Calambio
ENGINEERING AB

PM-1100-24 2017-11-06
Calambio – Feasibility studies
Revision 2 – 2018-10-05

CALAMBIO – FEASIBILITY STUDIES

1 GENERAL

A successful investment project will start with a feasibility study.

The feasibility study aims to find the best solution for the lifetime of the investment or the best alternative to solve a specific problem. When discussing power plants or other heavy industries this usually means looking 20-40 years into the future.

Finding the lowest invest volume is not unimportant, but building the right kind of equipment is much more important. You must start with finding out what actually should be done in the first place.

It is true that eventually everything boils down to economy in the end. We do not argue with that. The job is however finding out all the parameters and evaluating them in a proper way. With this attitude you will in the end find the cheapest alternative including all parameters. We have more than 30 year of experience in this as well as EPCM (Engineering, Procurement, Construction and Management) of energy projects

2 EXAMPLES IF ISSUES TO BE CONSIDERED

If we look at a power plant or a waste to energy facility there are virtually hundreds of parameters to look at:

2.1 Prerequisites

The first stage of a feasibility study is to verify all the basic parameters that will have an impact on a possible project. This can typically be divided in four major groups:

- Waste composition and volumes
- Infrastructure
- Boiler design
- Personnel

In appendix a typical check list is presented. These are typical questions to be verified before the actual work begins. These questions are usually not easily answered and regardless of project the answers are not readily available. We are used to mapping of this kind of parameters.

It is a good thing if the client browses the parameter in an early stage because it gives a mental preparation for the dialogue to follow. Some parameters can be found in existing documents, some will definitely need visits to actual sites and also some analysis.

A meticulous compilation of the result is paramount for the further work

Figure – Turbogenerator installation in Nybro Waste to Energy plant.

2.2 Revenues and cost

Consider all revenues and costs. For a waste to energy plant possible revenues are

- Gate fees for waste
- Production of electricity
- Possible production of steam for industrial use, district heating or district cooling
- Possible operation of other plants as you do have a competence collected in the control room.
- Recovery of metals
- Other special parameters that make a difference as discussed below.

There are also costs to consider

- Cost for preparing the waste
- Water supply
- Internal consumption of electricity
- Infrastructure during investment. Are there cranes available?
- Deposit of ashes. Sometimes this may be a revenue if the plant is designed correctly
- Operation issues. A W2E plant is sensitive to proper maintenance.
- Changes of prices on electricity and others.

It's easy to over- or underestimate these parameters.

2.3 Looking into the future

The only thing for sure about the future is that it is quite uncertain. In a feasibility study we look into what is probable to happen. This involves changes in fuel volumes and composition, legislation, demographics, wealth etc.

An example is changes of waste composition that may make certain technologies obsolete within a couple of years.

Figure – Waste to energy plant (40MW) located in the centre of the town of Västervik in Sweden.

2.4 Alternative cost

Choosing a budget solution will sometimes lower the initial investment volume. On the other hand an unsuitable solution will cause a lot of future problems that will ruin profitability if not considered. You must always look at overall cost during the lifetime of the plant.

Saving on keeping a dated plant may mean that some savings are made the next year. Then you are forced to make extensive repairs on obsolete machinery a couple years later. That is not always a good overall economy.

On the other hand spending investment funds on things that will never be needed is also false economy but not uncommon.

A profitable way to get around this is sometimes to divide an investment in steps where you can postpone some decisions a few years and collect further information before spending.

2.5 Extras that makes the difference

We have several examples of where we have managed to find extra benefits in a project that makes the change from a weak to a strong project economy.

- Including an extra fuel with a negative value (i.e. a special arrangement that makes an external customer paying extra. For example special wastes such as slaughterhouse leftovers made a huge profit for an industrial plant in Sweden.

- Finding ways to increase efficiency by means of integrating facilities. For examples supplying additional low pressure steam from waste heat as an example in a drying plant in the north of Sweden.

