環保能源科技有限公司
New Energy and Nano-Technology Co. Ltd.

Nov 19, 2004.

The Environment, Transport and Works Bureau
10/F., Citibank Tower,
3 Garden Road,
Central,
Hong Kong.

Dear Sir / Madam,

<u>Responses to the Government Public Consultation on the way Forward for Stage 2 of the Harbour Area Treatment Scheme (HATS)</u>

In response to the question raised, we have the following comments.

1. Do you agree with the preferred option, i.e. Option A – centralized treatment at Stonecutters Island?

Yes, basically we agree, as the total cost (HK$ 19.1 billion) will be the lowest, among the options.

2. Do you agree with that Stage 2 should be implemented in two phases, i.e. HATS Stage 2A and Stage 2B?

Yes, we agree to implement in two phases. One of the reasons is that the technology for biological treatment still needs to be evaluated more carefully and also some other new technologies may be matured for coming few years and at that time, the cost may be even lower than biological treatment proposed now. (Also, TiO_2 is more effective than UV light proposed.)

Besides, the technology of Reserve Osmosis can also be used for water purification on other non-drinking proposes, and the quality of the purified water can already meet the drinking standard. (Please refer to the report for the testing of our Reserve Osmosis Unit with Water Supplies Department on early 2004, and the result of the water quality shows that it is acceptable.)

3. Do you agree that protecting the water quality of Victoria Harbour is essential and that it is worth you paying higher sewage charges in line with the "Polluter pays Principle"?

Yes, we agree the protecting the water quality of Victoria Harbour is very important, hence, instead of discharging the treated water back to the sea, it should be considered to purify the treated water by some effective ways, like Reserve Osmosis technology, so that the purified water can be re-used. The purified water can be served an income for reducing the need for increasing the sewage charges required for such project, instead of charging the users. (Please refer to the Reference paper with title: Membrane-based water reuse in Kuwait.)

Yours faithfully,

Louis Ching

Louis M T Ching, New Energy and Nano-Technology Co. Ltd.
Re. Consultation booklet received on the Pool-side Gathering organized by Mr. Leung Wai On

[redacted]

Report on the Demonstration of the Reserve Osmosis Water Purifier Unit – BlueBox 1200 in Au Tau Water Treatment Plant during Jan 12 to 16, 2004

Submitted to

Mr. C K Ip,

Senior Engineer,

Water Supplies Department

By

Louis MT Ching,

New Energy and Nano-Technology Co. Ltd.

dated March, 2004

A. Our Company

Our company, New Energy and Nano-Technology Co. Ltd., are an energy service, consulting and engineering company in Hong Kong, working on new environmental-friendly technologies, in Renewable Energy (Wind/ Solar PV / Solar Heating / Solar Cooling), Fuel Cells & Hydrogen Storage Systems, and Nano-coating, including photocatalytic TiO2 coating on glass / curtain wall for self-cleaning.

We supply, design, install, test, commission, and provide maintenance for the following:

1) Solar water heaters and/or full systems;
2) Solar water collectors systems;
3) Solar PV panels; Solar PV System for lighting, etc.;
4) Solar / Wind Hybrid systems; Wind and Hydro-power systems;
5) Mobile Water Purifiers (Reserve Osmosis) and related Water Supply / Purification Systems;
6) Fuel Cell Systems and associated Hydrogen Storage System; and
7) Gas Detection System for Landfill Gas and other combustion gases.

B. Our Expertise Team

One of our expertise team member, Mr. Louis MT Ching, B.Sc.(Eng.) (HKU 1984) has been working for CLP Power Co. Ltd. and Hong Kong & China Gas (Towngas) Co. Ltd before, with technical background in Electrical, Mechanical, Gas and Energy Engineering.

Another member of the team, Mr. Vincent Kan, B.Sc. (Chem.) (HKU 1983) has been worked in various multi-national companies, including Fortune 500 Company, and has been set up a wholly-own subsidy in Shanghai, with profits reported starting from its 1st year operation.

