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LUCHTADVIES EN -METING

Memo number	:	**EV-01523**
Date	:	**25 juli 2015**
Concerning	:	**Cost-effective odour assesment of an iron foundry in the Netherlands**
Author	:	**Hans Schiricke**

1. Introduction

An iron foundry in the Netherlands emitted odours from varies sources (approximately 14 point sources). The total odour emission was responsible for odour complaints in the nearby populated area (estimated inhabitants 500). EnviVice executed an odour assesment for cost-effective abatement measures. In this assesment all the know influences on the decision proces are involved.

2. Description of assesment

In figure 2.1 the main research phases are given.

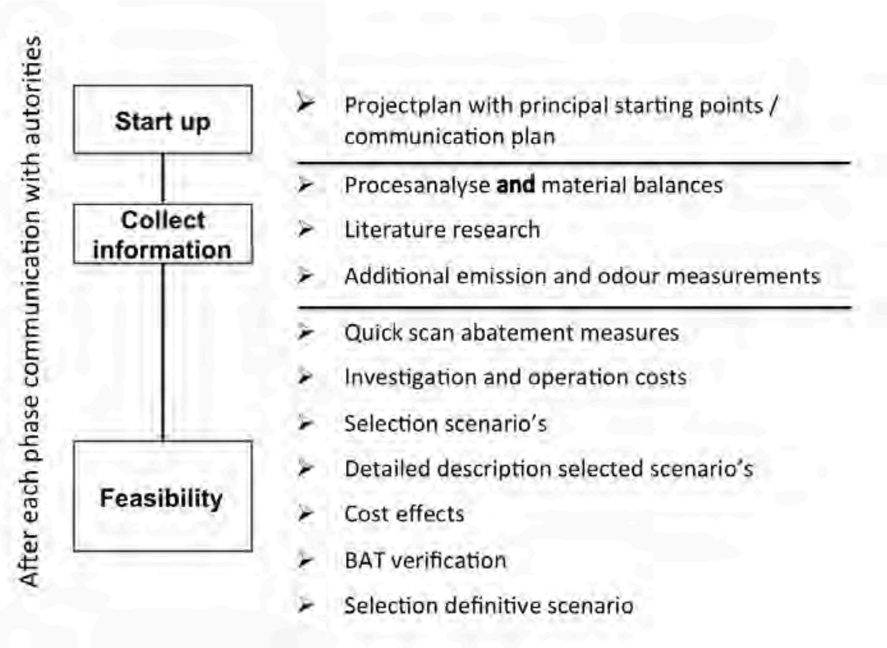

Figure 2.1. Main research phases odour abatement measures.

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The selection of scenario's of possible measures (combined measures are possible) takes place taking in account the influences as described in figure 2.2.

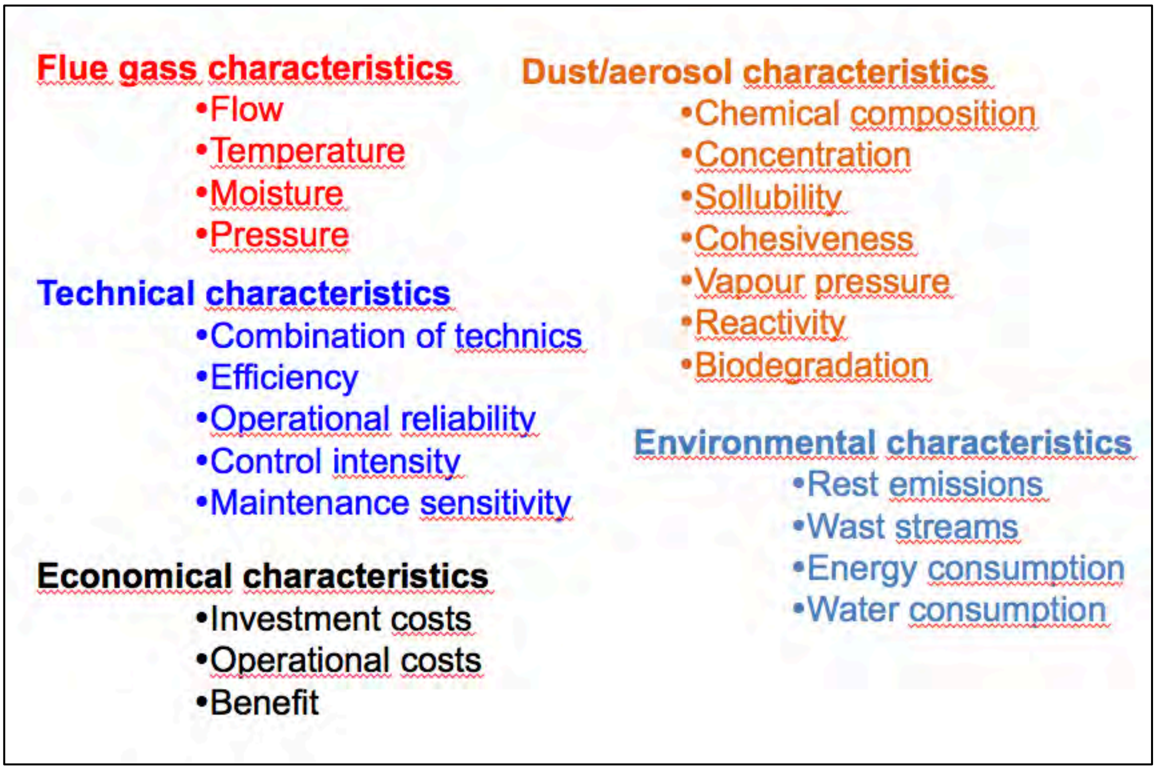

Figure 2.2. Know influences potential measures and scenarios.