- Looking into overall economics. Heat recovery in a steel mill in Norway was not an excellent business in its own. The possibility to lower prices slightly gave however a huge advantage against competitors. This upped the occupation in the plant from 70-90% and thus gave a considerable leverage of overall profits. This is something we have done several times.

2.6 Technical issues

The design of a plant is also depending on many practical issues. Different plant sizes are based on different technologies. Not so big boilers can be built as standing units. This reduces the complexity size and cost of the building considerably. The height may be reduced by some 10 meters.

A smaller unit can to a large extent be premanufactured in a workshop, providing there are necessary resources in the way of harbours, transportation facilities etc available.

Different waste compositions may demand completely different boiler designs. For fuels with very high moisture content different solutions from combustion, may be needed.

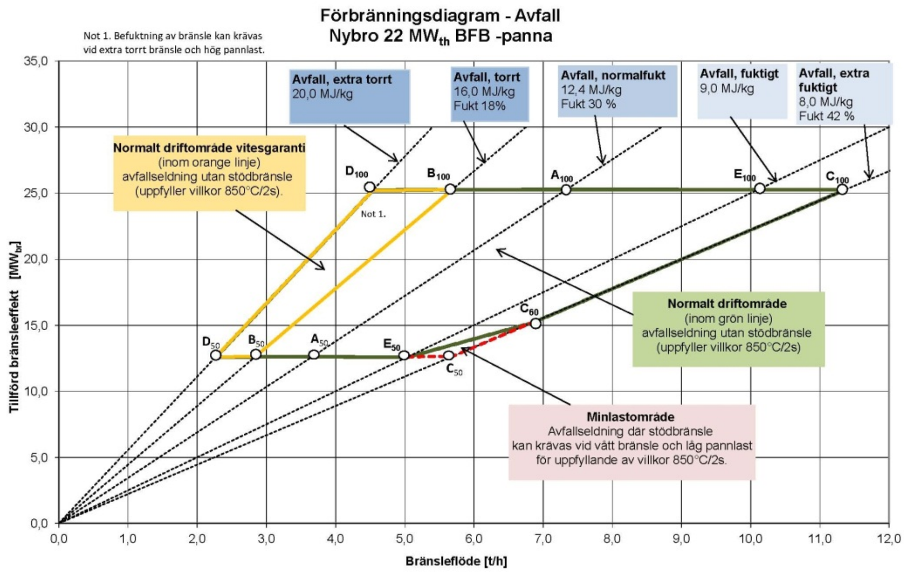

Figure – Typical combustion diagram for a waste to energy steam generator based on fluidised bed technology. This particular application can handle fuels from 18-42% moisture and ash contents up to 25%. With different designs moisture tolerance can be raised but then acceptance of dry waste will be compromised. There is no magic possible only hard work to find the right solution.

3 TIMELINE AND COST

A feasibility study can take from two weeks to two years to perform depending on type of project, complexity and ambitions. We can involve anything from 1-2 to 20 specialists in a work like this depending on extent.

The results are a firm recommendation on how to proceed. We are not linked to any particular supplier of equipment. That means we can pick the best technology for the client. We do however have an extensive network and knows more or less every company in the business.

Figure – Perstorp AB. In the front a 330 m^3 silo for storage of animal waste and a wet electrostatic precipitator. In the background the boiler house for the 55 MW boiler.

4 FURTHER STAGES

A feasibility study gives a firm indication of the total economy in a project.

4.1 Pre engineering

The stage after a feasibility study is a pre engineering stage. This can be performed if the outcome of the feasibility study is positive. The pre engineering stage involves more engineering with more detailed layouts. The budget work is extended and cost levels are verified by means of budget quotations and possible letters of intent. Possible local suppliers are contacted.

The pre engineering usually also involves further arrangement of financing details. A letter of intent with a financer will be arranged.