C. Our Reserve Osmosis Water Purifier - BlueBox 1200

Our company has got the exclusive distributor right for the Reserve Osmosis Water Purifier – BlueBox for the region of Hong Kong and China, from the supplier Pure H2O A/S of Denmark (www.pureH20.net). The BluxBox unit has a cleaning capacity of about 1,200 liters of water per hour. The unit weighs about 225 kilos and has a volume of less than a cubic meter. The plant is very sturdy and reliable, thus can be used in even the most inaccessible areas. The BlueBox unit may also be used for permanent water supply in smaller townships, where a combination of a water tower and a BluxBox plant make up a complete waterworks, with the clean fresh water from untreated or contaminated surface ground water and waters from wells.

The plant employs a self-priming diaphragm pump, which sucks the water in directly from the source. The following filtration process removes virus, bacteria, heavy metals and pesticides, etc. The purified water is finally exposed to strong UV lighting killing off all micro organisms.

D. The Supplier – PureH2O

Pure H2O A/S is a Danish owned company producing and marketing mobile/stationery water purifiers for use in areas affected by natural disasters or other places where clean drinking water is scare. The project reference of the BlueBox 1200 unit is attached in Appendix A.

E. Potential Applications of the BlueBox 1200 in Hong Kong

There are 20 remote villiages in Hong Kong, without fresh water supply, inlcuding Sam A Tsuen, Lai Chi Wo, Yung Shue Au in New Terretories. Besides, there are about 10 outer islands in Hong Kong, without fresh water supply, including some islands with electricity, like Shek Kwu Chau, Hei Ling Chau, Tap Mun Chau, and some without electricity, like Po Toi Island, Tung Ping Chau, Town Island.

Due to the incresing interests in Eco-tourism, it leads to the fresh water requirements for the visitors and/or island villiagers for some outer islands, where there are the hot spots for eco-tourism, like Tung Lung Island. In order to meet these requirement, expensive pipline laying cost may be resulted, if the water pipline was being layed from the main water pipeline to the remote villiages for providing fresh water. However, with our water purifier unit BlueBox 1200 to purify the existing ground water, either stream water or water from wells, there will be no need to lay the expensive pipling laying cost, and hence achieve a lot of savings..

Besides, the BlueBox 1200 unit can also be used for the following applications:

1) For Drainage Services Dept, to purifier the final treated water which will be discharged back to the sea now. Once with our unit, the water can be purified into drinking-standard clean water, which can be used for street-washing and plants by other dept. (Food, Environment and Hygiene Dept.), to reduce the waste of using fresh water now.
2) For seafood market in Aberdeen and others, in which artificial salt can be added to the purifier water from our unit, to replace the existing sea water, containing bacteria and virus.
3) For areas with contaminated water problem or other areas for emergency applications, such as water supply shortage due to piping bursting.
4) For hospitals and others important facilities, to provide clean drinking water from suspected contaminated water, such as SARS, H5N1 and other virus.

Hence, we approached water supplies department for the introduction of the BluxBox 1200 unit, and thanked to Mr. CK Ip, Senior Enginer and his collegues for the arrangement of the trial testing of the BluxBox 1200 unit in their water treatment plant. We then spent in our own to transport one set of the unit to Hong Kong in early Jan 2004, and thanked to the staff of Water Supplies Dept to arrange for the testing in their Au Tau Water Treatment Plant on the afternoon of Jan 13-16, for purifier the untreated water received from Mainland China.

F. Program Rundown of the Trial Test

The summary of the program rundown, agreed with Water Supplies Department, as follows:

Jan 12 (Mon)	Setting up of the Mobile Water Purifier
Jan 13 (Tue) - Jan 14 (Wed)	Demo A: Demonstrate the operation of the unit to be run by diesel (or petrol) engine
Jan 15 (Thur) - Jan 16 (Fri)	Demo B: Demonstrate the operation of the unit to be run by batteries with inverters and solar panels

G. Objectives setting for each part A and B (Demo A and B)

A) Objectives for Part A of the demonstration (Demo A) on Jan 13 and 14:

1) To demonstrate the operation of the unit run by diesel (or petrol) engine,
2) To take water sample for testing of water quality including the bacteria and metal content,
3) To measure or verify the output rate of fresh clean water output.

B) Objective for Part B of the demonstration (Demo B) on Jan 15 and 16:

1) To demonstrate the operation of the unit run by batteries with inverters and solar panels,
2) To take water sample for testing of water quality including the bacteria and metal content,
3) To measure and verify the output rate of fresh clean water output.

