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Arab Fertilizer Association  
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# Papers

**AFA Workshop:**

## Renewable Energy in Fertilizer Industries & Energy Auditing

**April: 28-30, 2013**  
**Amman - Jordan**

*Le* **MERIDIEN** Amman Hotel

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**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Program**

# PROGRAM

## DAY 1: April 28<sup>th</sup>, 2013

**08hr: 30      Registration**

**10hr: 00      Opening Cermony**

**Welcome address :**

- Dr. Shafik Ashkar, AFA Secretary General

**Opening Speech :**

- Mr. Jamal Sarayrah , AFA Board Member,  
Chairman, Arab Potash Company, Jordan

**10hr: 30      Networking Coffee / Tea**

**11hr: 00      Session I**

- 1- Jordan Energy Strategy- Renewable Energy Program**  
Yacoub Marar/ Solar Energy Section Head - MEMR - Jordan
- 2- Energy Conservation in Industry**  
Muhi aldeen Tawalbeh - NERC / RSS- Jordan
- 3- Feasibility and potential of renewable energies industries**  
**Feasibility study hybrid power plant with renewable energies,**  
Axel Ceglie Swoboda- Austria
- 4- The Stamicarbon low energy urea melt plant**  
Jo Meessen - Principal Engineer – Stamicarbon – The Netherlands

**14hr: 00      Networking Lunch**

## DAY 2 Monday: April 29<sup>th</sup>, 2013

**10hr: 00      Session II**

- 5- Activities of BUE Centre For Renewable Energy CRE in the Field of Securing Renewable Energy Provision for Rural Areas**  
Mostafa Gouda –Acting President - BUE - Egypt
- 6- GPIC Initiative to Renewable energy Adoption of Pioneering Technology**  
**Replacement of Urea High Pressure Stripper**  
Mohamed Jawad - Urea Plant Engineer – GPIC - Bahrain
- 7- Energy saving by Removing Bacteria /Algae Removal from SAFCO IV**  
**Demineralisation Unit**  
P.Balasubramanian and Hussain A. Al-Esmail – SAFCO – S. Arabia
- 8- Recent PV activities at RSS**  
Firas Mohammad Alawneh - Head of Photovoltaics (PV) Division -  
NERC / RSS- Jordan

**12hr: 00      Networking Coffee / Tea**

**12hr: 30      Session III**

- 9- Energy Saving projects at APC/Case Study: Prepared**  
Jamal Amira -Technical Department Manger  
Ala'a Al Omari - Senior Process Engineer – APC- Jordan
- 10- Energy Conservation in Modern Plants-Alexfert's View.**  
Mohamed Hassan Mowena – ALEXFERT - Egypt
- 11- Prospects of Energy Savings in the Jordanian Fertilizer Industry**  
Hassan Al-Seaf, Marketing Engineer, Eta-Max Energy & Environmental Solutions  
Ahmed M. Al-Ghandoor - Associate Professor - The Hashemite University
- 12- Enhancing Energy Efficiency of Ammonia Synthesis Section**  
Bashar Jaffar Al-Aradi - Designated Senior Process Engineer - GPIC- Bahrain

**14hr: 00      Networking Lunch**

***DAY 3: Tuesday, April 30 th, 2013***

**10hr: 00      Session IV**

- 13- Energy Conservation Program/ Case Study: Load Management at APC**  
Hussein Shorman/ Power Plant Superintendent – APC - Jordan
- 14- Reduction in Regeneration Heat duty by Using New Generation Activator in Benfield System of SAFCO3 Ammonia Plant**  
Anosh K Thomas and Saad Maymouni – SAFCO – S. Arabia
- 15- Demonstration of biogas digesters in small animal farms".**  
Ahmad Na'aman Al-Rousan - Studies and Consultation Specialist  
NERC / RSS - Jordan
- 16- Saving Energy Consumption in Semadco**  
El-Sayed Owidat - Consultant Electric – SEMADCO - Egypt

**13hr: 00      Networking Lunch**



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
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**Session I**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
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# **Jordan Renewable Energy Program**

**Yacoub Marar  
Solar Energy Section Head  
MEMR - Jordan**



## **Jordan Renewable Energy Program**

**AFA Workshop: Renewable Energy in Fertilizer  
Industries and Energy Auditing**

**Amman, 28-30 April 2013**

**Yacoub Elias Marar  
Ministry of Energy and Mineral Resources - Jordan**



*Ministry of Energy and Mineral Resources*

### **Main Challenges of Energy Sector in Jordan**

- Almost no indigenous energy resources .
- High dependency on imported energy (96% import in 2012).
- High cost (The energy imports accounted for 20% of GDP in 2012).
- High growth of primary energy demand.
- High growth of electricity.

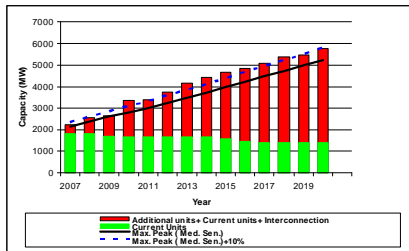


## Energy Demand

Jordan witnesses high growth of energy demand

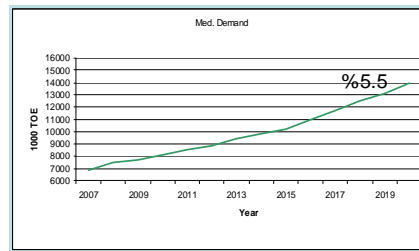
| Period      | Electricity Demand Growth (%) | Primary Energy Demand Growth (%) |
|-------------|-------------------------------|----------------------------------|
| (2008-2020) | 7.4                           | 5.5                              |

### Electricity Generated Capacity to Meet Future Demand.



The additional generated capacity needed up to 2020 is 4000 MW, an average of 300 MW per year.

### Growth of Primary Energy Demand



The expected demand for primary energy amounts is 15 million tons of oil equivalent in 2020 compared to 7.5 million tons of oil equivalent in 2008.



## Energy Strategy ( 2008-2020)

### MAIN GOALS :

- Diversifying the energy resources.
- Increasing the share of local resources in the energy mix.
- Reducing the dependency on imported oil.
- Enhancing environment protection.

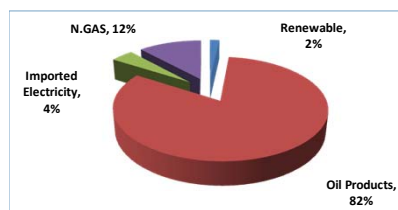
### This will be achieved through :

- Expanding the development of renewable energy projects.
- Maximizing the utilization of domestic resources.
- Promoting energy conservation and awareness.
- Generating electricity from nuclear energy.



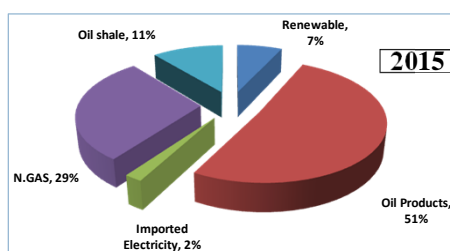
## Jordan's Energy Strategy for 2020

### The Energy Mix in Jordan (2011 – 2020)



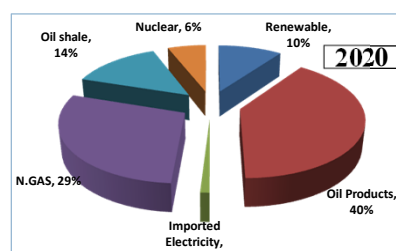
**2011**

Domestic Resources 3%, Imported 97%



**2015**

Domestic Resources 25%, Imported 75%



**2020**

Domestic Resources 39%, Imported 61%



Ministry of Energy and Mineral Resources

### Renewable Energy Targets:

Promoting Renewable Energy to share 7% in the primary energy mix by 2015 and 10% by 2020 :-

- ✓ 1200 MW Wind Energy.
- ✓ 600 MW Solar Energy.
- ✓ 30 - 50 MW Waste to Energy.



## **Renewable Energy Regulatory Framework**

### **Renewable Energy and Energy Efficiency Law :**

**Issued in April 2012, its main goals are to:**

- Provide a legal mandate for the Government and a regulatory framework for RE and EE development.
- Encourage private-sector investment in RE.
- Diversify energy sources in Jordan.
- Reduce greenhouse gases.
- Develop in-country expertise related to RE and EE.
- Establish a “Renewable Energy and Energy Efficiency Fund”



### **Main Articles**

- Creates a registry of renewable energy sites (Develop a Land Use List for RE projects based on resource maps and measurements).
- Tendering of RE Projects:
  - Authorizes MEMR to issue public tenders on competitive basis for developing RE projects at specific sites in accordance with MEMR's development plan.
  - Allows for the Direct Proposal Submissions of projects for generating electrical power and connecting to the grid.



- **Obligation to purchase renewable energy:**

All Energy Output from RE projects must be purchased pursuant to Power Purchase Agreements (PPA).

- **Interconnection and Licensing Incentives:**

NEPCO to interconnect and assume the costs of interconnection line between the project and the nearest substation.

- **Allows for the so-called “Net Metering”:**

small RE projects and residences having RE systems can sell power to the Grid pursuant to instructions that have been issued by ERC.

- **Establishing a Renewable Energy & Energy Efficiency Fund.**

- **Allows for Bylaws to be issued for EE measures in different sectors.**



### **By-Laws and Regulations for Investment:**

The by-laws and regulations related to renewable energy projects for electricity generation have been issued by the Electricity Regulatory Commission, especially the Reference Price List which include the indicative prices for each type of Renewable Sources.



### **Energy Efficiency By-Law**

Issued on 14 November 2012 , where SWHs are mandatory as of April 2013 for new buildings, ESCOs market has to be licensed and regulated , as well as Labeling is mandatory to all Electrical Appliances.

### **Tax Exemptions By-law**

Recently approved (issued on 14 February), exempting all Renewable Energy and Energy Efficiency Systems and Equipment's from Sales Tax and Custom duties.

Moreover, All Renewable Energy Projects shall enjoy the tax exemptions applicable to Conventional IPP projects.

### **Ongoing Grid Reinforcement Plans by NEPCO**

The so-called "Green Corridor" transmission line is under development, to be ready by 2015 to absorb all renewable power.



## **Investment Opportunities - Floated and Planned Renewable Energy Tenders**

| <b><u>Tender</u></b>   | <b><u>Status</u></b>   |
|--|--|
| Fujeij wind project 90MW BOO Basis                                   | First ranked bidder announced, Under final Award, operational by 2014.                                       |
| Maan wind project 65-75 MW EPC Basis                                 | Under Prequalification, 26 Applications received by the Deadline on January 30 <sup>th</sup> , 2013.         |
| Azraq PV Solar Project Spanish Debt Swap Grant (above 2MW EPC basis) | (7) Proposals received by the deadline on February 18 <sup>th</sup> 2013.                                    |
| Quweirah PV Solar project (50-60) MW EPC basis                       | Under Prequalification, more than 70 Applications received by the Deadline on April 11 <sup>th</sup> , 2013. |





## Additional RE Tenders

### Direct Proposal Submissions

- As per the Renewable Energy Law on Direct Proposals, MEMR received (64) EOIs, (34) of them have been shortlisted in April 2012 , and (30) MOUs were signed with total capacity of about 850 MW classified in the following Table.
- Expected Submission Date of Direct Proposals:
  - Photovoltaic (PV) Projects; received on 31 March 2013
  - Concentrated Solar Power (CSP) Projects; mid 2014
  - Wind Energy Projects; 1st quarter of 2014.
- Next round for EOI submissions expected in the second half of 2013.



| Technology       | Received Applications |                          | Qualified Applications |                          | Signed MOUs |                          |
|------------------|-----------------------|--------------------------|------------------------|--------------------------|-------------|--------------------------|
|                  | Total No.             | App. Total Capacity (MW) | Total No.              | App. Total Capacity (MW) | Total No.   | App. Total Capacity (MW) |
| <b>Solar PV</b>  | 24                    | 545                      | 15                     | 225                      | 14          | 220                      |
| <b>Solar CPV</b> | 5                     | 125                      | 2                      | 20                       | 2           | 20                       |
| <b>Solar CSP</b> | 8                     | 370                      | 5                      | 225                      | 5           | 225                      |
| <b>Wind</b>      | 22                    | 1,190                    | 12                     | 530                      | 9           | 395                      |
| <b>Other</b>     | 5                     | ---                      | 0                      | 0                        | 0           | 0                        |
| <b>Total</b>     | <b>64</b>             | <b>2,230</b>             | <b>34</b>              | <b>1000</b>              | <b>30</b>   | <b>860</b>               |



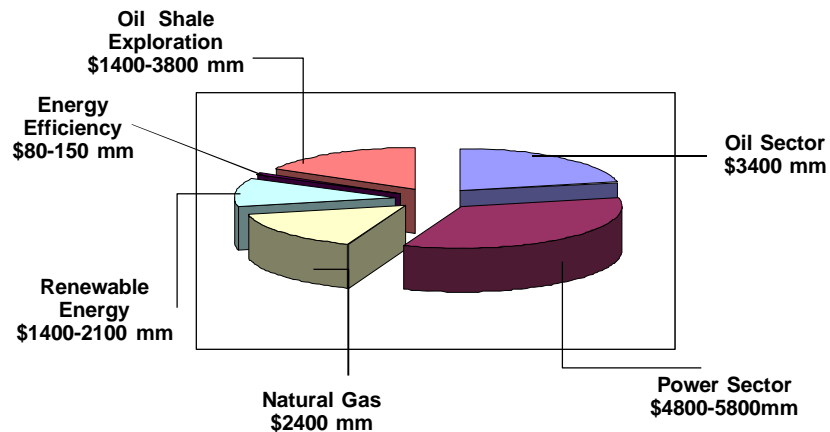
## **Renewable Energy and Energy Efficiency Fund**

This Fund was established in accordance with Articles of the RE & EE Law aiming to:

- Provide Financial Framework for RE and EE.
- Promote the use of RE and EE in Jordan.
- Provide incentives and financial support for RE and EE measures, studies and projects.
- Encourage private-sector investment in RE and EE projects and activities.