It is common to make arrangements for environmental and building permits in order to save time. Sometimes also procurement of land is initiated.

The pre engineering forms the basis for the very final decision on an investment.

Figure – 3D model of 32 MW$_{th}$ (90 bar(g) 500 ℃) CHP for Härjeåns Energi in the very north of Sweden. This plan can also be operated in condensing mode for maximizing of power output.

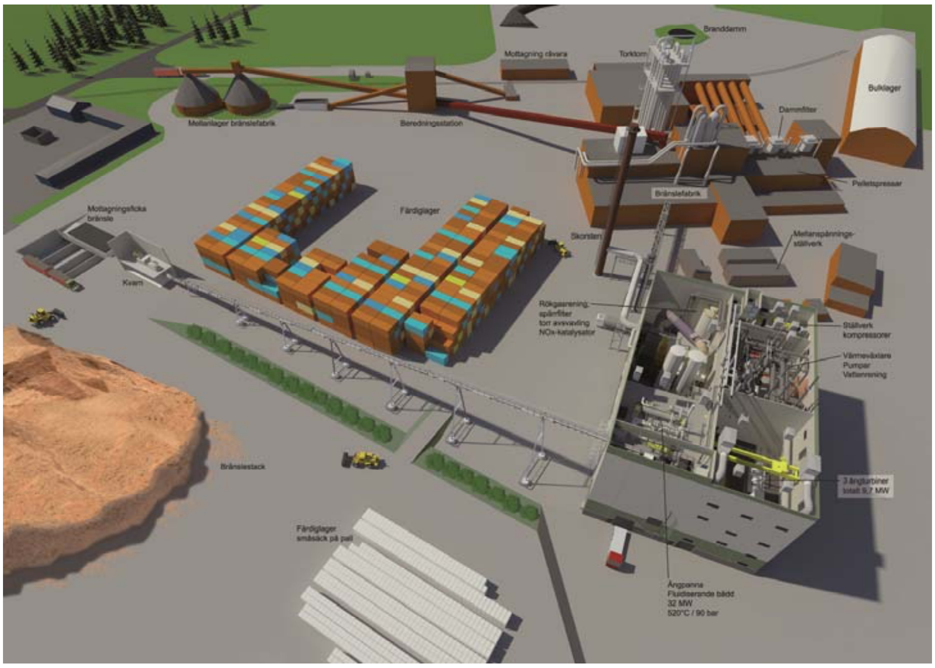

Figure – CHP plant for 12 MW net electricity combined with a 200.0000 ton per year pellet production plant.

4.2 Project execution

Calambio has a long history of executing complex projects on an EPCM basis. This way of work means we are free to use the best supplier for each task in a project. This will result in a plant with a homogeneous high quality as we do not need to sub optimizing in order to suit a particular supplier. Our specialty is a comprehensive balance of plant working with different contractors.

On the other hand a turn-key solution is sometimes advocated and we know how to supervise this kind of installations as well.

Figure – CHP Kährs, Nybro.

5 APPENDIX

1 Waste to energy project questionnaire

2 Brief overview of large waste to energy plants depending on size and general waste composition

3 Typical mapping of energy demand for district heating network

4 Example of one dimensional investment analysis (extract)

5 Example of investment volume calculations (extract)

References are available in separate documents.

Please note that there are no standard solutions and it is easy to jump into conclusions from material made for another application.

Waste to energy project questionnaire

Please indicate status of issues addressed below. This is a basis for further discussion on project development.

Waste composition	Completely clarified	To be clarified in prestudy	Comments and verification of completely clarified data
Total waste volumes annually. Must be related to moisture content.			
Variations in waste flow over the year?			
Moisture content. Incl ranges in hour/ month timescale for the next decades			
Ash content. Incl ranges in hour/ month timescale for the next decades			
Heavy metals analysis in ashes. Incl ranges for the next decades			
Contents of S, HF and HCl in wastes. Incl ranges for the next decades.			
May waste contain latrine, steel, glass, gypsum etc. Volumes? Concentrations?			
Need for hazardous wastes? Foreseen types			
Is slaughterhouse waste a possibility?			