H. Demonstration details arrangements

A) Demo A (Jan 13 & 14)

1) To run the unit continuous by a diesel engine for few hours per day, totally for 2 days.
2) The untreated raw water taken from Au Tau water plant will be prepared in a tank.
3) After the unit runs for some times, the output rate of the clean fresh water was measured, together with the power consumption.
4) After the unit runs for few hours, some samples of the water output will be taken to the nearby laboratory for testing the amount of metal and bacteria.

B) Demo B (Jan 15 & 16)

1) To introduce the set-up and the connection of the water purifier unit to the inverters and batteries, that can be powered by solar panels.
2) To run the unit continuous by batteries with inverters for few minutes to demonstration the application of BluxBox unit for islands, such as Po Toi Island., with some water samples taken, and water output rate & power consumption measured, if time is allowed.
3) To demonstrate (if sunshine is good), otherwise explain how the unit can be powered by batteries that can be charged up by solar panels for other departments of Water Supplies Departments, especially Mr. HY Chow & Mr. TH Chan, and discuss the operation mechanism for solar/wind hybrid system for outer Island and other matters, if any.

I. Technical Details of Equipment

1) BluxBox 1200 Unit (can be operated by grid AC 220V or 110V, diesel generator, etc.)

General Description: Reserve Osmosis Water Purifier Unit

Model Reference No.: BlueBox 1200 Electrical (with Pump Unit 2200 Electrical)

Description: (1) BlueBox 1200, for 220 V at 1500 Watt, with capacity 1200 liters per hour, including:

a) 100 micro, 25 micro and 5 micro pre-filtering;

b) Active Carbon filtering;

c) Reserve Osmosis membrane filtering;

d) UV Filtration.

(2) Pump Unit 2200, for 220 V at 1500 Watt, with Double Diaphragm pump, with capacity 2200 liters per hour, including:

a) Pump Type 600/7, lifting height: 6 m (maximum)
1" suction port, 1" pressure port

b) Engine fabricate ABB, 1,5 kW., 695 rpm. B3, IP54
Type M3AA112M-8, 3x230/400V 50Hz, 21 NM

c) Inverter fabricate ABB, 2.2 kW.-1x230V / 3x230V, IP 54

Working Pressure: 8 Bar

Gross Weight: 195 kilos

Dimension: 1.20 (L) x 1.00 (W) x 0.80 (H) m

Connection: All connections are fitted with quick couplings to ensure fast set-up.
Raw water intake: 1"
Clean water outlet: ¾"
Waste water outlet: ¾"

2) Petrol Generator

Brand/Model: Robin RGV 10000

Power: 10000W (10KW)

Fuel: Petrol (Unleaded Super Petrol)

Starting Method: By 12V DC battery

3) Solar panels

Brand/Model: one 150W/12V and one 120W/12V in series to give 24V output power

(It should be pointed out that two 150W solar panels should be used, however, as we do not have two 150W on-hands, therefore we use one 150W/12V and 120W/12V. As they are connected in series, it is still acceptable, although not preferable.)

Output/Connection: 12V for 150W and 120W connected in series to give 24V output power

4) Batteries

Brand/Model: two 12V/44Ah batteries in series giving a battery bank of 24V output. The batteries should be charged by solar panels during good sunshine condition.

(A charge controller is preferable for charging the batteries, to extend the batteries life.)

Running time estimation:

A current of about 105A (at 24V output) was drawn for the 2.5kW inverter to provide electricity power for the water purifier, therefore, the running time is estimated to be about 10 minutes, if the batteries is started from fully-charged condition. Also, due to the internal setting of the inverter of 40% for low-battery cut-off, actual running time will be even less.

Charging method:

Due to the sunshine conditions on Jan 14 and 15 are not too good, and Jan 16 is even a raining day with very thick dark clouds, we did not charge the batteries by solar panels, otherwise it will NOT be in fully charged condition and affect the running time for the demonstration. Instead we charge the battery by power from petrol generator as well as from grid later (so as to save the petrol for further demonstration).

5) Inverter

Power: 2500W DC to AC inverter

Type: Modified sine wave inverter

Input: 24V DC

Output: 230V AC 50Hz

Options: with a built-in AC charger to charge the batteries from AC power

The photo (in left) showing the BluxBox 1200 unit that borrowed from the agent in South Korea for our demonstration in Hong Kong with Water Supplies Department.

J. Results and Measurements

1) 13 Jan 2004

The purifier was started at 2:15pm and finished at 3:30pm.

