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ASSISTANCE IN COMPOSTING MUNICIPAL WASTES, BAHRAIN, PHASE I

DP/BAH/85/010

Technical report: Evaluation of pre-qualification proposals for
a refuse and sewage sludge composting plant *

Prepared for the Government of the State of Bahrain
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

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Consultants in Compost Production from Municipal Wastes

United Nations Industrial Development Organization
Vienna

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EXECUTIVE SUMMARY

On behalf of the State of Bahrain (Central Municipal Council), UNIDO invited twenty-eight companies of international standing to submit a pre-qualification proposal for a refuse and sewage sludge composting plant.

Out of the total number of companies approached, UNIDO received thirteen proposals.

UNIDO retained two experts in the field of composting to assist in the evaluation of the proposals.

The proposals ranged from a two-page letter to a document containing five separate proposals.

After a careful evaluation, it is recommended that the following six bidders be invited to submit final tenders:

- Bühler Brothers Ltd.
- Dano AG and Motherwell Waste Treatment
- I. Krüger AS and S.p.A. De Bartolomeis
- Newell Dunford Ltd. and Ahmed Mansoor A' A'Ali
- O.T.V.
- Voest-Alpine AG

This list is in alphabetic order and no order of preference is intended.

The six bidders have offered five different composting systems (Newell Dunford and OTV are proposing the same process). Any of these proposed systems will be suitable for Bahrain.

It is considered important that the bidders be instructed to supply the recommended letters of satisfaction where asked for.

It is recommended that a study tour should be made by Bahraini officials to composting facilities that have been built by the qualified bidders.

It should be noted that the prices of the tenders submitted by the six qualified bidders ranged from US\$ 6,800,000 to US\$ 21,380,000.

It is recommended that any bidder utilizing the existing pulverizer plant be required to extend his guarantees to cover the pulverizing plant in the final offer.

QUESTIONNAIRE EVALUATION

The document issued by UNIDO, for the pre-qualification of companies to be invited to tender for the turn-key construction of a compost plant in Bahrain, contained a number of questions. The purpose of these questions was to form a basis on which an evaluation could be made regarding the suitability of the process offered, the experience and capability of the companies responding, plus the costs of the installation and operation.

Eleven questions were involved with some of these questions being broken down into subsections. The result of this is that each company was asked to submit answers to a total of thirty-six questions.

The evaluations of the thirteen companies involved were based on their answers to the thirty-six questions.

	Bühler Brothers	Hazemag GmbH	Krüger AS	Newell Dunford Eng.	OTV	Skanska	Sofregaz	Taylor Woodrow	Voest Alpine	WPF Corp.	Agrobio	Dano (N.B.)	Babcock
A. Company financial data	+												
B. Experience in composting	+												
C. Outline of a composting process suitable for Bahrain	+	+	+	+	+	+	+	+	+	+	+	+	+
1. Description of the process													
a. Material flow	+												
b. Mass balances	+	+	+	+	+	+	+	+	+	+	+	+	+
c. Information on similar plants and budget prices	+	+	+	+	+	+	+	+	+	+	+	+	+
d. Location of similar plants	+	+	+	+	+	+	+	+	+	+	+	+	+
2. Descriptive diagrams													
a. Schematic arrangement	+												
b. Land area requirements	+												
c. Building requirements and locations	+												
d. Proposed future plant expansion by up to 50%	+												
3. Schedule of the following													
a. Required site buildings, civil works, and utility facilities	+												
b. Mobile equipment	+												
c. Mechanical and electrical equipment	+												
d. Brief descriptions of plant, mechanical and mobile equipment	+												
e. Laboratory equipment for analysis of product	+												
4. Supervisory and operating personnel requirements	+												
5. Fuel and power consumption and other maintenance costs	+												
6. Estimated costs for the completed plant classified into:													
a. Buildings and civil works, with utility facilities	+												
b. Fixed mechanical equipment	+												
c. Electrical equipment and controls	+												
d. Mobile equipment	+												
e. Estimated spare parts inventory	+												
f. Erection, commissioning and training	+												
g. Laboratory equipment design	+												
7. Time schedule incl. proposed length of time required for constr., start-up + train.	+												
8. Warranties provided - both process equipm., and buildings/civil works/ util. fac.	+												
9. Description of the compost produced by the plant													
a. Expected quantity and analysis of the compost	+												
b. Expected final moisture content	+												
c. Expected final pathogen levels	+												
d. Size distribution	+												
e. Anticipated yield of compost per ton of refuse	+												
f. Description of measures to control noise, odour, flies, rodents, etc.	+												
g. Other information	+												
10. Oper. and mainten. costs per ton of compost produced and/or per ton of refuse comp.	+												
11. Add. inform. regarding the process and plant helpful for UNIDO/Bahraini evaluations	+												
12. Sludge treatment (not on original request document)	-												
Total questions answered (out of 36):	35	5	34	36	32	1	36	33	34	8	21	35	32