In the next chapter the descripted odour assesment procedure is documented for the iron foundry located in The Netherlands.

3. Results

Start up phase

The competent authority (county) ordered that the company must decreased the odour emission. The current legislation is not sufficient to prevent odour complaints.
The odour assesment must comply the Dutch regulation, described in the Dutch Emission Guideline (NeR).

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Collect information

There are 14 relevant emission sources of odour. Measurements were performed in the past. The emission sources are described in table 3.1 included flow, emission duration and odour mass flow.

Table 3.1. Relevant odour sources.

Source nr.	*Production line*	*Source description*	*Flow* *[m³/h]*	*Emission duration [h/year]*	*Odour mass flow [MOU_E/h]*	*Portion* *[%]*
1	Both	Cupola	19.000	6.912	93	5,1
2	Both	Melt proces fans	30.000	6.912	3,5	0,2
3	Both	Melt proces roof hatches	104.000	6.912	13	0,7
4	Both	Calciumcarbid furnace	32.000	5.760	3,5	0,2
5	HWS	Core dairy (amine scrubber)	20.000	5.760	72	3,9
6	HWS	Cast and cool lines	127.000	5.760	187	10,2
7	HWS	Sandblast (BMD)	98.000	6.912	8	0,4
8	HWS	Sand prepartion and coolunit	67.000	5.760	259	14,1
9	HWS	Dip	22.000	3.840	25	1,4
10	Furaan	Core dairy (amine scrubber)	25.000	5.760	12	0,7
11	Furaan	Hall extraction BMD 1	146.000	6.912	385	21,0
12	Furaan	Hall extraction BMD 2	158.000	6.912	590	32,1
13	Furaan	Torit	94.000	3.840	159	8,7
14	Furaan	Dip section	6.300	5.760	27	1,5
				Total	1835	*100*

Sources number 6, 8, 11, 12 and 13 are the most relevant (apr. 86% of the total odour mass flow). These sources are also mentioned as the most important sources by the employees of the factory and the neighbours.

Source number 1 is not included in the feasibility, the technical lay out of these source is already best practice. The odour mass flow of sources number 9 and 14 decreases due the fact that legislation is changed. The solvent content and therefore the odour must be decreased.

In table 3.2. the odour mass flow is calculated annually.

De Dieze 31B, 5684 PR, Best, The Netherlands, tel: 0031 40 2984639 / 0031 6 83252355
KvK nr. 17284829, BTW nr. NL142942066B01, e-mail: postbus@envivice.nl, www.envivice.nl

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Table 3.2. Emission sources and odour mass flow annually (GOU$_E$/year).

Scenario:			*present day*		*solvent reduction*	
Source nr.	*Production line*	*Source description*	*Odour mass flow*) [Mge/h]*	*Portion [%]*	*Odour mass flow*) [Mge/h]*	*Portion [%]*
1	Both	Cupola	643	5,6	643	5,7
2	Both	Melt proces fans	24	0,2	24	0,2
3	Both	Melt proces roof hatches	90	0,8	90	0,8
4	Both	Calciumcarbid furnace	20	0,2	20	0,2
5	HWS	Core dairy (amine scrubber)	412	3,6	412	3,7
6	HWS	Cast and cool lines	1078	9,4	1078	9,6
7	HWS	Sandblast (BMD)	57	0,5	57	0,5
8	HWS	Sand prepartion and coolunit	1488	13,0	1488	13,2
9	HWS	Dip	96	0,8	9,6	0,1
10	Furaan	Core dairy (amine scrubber)	69	0,6	69	0,6
11	Furaan	Hall extraction BMD 1	2657	23,2	2657	23,6
12	Furaan	Hall extraction BMD 2	4075	35,5	4075	36,2
13	Furaan	Torit	610	5,3	610	5,4
14	Furaan	Dip section	156	1,4	15,6	0,1
		Total	*11.500*	*100*	*11.000*	*100*

The portion of sources 6, 8, 11, 12 and 13 is apr. 88 % of the total odour mass flow of 11.000 GOU$_E$/year.

The odour reduction of the decreasing in solvent amount is apr. 2% in comparison with the scenario present day.

Feasibility

Quick scan abatement measures

There are 37 measures detected. They are categorised in source- and proces related (23 measures) and end-of-pipe measures (14). The complete overview is listed in appendix 2.

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Some measures have a technical certainty, some measures are experimental and some measures are in the research phase. Table 3.3 describes the source- and proces measures which are most promising for realising odour reduction in short term.