Time	Power	Pressure (bar)	Treated water flow rate	Rejected water flow rate
3:00pm	missed	9 bar	20 liters per 1min 45sec	20 liters per 1min 35sec
3:30pm	missed	10.5 bar	20 liters per 1min 30sec	20 liters per 2min

2) 14 Jan 2004

The purifier was started at 3:35pm and the water samples were collected at 3:45pm. The purifier was stopped while we were delivering two water samples to Tuen Mun WTW. The purifier was restarted at 4:30pm.

Time	Power	Pressure (bar)	Treated water flow rate	Rejected water flow rate
4:45pm	missed	9 bar	20 liters per 1min 50sec	20 liters per 1min 28sec
5:00pm	missed	10.5 bar	20 liters per 1min 30sec	20 liters per 2min 5 sec

3) 15 Jan 2004

The purifier was started at 2:45pm using solar batteries with the inverter to power up the purifier (at 9 bar) for only 2 minutes, then the batteries were run out of power.

The purifier was re-started again at 3:00pm using local electricity power (grid power) supply to start up the purifier (at 13 bar) for only a few minutes was stopped because of burned fuse.

The purifier was re-started at 3:15pm using local electricity power (grid power) supply to start up the purifier (at 11.5 bar), after a new fuse is replaced.

Time	Power	Pressure (bar)	Treated water flow rate	Rejected water flow rate
3:15pm	missed	11.5 bar	20 liters per 1min 20sec	20 liters per 1min 45sec

4) 16 Jan 2004

The purifier was started at 2:25pm using grid electricity power (grid power) supply to start up the purifier (at 9.75 bar) and stopped at 2:40pm.

Time	Power	Pressure (bar)	Treated water flow rate	Rejected water flow rate
2:25pm	missed	9.75 bar	20 liters per 1min 30sec	20 liters per 1min 30sec

The purifier was re-started again at 3:00pm using grid electricity power (grid power) supply to start up the purifier (at 12 bar) and stopped at 3:20pm.

Time	Power	Pressure (bar)	Treated water flow rate	Rejected water flow rate
3:00pm	1.5kW	12 bar	20 liters per 1min 17sec	20 liters per 1min 30sec

K. Evaluation and Discussion

1) Lower output rate or purified water measured

Based on the measurement, we can calculate the output rate of purified water and rejected water at various pressures setting, as follows:

Date	Time	Pressure (bar)	Power consumption	Purified water output rate (liter / hour)	Rejected water output rate (liter / hour)
Jan 13	3:00 pm	9	N/A	686	758
Jan 13	3:30 pm	10.5	N/A	800	600
Jan 14	4:45 pm	9	N/A	655	818
Jan 14	5:00 pm	10.5	N/A	800	576
Jan 15	3:15 pm	11.5	N/A	720	686
Jan 16	2:25 pm	9.75	N/A	800	800
Jan 16	3:00 pm	12	1.5 kW	935	800

The measured purified water output is less than the expected 1200 liters per hour. Hence, we forwarded the question to the supplier and some possible reasons were suggested as follows:

- *The output may vary due to different circumstances such as: raw water temperature (warm water will increase the output), pre-filters need to be changed (if output rate drops), RO membranes need to be cleaned (if output rate drops).*

- *The normal working pressure, as suggested by the supplier for the Bluebox unit, is 8 - 10 bars. However, as from the RO membrane filter's website, it is suggested that the typical operation pressure is around 13 bars, and max. 31 bars. And the higher the pressure, the higher the output will be.*

Based on the reply from the supplier, as the demonstration unit was borrowed from the agent in South Korea, we did not know whether the filters of the unit had been cleaned (or changed) before the demonstation, and how long it had been used before our demonstation, and hence, it might affect and reduced the water output rate, if the filters were already very dirty and needed to be cleaned or changed.

2) <u>Initial result of water samples showing turbidity is slightly high during trial test</u>
The initial result of the water samples showed that the Turbidity of the water output is little bit higher, around 0.45 unit, in which they would expect 0.1 unit for water after RO. Besides, some very small white fibre-shape substances are seen floating in one of the water sample. The reply from the supplier is as follows:

- *Since the unit has been on storage for quite a while, the system probably needs to be cleaned and to have new pre-filters. The small fibres you have seen is probably some material form the RO membranes. It is not harmful in any way, but it indicates that water has been in standstill inside the unit for a long time. This also explains the problem with turbidity.*

Based on the reply, we believe the BlueBox unit is already really used for some times, and already kept in the agent in South Korea for a quite long time, and hence, the filters may meed to be cleaned and changed.This also explain the lower output rate of purified water.