**According to the Master Plan the required investment in the energy sector is around \$14-18 billion over the period ( 2008-2020)**





**Thank You**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Potential of Energy Efficiency  
in  
Industry**

**Muhi aldeen Tawalbeh  
NERC / RSS  
Jordan**





المركز الوطني لبحوث الطاقة  
National Energy Research Center



# Potential of Energy Efficiency in Industry

*AFA Workshop*

Renewable Energy in Fertilizers Industry and Energy Auditing

April, 2013

Muhieddin Tawalbeh

[www.nerc.gov.jo](http://www.nerc.gov.jo)



المركز الوطني لبحوث الطاقة  
National Energy Research Center



- Photovoltaic
- Wind Energy
- Rational Use of Energy
- Oil Shale
- Solar Thermal
- Water Conservation

R & D

Training

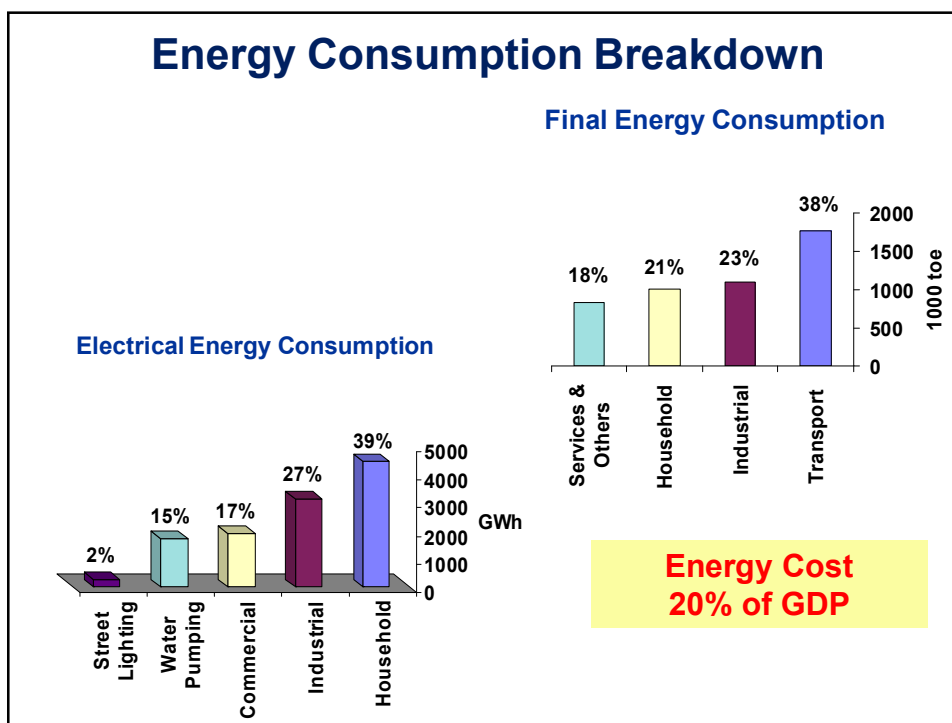
Consultations

Testing

Maintenance

Applications

[www.nerc.gov.jo](http://www.nerc.gov.jo)



## Current and Evolving Policies for EE-Framework

- Tax and customs exemptions granted to RE and EE, 2008
- Renewable Energy & Energy Efficiency Law, 2012
- Jordan Renewable and Energy Efficiency FUND (JREEEF ) designed to mobilize and provide financial and technical support
- Energy Efficiency By-Law, 2012
- Jordan National Energy Efficiency Action Plan (NEEAP), hopefully within two months

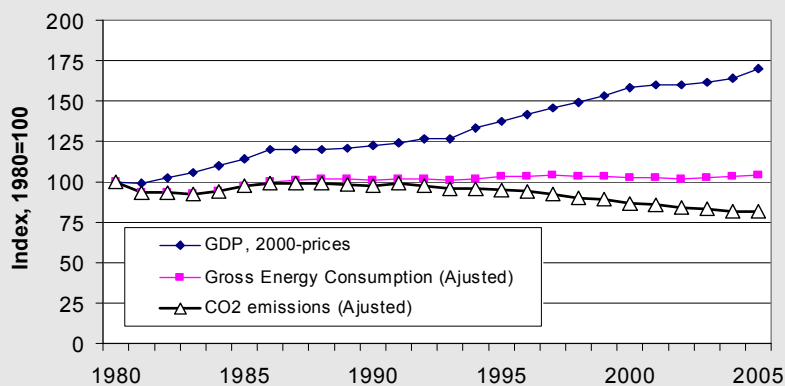
## Why we waste our Resources?

**Our Greatest National Energy Resource is the Energy we Currently Waste**



## Constant Energy Consumption in 25 years

**Energy Consumption, CO2 Emissions and Economic Activity in Denmark 1980-2005**



**Energy efficiency is not a question  
of latest technology!**

**Reduce or  
eliminate  
Visible  
Waste**



## **How Energy Consumption Can be Reduced?**

### **1. Reduction of operating Hours**

*Use Energy when needed only*

### **2. Improve equipment efficiency**

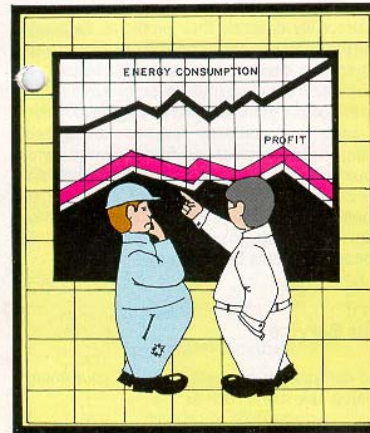






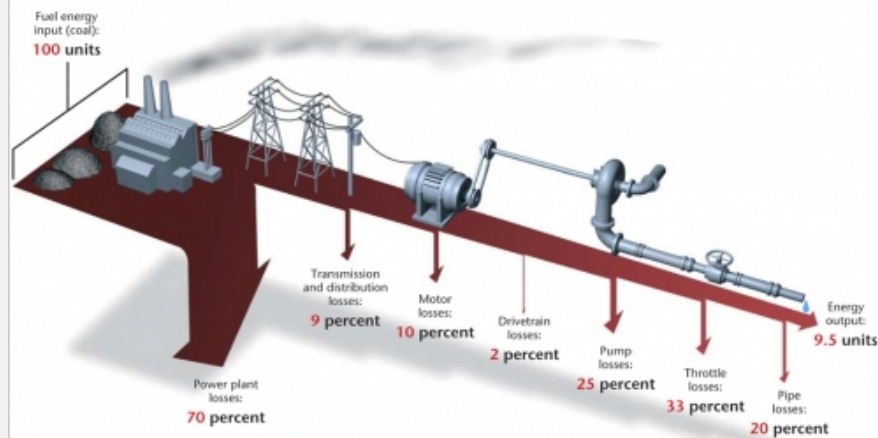
## Cost Reduction Through Hidden Wastes Reduction

**Focus On  
Hidden  
Wastes  
&  
Inefficiencies  
In Energy  
Systems**



### How much energy we loss?

"More than 90% of energy extracted from the ground is wasted before it becomes useful work."



## Energy Conservation Elements

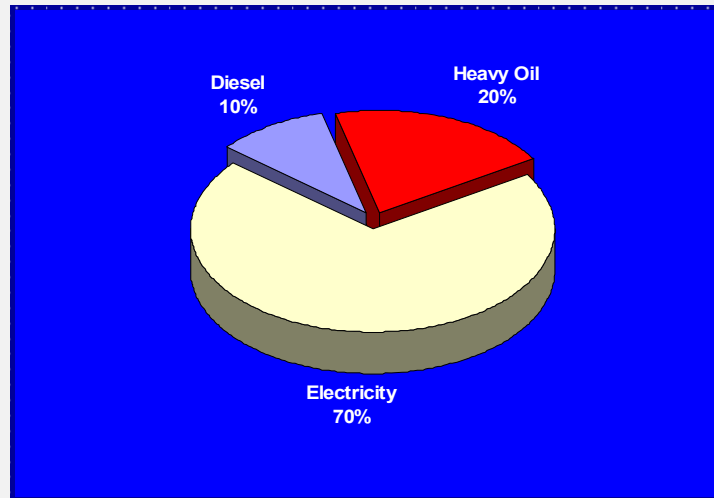


## Energy Audit

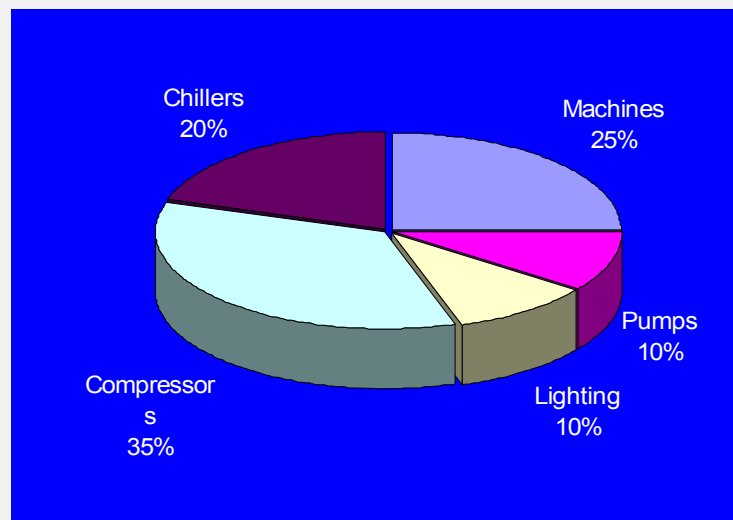
### Types of Energy Audit

1. Preliminary Energy Audit
  - Focus on Major Consumers of Energy
  - Visible Wastes
2. Detailed Energy Audit
  - Focus on All Energy Consumption Points
  - Hidden Wastes
  - Operation Procedures/Plans
  - Baseline and Benchmarking

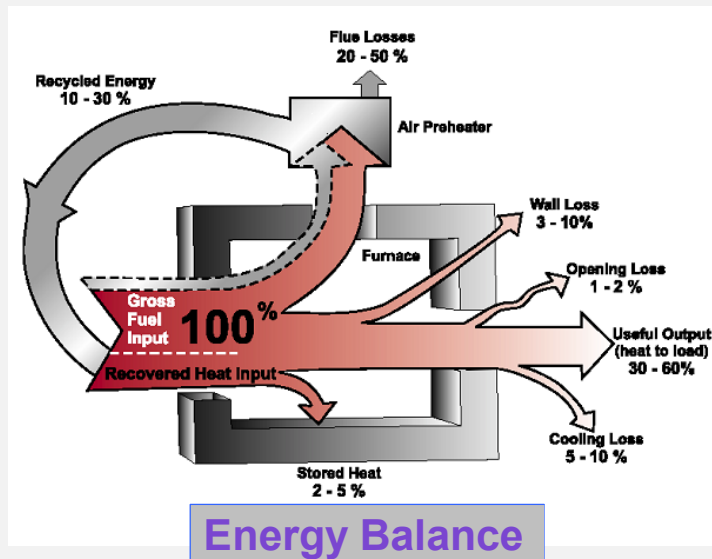
## Where should we focus?