Table 3.3 Source- and proces measures.

source number	measure number	measure	odour reduction [%]	implementation
6, 8	b.1	Implementation Envibond May 2007	10	sure
11, 12 en 13	b.2	Implementation resin and activator 4e generation cold box furaan	40	sure
11, 12 en 13	b.7	Experiment more reactive furane resin	10	sure
8	p.1	Study different breakout and cool proces	20	research
8	p.2	Study water treatment and replacement	50	research
8	p.3	Study cooling time	50	research
4	p.4	Change of desulphuring method	95	sure
11, 12	p.11	Study BMD 1 is less odour in comparison with BMD 2 ?	?	experimental
11, 12	p.14	Partitioning by air wall	?	studie

Table 3.4 mentions the flue gas characteristics of the selected odour sources.

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Table 3.4 Flue gas characteristics selected sources.

		source number:				
flue gas characteristics		6 Cast- and cool lines	8 HWS sand/cool	11 BMD 1	12 BMD 2	13 Torit break out
Flow	[m^3/uur]	117.000	65.000	130.000	150.000	100.000
Temperature	[°C]	35	40	35	35	20
Moisture	[% RV]	30	100	25	25	35
Stof	[mg/m^3_0]	3	15	3	3	3
Chemical content						
C_xH_y emission	[mg/m^3_0]					
benzene	[mg/m^3_0]	2	5	0.0013	0.5	0.16
fenole	[mg/m^3_0]	0.0003		0.0001	0.0001	0.0001
cresolen	[mg/m^3_0]	0.0002				
toluene	[mg/m^3_0]	0.6	2.5	0.005	1.3	0.001
xylene	[mg/m^3_0]	0.2	1.8			
formaldehyde	[mg/m^3_0]	0.0002		0.0001	0.0001	0.0001
SO_2	[mg/m^3_0]				5	20
Solubility in water		little	little	little	little	little
Biologische degradatie		bad	bad	bad	bad	bad
Emission pattern*		continu fluctuating				
End-of-pipe measure		no	wet dedusting	dustfilter	dustfilter	dustfilter

**) conform NeR paragraph 2.4*

All the selected sources have a fluegas flow of apr. 100.000 m^3/h.

Table 3.5 mentiones all the technical approved end-of-pipe measures of the selected sources. The measure injection of odour neutralization is not selected, the authorities do not approve this measure due the additional effect of emission of organics and the scientific doubts about working principle.

The selection of measures took place with regard of flue gas flow.

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Table 3.5. Overview end-of-pipe measures.

measure number	measure	mark
n.1	Air scrubber	++
n.2	Chimney height increment	++
n.3	Thermal afterburning	--
n.4	Adsorption and regenerative afterburning	+/-
n.5	Adsorption active cokes	-
n.6	Biological cleaning	+

++ Very suitable + Suitable - Less suitable -- Not suitable

The investment and operational costs of measures n.3 and n.5 are very high due the fluegas amount of 100.000 m^3/h. Further investigation of these measures is not effective and neccesary. Table 3.6 compares in more detail the 4 suitable end-of-pipe measures.

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Table 3.6 Quick scan selection end-of-pipe measures.

Measure nr.:	n.1 Air scrubber	n.2 Elevation chimney height	n.4 Adsorption wheel and RNV	n.6 Biological
Flue gas characteristics				
Temperature	+	+	+	+
Physical characteristics				
Content	-	i.a.	+	-
Concentration	-	i.a.	-	-
Solubility	--	i.a.	i.a.	--
Stickeness	+	i.a.	+	i.a.
Biodegredation	i.a.	i.a.	i.a.	--
Technical evaluation				
Composability	+	+	+	-
Efficiency	-	+	++	--
Reliability	++	++	-	+
Proces control	+	+	+	+/-
Maintenance	-	+	-	-
Environmental evaluation				
Rest emission	-	+	++	--
Waste stream	-	++	+	+
Energy consumption	-	+	-	-
Water consumption	-	i.a.	i.a.	-
Economical evaluation				
Investments [Eur]	+	+	+	-
Operational costs [Eur/jaar]	-	+	-	+
Bennefits	i.a.	i.a.	i.a.	i.a.
Total evaluation	--	+	+/-	--

++ Very suitable + Suitable - Less suitable -- Not suitable

Measure n.2 seems the most suitable due the fact of low operational costs. The disadvantage is the low 'efficiency' of odour reduction on residence farther away from emission sources.

The option scrubbing n.1 and biological n.6 are not suitable, mainly due the very poor solubility in water of the odour components.

The option n.4 has a good efficiency but the adsorpion unit cannot function properly by dust content > 0,1 mg/m^3. Therefore high investment costs for dedusting units are necessary.

In figure 3.1 the odour reduction is calculated for the elevation of the existing chimney height of 30 m. The elevation is + 25 m (total height 55 m) and + 70 m (total height 100 m). In appendix 3 the calculation method is given.