3) <u>Function of the activated carbon before RO membranes</u>
It was also raised by Mr. SY Ho, waterworks chemist of Water Supplies Department, that the function of the activated carbon before RO membranes, and we got the reply form supplier as follows:

- Activated carbon is similar to ion exchange resin in density and porosity. It adsorbs many dissolved organics and eliminates chlorine and other halogens in water. It does not remove salts. Active carbon filters are one of the only low-cost methods available to remove low molecular weight (<100MW) organics and chlorine. Since the RO membranes will be damaged when being in contact with chlorine it is necessary to use activated carbon in order to protect the RO membranes. Furthermore Activated Carbon is used to reduce colour level, taste and smell.

4) <u>Function of the UV light after RO membranes</u>
If was also concerned about the function of the UV light after RO membrane, which was mainly used as a precaution procedure, as well as to kill any micro organisms, if any. However, the UV light needed to be waited for few minutes after started, to reach the fully on condition. If the water samples were taken too early after the start-up, some general bacteria plant count might observe. This might also occur when small trace of purified water had been kept in the RO membranes for long time, after being used without washed.

5) <u>Design of the unit for running continuous 24 hours a day with solar panels for Islands</u>
Two questions were received afterward as follows:

Q1. *Your mobile purifiers have a power consumption of 1500W, how many solar panels do you need to support the mobile purifier running for 24 hours continuously*

Q2. *How much energy can your solar panel of size (1580 mm x 788 mm) be generate under the Hong Kong condition of mean daily solar radiation of 14.46MJ/m2 and sunshine days are about 5.3 hours per day.*

The number of solar panels required should be around 73, as calculated below. The following is only a preliminary estimation, it is recommended to measure the actual solar radiation on the installation site for more accurate calculation.

1) For power consumption of 1500W operating for 24 hours:
Total power consumption = 36 kW-hr
Allow 15% loss for inverter and cable, total power required = 36 kW-hr / 0.85 = 42.35 kW-hr
For a mean daily solar radiation of 14.46 MJ/m2 and 5.3 sunshine hours per day, the irradiance= 14.46MJ/m2 / (5.3 x 60 x 60) = 758W/m2
Based on the characteristic chart of 150W panel, the power output is about 110W
With 5.3 sunshine hours per day, power generated per 150W panel per day = 583 W-hr
Total number of 150W panels required = 42.35 / 0.583 = **73**
(If the power output is not in maximum condition, then more panels are required.)

(Remarks: If the installation location has good wind resources, say Po Toi Island, it is recommended to use wind turbines and supplemented by solar panels, then the price will be lower than purely solar panels. For your information, a 10kW wind turbine can produce around 48 kW-hr per day, which costs about HK$200,000.)

2) For our 150W solar panels, the size is 1580 x 788 mm, and the glass area (receiving sunshine) is 1574 x 782 mm, that is 1.23 square meter net area.
As the efficiency of the panel is around 12% (for completed module, which is slightly less than 13.3% of solar cells, due to the reflection of top glass of the complete module reducing the intensity of the incoming sunlight), hence, for a mean daily solar radiation of 14.46 MJ/m2 in HK, energy generated = 2.13 MJ per day (= 14.46 MJ/m2 x 1.23 m2 x 12%)

Should you require any further information, please do not hesitate to contact us.

Louis MT Ching, March 2004

Membrane-based water reuse in Kuwait

Described as 'the Wastewater Deal of the Year' and the 'World's Largest Membrane Re-use Project', Ionics Incorporated and Mohammed Abdulmohsin Al-Kharafi & Sons have teamed up on the massive Sulaibiya project. Guido Vaccaro of Ionics Inc., Italba S.p.A reports on the progress of this Middle Eastern benchmark.

In May 2001, a consortium including Mohammed Abdulmohsin Al-Kharafi & Sons (The Kharafi Group) and Ionics Inc. won a 30-year concession from the Kuwait government to recover municipal wastewater from Kuwait City and the surrounding area.