Boiler design	Completely clarified	To be clarified in prestudy	Comments and verification of completely clarified data
Will emission standards according to EU standards be satisfactory? Are more/ less strict regulations foreseen?			
Time schedule for environmental permit			
Time schedule for building permit			
Overall time schedule?			
Is a need for part load operation foreseen?			
Is double screened silicate sand for FBC combustors available or must this be prepared on site.			
Availability of bicarbonate or limestone for flue gas treatment?			

Infra structure	Completely clarified	To be clarified in prestudy	Comments and verification of completely clarified data
Is land for the plant allocated or considered?			
Are roads to the site available?			
May there be a possibility to sell heat for district heating to for example a hospital or a university at reasonable distance? Price level			
May there be a possibility to sell steam for industrial use? Price level			
Price level for electricity? Variations over time? Separate power/ energy tariffs. Variations over time for decades to come. Grid fees.			
Is the electric grid available for connection. What capacity is available?			
Is city water for production of boiler make up water available? (typical 20 m^3/h and upwards depending on plant size). Cost?			
Are large amounts cooling water for vacuum condensers or wet cooling towers at all a possibility?			
Is it possible to feed drains to an existing sewage water system or will this need to be included in plant?			
Is a gate fee for incoming waste possible?			
Are deposits for hazardous and non hazardous ashes available? Deposit cost? Distances? Forms of delivery preferred?			
Taxes related to emissions foreseen?			

Personnel	Completely clarified	To be clarified in prestudy	Comments and verification of completely clarified data
Possible local availability of machinery. Cranes 1500 tonnes and upwards.			
Accommodation for 100-200 people on site. Distance?			
Availability of civil contractors.			
Availability of qualified scaffolders.			
Possible existing organisations for development of management, operation and maintenance? Education level and practical experience? Salary levels.			