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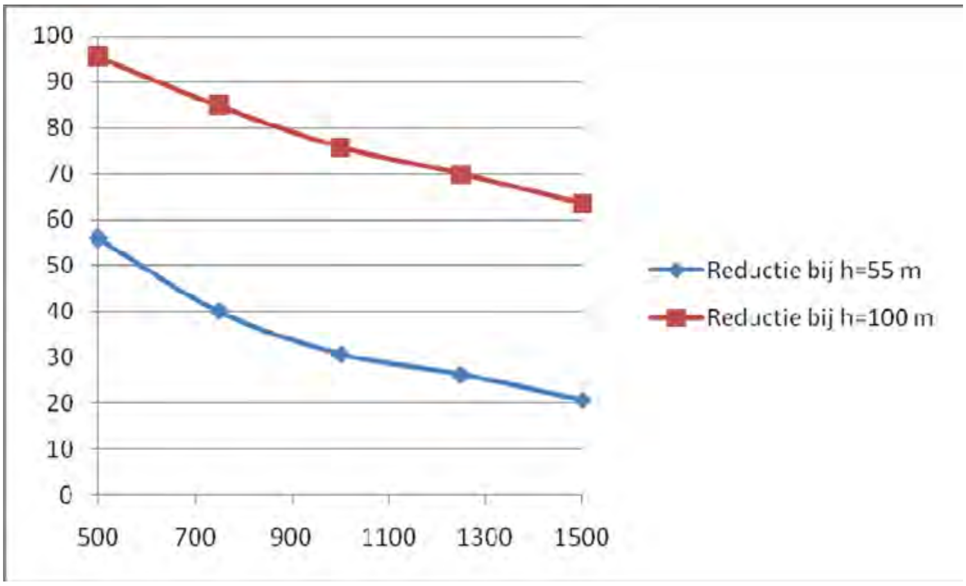

Figure 3.1. Odour reduction in % depending from distance residence and chimney height elevation.

For a distance of 900 m to the residences the reduction is apr. 33% for chimney height of 55 m. The reduction is apr. 78% for chimney height of 100 m.

Scenario's

For the calculations of odour reduction and costs effectiveness the VOS measures on sources number 9 and 14 are implemented. The measures described in table 3.7 are selected to describe scenario's.

Table 3.7. Selected measures.

source number	measure number	description	odour reduction [%]
		source related measures	
6, 8	b.1	Implementation Envibond (new binding agent sand)	10
11, 12 en 13	b.2	Implementation resin and new activator 4e generation, furaan line	40
11, 12 en 13	b.7	Experiment more active furane resin	10
		proces related measure	
4	p.4	change in desulfuringmethod	95
		end-of-pipe measures	
6, 8, 11, 12 en 13	n.2	Elevation chimney height	33 - 78*
6, 8, 11, 12 en 13	n.4.	Adsorption wheel and regenerative after burning (RNV)	95

**) chimney elevation of +25 and +70 m, distance of source to residence 900 m.*

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The following scenario's are possible for odour reduction on short term:

1. Implementation of b.2 and b.7 (source related measures).
2. Implementation of n.4 (adsorption wheel and RNV) for sources 6, 8, 11, 12 and 13.
3. Implementation of n.4 (adsorption wheel and RNV) for sources 11, 12 and 13.
4. Scenario 1 AND 2.
5. Chimney height elevation of 60 m for sources 6, 8, 11, 12 and 13.
6. Chimney height elevation of 100 m for sources 6, 8, 11, 12 and 13.
7. Scenario 1 AND 5 (60 m).
8. Scenario 1 AND 6 (100 m).

The total odour reduction of the 8 scenario's is given in figure 3.2.

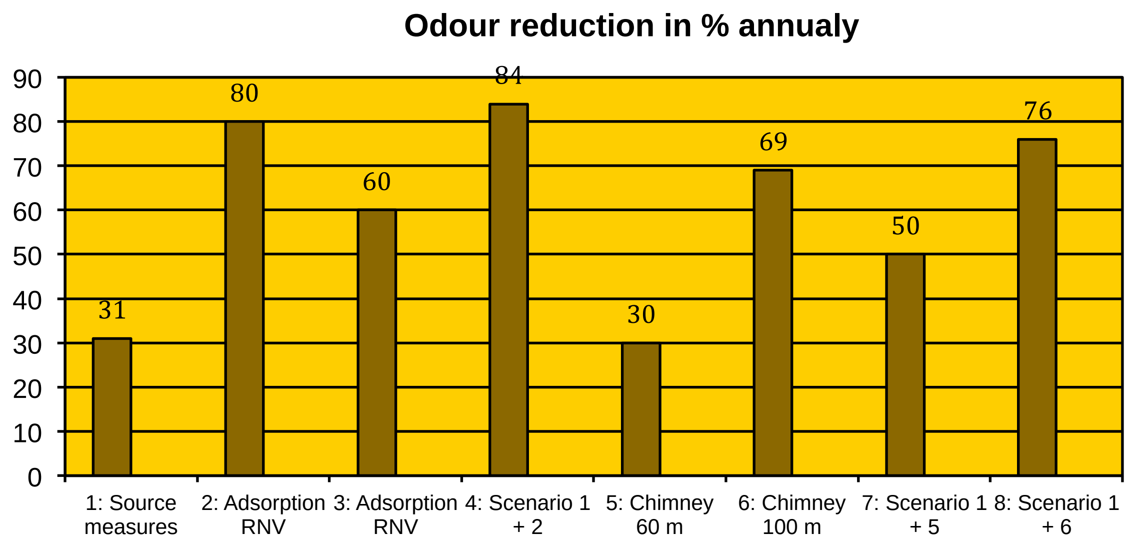

Figure 3.2. Odour reduction in % (year average).