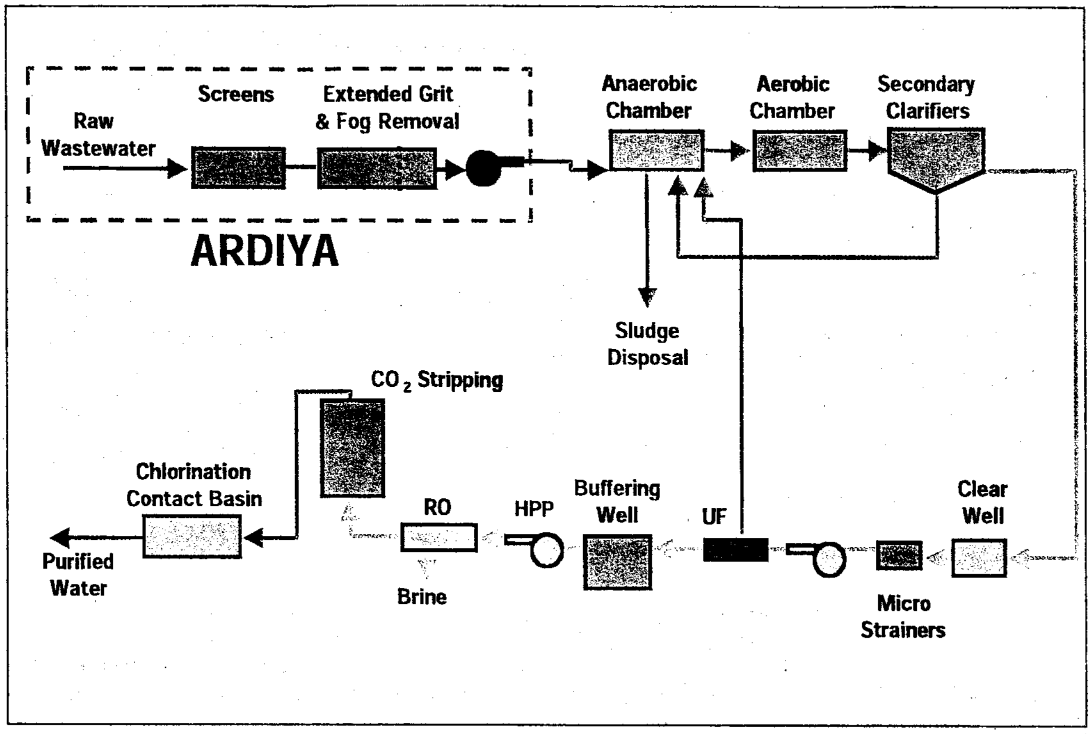


Figure 1: major treatment steps at Sulaibiya.

The consortium is engaged in the design, build, own, operate and maintenance of a 100 million gallon per day (mgd) wastewater treatment facility at Sulaibiya situated near Kuwait City [1]. Sulaibiya is reportedly the world's largest membrane-based water reclamation facility currently under construction.

The purified water from Sulaibiya will be used for non-potable uses that are currently impacting the drinking water supply, by blending with brackish water to better exploit existing brackish water distribution facilities.

In designing the world's largest membrane-based water reuse plant, the team opted to use well-proven processes. The major treatment steps for the project are shown in *Figure 1*. Municipal effluent is given preliminary treatment at Ardiya and then piped 25 kms to the Sulaibiya plant. A conventional biological wastewater treatment plant (WWTP) treats the effluent to better than secondary effluent quality.

The secondary effluent then flows to the water reclamation plant, which uses ultrafiltration (UF) and reverse osmosis (RO) to further purify the water for reuse. Sludge from the wastewater treatment plant is treated to allow for disposal by landfill, incineration, or by composting.

Accommodating peaks

The water quality used as the basis of design and the projected treated water quality are detailed in *Table 1*. The plant influent is typical domestic sewage.

The WWTP design average monthly value is 5 mg/l BOD and 10 mg/l TSS, considerably better than the original requirement of 20 mg/l BOD and 20 mg/l TSS. However, the water reclamation plant is designed to accommodate peaks in water quality due to upsets in performance of the WWTP. The average total dissolved solids (TDS) in the feed is 1280 mg/l, and the plant product will be less than 100 mg/l, significantly better than World Health Organization (WHO) potable water guidelines.

WWT Plant

The Kharafi Group's extensive experience with constructing and operating sewage treatment plants in Kuwait was used as a basis for the wastewater treatment plant design.