## Where should we focus?



### Sankey Diagram



[www.nerc.gov/jo](http://www.nerc.gov/jo)

### How to check .. .. if energy is used rationally?

#### Self comparison and with others!

- Compare energy consumption on: weekly bases, monthly bases or yearly bases
- Compare specific energy consumption

## Variable Costs and Fixed Costs

### ■ Variable costs = Related to production:

- Fuel for drying lines
- Electricity for conveying, processing
- Steam for pre-heating raw materials

### ■ Fixed costs = not related to production:

- Light for office and manufacturing lines
- Motor Idling

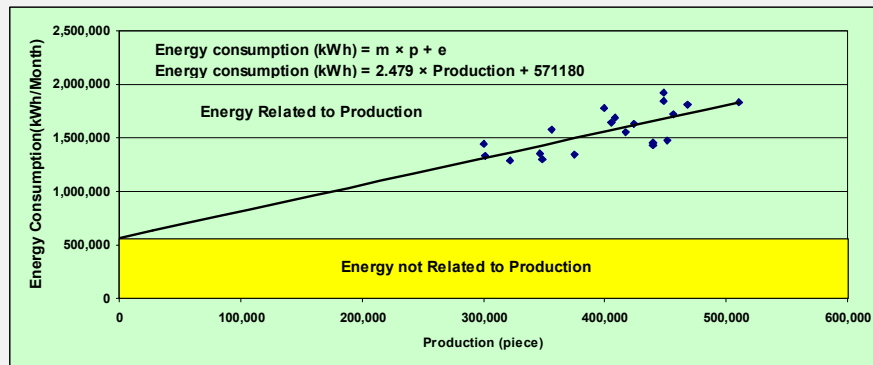
## Specific energy consumption (C)

$$C = \frac{\text{Energy consumption of factory}}{\text{Quantity of manufactured goods}}$$

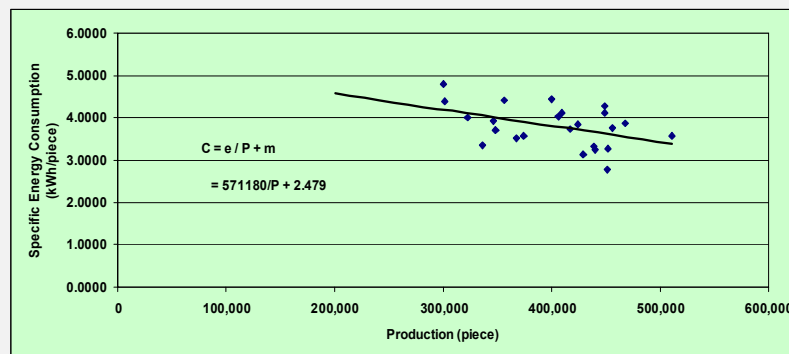
### ■ Examples

|                     |                       |
|---------------------|-----------------------|
| Tissue paper mill X | C = 1806 kWh/t        |
| Cement factory Y    | C = 155 kg oil/t      |
| Glass factory Z     | C = 680 kg fuel oil/t |

## Energy Consumption Vs. Production

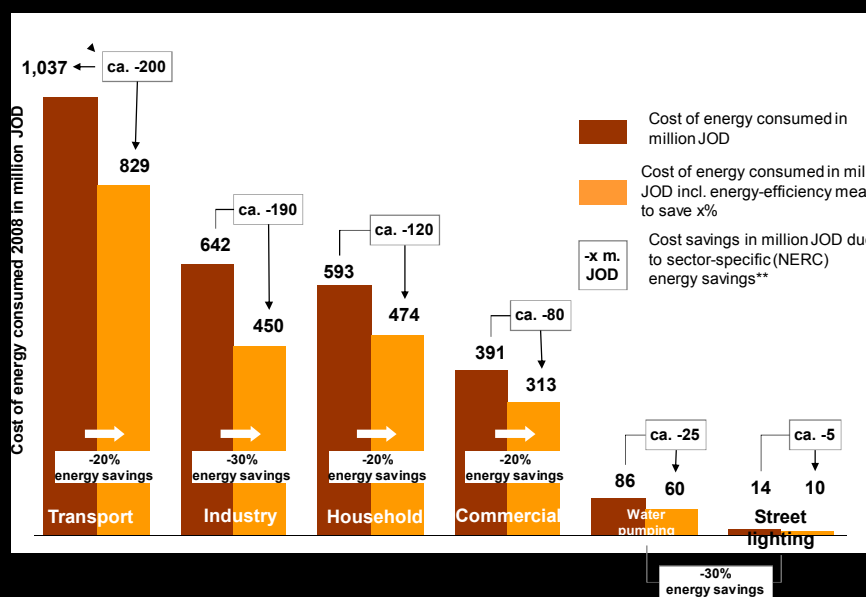


## Specific Energy Consumption Consumption

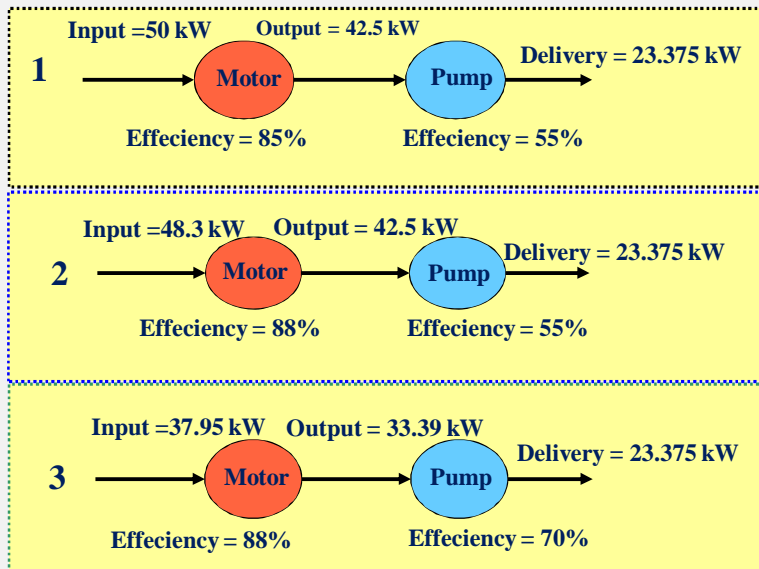


## Possible Energy Efficiency Measures

Savings of 20 - 30% of final energy consumption per sector represents a reduction in annual energy cost of Jordan of about 620 million JOD\*



# Motors Efficiency



## Cost effective condensate return

### Fuel Saving:

Condensate recovered = 1000 kg / h  
 Hours per year ( 10 x 5 x 48 ) = 2400 h  
 Total condensate recovered = 1000 x 2400 = 2,400,000 kg  
 Assume condensate 85 deg C, cold make up 15 deg C ,  
 Heat saved = 2,400,000 x 4.186 x ( 85 - 15 ) kJ / year  
 Calorific value of diesel = 42,000 kJ/Kg  
 Boiler efficiency , say 80 %  
 Fuel saved = 2,400,000 x 4.186 x 70 / 42000  
 = 200930 Kg / 0.8/0.84= 24916 L

Fuel cost (Assuming the Price of 1 L of diesel=0.67 JD)

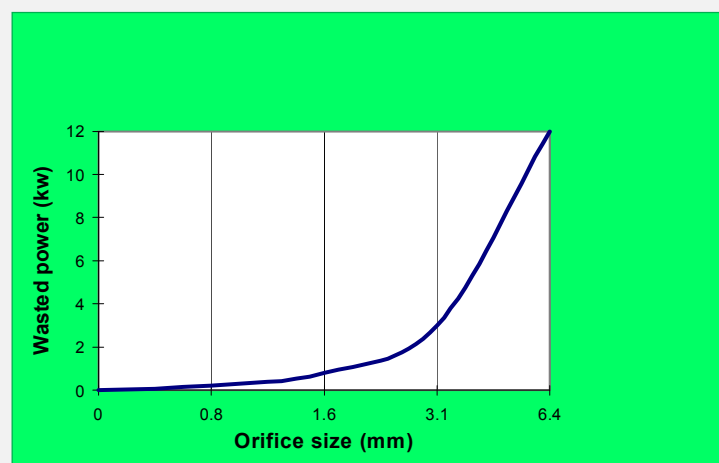
Annual saving in fuel = 16694 JD / Year



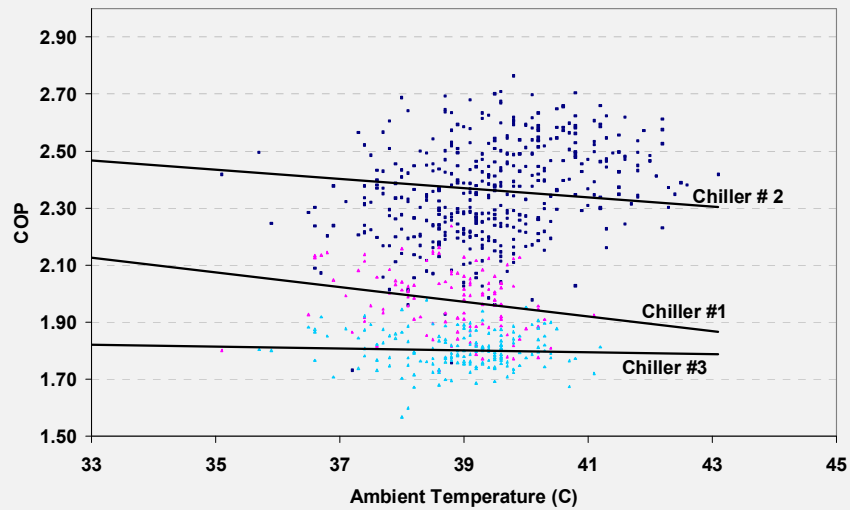
## Energy saving areas in compressed air systems

- (1) Compressed air generation
- (2) Compressed air distribution
- (3) Compressed air utilization.

## Compressed air Leakage



## Chillers Performance Evaluation



**Chiller 3**  
COP=1.8

Keep chiller #3  
St.By

**Chiller 2**  
COP=2.4

Run chiller #2

**Chiller 1**  
COP=2.0

Then Run chiller #1



- 1) Run chiller #2 alone as much as it possible.
- 2) When more chillers are needed to cover additional cooling load, chiller #1 will be run with chiller #2 .

Annual cost of saving = JD 8,190

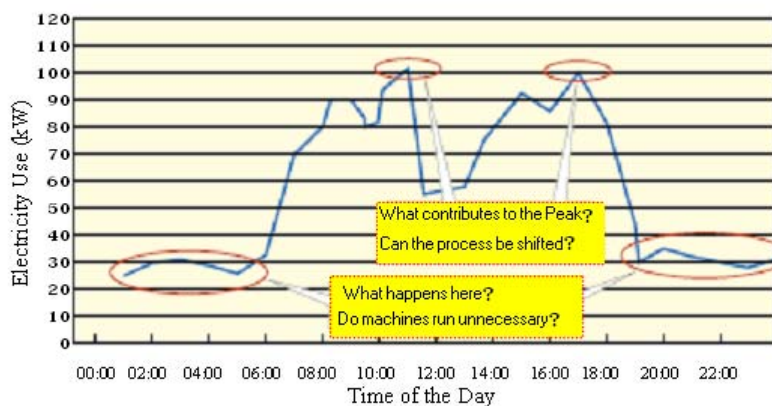
- 1) No investment is needed.

## Case Study

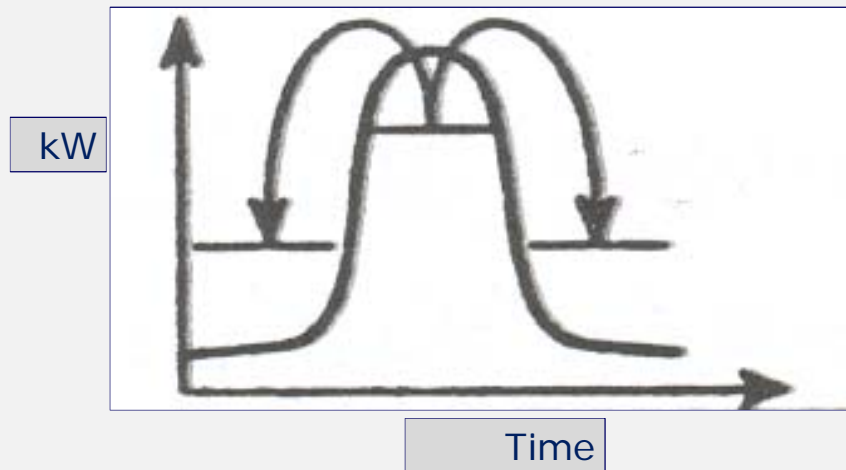


| Area  | Annual Energy Savings |            |                       | Investment Required (JD) | Pay Back Period (Years) | CO <sub>2</sub> (TON/year) |
|---|-----------------------|------------|-----------------------|--------------------------|-------------------------|----------------------------|
|   | KWh/yr                |            | Cost Savings (JD/yr.) |                          |                         |                            |
|   | Electrical            | Thermal    |                       |                          |                         |                            |
| Steam System  |                       |            |                       |                          |                         |                            |
| 1. Operating the Synchronous Generator as a Motor   | 0                     | 12,684,272 | 379,000               | N/A                      | N/A                     | 2900                       |
| 1. Blowdown heat recovery: Combination of the Flash Steam Recovery and Blow down Recovery | 0                     | 2841384    | 65190                 | 19,930                   | 0.3                     | 160                        |
| 1. Insulation of the Uninsulated Valves and surfaces.                                     | 0                     | 250852     | 5683                  | 530                      | 0.09                    | 58                         |
| 1. Condensate Recovery  | -                     | 1224154    | 28000                 | 1,000                    | 0.04                    | 286                        |
| 1. Converting the Flash Dryer from working by Diesel to working by LPG                    | 0                     | 00         | 122938                | 256,500                  | 2.09                    | 0                          |
| Compressed Air System   |                       |            |                       |                          |                         |                            |
| Reducing the working pressure of the compressed air from 7.5 to 7 bars.                   | 92,667                | 0          | 3,940                 | 0                        |                         | 62                         |
| Lighting System   |                       |            |                       |                          |                         |                            |
| Replacing the Conventional ballasts by Electronic Ballasts for Fluorescent Lamps          | 52486                 | 0          | 2231                  | 6,773                    | 3                       | 30                         |
| Water cooling system  |                       |            |                       |                          |                         |                            |
| Sea Water pumping system.   | 377,952               | -          | 16,000                | 24,000                   | 1.5                     | 250                        |
| Cooling water pumping system  | 186,893               | -          | 7,940                 | 9,000                    | 1.2                     | 125                        |
| Total   | 709,998               | 17,000,662 | 630,922               | 317,733                  | 0.55                    | 4376                       |
| % Saving (based on consumption cost)  |                       |            |                       |                          | 15%                     |                            |
| % Saving (based on consumption in MWh)  |                       |            |                       |                          | 10%                     |                            |