+ Answer provided to question

- Answer not provided to question

COMPANIES

RECOMMENDED TO TENDER

BUHLER BROTHERS LTD.

Buhler Brothers Ltd.

The documents received from Buhler Brothers Ltd. answered thirty-five of the thirty-six questions.

Their reference list refers to over 100 plants built in over 30 years in all climatic conditions.

Their documents show a requirement of 21 men to operate the plant. The fuel requirement is given as 1.2 l/t and the electricity used is 11 kwh per tonne of refuse.

To their maintenance costs must be added the maintenance costs of the existing pulverizing mills.

The construction time is given as 21 months.

The turn-key budget price amounts to US\$ 17,710,000.

The maintenance cost is US\$ 213,000 p.a. plus the maintenance cost of the existing pulverizers which equals US\$ 2.37 per tonne plus pulverizer costs.

This document is for the construction of a 300 t/d plant, not 400 t/d as requested, as they say the machinery will not handle 400 t/d.

In the final tender document we recommend that Buhler be required to submit letters of satisfaction from the owner and operator of the Shoubra/Cairo, Abu Dhabi and Al Ain/U.A.E. compost plants.

We recommend that Buhler be invited to submit a final tender.

Process Description

Buhler offered their own system utilizing the existing pulverizing plant.

After the refuse has been weighed and pulverized, it can be compacted, to by-pass the composting plant, or transferred by conveyor belt to the mixing and screening drum where it is mixed with sewage sludge, from the sludge storage tank or water.

From the drum the material is screened by the integral screen and the oversize rejects are conveyed to the compactor station. The fine materials are moved by a chain conveyor to a belt conveyor, and conveyed to the fermentation area. This belt conveyor incorporates a magnet for fine ferrous metal extraction. From this belt a travelling tripper automatically forms a windrow on each side of the conveyor. Periodically, each windrow is turned by a turning machine and the complete fermentation area is aerated. The retention time in this area is six weeks.

After these six weeks have elapsed, the compost is transported by front end loader to the refining unit.

The material is screened and the medium size fraction is milled and then remixed with the fine fraction. The material is then destoned and passed to the bagging plant or the bulk storage area.

120 tonnes of compost per day are produced and 90 tonnes of rejects must be transported to the dumpsite.

D A N O

with

Motherwell Waste Treatment

The documents received from DANO answered thirty-five of the thirty-six questions.

The reference list refers to over 140 plants built to the DANO system over 41 years in all climatic conditions. Motherwell Waste Treatment have built 10 of these.

Their documents show a requirement of 40 men to operate the plant with a further 11 men if a bagging plant is installed.

The fuel requirement is given as 720 l/day.

The electricity consumption is given as 10 kwh/tonne of refuse.

The operation and maintenance cost is given as US\$ 6.38 per tonne input and US\$ 13.32 per tonne of compost produced.

The construction time is given as 23 months.

The turnkey budget price amounts to US\$ 6,800,000.

Letters of satisfaction have been included in the documentation. We recommend that DANO with Motherwell Waste Treatment be invited to submit a final tender.

Process Description

DANO Switzerland in association with Motherwell Waste Treatment have offered a solid waste and sewage sludge co-composting plant using the DANO system.

This system does not use the existing pulverizing mills but they are retained for emergency use.

The solid waste and sewage sludge enter the plant after being weighed on the weigh bridge. The sewage sludge is from the drying beds and is transferred to a hopper within the reception hall from where it is fed into the drum ram feeder by screw conveyor. The solid waste is fed into the ram feeder by front end loader. The mixture enters the revolving drum where it is pulverized, conditioned, homogenized, and the moisture content is adjusted. The retention time in the drum is four hours.