Preliminary treatment at Ardiya consists of particulate & grit removal, and oil & grease removal. The waste is then pumped to Sulaibiya. The WWTP consists of anaerobic, anoxic and aerobic systems for enhanced biological removal of nitrogen and phosphorus, plus secondary clarifiers. To minimize variation in flow, buffer volume was taken into account in the design of the facilities at Ardiya, the aeration basins and the clarifiers.

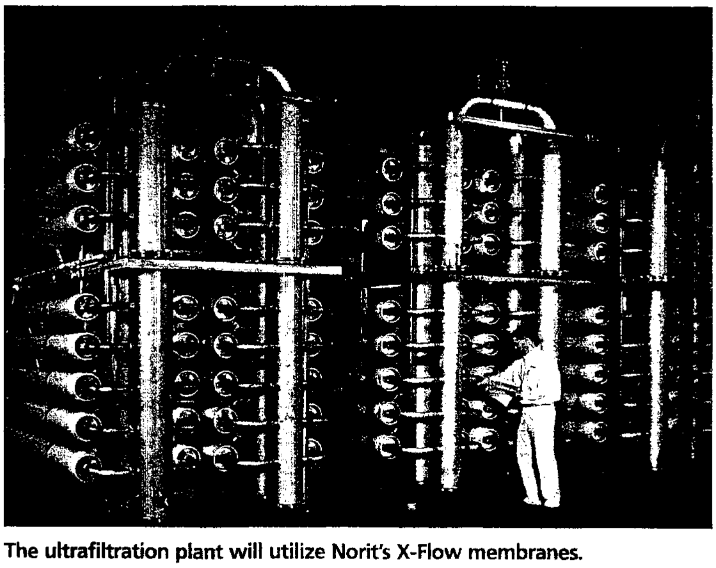
Sludge treatment involves aerobic digesters and drying beds. This process is well-proven in Kuwaiti conditions, and was selected for low odour, low operation & maintenance costs, minimum sludge quantity for disposal, and the environmental benefit of being able to use the sludge as a soil conditioner or organic fertilizer.

Water Reclamation Plant

The water reclamation plant is designed to treat 375,000 metres³/day (100 mgd) of secondary effluent, which will be prefiltered with disk filters and then fed to the ultrafiltration system. UF product feeds a reverse osmosis plant, and UF waste is recycled to the WWTP. The UF system will treat 100% of the flow after biological treatment since the UF waste is recycled. Hence the feed to the RO system is also 100 mgd. The RO plant is designed for 85% water recovery, so the expected production rate is 85 mgd.

Ultrafiltration System

Membrane filtration was selected to provide robust pretreatment of the secondary-treated municipal effluent before being fed to the RO. The reason was that in contrast to conventional tertiary clarification and filtration, membrane filtration reduced the plant chemical consumption and could guarantee that low turbidity water is fed to the RO. It is expected that better quality pretreatment to



The ultrafiltration plant will utilize Norit's X-Flow membranes.

the RO will lead to longer membrane life, lower operating pressure, and reduced cleaning frequency for the RO system. Also, the combination of UF and RO removes bacteria and pathogens and provides potable quality water suitable for agriculture or groundwater recharge.

Bids for the membrane filtration system were solicited from major suppliers of membrane filtration equipment. After a thorough evaluation, Norit's UF technology was selected.

Membrane specification

The technology was selected both for favorable life cycle costs and, since this is a UF membrane, for the better quality of water to the RO membranes. The ultrafiltration plant will utilize Norit's X-Flow membranes, which are capillary hydrophilic hollow fibres. These membranes are packaged in 8" x 60" membrane elements that provide 35 metres^2 of membrane area per element.

Four membrane elements are placed inside a membrane housing, and thirty-two membrane housings are installed in each UF unit [2]. This plant consists of 68 skids, each with 32 membrane housings for a total of 8,704 membrane elements. The plant will be operated continuously and is fully automatic, with very little operator attention required.

The UF units are operated individually. Each unit is backwashed regularly, whereby all suspended matter that is being retained by the membranes is removed from the plant. The backwash water is pumped back upstream of the WWTP to achieve the highest possible overall water recovery for the plant. Occasionally, a low dose of chemicals will be added during a backwash.