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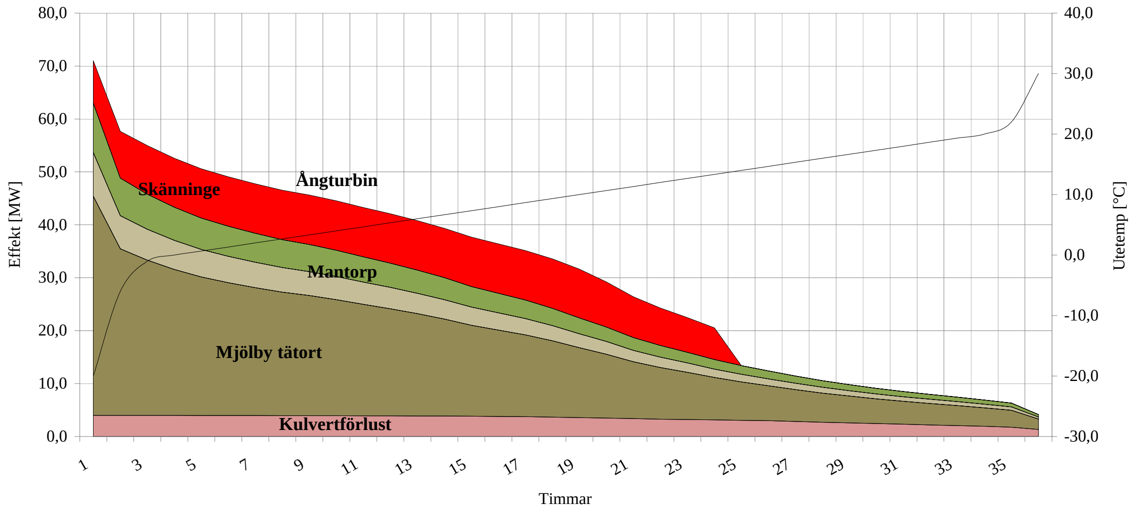
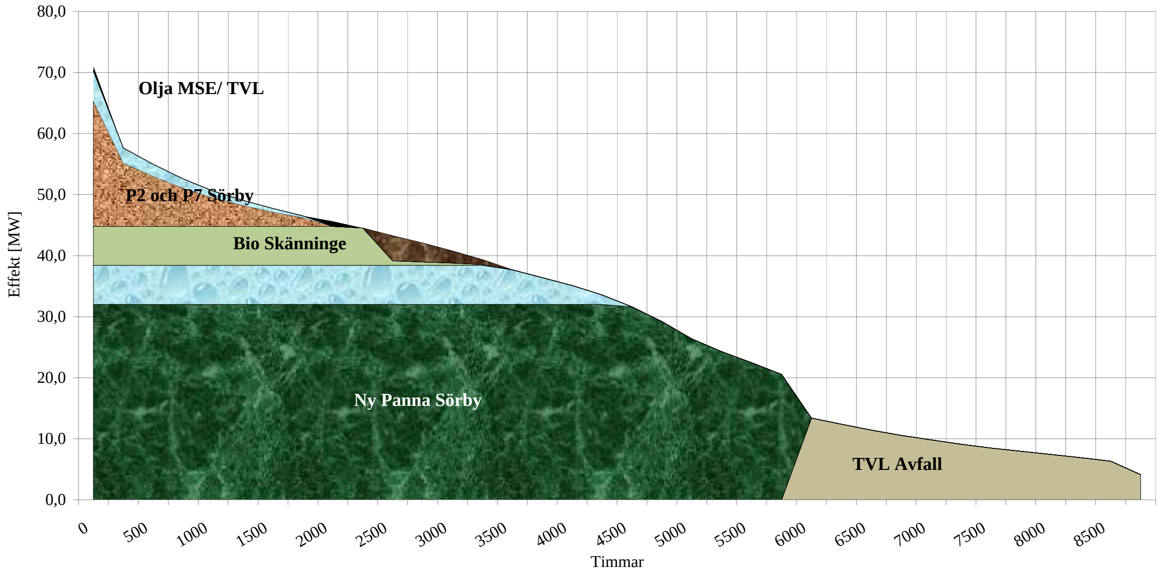
VARAKTIGHETSDIAGRAM

MJÖLBY SVARTÅDALEN ENERGI AB

Ny 32 MW Panna + Turrbin hos MSE. Befintlig utrustning hos TVL





Effektbehov

Mjölby	41 MW_{th}	
Mantorp	8,3 MW_{th}	
Skänninge	9,4 MW_{th}	
Kulvertförluster	4,0 MW_{th}	
Ångturbin 80 bar(g) 480°C	9,3 Mw_{el}	0,41 Alfa P8
Totalt	**72 MW**	0,27 Alfa verk

Tillgänglig effekt

Tekniska Verken, Linköping	14 MW_{th}	0,05 Minlast
Ny biopanna Sörby	32 MW_{th}	0,4 Minlast
Rökgasskrubber Ny panna	6,4 MW_{th}	0,05 Minlast
Biopanna P2 & P7	20,5 MW_{th}	0,05 Minlast
Kondensorer P2 & P7	4,9 MW_{th}	0,05 Minlast
Biopanna Skänninge (inkl kond)	6,4 MW_{th}	0,2 Minlast
Olja MSE	24 MW_{th}	0,1 Minlast
Totalt	**108 MW_{th}**	

Energiförbrukning

Mjölby	128 $GWht_h$	3 095 h[(1)]
Mantorp	26 $GWht_h$	3 095 h[(1)]
Skänninge	29 $GWht_h$	3 095 h[(1)]
Kulvertförluster	29 $GWht_h$	7 242 h[(1)]
Ångturbin 80 bar(g) 480°C	52 GWh_{el}	5 543 h[(1)]
Totalt	**263 GWh**	3 640 h[(1)]