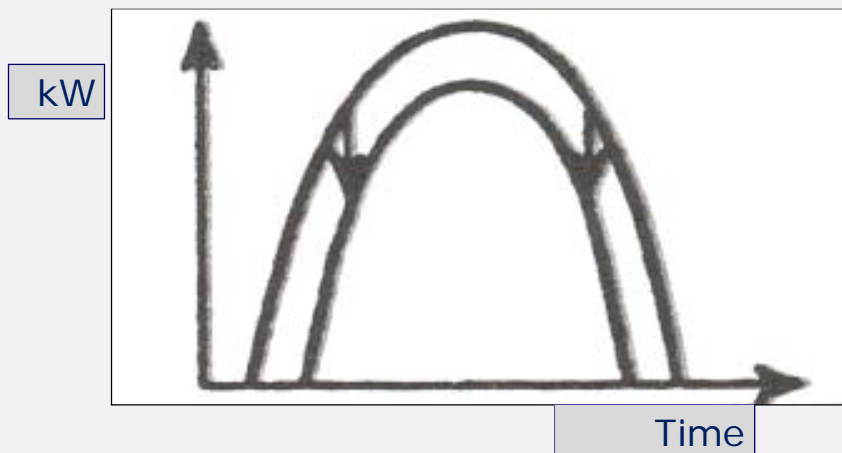
## Load Management



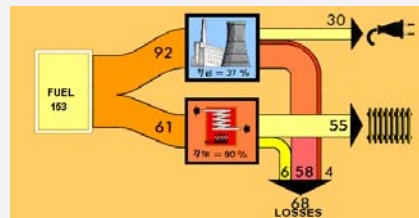
## Load shifting



## Conservation

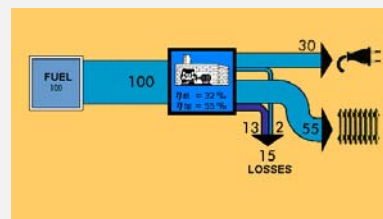


# Cogeneration



Makes more efficient use of fuel used for power generation.

- ☐ Electricity
- ☐ Heat
- ☐ Cooling



## *Thank You*

**Muhieddin Tawalbeh**

Tel: 06 5338014 ext: 107

Mobile: 0799050753

Fax: 06 5338043

Email:

[m.tawalbeh@nerc.gov.jo](mailto:m.tawalbeh@nerc.gov.jo)

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Feasibility and potential of renewable  
energies industries**

**Axel Ceglie Swoboda  
Developing Manager For Renewable Energies  
Austria**

### feasibility and potential of renewable energies in Egypt

**AFA energy workshop in Amman 28.-30.04.2013:**

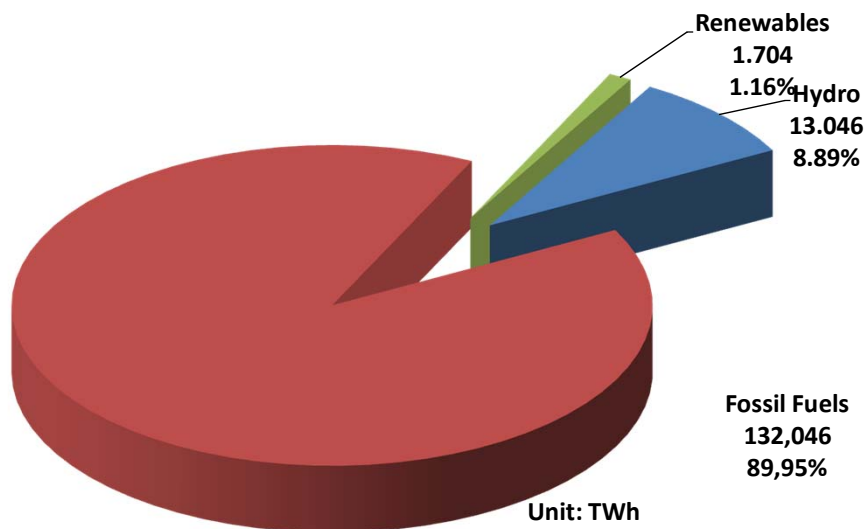
**Title: Feasibility of hybrid power plant and potential of renewable energies.**

**Content:**

- Introduction of a study, made in cooperation with Austrian University and CSK.
- Data and benchmarks from abroad.
- Considerations on present RE situation in Egypt and Jordania.
- Sketch of feasibility of a hybrid power plant.
- Conclusions

**Eng. Axel Ceglie Swoboda**

## Electricity Generation in Egypt (2012, 30 GW, 147 TWh)



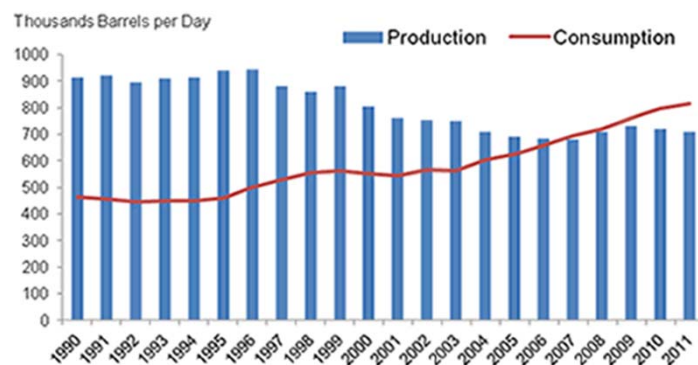
20.05.2011

Michael Puttinger

2

## 1) market study Egypt today

**Total Oil Production and Consumption in Egypt,  
1990-2011**



**EGYPT INDEPENDENT**

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**Egypt imports 100 megawatts of Jordanian electricity in single day**

Hisham Omar  
Abdel Halim  
MENA  
Thu, 02/09/12 19:35

**Can power be generated from Iraq, Qatar to supply Egypt?**

Rana Khaled  
Wed, 10/09/2012 12:35

**“India PV market till 2016 will be 12 GW”  
(50% of full power installation in Egypt)  
newsletter Intersolar from 121001**

**Germany August 2012:  
changed goals for RE from 202020 to 202045**

**April 2013: Record for RE, 56%: 36 GW (wind+solar)**

**KSA started program 54 GW till 2034 (wind, solar),  
2 times Egypt !!! first 7 bil \$ signed 2013**

**Libya announced April 2013 to have 202020 with sun!**

**China changed the PV-plan from 5 to 40 GW till 2015 !**

20.05.2011

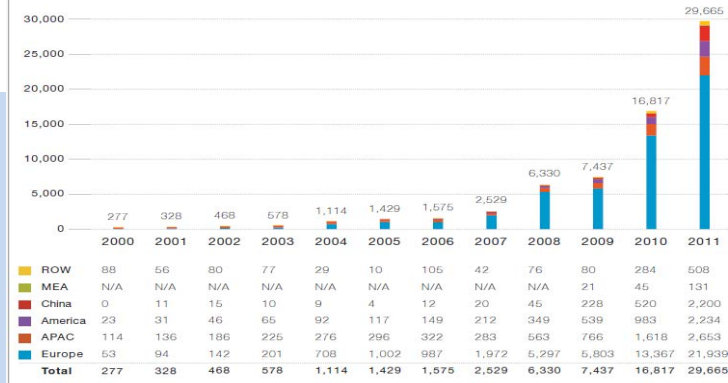
CAIRO -- Egypt was plunged into a power outage swept across much of the capital on Thursday when a power line collapsed.

4



## PV global annual inst.

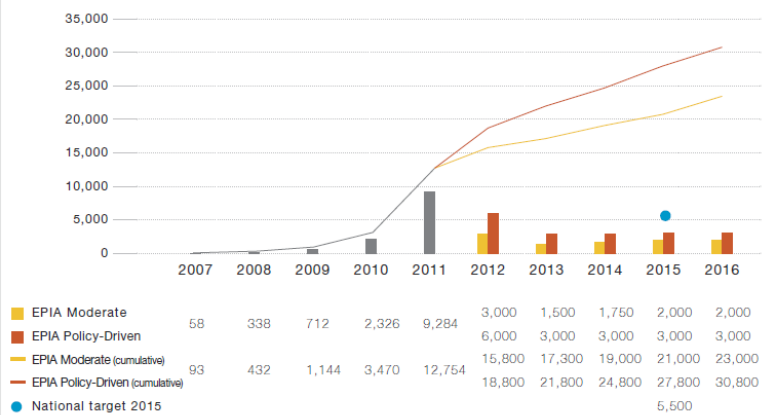
Figure 2 - Evolution of global annual installations 2000-2011 (MW)



ROW: Rest of the World  
 MEA: Middle East and Africa  
 APAC: Asia Pacific

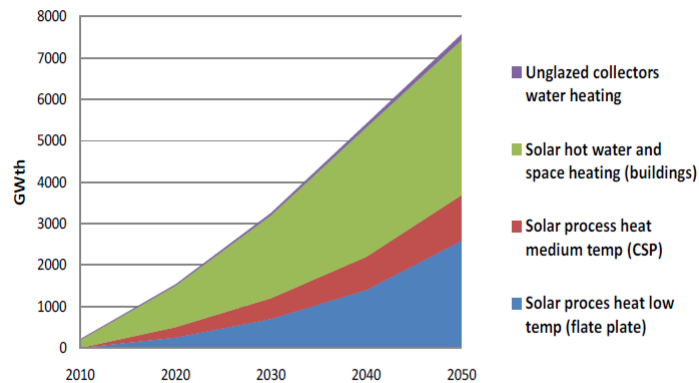
## PV Market Italy

Figure 20 - Italy (MW)



## potential solar thermal world market

**Solar Thermal Heat – Potential** (IEA 2011, “SHC Roadmap” 2050)



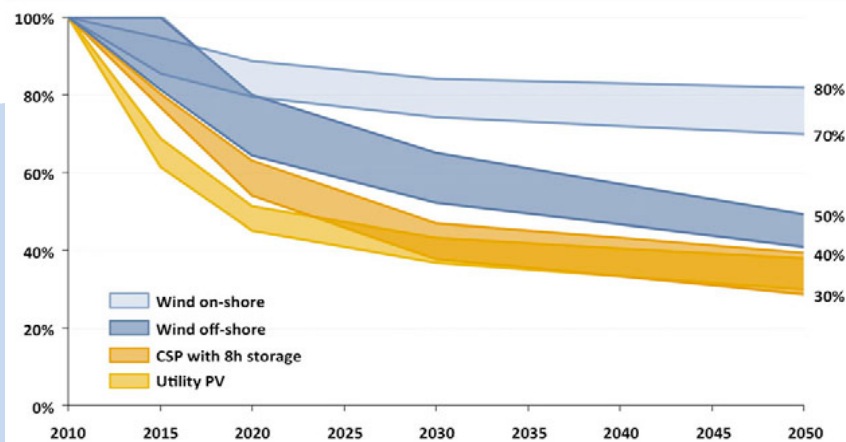
source: IEA 2011 – “SHC Roadmap”, preliminary findings

Werner B. Koldehoff, Management Beratung D-87657 Göttersried

SEDA Strategy Workshop - Cairo, Egypt - September 2012

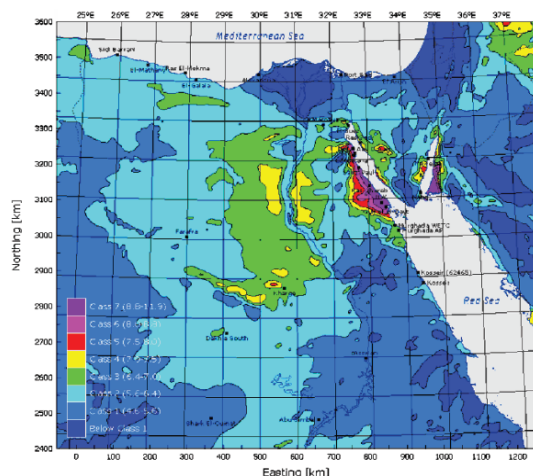
## desertech study July 2012

**System cost development per kW<sup>1</sup> in percent of 2010 cost estimate**



Source: Dii 1. Refers to nameplate capacity, i.e. kW<sub>p</sub> (kW peak) for Utility PV and Wind and kW<sub>e</sub> (kW electric) for CSP