In figure 3.3 and 3.4 the investment and operational costs are given.

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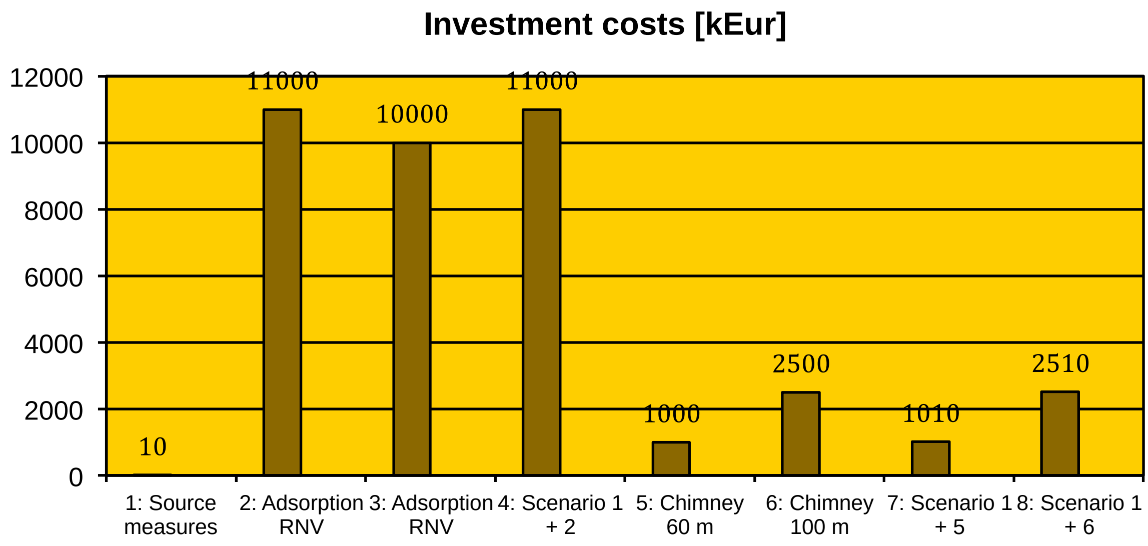

Figure 3.3. Investment costs scenario's in k €.

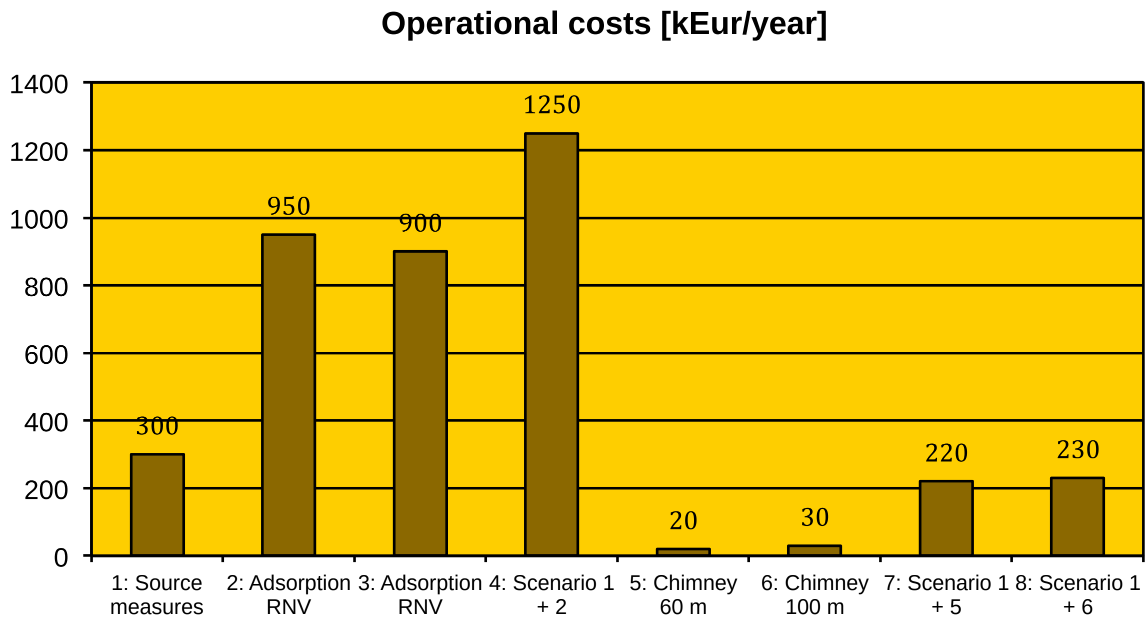

Figure 3.4. Operational costs scenario's in k €.