Not 1 - Ekvivalenta fullasttimmar

Energiproduktion

TVL Avfall	26 $GWht_h$	1 893 h[(1)]
TVL Bio/ RT (planerad)	0 $GWht_h$	0 h[(1)]
TVL Bio/ RT P3	0 $GWht_h$	0 h[(1)]
TVL Kol	3 $GWht_h$	179 h[(1)]
Ny biopanna Sörby	179 $GWht_h$	5 582 h[(1)]
Rökgasskrubber Ny panna	25 $GWht_h$	3 951 h[(1)]
Biopanna P2 & P7	12 $GWht_h$	572 h[(1)]
Kondensorer P2 & P7	2,8 $GWht_h$	572 h[(1)]
Biopanna Skänninge (inkl kond)	16 $GWht_h$	2 437 h[(1)]
Olja MSE	0,3 $GWht_h$	13 h[(1)]
Totalt	**263 $GWht_h$**	

Turbin			
Entalpi ånga till turbin [kJ/kg]	3311	3360	3360
Avtappningstryck [bar(g)]	3,0	3,0	3,0
Mottryck [bar(a)]	0,10	0,10	0,10
Temperatur i kondensor [°C]	46	46	46
Temperatur avtappning [°C]	180,0	180,0	180,0
Ansatt avtappningsflöde [kg/s]	1,7	2,3	2,8
Entalpi ånga från avtappning [kJ/kg]	2848	2848	2848
Entalpi i mottrycksånga [kJ/kg]	2350	2350	2350
Fukt i mottrycksånga	10%	10%	10%
Bruttoeffekt från turbin [MW]	14,9	18,8	22,9
Verkningsgrad växellåda, generator mm	93%	93%	93%
Nyttig eleffekt från turbin [MW]	**13,8**	**17,5**	**21,3**
Emissioner			
Svavel			
Andel av svavel som binds i produkt	5%	5%	5%
Årlig emission av svavel [ton SO_2]	**301**	**328**	**453**
NOx			
Typisk koncentration NOx i rökgas [mg NO_2/Nm^3 torr gas]	200	200	200
Årlig emission av NOx [ton NO_2]	**302**	**330**	**382**
(typiskt vid 15% H_2O i gas)			
Underhållskostnader			
Ugn 1 [MNOK/år]	3,2	3,2	3,2
Ugn 1 [MNOK/år]	4,5	4,5	4,5
Hetgaskanaler [MNOK/år]	0,3	0,2	0,2
Rökgasfilter [MNOK/år]	0,5	0,5	0,5
Stofthantering [MNOK/år]	0,7	0,7	0,7
Rökgasfläktar [MNOK/år]	0,2	0,1	0,1
Hätt ugn 1 [MNOK/år]	0,1	0,1	0,1
Avgaspannor [MNOK/år]	1,1	0,7	0,7
Turbingenerator [MNOK/år]	0,4	0,4	0,4
Späd- och matarvattenanläggning [MNOK/år]	0,3	0,3	0,3
Tryckluftanläggning [MNOK/år]	0,6	0,5	0,5
Summa underhåll [MNOK/år]	**11,9**	**11,2**	**11,2**
Diverse kostnader			
Vatten [MNOK/år]	0,6	0,6	0,6
Emballage microsilika [MNOK/år]	9,0	9,9	9,9
Summa diverse kostnader [MNOK/år]	**9,6**	**10,5**	**10,5**
Sammanställning ekonomi			
Intäkter Si, SiO_2 [MNOK/år]	**572**	**627**	**627**
Intäkt kraftproduktion [MNOK/år]	**35**	**44**	**54**
Kostnad inköpt kraft brutto [MNOK/år]	**133**	**145**	**145**
Kostnad elektroder [MNOK/år]	**49**	**51**	**51**
Kostnad råvaror [MNOK/år]	**54**	**59**	**59**
Kostnad reduktionsmaterial [MNOK/år]	**130**	**142**	**117**
Underhållskostnader [MNOK/år]	**12**	**11**	**11**
Diverse kostnader [MNOK/år]	**10**	**10**	**10**
Övrigt (Personal, kapital, overhead vinst mm)	**229**	**262**	**298**
Besparing jämfört med nuläge [MSEK/år]	**---**	**33**	**68**
Investeringsbedöming			
Investeringsvolym [MNOK] (Enligt separat sammanställning)	---	150	150
Ekonomisk livslängd [År] Lågt ansatt	2	12	12
Kalkylränta [%]	---	10,0	10,0
Rak Pay-off [år]	---	**4,5**	**2,2**
Nuvärde [MNOK]	**Negativt**	**75**	**315**
Internränta [%]	**Negativt**	**18**	**44**
Kapitalkostnad (annuitetsränt + avskrivning) [MNOK/år]		**22**	**22**