**potential wind**



**Figure 1** Wind regime map for Egypt (wind atlas for Egypt).

### Target Egypt 2020:

**7.200 MW,**

**Production cost:**

**< 6 Ec/KWh !!!! (SWEG)**

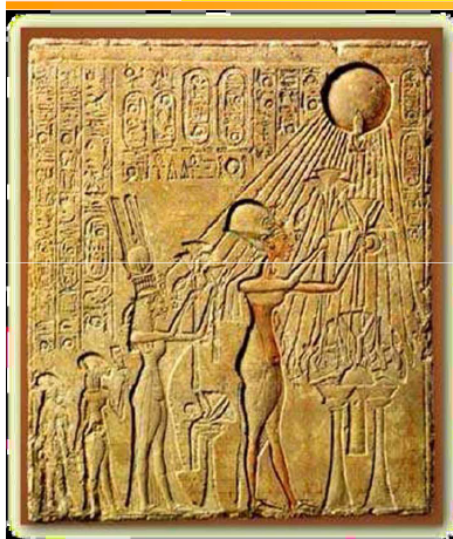
**Gas turbine: 5 Ec/KWh**

(CSK, at gas price 2\$/MBTU)

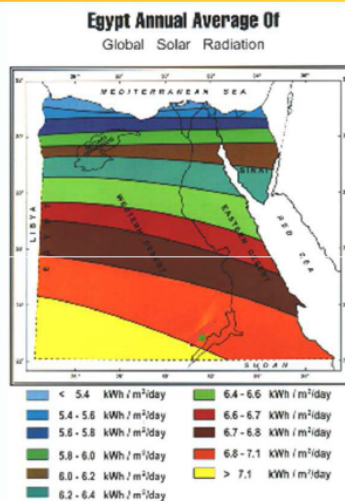
**Without subsidies  
Wind energy  
is competitive !**

## solar potential

**“Download the SUN”**



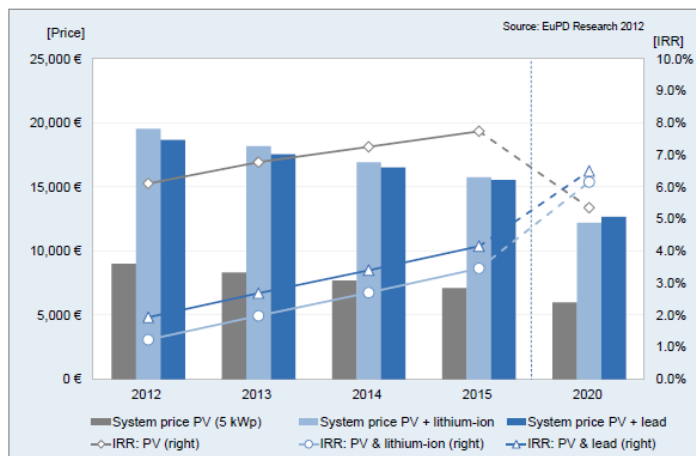
Werner B. Koldehoff, Management Beratung D-87657 Görisried



SEDA Strategy Workshop - Cairo, Egypt – September 2012

## intersolar webinar July 2012

### Economic Efficiency of Electricity Storage Solutions



## waste potential



**Potential of waste:**  
 21 mio t/a MSW, 80% collected from 150.000 people,  
 Recycle ratio of municipality and industrial waste is low.  
 + 30 mio t/a agriculture waste

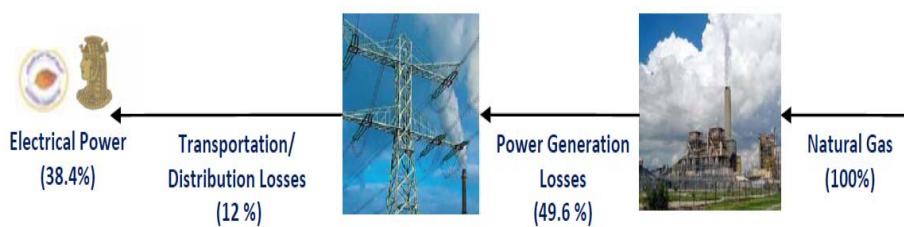
Axel Ceglie Swoboda

## “Industrial Incinerator with Heat Recovery -Waste To Energy Concept ”

- 1 Ton/hr Solid Wastes
- 100 liter/hr Liquid Wastes
- 1x2000 USRT Steam absorption Chillers



## Losses of grid and economic parity realistic?



Renewable energies  
can be installed where the energy  
is needed without grid  
and transformation losses!

**Solar pv reached grid parity 2013**  
**Decentralized solutions !**  
**...Wind energy even in utility scale**  
**up to atomic power plants dimensions.**

*Grid to parity study for Arab region,  
executed by RCREEE is available !*

by far biggest potential

## **Energy efficiency !**

**50% saving with little investment is feasible!**

**UNIDO project industrial energy efficiency has just started.**

### **sketch of feasibility analysis hybrid 5 MW wind farm (i.e. Jordan)**

- Assumption: wind speed 7 m/s,
  - standard grid connection and access to location with standard trucks
- Wind turbine:
  - Power: 5 times 1 MW for spare part reasons. Height tower 80 m.
- Investment: 7 mio €
- Energy production: 8 GWh/a (2000 residential bldg.)
- Maintenance contract: costs 5 % of total investment.
- Financing: 1/3 equity, 2/3 loan interest rate 8%,
- Cost of energy: less than 10 € Cent/KWh
- ROI: depends from EPC contract.
- Planning: 6 month
- Montage: 6 month
- CO2 Reduction: 16.000 t/a
- Cost for detailed study: 50.000 €

### sketch of feasibility analysis hybrid 1 MW solar farm (i.e. Jordan)

- Assumption: solar radiation 5 KWh/m<sup>2</sup>/a, needed area 2 ha.
- Energy production: 1 MW produces 2 GWh/a (500 res. bldg.)
- Panel guarantee: min 80 % after 25 years
- Full maintenance contract, 4 % of investment per year
- Investment: 1,3 mio € (European technology)
- Financing: 1/3 equity, 2/3 loan, interest rate 8%,
- Cost energy: 13 € Cent/KWh
- ROI: depends from EPC
- Planning: 6 month
- Montage: 6 month
- CO<sub>2</sub> reduction: 4.000 t/a
- Alternative with sun-tracker system, 15 % higher investment, 20 % more energy production. 2 % more maintenance costs.
- Cost for detailed study: 20.000 €

### Economic details of the solar plant in comparison with diesel engine:

|  |            |
|--|------------|
| System Operational Capacity (kWe)                | 1,000.00   |
| Interest/Discount Rate (%)                       | 15.00%     |
| Annual Insurance Rate (%)                        | 0.25%      |
| Annual Inflation in Energy (%)                   | 0.00%      |
| USD/EGP  | 7.00       |
| Euro/EGP   | 9.00       |
| Capex Figure ( € /kWe)                           | 1,200      |
| Annual Opex Figure (%)                           | 2.00%      |
| Specific Revenue Stream (kWh/kw)                 | 1,800.0    |
| Degradation Rate (%)                             | 0.50%      |
| Fuel Consumption (L/hr)                          | 250        |
| Diesel Oil (LE/L)                                | 5          |
| Annual Operating Hours (hrs/yr)                  | 1,500      |
| Estimated system capital for solar PV (EGP)      | 10,800,000 |
| Estimated system capital for diesel-gen set(EGP) | 3,3050.000 |
| Break-even point (years)                         | 6,2        |

### 120 MW wind farm in Egypt for cement factory

- Power: 120 MW
- Location: region of Zafarana, red sea Egypt.
- Investment: est. 100 mio euro
- Wind speed: over 8 m/s
- Energy production: over 200 GWh
- Cost of energy: under 8 Eurocent/KWh !
- Strategy: Feed in the grid and use the energy over 200 km away for cement factory.
- Fees and losses haven't been published yet.
- Status: All contracts, permissions, engineering is done, missing is final approval of financing.

### conclusion

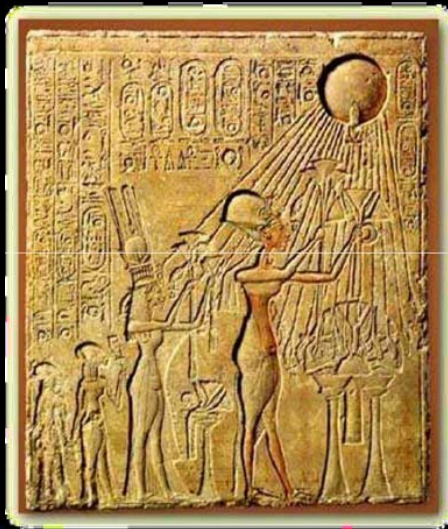
- 1) Energy mix of Arab region is NOT sustainable.
- 2) RE world market is booming.
- 3) RE resources are immense.
- 4) Technologies are ripe and affordable.
- 5) RE can create jobs and offers opportunities for SME development.
- 6) With the right market conditions the RE sector can become one of the fastest growing industrial sectors and contribute to solve some of the most urgent development bottlenecks!

Sun and wind energy can bypass oil and gas in terms of export potential!

Eng. Axel Ceglie Swoboda



download the sun !!!



*The Stone age*

*didn't end*

*because of a*

*lack of stones...*

Eng. Axel Ceglie Swoboda, m: 0020 100 323 4433, email: [acs1@chello.at](mailto:acs1@chello.at)

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**The Stamicarbon low energy  
urea melt plant**

**Jo Meessen  
Principal Engineer  
Stamicarbon - The Netherlands**

# The Stamicarbon low energy urea melt plant.

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AFA Workshop Renewable Energy in Fertilizer Industries &  
Energy Auditing

April 28 – 30, 2013 – Amman – Jordan

J. van den Tillaart – Stamicarbon

J. Meessen – Stamicarbon

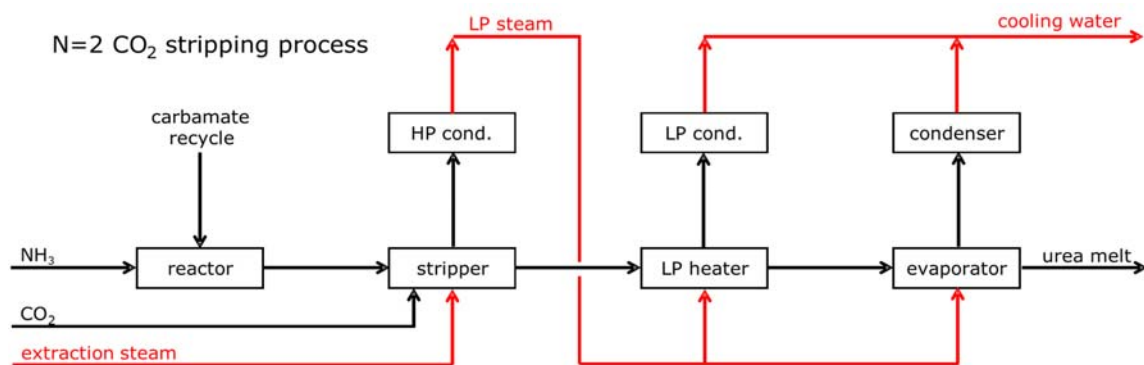
## Summary

In this paper the Stamicarbon concept for a low energy urea melt plant is presented. By direct heat integration between the HP pool condenser and the MP rectifying heater and between the MP condenser and the 1<sup>st</sup> stage evaporator heater, the steam consumption can be lowered considerably. For instance, for a urea melt plant with prilling as finishing technique, the turbine extraction steam consumption can be lowered from 868 kg<sub>steam</sub>/ton<sub>product</sub> to 558 kg<sub>steam</sub>/ton<sub>product</sub>. The design challenges for the critical equipment in this low energy concept with respect to corrosion and sizing have been addressed and solved.

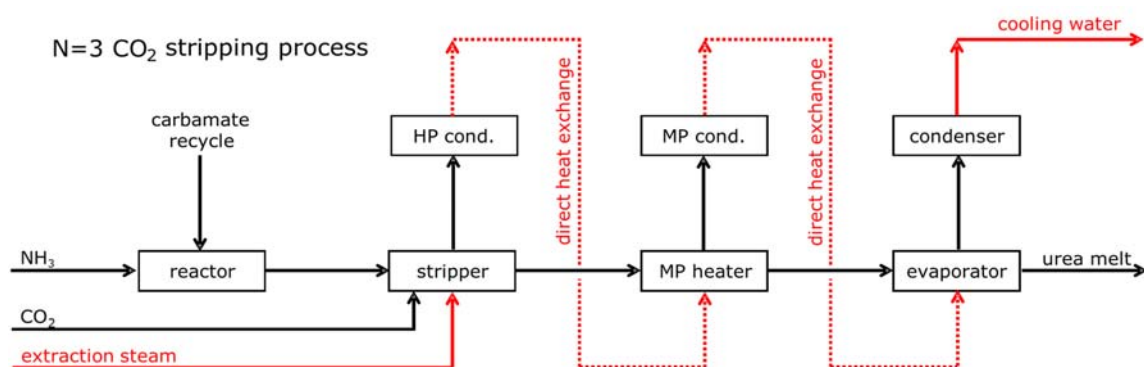
## Introduction

As Stamicarbon is a well known innovative company, several successful concepts for urea were developed in the past.