Upon exit from the drum the material is screened on an integral screen to separate out the oversize rejects. At this point ferrous metal separation should take place, but is has not been quoted.

The organic rich material is transferred by tractor and trailer to the aerated fermentation beds. The rate of aeration is variable. The material remains on the fermentation bed for two to three weeks.

After the fermentation period is complete, the material is moved to the curing and storage area.

After the maturing and curing stages, the compost is final screened. The final screened compost is then bagged or stored for loose bulk sale.

Each day 140 tonnes of refined compost are produced and 231 tonnes of rejects need to be landfilled.

K R U G E R

Krüger

The documents received from Krüger answered thirty-four of the thirty-six questions.

Their documents are submitted in conjunction with De Bartolomeis of Italy.

Krüger have not been the main contractor on any compost plant, but the reference list shows 10 plants built by Bartolomeis although none of these are in hot climates.

Five separate proposals have been submitted, at prices ranging from US\$ 8,060,000 to US\$ 21,380,000.

Operation and maintenance costs are given as US\$ 214 to US\$ 316 per tonne without personnel costs.

Construction time is given as 20 months.

In the final tender document we recommend that Krüger be required to submit letters of satisfaction from the owner and operator of the plant in Seoul and from the owners and operators of the compost plants, of which they supervised the construction, at Giza and Cairo in 1981/82.

We recommend that Krüger be invited to submit a final tender.

Process Description

Krüger have offered the De Bartolomeis composting system.

They use the existing pulverizing plant.

Krüger have submitted five separate proposals with the main differences being in the residence time in the fermentation and post maturation areas and the method of aeration. Krüger say that proposals 1a, 1b, 2a and 2b are in excess of the request for tender but that their 'alternative' proposal meets the requirements. For that reason this process description is based on their 'alternative' proposal.

After the refuse has been weighed and pulverized, it is conveyed to the homogenizing/classifying drum where it is mixed and screened. The oversize rejects are compacted for removal to the dump site. The compostable material is mixed with the dewatered sewage sludge from the belt press. (The mixing method is not described).

The material is then conveyed to the forced aeration digester that has a built-in homogenizer where it has a retention time of 36 hours.

After this time has elapsed, the material is transferred to the post composting area by front end loader. The material stays in windrows for three weeks and is turned every three days by the turning machine. After three weeks

Krüger say that the compost is mature and ready for sale after passing through an unspecified compost refining plant.

172 tonnes of compost will be produced per day and 170 tonnes of rejects will be transported to the dumpsite daily.

NEWELL DUNFORD

NEWELL DUNFORD

The documents received from Newell Dunford answered all thirty-six questions.

Their reference list refers to one composting plant built in Saudi Arabia with machinery (pulverizers) supplied to eight others.

Their documents show a requirement of 30 men plus drivers plus reject drivers to operate the plant.

The fuel requirement is given as 70,000 l/y + fuel for the transport of rejects.

The electricity used is given as 8,000 kwh/day i.e. 20 kwh/t of refuse.

The construction time is given as 22 months.

The turnkey budget price amounts to US\$ 10,380,000.

The operating and maintenance cost is given as US\$ 6.88 plus reject disposal costs, but to this must be added the operating and maintenance costs of the existing hammer mills.

In the final tender document we recommend that Newell Dunford be required to submit letters of satisfaction from the owner and operator of their composting plant in Saudi Arabia and also Newell Dunfords company financial data.

We recommend that Newell Dunford be invited to submit a final tender.

Process Description

Newell Dunford is offering the SILODA process, owned by the competing company O.T.V. Newell Dunford are proposing to use the existing installation. After the refuse has been weighed and pulverized, it is rotary screened to minus 60 mm. The reject is compacted. The fine material is mixed in the paddle type mixing unit with dewatered sludge from the filter presses and additional water for moisture control.

The mixture is transported to one of eight fermentation bays which each hold one day's production. The material is turned from bay to bay by the SILODA wheel and the bays are aerated. After the eight days fermentation conveyor belts transfer the material to the maturation building, where it remains for a minimum of forty-two days.

The material is then conveyed to the refining building, where glass is removed, the material is ground and then screened to 10 mm. It can then be bagged or stock-piled.