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Calambio ENGINEERING AB

Rökgasfilter ugn 2 P&ID ej upprättat

Objekt	Vald offert	Nummer	Datum	Kontakt	Notering vald offert	Pris
Stoftfilter	Indutec GmbH	6727 Rev 01	2008-03-10	Arno Engstler	2 st föravskiljare, Induclon. 10 kammare slangar. Yta 10.382 m^2. 3.240 Strumpor ø 110 x 6800. Materialk Heimbach Glasfiber/ ePTFE 750 g/m^2. Garanterat tryckfall < 1800 Pa. Lufttryck 4 bar. 180 pilotventier. 10 rengasspjäl. Pneumatiska. Inkl transport, montage, driftsättning. exkl isolering. 1 € = 8,07 NOK	27 760 800
Isolering av filter	Skattad	---	2008-03-24	Pär Stenberg	200 mm + aluzink. Kostnad 2.000 NOK/ m2. Yta totalt inkl penthouse och kjolar 2.750 m^2. Inkl 2 portar 3 x 3 m. à 25 kNOK/ st	5 550 000
Blåsledning och sändare	Bameco AB	Telefonoffert	2008-03-19	Håkan Frank	2 x 80 m 4" slang (grövre än bulkbilsslang. 8 pneumatsiskrt styrda växelventiler med pneumatiska don. Två sändare för 4 ton/h 150 kg/$m^3{}_s$. 1 SEK = 8,7 NOK	870 000
Kompletterande skruvar, behållare	Gissning	---	2008-03-24	Pär Stenberg	Antal skruvar med stor ø låg hastighet. 2 st mellanbehållare. Allt i SS 2343. Priser i rätt storleksordning jämfört med leveranser från Noxor AB. Vissa skruvar ingår i offert från Indutec.	1 000 000
Tryckluftledningar	Se separat sammanställning	---	2008-03-26	Pär Stenberg	Matarledning och fördelningar DN 80/ 25 SS 2343 1 SEK = 0,87 NOK	431 462
Layouter konstruktion kanaler rör mm						
Kampakteringsutrustning	Gissning	---	2008-03-24	Pär Stenberg	Ren gissning av omfattning på hemlig och för oss helt okänd utrustning	2 000 000
Tillkommande stål för kompakterings-utrustning	Uppskattning	---	2008-03-24	Pär Stenberg	Filtret höjs ca 3 meter för att medge inplacering av kompaktering. Medför 20 ton stål à 60 NOK / kg. Dessutom 100 m^2 isolering à 2000 NOK/m^2.	1 400 000
El- & instrumentarbeten	Siemens Kalkyl	Ej numrerad	2008-03-27	Rolf Rømma	Montagematerial, montage, utcheckning och driftsättning av elektriska driftersamt instrument	1 140 000
Summa						**40 152 262**