This Chemically Enhanced Backwash (CEB) will remove any matter that may have adhered to the membrane surface and is not removed by a hydraulic backwash alone. Since the backwash and CEB actions are scheduled on an individual unit basis, taking only a minor section of the plant out of filtration mode, the continuous flow of effluent from the biological plant can be accommodated.

The effluent fed to the UF first passes through a disk filter, after which a small amount of coagulant is added to coagulate fine particulates and possibly allow some TOC removal to facilitate the operation of the plant.

The SDI15 of the UF product will be below 2, an important criterion for the RO plant performance. Previous experience treating secondary municipal effluent with UF has shown that SDI values of less than 1 are possible.

RO System

The salinity of the municipal effluent has an average monthly value of 1,280 mg/l TDS, with a maximum value of 3,014 mg/l. RO will be used to desalinate the water to 100 mg/l TDS, as well as provide a second barrier to bacteria and viruses.

RO technology is well proven for desalinating municipal effluent. The system will consist of 42 identical skids in a 4:2:1 array. Approximately 21,000 membranes will be required for this project. The RO system is limited to operating at 85% recovery and will be limited for this plant by calcium phosphate precipitation, which can frequently be the limiting factor for water recovery in membrane systems desalinating municipal effluent.

The RO product will pass througha stripper to remove carbon dioxide to adjust pH with a minimum amount of caustic before distribution, and the product will then be chlorinated before leaving the plant RO brine is disposed of to the Persian Gulf.

Guidelines	WWTP Effluent Average monthly value	Water Reclamation Plant Product Average monthly value	WHO Potable Water
PH	7	6 - 9	6.5 - 8.5
TSS (mg/l)		12	<1
BOD (mg/l)	5	<1	
Ammonia Nitrogen as N (mg/l)	<2	<1	
Nitrate (mg/l as N)	<9	<1	10
Phosphate (mg/l as PO_4)	<15	2	
Fat, Oil & Grease(mg/l)	<0.5	<0.5	
Conductivity (µS/cm)	2000		
TDS (mg/l)	<128.0	100	100

Table 1: Water Quality Data - plant influent is typical domestic sewage.

Plant Operation

Since this is a build, own, operate and maintain contract, the consortium will also be responsible for running the plant once construction is complete. The Kharafi Group will operate & maintain the WWTP and Ionics will operate the water reclamation facility. The Kharafi Group has extensive experience in the Gulf and internationally, and has previously operated other WWTPs in Kuwait.

Ionics owns and operates over 120 membrane installations around the world, and operates 40 additional installations. This vast array of experience will be beneficial for the operation of the Sulaibiya facility.

To ensure ease of operation, operator input was solicited at design stage. The treatment steps have been selected to minimize the use of power and chemicals, and are simple to operate and maintain. A high degree of standby equipment and redundancy was incorporated into the design to ensure reliable operation.

A key to the successful operation of a world-class facility such as Sulaibiya is to employ highly trained and motivated staff. Operating personnel will include a number of managers, chemists and engineers, as well as qualified technicians and laborers. Training to the appropriate level will be provided at the manufacturers' premises and on-site during commissioning and testing. During start-up and commissioning of the facility, a total of 42,000 person-days of training are expected to occur. Continuous performance monitoring of the plant will be necessary to ensure compliance with the required standards and for process monitoring and control.

There will be on-line monitoring of flow and water quality parameters. Key process parameters will be calculated and trended to ensure that the plant is performing up to expectations. An on-site laboratory will be fully equipped to carry out the required water analyses.

Summary

Construction on site is well underway, and both the project scale and progress can be seen from the photographs of the RO and UF buildings. The civil work is approximately 80% complete, and mechanical/electrical installation is about 30% complete (with some variation between different parts of the facility).

The installation of the equipment in the UF and RO buildings began in June 2003. The first phase was commissioned in mid-2004, and the full plant is expected to be in operation by the end of this year.

This project will convert 100 mgd of municipal effluent (expandable to 160 mgd) to 85 mgd of high quality reclaimed water that will be used for agriculture, providing an alternate source to potable water in Kuwait.

The project uses proven technology both for the wastewater treatment plant and for the water reclamation facility. A combination of UF and RO will provide bacteria, virus and TDS removal, producing water that meets potable water quality standards.

This project is expected to provide the benchmark and catalyst for the successful implementation of similar BOT projects in the Middle East region.

References

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