195 tonnes of compost are produced daily and 150 tonnes of rejects used to be transported to the dumpsite.

O . T . V .

O . T . V .

The documents received from OTV answered thirty-two of the thirty-six questions.

Their reference list refers to 18 composting plants built over 18 years in all climatic conditions.

Their documents show a requirement of 23 men plus the existing staff to run the plant.

The fuel requirement is given as 0.8 litres per tonne of refuse.

The electricity used is given as 10 kwh per tonne of refuse plus the electricity used by the existing plant.

The construction time is given as 25 months.

The turn-key budget price amounts to US\$ 16,710,000.

No maintenance costs are given.

In the final tender document we recommend that OTV be required to submit letters of satisfaction from the owner and operator of their Hail Saudi Arabian and Muscat-Oman plant.

We recommend that OTV be invited to submit a final tender.

Process Description

OTV have offered their own SILODA composting system which uses the existing pulverizing installation. Centrifuges are installed to dewater the sewage sludge.

After the refuse has been weighed and pulverized, it is screened to below 50 mm in rotating screens. The organic material is conveyed to the mixing units where dewatered sewage sludge and water is added to it.

The mixture is placed by moving tripper conveyors into the bays where it is retained for eight days being turned by the SILODA wheel and aerated through the floor of the bay.

After the eight day fermentation period, the material is transferred to the curing yard by the paddle wheel and conveyors.

It remains in the curing yard for about 45 days in windrows which are not aerated.

The material is taken by front end loader and conveyor belts via a mobile hopper to the refining unit where it is screened to below 10 mm in a rotary screen and then passed through an air classifier for glass removal. The rejects from the

rotary screen are pulverized to increase the compost yield.

From the refining unit the finished compost goes to the storage area.

110 tonnes per day of finished compost are produced and 220 tonnes per day of rejects require to be transported to the dump site.

VOEST - ALPINE A. G.

The documents received from Voest-Alpine answered thirty-four of the thirty-six questions.

Their reference list refers to over 15 plants built in all climatic conditions.

The documents show a requirement of 11 men plus an unspecified number of non-technical personnel to operate the plant.

The fuel requirement is 400 l/day.

The electricity consumption is 4,200 Mwh/yr (approximately 35 kwh/tonne of refuse).

A monetary figure was not given for the operation and maintenance costs.

The turn-key budget price is given as 138,600,000 Austrian Shillings plus 1,600,000 Bahraini Dinars which totals to US\$ 15,330,000.

Letters of satisfaction have been included in the documentation. It should be noted that Voest-Alpine is also a member of the Agrobio consortium which we have rejected as not meeting the requirements. It should also be noted that this document contains a large number of exclusions.

We recommend that Voest-Alpine be invited to submit a final tender.

Process Description

Voest-Alpine offered their own system. This uses the existing lines of the refuse pulverizer plant.

After the incoming refuse has been weighed and passed through the existing plant to the discharge box of the reversing conveyor, it is screened in the sieving drum to less than 50 mm. Rejects are compacted and transported to the dumping site by trucks.

Conveyors transport the fine material to the mixing drum where it is mixed with sewage sludge from the sludge tank. The volume of the sewage sludge added is metered automatically.

The mixed material is transferred to the pre-composting area by conveyor belt, where it is stacked automatically. Forced aeration is used with the exhaust gases being passed through a deodorizing compost filter. The intermittent aeration is automatic. The retention time in the pre-composting area is 21 days.

After this pre-composting period, the compost is taken by front end loader to a feed hopper, where it is transferred to the post-composting area by conveyor belt. Again it is stacked, watered and aerated automatically with the exhaust gases passing through another deodorizing compost filter. The retention time in the post-composting area is 60 days.

After these 60 days, the compost is taken by front end loader to a feed hopper, from where it is transferred by conveyor belt to a dressing, screening and de-stoning installation. From here it can be automatically bagged or stored in bulk.

The output is 88 tonnes/day of screened compost and a total of 140 tonnes per day of rejects need to be transported to the dumpsite.