In the past Stamicarbon focused on a low investment plant, reducing the total number and size of equipment. With the Urea 2000plus™ process the focus was on decreasing the plant elevation and efficient condensation of the stripped vapors in the synthesis. Furthermore the reactor and the condenser could be combined in one piece of equipment in the Urea 2000plus™ pool reactor concept. The Avancore® process was developed and introduced in the 11<sup>th</sup> Stamicarbon Urea Symposium with focus on decreasing the elevation further and low inert operation. All these processes are based on the so-called “n=2” heat integration concept in which heat supplied to the plant in the form of extraction steam from the steam turbine is used twice.



In this “N=2” concept, the first time this steam is used as heating agent to obtain high stripping efficiencies in the high pressure stripper. Subsequently the heat is recovered by condensing the strip gas in the high pressure carbamate condenser, pool condenser or pool reactor in the synthesis section to produce low pressure steam that is used in the sections downstream the synthesis section.



Already in the 1980's Stamicarbon presented a urea process concept in which an “n=3” process was introduced. In this concept the heat supplied in the form of steam is used three times. To reuse this heat two times, a medium pressure recirculation section (MP section) is required.

Given the increasing cost of energy, Stamicarbon recently decided to once more take the challenge to realize a considerable improvement on steam consumption. In this paper the outcome of our latest study, a new process concept for n=3 heat integration is described.

## Targets

The low energy process to be developed should make efficient use of the lessons learned in the past with respect to low investment and low elevation. Also the experience using MP sections should be incorporated.

As a base of comparison it was decided to demonstrate the concept for a melt plant for prilled product as steam consumption is generally highest for this type

of plant. The target was to reach an extraction steam consumption (23 bara, 330 °C), with minimum low pressure steam export, below the 599 kg<sub>steam</sub>/ton<sub>product</sub> compared to the steam consumption of 868 kg<sub>steam</sub>/ton<sub>product</sub> for a Urea 2000plus™ process. Hence also the code name for the project "5XX" was chosen.

## Description of the "5XX" process

The synthesis of the new process is depicted in figure 1.

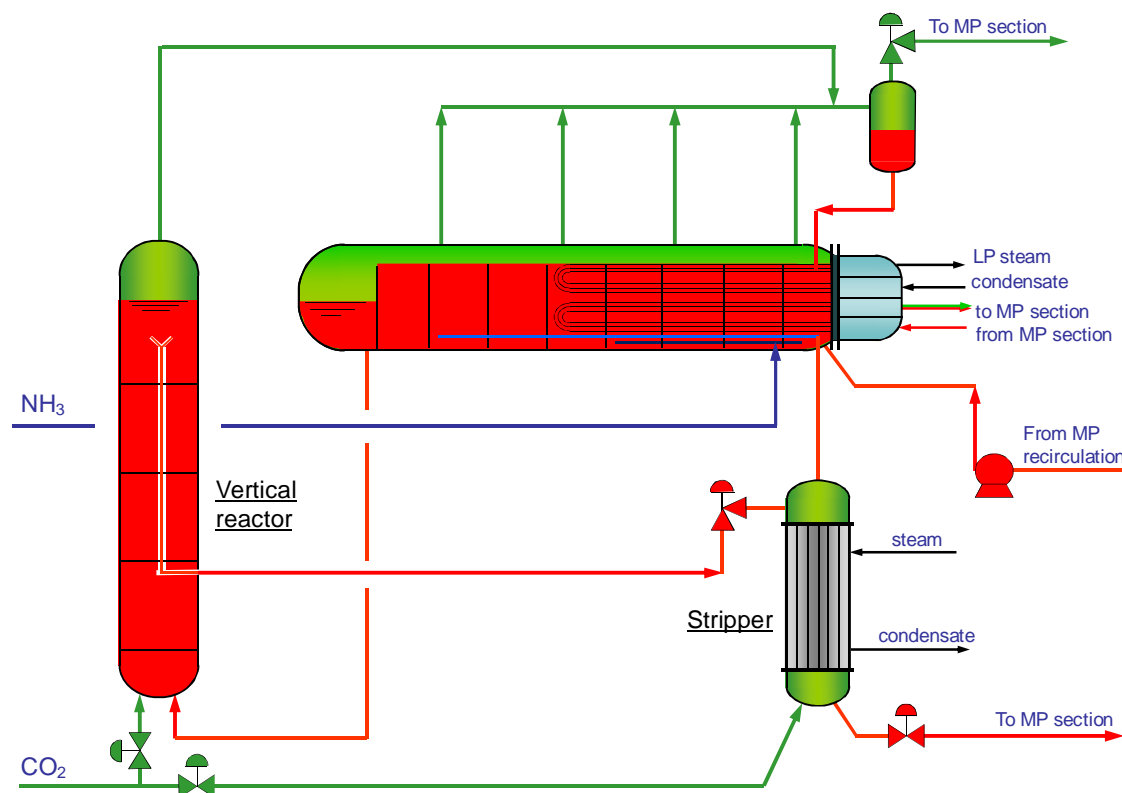


Figure 1. The high pressure synthesis section of the "5XX" process.

As is visible from figure 1 the synthesis for the low energy process is essentially the same as the synthesis for the Avancore® process and consists of a high pressure stripper, a pool reactor and a vertical reactor which is located at ground level. However closer inspection of the pool reactor reveals that now two separate U-tube bundles have been incorporated in the shell. The top bundle is the bundle for generating low pressure steam as is commonly found in Stamicarbon pool condenser and pool reactor plants.

The bottom bundle, however, is used for the heat integration with the MP recirculation section. On the shell side of this bundle the condensation of carbamate releases heat which is used to decompose carbamate to  $\text{CO}_2$  and  $\text{NH}_3$  on the tube side. Consequently the tube side of this tube bundle in the pool reactor functions as a medium pressure rectifying heater. By integration of these two functions, without any intermediate heat transfer medium, the available temperature difference between both process sides enables the bundle to be

relatively small. The temperature profile for shell side and tube side of both bundles in the pool reactor is depicted in figure 2.

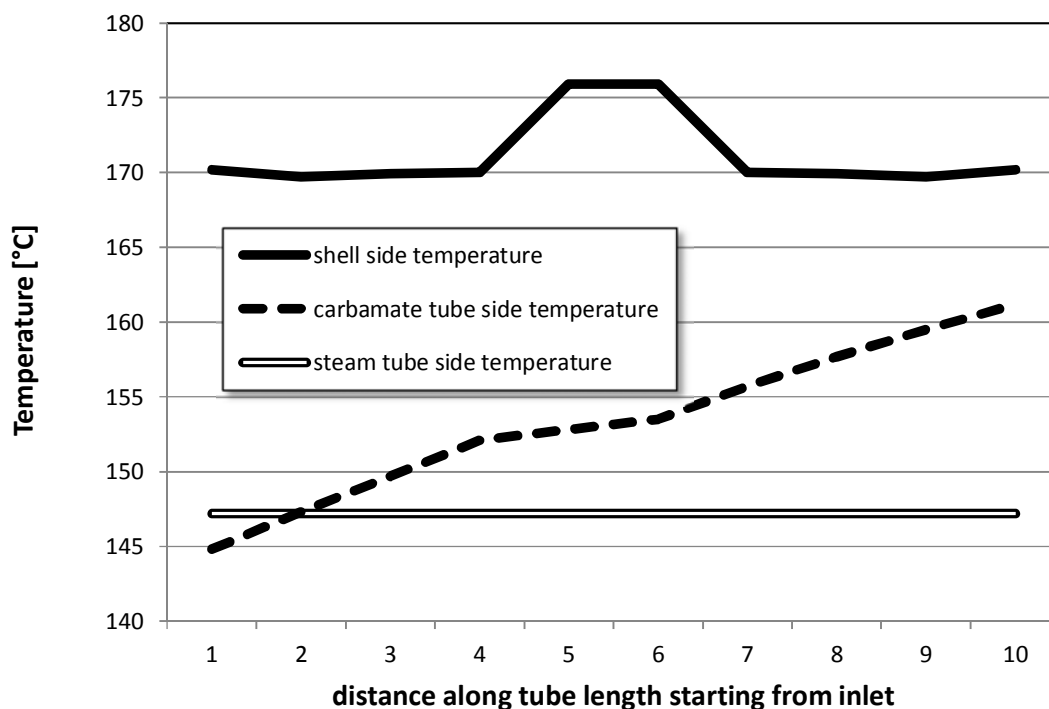


Figure 2. Temperature profile for shell and tube side of the U-tube bundles in the pool reactor.

The low pressure sections of the plant according to the 5XX concept are shown in figure 3. After leaving the stripper the urea/carbamate solution is flashed to an intermediate pressure. The urea solution leaving the intermediate flash tank is further expanded to medium pressure and heated inside the bottom tube bundle of the pool reactor, effectively reusing the heat a first time. The carbamate in the liquid decomposes to  $\text{CO}_2$  and  $\text{NH}_3$ . Gas phase and liquid phase from the bottom tube bundle is separated in a separator. The  $\text{CO}_2$  rich gas from the intermediate flash tank is used in the MP rectifying column to correct the  $\text{NH}_3/\text{CO}_2$  ratio of the liquid from the MP heater (=bottom tube bundle in the pool reactor), before discharging this liquid to the low pressure recirculation section.

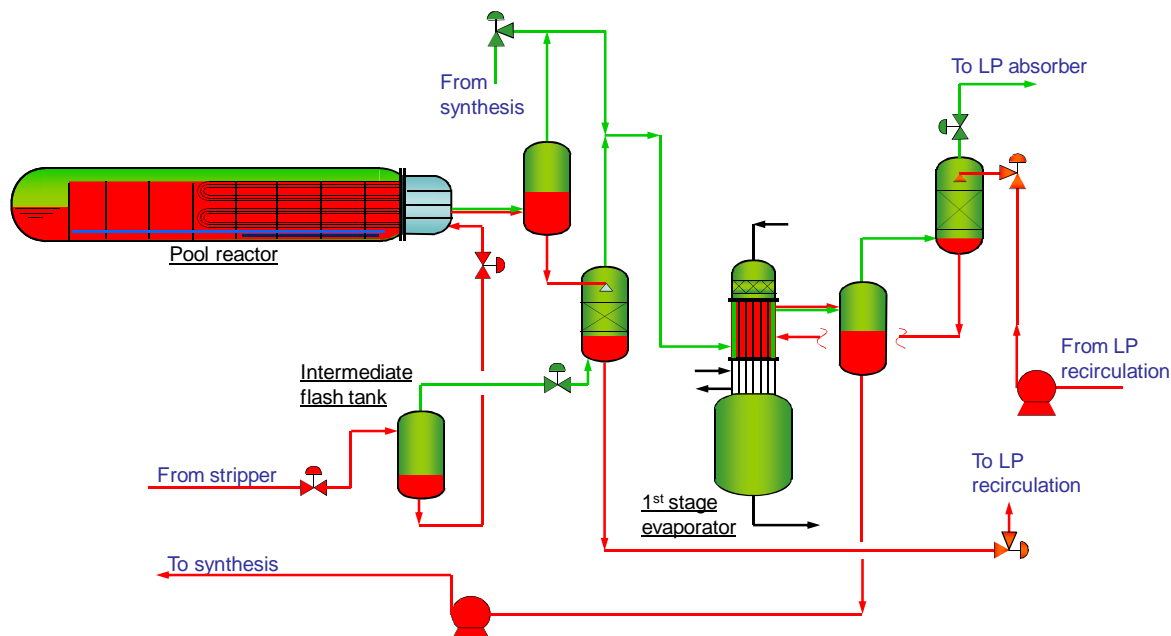


Figure 3. The medium pressure recirculation section of the "5XX" process.

The gas from the MP rectifying column together with the carbamate gas from the tube bundle separator, and the non condensed gas from the synthesis are combined and condensed in the shell side of the 1<sup>st</sup> stage evaporator heater, effectively using the heat for the third time to evaporate water from the urea melt solution on the tube side.

The heater for the first stage evaporation is designed as a falling film evaporator to enable efficient counter current operation. Halfway the condensation trajectory, carbamate coming from the LP recirculation is added after it is first used as absorbent in an MP scrubber to purify the gas vented from the MP section. This way sufficient temperature difference is maintained between shell and tube side of the falling film evaporator for an efficient heat exchanger design.

