precipitation efficiencies. This was due to the fact that they have been calculated from measurement data from two successive days, one with and one without ESP operation. Additionally, flaking (re-entrainment of already precipitated soot agglomerates from the filter surfaces) sometimes occurred. However, the highest precipitation efficiencies determined (>83% for TSP and >93% for PM_1), were well comparable with those gained during the lab-tests. Moreover, the measurements revealed no significant changes of the precipitation efficiencies over the heating season. The total dust emissions could be reduced to 39 mg/Nm³ (site 1 – OekoTube), 22 mg/Nm³ (site 1 – OekoTube inside), 84 mg/Nm³ (site 2) and 28 mg/Nm³ (site 3; all data related to the dry flue gas and 13 vol% O_2)

From the project also some proposals for further improvements resulted. At boilers and stoves with high flue gas temperatures, electrodes have to be applied which are not sensitive regarding thermal deformations as such deformations lead to increased sparkovers or even to electrode damages. Secondly, the re-entrainment of already precipitated soot particles with the flue gas (so called flaking) should be avoided by the implementation of automated cleaning systems which regularly remove soot agglomerates from the ESP surfaces. This cleaning should be done during shut down phases without reasonable flue gas flow so that the soot flakes can drop to the bottom of the chimney.

Summing up, the results of the project have revealed, that ESP models like the OekoTube have the potential to contribute to a significant reduction of particulate matter emissions from outdated and high-emission residential wood burning systems. More of relevance than the acceptable precipitation efficiencies is thereby the fact, that even at problematic framework conditions such as flue gases with high temperatures, high tar contents and high soot contents during both field test seasons high availabilities were achieved.

6 REFERENCES

[1] European Biomass Association, 2014: European Energy Outlook 2014

[2] Jokiniemi J. (ed.), 2008: Biomass combustion in residential heating: particulate measurements, sampling and physicochemical and toxicological characterisation. Final report of the ERA-NET Bioenergy Project "Biomass-PM", University of Kuopio, ISSN 0786-4728, Kuopio, Finland

[3] Johannsson L., Leckner B., Gustavsson L., Cooper D., Potter A., Tullin C., Nerntsen M., 2005: Particle emissions from residential biofuel boilers and stoves – old and modern techniques, in: Proc. of the Internat. Seminar "Aerosols in Biomass Combustion", March 2005, Graz, Austria, book series "Thermal Biomass Utilization", Volume 6, ISBN 3-9501980-2-4, pp.145-150, BIOS BIOENERGIESYSTEME GmbH, Graz, Austria (ed.)

[4] Obernberger I., Brunner T., Bärnthaler G., 2005: Fine particulate emissions from modern Austrian small-scale biomass combustion plants. In: Proceedings of the 15th European Biomass Conference & Exhibition, May 2007, Berlin, ETA-Renewable Energies (Ed.), Italy

[5] Obernberger Ingwald, Mandl Christoph, Biedermann Friedrich, 2012: State-of-the-art and assessment of filter technologies for residential biomass combustion systems. In: Proceedings of the IEA Bioenergy Conference 2012, Vienna, ISBN 978-3-9502754-4-5, pp. 167-174

7 ACKNOWLEDGEMENTS

The authors gratefully acknowledge the financial support of the Styrian Government and of the City of Graz - Environmental Department who made this project possible.

8 LOGO SPACE

BIOS
Bioenergiesysteme GmbH
Research, Development and Design of Plants for Heat and Power Production from Biomass

Das Land Steiermark
Energie, Wohnbau, Technik

STADT GRAZ UMWELT

bionic fire

bionic fire

The Fine Art of Modern Green Living

User Manual for New Zealand and Australia

Bionic fire

New Zealand:	Authorisation number: 152619 (AS/NZS 4012/4013)
	Authorisation number: 154319 (ULEB)
Australia:	Australian Home Heating Association Inc.: H1018/0217

Bionic fire Studio

New Zealand:	Authorisation number: 166404 (AS/NZS 4012/4013)
	Authorisation number: 166197 (ULEB)
Australia:	Australian Home Heating Association Inc.: H1025/0217

Resource Consent Number Environment Canterbury: CRC 155430

Website for authorized burners:

in New Zealand:	http://solidburner.ecan.govt.nz
in Australia:	www.certifiedwoodheaters.com.au

envirosolve

EnviroSolve Ltd
Exclusive Agent for New Zealand
Dr Rene Haeberli
Ohakune Road
RD 3
Raetihi

Phone: + 64 6 485 4871
Mobile: + 64 21 24 24 211
Email: rene.haeberli@envirosolve.co.nz
Web: www.envirosolve.co.nz

Trish Peers-Adams

From:	Rene Haeberli <rene.haeberli@xtra.co.nz>
Sent:	Tuesday, 17 April 2018 5:48 a.m.
To:	Air Plan
Subject:	Submission on Proposed Plan Change 13
Attachments:	submission_front.pdf; Submission_Rotorua.pdf; Test_report_short_version.pdf; Latest field trials.pdf; Authorized numbers.pdf

Hi there,

please find attached the following documents for my submission for the Proposed Plan change (Air Quality) to the Regional Council:

1. Complete filled out submission form

2. Submission Points

I have done a general submission for various points regarding your proposed Plan change. One of the major problem was that the Regional Council put a new bylaw into place for domestic burner to 0.6g/kg fuel under the standard AU/NZS 4012/4013 and therefore I can not sell my bionic fire, which is and ULEB in that Rotorua air zone anymore. I put a general submission in for all Ultra Low Emission Burners.

The bionic fire is the first fully automatic mechanic Ultra Low Emission burner which has been tested under the Standard AU/NZS 4012/4013 for soft wood (0.7g/kg fuel) under the standard AU/NZS 4012/4013 for hard wood (0.43 g/kg fuel) - the only ULEB with hard wood so far - and under Canterbury Method 1 (CM1) for all ULEBs (0.5 g/kg). The relative high result from the soft wood comes form the test regime and form relative little combustion box, which the bionic fire has due to its high efficiency. The results also show very clearly that the bionic fire is performing very well under real life condition and not only under lab condition.

If you want to talk to an independent expert regarding the above results please contact Philip Sparrow from Spectrum Laboratory in Auckland (phone: 09 271 1616) who supervised all the tests on the bionic fire.

Attached hard wood results for the bionic fire (short form) and all authorized numbers from the manual.

I also attached you some support information of the latest university results of the secondary reducing emission devices which you may or my not have a look and consider.

If you have any question please do not hesitate to contact me.

Can you please send me a confirmation that your received all the details of my submission.

Regards,

Rene Haeberli

--
Dr Rene Haeberli
Director

EnviroSolve Ltd

Ohakune Road
RD 3
Wanganui
New Zealand

email: rene.haeberli@xtra.co.nz
phone: +64 (0)6 385 4871
mobile:+64 (0)21 24 24 211
www.envirosolve.co.nz