M A S S B A L A N C E (t / d)

	Bühler	DANO	Krüger	Newell Dunford	O.T.V.	Voest Alpine
<u>INPUT</u>						
Solid refuse	300	400	400	400	400	400
Sludge	<u>60</u>	<u>113</u>	<u>250</u>	<u>400</u>	<u>250</u>	<u>16</u>
TOTAL INPUT	360	513	650	800	650	416
<u>OUTPUT</u>						
Iron	15	--	46	40	40	21
Glass/stones	7,5	--	20	4	25	6
Screenings	82,5	231	150	146	195	134
Compost	120	140	172	195	110	88
Waste water	--	--	174	309	210	--
Fermentation losses	<u>135</u>	<u>142</u>	<u>88</u>	<u>106</u>	<u>70</u>	<u>167</u>
TOTAL OUTPUT	360	513	650	800	650	416

PRICE LIST

	Bühler	DANO	Krüger	Newell Dunford	O.T.V.	Voest- Alpine
Capital costs (\$)	17,710.000	6,800,000	8,060,000 - 21,380,000	10,380,000	16,710,000	15,330,000
O + M costs:						
Personnel (men)	21	40 (+11)	15 - 18	30+	23+	11+
Electricity (kwh/t)	11	10	10 - 14	20	10	35
Fuel	1,2 l/t	720 l/d	0,4 l/t	0,6 l/t	0,8 l/t	1 l/t
O + M total (\$)	-	6,38 13,32 (on compost)	2,14 - 3,16	6,88	-	-

Note: The following exchange rates for the conversion of different currencies into US\$ were used:

1 US\$ equals 1,525 SFR
 0,647 LST
 6,862 DKR
 5,986 FF
 12,900 AS
 0,324 BD

COMPANIES

NOT

RECOMMENDED TO TENDER

A G R O B I O

This bidder is a consortium consisting of 15 to 20 separate companies including Voest Alpine who have entered a separate proposal. Their system is based on introducing an innoculum of laboratory bred biological micro-organisms into the wastes to speed up the composting process.

No independent scientific research has proved the effectiveness of the innoculum method as all the necessary micro-organisms occur naturally in organic wastes.

The documents presented did not answer fifteen of the thirty-six questions. The volume of proposed delivery and the price data are not clear and for example not completed for the electrical equipment, mobile equipment, erection, commissioning and training.

It is recommended that Agrobio is NOT invited to tender.

DEUTSCHE BABCOCK ANLAGEN A.G.

The documents received from Babcock answered thirty-two of the thirty-six questions. In spite of the short preparation time, the documentation was comprehensive and complete. We appreciate their expertise in refuse incineration, but we also realize their lack of experience of composting in hot countries.

The compost proposal does not meet the requirements for pathogen reduction due to the short retention time in the fermentation area and the lack of a maturation area.

We have strong doubts about the viability of the fine screening prior to the fermentation period.

We recommend that Deutsche Babcock Anlagen AG is NOT invited to submit a final tender.

H A Z E M A G

Hazemag failed to answer thirty-one of the thirty-six questions. The documents do not specifically refer to the requested composting plant in Bahrain.

From the information presented, it appears that their last plant was built in 1976, that they have not built a turn-key plant and that they have no experience of composting in hot climates.

It is recommended that Hazemag is NOT invited to tender.

SKANSKA

SKANSKA failed to answer thirty-five of the thirty-six questions.

They do not have experience in the field of composting and do not refer to the requested composting plant.

It is recommended that SKANSKA is NOT invited to tender.

S O F R E G A Z

Sofregaz answered all thirty-six questions.

Their proposal was not for a composting plant but was for a methanization plant with the capacity of 100 tonnes per day refuse instead of the requested 400 tonnes per day.

As a methane production plant was not asked for, it is recommended that Sofregaz is NOT invited to tender.

TAYLOR WOODROW

Taylor Woodrow answered thirty-three of the thirty-six questions.

The proposal was for a plant that makes methane from the wastes and not for a compost plant as specified. The capacity of the proposed anaerobic methanization plant is 200 tons per day refuse only, instead of 400 tonnes per day.

It is recommended that Taylor Woodrow is NOT invited to tender.

W. P. F.

W.P.F. did not answer twenty-eight of the thirty-six questions. They gave no indication of their experience.

The second and final page contained a garbled sentence and the letter was unsigned and undated.

They did however quote a price of US\$ 21,780,000 and required a management fee of US\$ 465,000 per year.

It is recommended that W.P.F. are NOT invited to tender.