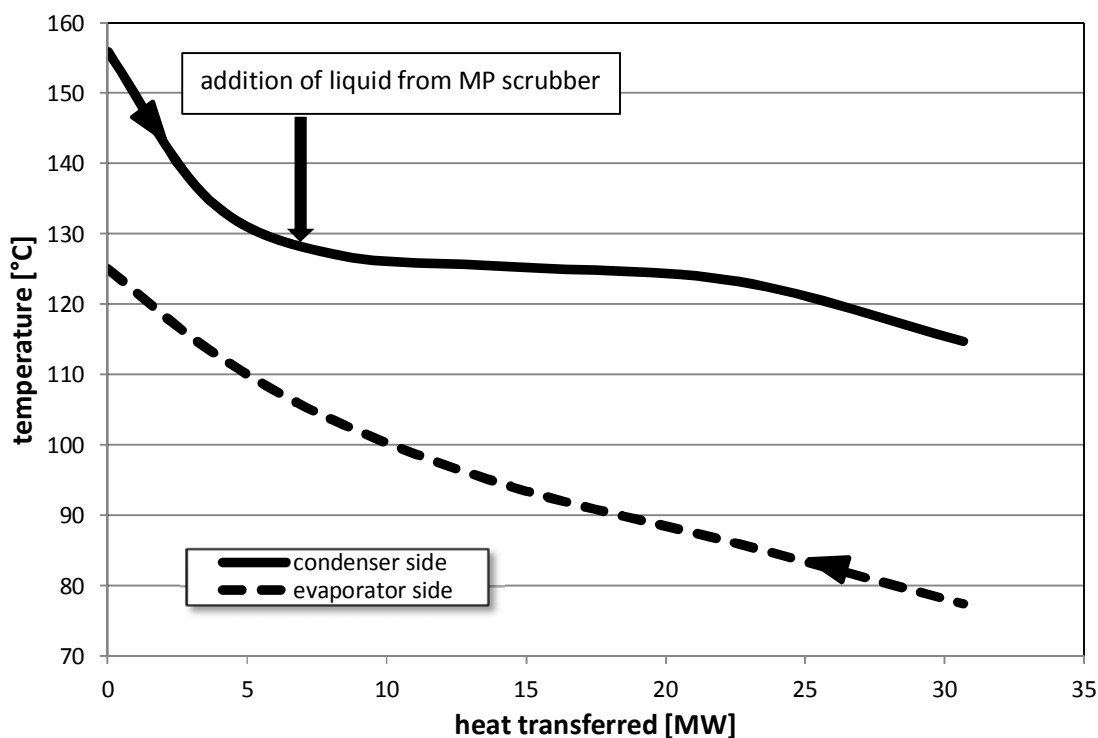


Figure 4. Temperature profile for the evaporator heater/MP condenser

The concentrated carbamate solution coming from the shell side of the evaporator heater is sent to the pool reactor using a HP carbamate pump. The uncondensed gases together with the inerts are scrubbed in a MP scrubber using the carbamate coming from the low pressure recirculation section. The resulting gas is sent to the LP absorber.

With exception of the design of the 1<sup>st</sup> stage evaporator the other sections in the "5XX" process design, the LP recirculation, the evaporation, and the waste water treatment are according the standard Stamicarbon Urea 2000plus™ process and need not to be discussed here.

## Optimization of operating conditions

The process design as depicted above was simulated using our well proven proprietary flow sheeting program. To evaluate the optimum operating conditions the model was used to optimize selected parameters like e.g. gas and liquid distribution in the pool reactor, efficiency of the stripper, pressure level of the MP and LP sections with as target a minimum extraction steam consumption.

The synthesis pressure was kept at the normal Stamicarbon operating level of 144 bar. Typical conditions for feedstock and utilities were used.

This procedure leads to an optimal set of operating conditions. Most notably are the pressure of the intermediate flash tank at 55 bar, the pressure of the MP section at 22.5 bar and the pressure of the LP section at 5.8 bar. Also the required pressure of steam on the HP stripper shell is significantly lower as compared to the steam pressure required for the stripper in the Urea 2000plus™ or Avancore® process. This is a result of the quite low required stripping



efficiency of the stripper in the N=3 process at optimum steam consumption. This lower steam pressure requirement is used for a further decrease of the total energy consumption as the pressure of the turbine extraction steam can be significantly lowered.

The "5XX" process as described above for a prilling plant leads to an expected extraction steam consumption of  $558 \text{ kg}_{\text{steam}}/\text{ton}_{\text{product}}$ . This is a saving of more than 300 kg/ton compared to the steam consumption of the reference plant and below the target set for the development.

## **Mechanical considerations for the pool reactor**

To be able to profit from the above mentioned improved steam consumption the process design consequences have to be implemented in hardware design. For the design of the pool reactor two major challenges were recognized.

First the design of the pool reactor should allow for corrosive media on the shell side as well on tube side. Stamicarbon, together with its partners, has already in the past solved the problem of corrosion on the shell side with materials as Safurex<sup>®</sup> and procedures like internal bore welding. Now the design of the tube sheet should protect the tube sheet on both sides including the tube hole side against corrosion.

One solution to this problem is to manufacture a full grade duplex tube sheet. Whether this solution is feasible for the size required still is under investigation at this moment. Alternatively a carbon steel tube sheet can be protected on both sides with a protective layer. The tube hole is protected from corrosion by insertion of a sleeve. This alternative design should also include a leak detection possibility; in a standard pool condenser/pool reactor design this is done by detection of  $\text{NH}_3$  in the steam condensate. A leak from the shell side to the MP section would however now go undetected. Last but not least the design should allow for repairs and plugging of tubes.

This solution with a carbon steel tube sheet with a Safurex<sup>®</sup> corrosion protection layer on both sides is depicted in figure 5. Short Safurex<sup>®</sup> sleeves are inserted through the tube holes and welded to the protection layer on both tube sheet sides. The Safurex<sup>®</sup> U-tube is connected to this sleeve with an internal bore weld. A leak detection system is provided underneath the protection layer.

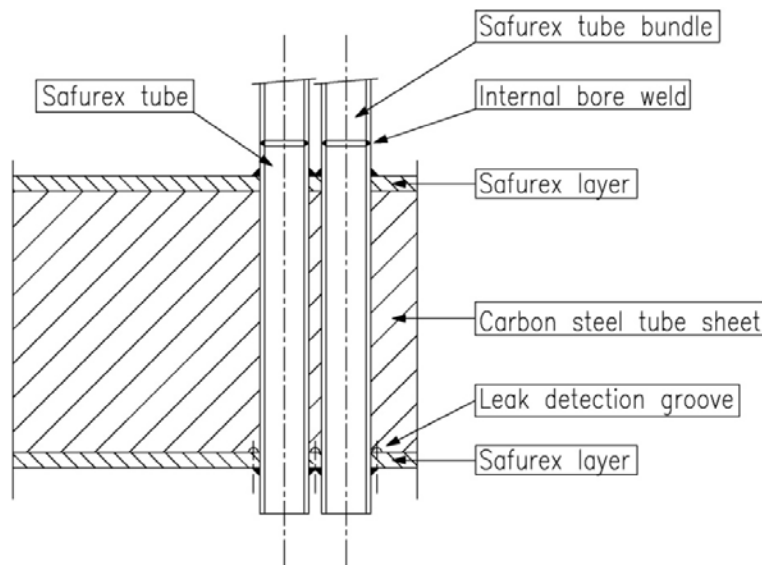


Figure 5. Cross section of carbon steel tube sheet with Safurex<sup>®</sup> layer for corrosion protection and Safurex<sup>®</sup> tubes.

The second challenge is to incorporate 2 separate U-tube bundles in the shell of the pool reactor with the required heat exchanging areas. Using the results of the optimized mass and heat balances a design for the pool reactor was prepared. This resulted in a satisfactory design in which both bundles could be accommodated without difficulty. This was largely possible due to the fact that no intermediate heat transfer medium was used and hence the size of the bottom U-tube bundle could be kept minimal.

### **Mechanical considerations for the 1<sup>st</sup> stage evaporator**

The 1<sup>st</sup> stage evaporator is designed as a falling film evaporator. Normally Stamicarbon designs rising film evaporators heated with steam on the shell side. However, as the evaporator heater serves as MP carbamate condenser on the shell side, true countercurrent operation is preferred to minimize the required heat exchanger surface area. Hence the choice for a falling film evaporator. In the past Stamicarbon already successfully designed such evaporators for specific purposes. These have already been in operation for a long time a.o. in the urea plants of OCI in The Netherlands, Kaltim in Indonesia, PIC in Kuwait and Erdos in China.

As carbamate is condensed on the shell side, all construction material in contact with this carbamate should be corrosion resistant at the operating conditions. This requires that the tubes, tube sheets, shell, baffles and tierods are to be constructed from corrosion resistant material.

Another point of attention for this type of evaporator is the liquid distribution of the urea solution over the tubes. Incorrect distribution will lead to decreased evaporation performance and hence also to decreased condensation performance.

For operability reasons a 2<sup>nd</sup> heater, operated with LP steam, is added downstream the evaporator heater/MP carbamate condenser.

## Conclusions

The extraction steam consumption of a Stamicarbon CO<sub>2</sub> stripping urea plant designed for prilled product can be reduced from a value of 868 kg<sub>steam</sub>/ton<sub>product</sub> for an Avancore<sup>®</sup> process to a value of 558 kg<sub>steam</sub>/ton<sub>product</sub>. This can be accomplished by direct heat integration between the HP condenser and the MP rectifying heater followed by direct heat exchange between the MP condenser and the 1<sup>st</sup> stage evaporator heater. By the application of this heat integration the cooling water consumption of this N=3 process concept is decreased considerably as well. These low steam and cooling water consumption figures are reached without affecting other consumption and emission figures.

From hardware point of view there are no fabrication and safeguarding limitations. This process concept with lower energy consumption can be implemented in reliable hardware. The required second tube bundle in the pool reactor can be accommodated within the pool reactor shell. The required corrosion resistance of both sides of the tube sheet in the pool reactor can be reached by either a full duplex tube sheet or a carbon steel tube sheet with at both sides a Safurex<sup>®</sup> corrosion protective layer, including Safurex<sup>®</sup> sleeves in the tube holes.

The integration of 1<sup>st</sup> stage evaporation heater with the MP carbamate condenser in the form of a falling film evaporator is already proven commercially.

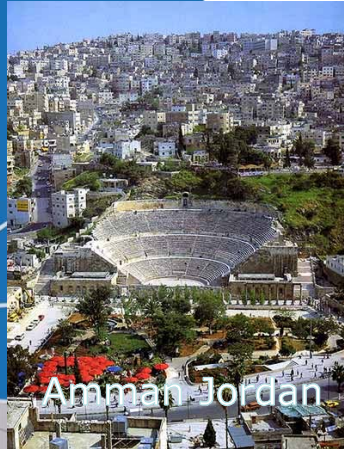
In the future Stamicarbon can even better customize plant designs for different customers by adding this low energy concept to its other available urea plant concepts.

# The Stamicarbon low energy urea melt plant

Jo Meessen  
*Principal engineer*

*AFA Workshop Renewable Energy in  
Fertilizer Industries & Energy Auditing*

*April 28 – 30, 2013  
Amman – Jordan*



## Agenda



1. Introduction and target
2. The "5XX" process
3. Specific "5XX" equipment
4. Mechanical considerations pool reactor
5. Conclusions

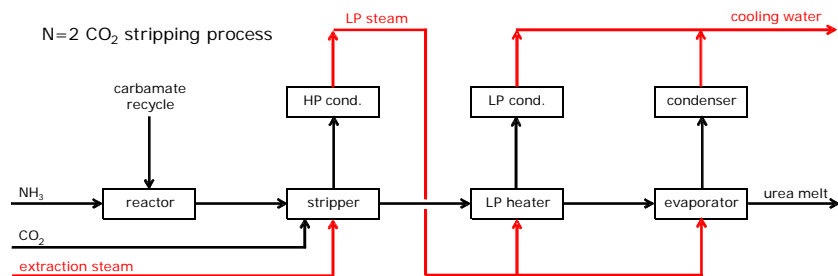
## Introduction and target



Stamicarbon focuses on lowering Total Cost of Ownership

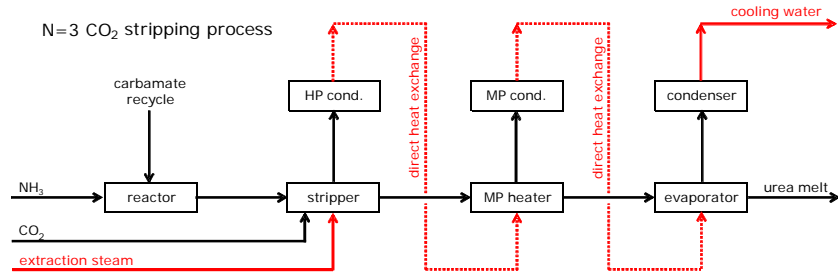
- Focus on investment
  - Minimizing number and size of (HP) equipment
  - Minimizing plant elevation
- Focus on reliability
  - Maximizing reliability and Time on Stream
- Focus on low energy consumption