De Dieze 31B, 5684 PR, Best, The Netherlands, tel: 0031 40 2984639 / 0031 6 83252355
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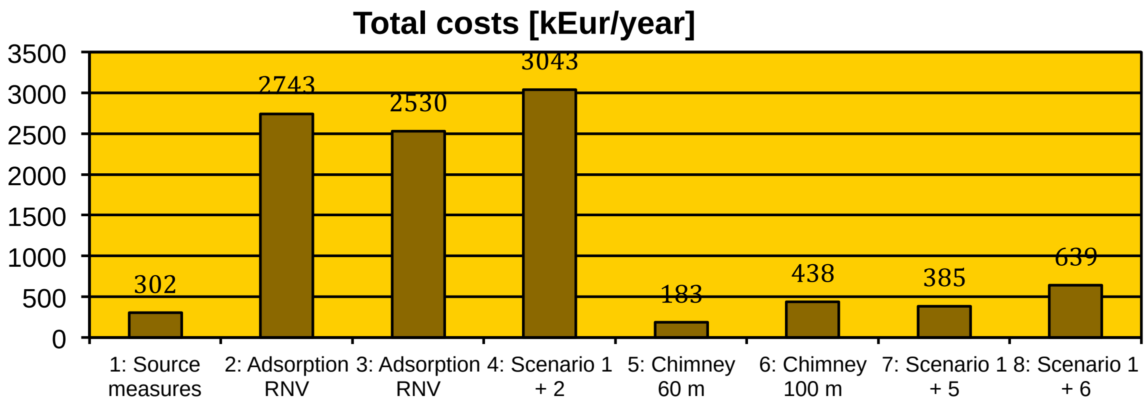

Figure 3.5. Total costs scenario's in k € annualy.

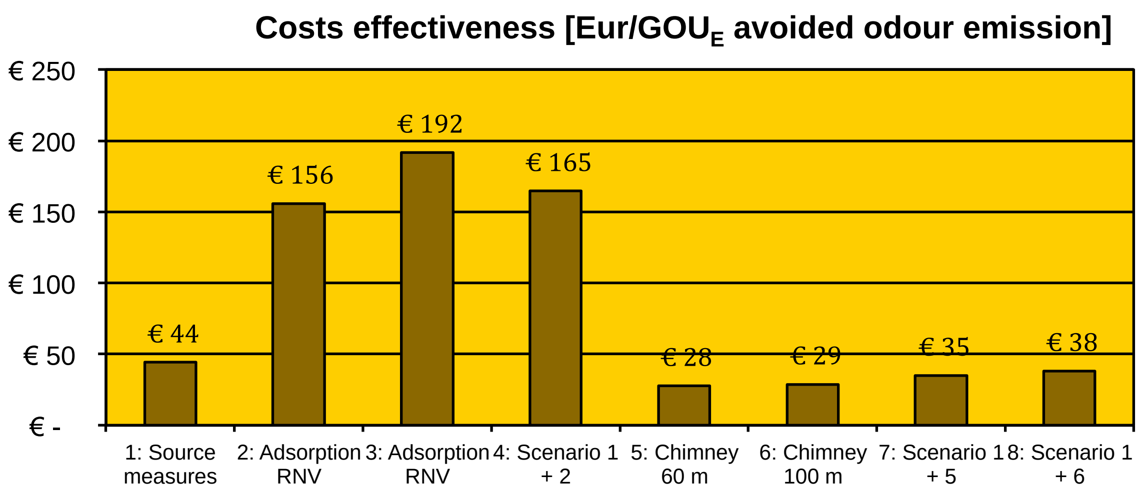

Figure 3.6. (Relative) costs effectiveness scenario's in € and avoided GOU_E annualy.

In figure 3.6 scenario 5 and 6 followed by scenario 7 and 8 are the most cost effective measures.

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4. Conclusions and recommendations

The described odour assesment procedure gives a detailed insight in most effective measures for odour abatement. This assesment included technical, environmental, legal and economical characteristics.

The results can be communicated to all stakeholders for maximum support. The documentation can help with the implementation proces of measures; less appeal can be expected.

Appendix 1: References
Appendix 2: Overview possible odour measures
Appendix 3: Calculation method figure 3.1.

Appendix 1 References

References	Description
1	Notitie Xxxxxxx met kenmerk Xxxxxxx/Xxxxxxx/geur/reductieplan 20XX
2	Persbericht van provincie XXXXXXX 'Handhavingsverzoek Xxxxxxx-XXXXX afgewezen'
3	Brief Provincie XXXxxx met als onderwerp Beoordeling geurreductieplan vestiging Xxxxxxx met kenmerk XXXXXXXX van XX XXXXXXX 20XX
4	Brief Xxxxxxx betreffende Geurreductieplan Xxxxxxx Xxxxxxx met kenmerk XXXXXXXXX van X-X-20XX
5	Rapport OpdenKamp Adviesgroep B.V., 'Opzet nader geuronderzoek ijzergieterij Xxxxxxx te Xxxxxxx', eindversie XX XXXXXX 20XX
6	Persbericht van provincie XX XXXXX 20XX 'Verslag voorlichtingsbijeenkomst milieuproblematiek Xxxxxx, gehouden op XX XXXXXi 20XX in het Xxxxxx
7	Brief Provincie XXXxxx met als onderwerp Aanvullend geuronderzoek Xxxxxxx Xxxxxxx met kenmerk Xxxxxxxxx van XX XXXXl 20XX
8	Brief Xxxxxxx aan projectgroep betreffende 'Voorlopige resultaten geuronderzoek Xxxxxxx' van XX-XX-20XX
9	Mail van XX-XX-20XX van Xxxxxxx Xxxxx Xxxxxxx aan XXXX betreffende geuronderzoek Xxxxxxx
10	Rapport PRA Odournet B.V., 'Onderzoek naar geurproblematiek Xxxxxxx te Xxxxxxx', rapport nummer Xxxxxxxx, XX XXXXXX 20XX.
11	Meeting minutes van Xxxxxxx, 'Bijeenkomst plan van aanpak geur', XX XXXX 20XX
12	Infomil document L26, 'Beschrijving van luchtemissiebeperkende technieken', maart 2000.
13	Handreiking bepaling van het immissieniveau (RIVM), versie 9 augustus 2004.
14	Beschikking milieuvergunning Gieterij Nijg te Nijmegen 2006.
15	Reference Document on Best Available Techniques in the Smitheries and Foundries Industry, European Commission, May 2005.
16	Brief Xxxxxxx aan Provincie schoorsteenverhoging en ioniseren met ozon
17	Nederlandse Emissie Richtlijnen lucht (NeR), uitgave 9 december 2004 met updates

Appendix 2 Overview possible odour measures

bron nummer PRA	maatregel nummer	emissiepunt	mogelijke maatregel/actie	indeling	tijd	effect	geurreductie (%) schatting	zeker/ experiment/ studie	Onmogelijkheden, beperkingen, benodigde tijd
8	p.1	koeltrommel, natwasser	studie naar ander uitbreek- en koelproces	proces	Q3 2008	afhankelijk van mogelijke maatregel; (contacttijd tussen zand en ijzer verlagen, verklammeren)	20	studie	In de huidige situatie is het door plaatsgebrek niet mogelijk om het uitbreekproces met geintegreerde waterkoeling te vervangen door een uitbreekproces met separate luchtkoeling
8	p.2	koeltrommel, natwasser	studie naar mogelijkheden waterbehandeling en verversing	proces	Q3 2008	Geurbijdrage uit water bepalen. Wat is de invloed op het proces (slib)	50	studie	Voorwaarden voor lozen op riolering? Maatregel heeft grote invloed op het proces i.v.m. beheersing van percentage slib in het vormzand. Proefperiode 6 tot 12 maanden
8	p.3	koeltrommel, natwasser	studie naar mogelijkheid tot verlengen afkoeltijd	proces	Q3 2008	verlengen t, verlagen T. Bijdrage?	50	studie	Zie opmerking ander uitbreek- en koelproces
8, 6	b.1	koeltrommel, giet-en koelbaan	Invoeren Envibond. Project gestart in mei 2007	bron	Q2 2008	0-situatie is vastgelegd. Eindsituatie Q2 2008	10	zeker	Meting uitgevoerd, resultaten nog niet bekend
8, 6	b.2	koeltrommel, giet- en koelbaan	Invoeren hars en activator 4e generatie	bron	Q2 2008	bepalen mbv meting.	40	zeker	Meting uitgevoerd, resultaten nog niet bekend
8, 6	b.3	koeltrommel, giet- en koelbaan	~~Cold box binder vervangen door anorganisch bindmiddel~~	bron			50	~~studie~~	Alleen mogelijk in hot box systeem
	p.4	carbidebrander	Wijzigen ontzwavelingsmethode	proces	Q4 2008	100%. Daarbij ook energiebesparing	95	zeker	Locatie geschikt voor plaatsen zuurstoftank, Proefperiode vanaf week 12. Benodigde tijd ca. 6 mnd.
1	p.5	oven	Vervangen recu	proces			50		

8, 6, 11, 12, 13	n.1	n.b.	Gaswassing	nagesch.		70-80%	70		Water is chemisch afval. Oplosbaarheid is slecht
8, 6, 11, 12, 13	n.2	allemaal	Micro gaswassysteem zonder druppelvanger	nagesch.		Tot 50% hedonische verbetering	50		Verbruik concentraat 7 - 14 euro per uur. Effect moeilijk te bepalen. Alleen hedonische verbetering
1, 8, 6, 11, 12, 13	n.3	allemaal	Schoorsteenverhoging	nagesch.		bepalen mbv verspreidingsberekening	80		800.000 kuub 100 m vrijstaand geen probleem (d=4,75 m), stralen slijpen apart
8, 6, 11, 12, 13	n.4	allemaal	Thermische naverbranding	nagesch.		90%	90		Totaal gasverbruik 1000 m^3/uur; Ook bekeken als zandwasser. Hetzelfde gasverbuik dus energievernietiging
8, 6, 11, 12, 13	n.5	allemaal	Adsorptie +regeneratieve naverbrander 700.000 m3/hr; zelfreinigende ontstoffing	nagesch.		90%	90	experiment	continu adsorptie, discontinu desorptie. Hierdoor waarschijnlijk autotherm, aanbieding voor onderzoek werking ad- en desorptie plus werking, 4000 TNV en 7000 ontstoffing
8, 6, 11, 12, 13	n.6	allemaal	Adsorptie +regeneratieve naverbrander 350.000 m3/hr; zelfreinigende ontstoffing	nagesch.		90%	90	experiment	continu adsorptie, discontinu desorptie. Hierdoor waarschijnlijk autotherm, aanbieding voor onderzoek werking ad- en desorptie plus werking
8, 6, 11, 12, 13	n.7	allemaal	Biologisch reinigen	nagesch.			90		Emissie bevat te veel storingelementen (zwavel en formaldehyde). Proces is moeilijk beheersbaar
1, 8, 6, 11, 12, 13	n.8	allemaal	Ioniseren met Ozon	nagesch.		niet bekend	100		Aromatische KWS worden moeilijk door ozon verwijderd; techniek is voor deze toepassing nog nergens aangetoond

1, 8, 6, 11, 12, 13	n.9	allen	koud oxideren	nagesch.		100%	100		nieuwe techniek, onderzoek nodig. Start misschien zomer, 2008 bij Ifg. Extra voorontstoffing (wassing) noodzakelijk. Verwijderen van Arom. KWS moeilijk
8, 6, 11, 12, 13	b.4	allen	Geurabsorptiemateriaal inbouwen in binders KM ??	bron			5	studie	Afhankelijk van ontwikkelingen bij leverancier
1, 8, 6, 11, 12, 13	n.10	nb	filteren deeltjes (nanometer)	nagesch.		Niet bekend. Onderzoek noodzakelijk; Experiment relatie extra filteren - geurreductie; Week 9 contact voor kleinschalige proef	70		Stof wordt periodiek met spoelwater verwijderd. Water is chemisch afval; Waterstroom is groot. Installatie tot 30.000 kuub waardoor capaciteit te laag.
11, 12, 13	b.5	giethal; Thorit	Invoeren hars en activator 4e generatie	bron	Q1 2009	bepalen mbv meting.	40	zeker	proefperiode ca. 4 mnd.
11, 12, 13	b.6	giet- en koelbaan Thorit	optimaliseren kern- en vormzand dmv extra ontstoffen	bron		Lager verbruik van bindmaterialen; effect bepalen met metingen	5	studie	bijdrage beperkt
11, 12, 13	b.7	giet- en koelbaan Thorit	Vervolg experiment reactievere hars	bron	Q4 2008	lager verbruik bindmaterialen en minder zwavel; effect bepalen met metingen	10	zeker	proefperiode ca. 4 mnd.
11, 12, 13	b.8	giet- en koelbaan Thorit	houtmeel vervangen door anorganisch additief	bron		nog bepalen mbv metingen	5	experiment	
11, 12, 13	p.6	giet- en koelbaan	aansteken gietgassen tijdens kwalmen	proces		nog bepalen mbv metingen	5		nadelig effect energieverbruik. Steunbranders nodig. Verbranding vindt al deels door proces plaats. Vlammen doven uiteindelijk
11, 12, 13	p.7	giet- en koelbaan Thorit	Periodiek schoonmaken leidingen (condens)	proces		nog bepalen mbv metingen	0		evenwicht. Bijdrage beperkt
11, 12, 13	p.8	giet- en koelbaan Thorit	kerngewicht besparen (holle kernen, dikkere wapening)	proces		nog bepalen mbv metingen	5	experiment	
11, 12, 13	p.9	giet- en koelbaan Thorit	Zandreductie in vormkasten	proces		nog bepalen mbv metingen	5	experiment	Gevaar voor leeglopen vorm is groot

11, 12, 13	p.10	giet- en koelbaan Thorit	kastenpark uitbreiden	proces		koeltijd verlengen	5		thermische belasting kernzand blijft gelijk. Bijdrage beperkt
11, 12	p.11	giet- en koelbaan	Uitzoeken waarom BMD1 minder geur levert dan BMD 2	proces	Q2 2008		0	experiment	CxHy metingen bij BMD I & II uitgevoerd. Resultaten nog niet bekend.
11, 12, 13	b.9	giet- en koelbaan Thorit	~~Cold box binder vervangen door anorganisch bindmiddel~~	bron			50	~~studie~~	Alleen mogelijk in hot box systeem
11, 12	p.12	giet- en koelbaan	Furaanvormen voorzien van adsorberende coatinglaag	proces			5	studie	Orienterende proef uitgevoerd in week 17 2008
11, 12, 13	b.10	giet- en koelbaan	Bindmiddelen furaan vervangen door anorganisch bindmateriaal	bron			50	studie	Ontwikkelingen leverancier afwachten
		Thorit							
8, 6, 11, 12, 13	p.13	allen	Verlengen afkoeltijd; In welk T traject ontstaat de geur?	proces			5	studie	
11, 12	p.14	giet- en koelbaan	Compartimentering door luchtwand	proces	Q2 2008	Compartimentering, te behandelen debiet lager	nvt	studie	Inventarisatie van mogelijkheden gestart in week 17.

Appendix 3 Calculation method figure 3.1.

Distance in m	C_L in µg/m^3			Reduction % at h=55 m	Reduction in % at h=100 m
	H=30 m	H=55 m	H=100 m		
500	0,077	0,034	0,0036	56	95
750	0,04	0,024	0,0061	40	85
1000	0,026	0,018	0,0063	31	76
1250	0,019	0,014	0,0057	26	70
1500	0,014	0,0111	0,0051	21	64

Source ref. 13