## Traditional: "N=2" process



"N=2": Double use of heat

## Reduced energy consumption: "N=3"



"N=3": Triple use of heat

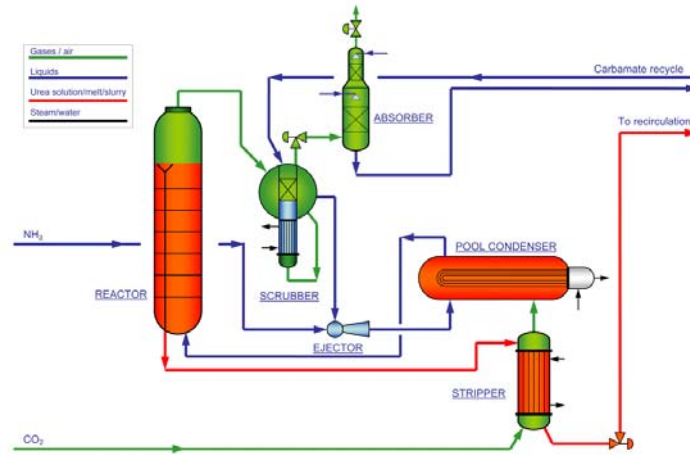
## Introduction and target



### Benchmark

- Urea 2000plus® process for prilled final product
  - Synthesis (Pool condenser, vertical reactor, HP scrubber and HP stripper).
  - LP recirculation
  - Evaporation & condensation
  - Waste water treatment
- Extraction steam consumption 868 kg/ton  
(23 bara, 330°C)

## Benchmark: Stamicarbon Urea 2000plus®



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## Introduction and target



## Target

- New low energy process for prilled final product
  - Based on  $n=3$  (heat integration)
  - Based on Avancore concept (low elevation)
  - Using efficient pool condensation
  - Using experience with MP sections
- Extraction steam consumption <599 kg/ton  
(23 bara, 330°C) => "5XX"

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## Agenda

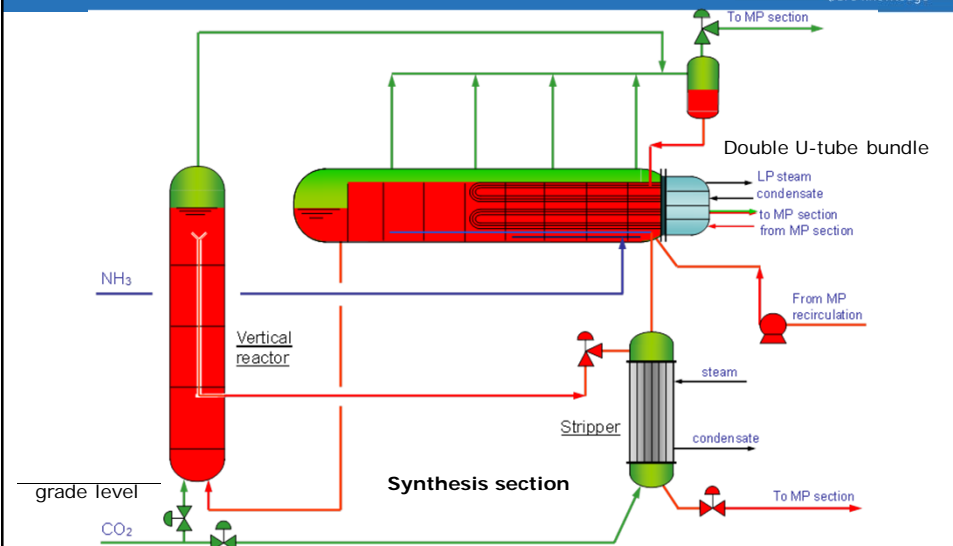


1. Introduction and target
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5. Conclusions

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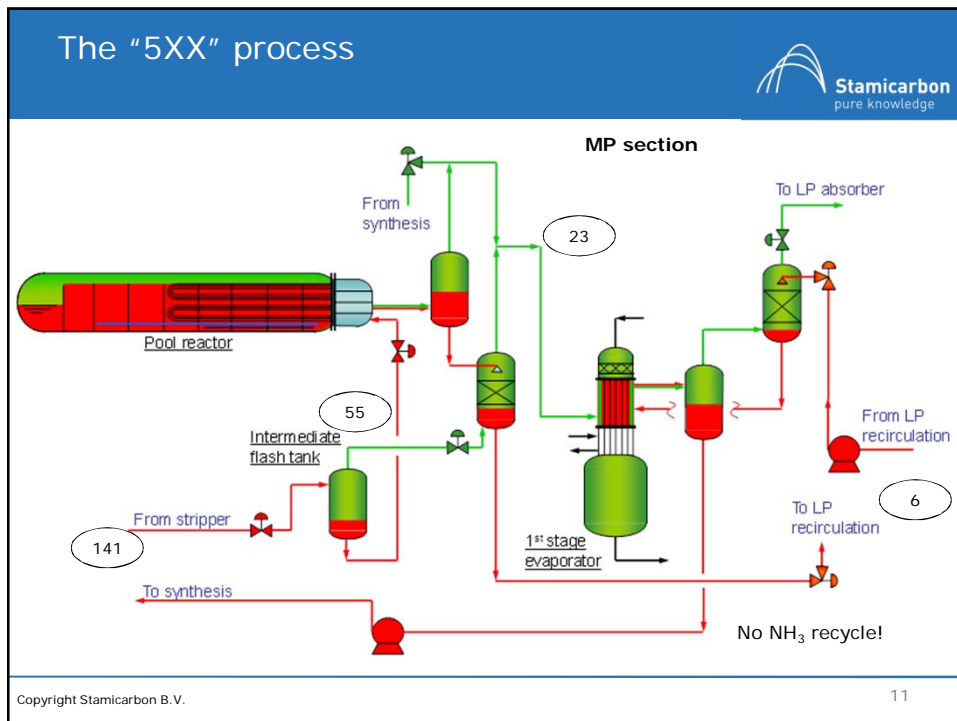
## The "5XX" process




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### The "5XX" process



Optimization process conditions

- E.g. gas and liquid distribution in pool reactor, stripper efficiency, pressure levels (flash tank, MP section and LP section)
- Synthesis pressure kept at 141 bar
- Pressure levels:
  - Intermediate flash tank 55 bar
  - MP section 23 bar
  - LP section 6 bar
- Extraction steam consumption: **558 kg/ton**

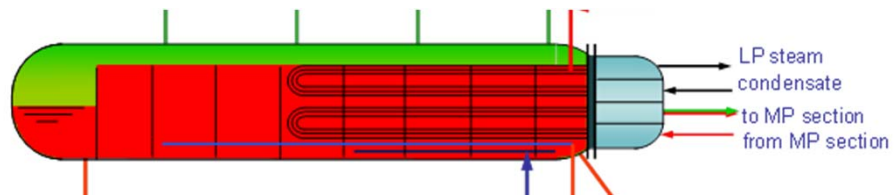
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## Agenda

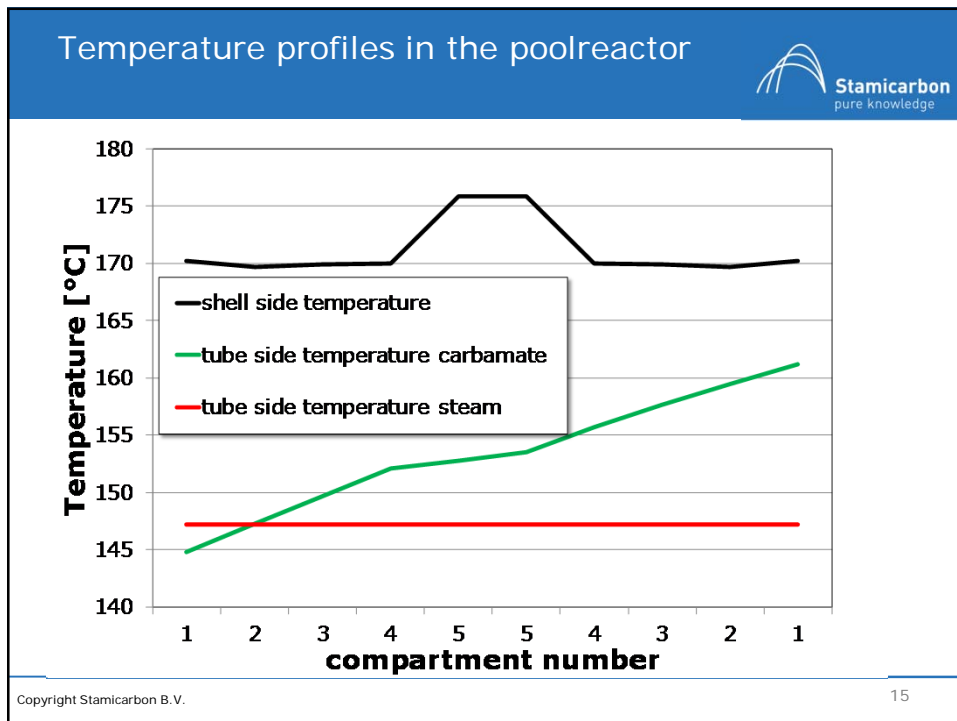


1. Introduction and target
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## Specific "5XX" equipment



Poolreactor for 5XX process



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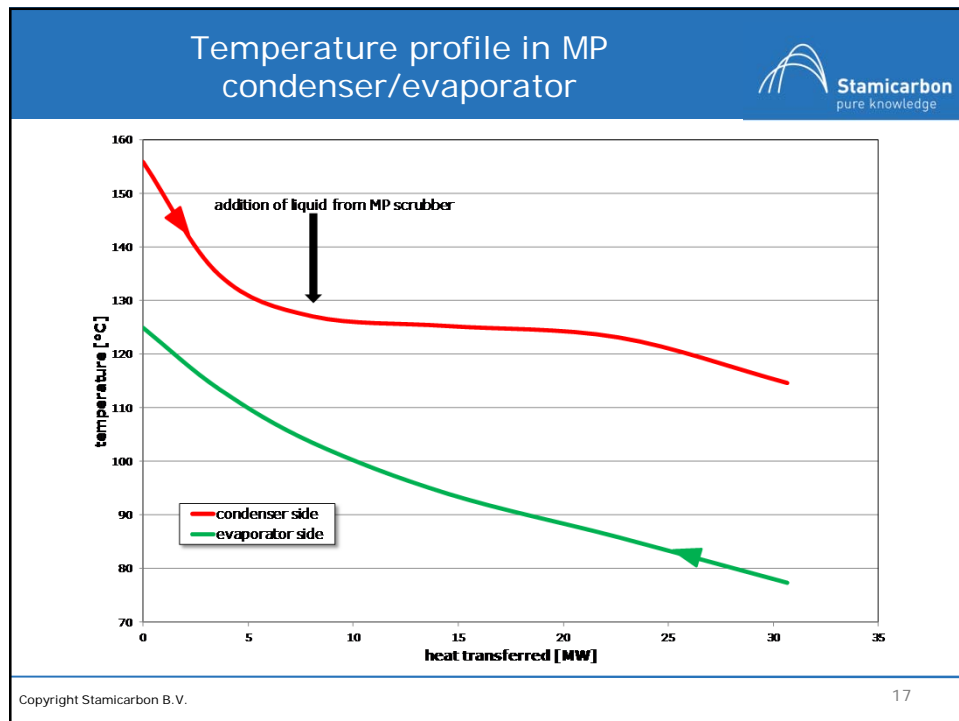
### Specific "5XX" equipment

#### MP condenser / evaporator.

- For efficient heat transfer countercurrent operation between condenser and evaporator side => falling film evaporator
- Falling film evaporator in operation at OCI Netherlands, Kaltim Indonesia, PIC Kuwait, Erdos China

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- ### Agenda
- 
1. Introduction and target
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## Mechanical considerations pool reactor



Challenge 1: fitting two U-tube bundles with required area

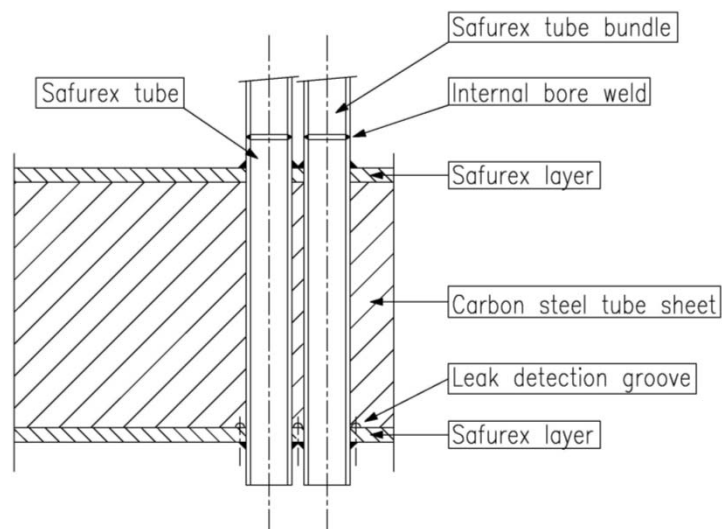
- Optimization of integrated process
- No intermediate heat transfer medium
- => Minimal size bottom (carbamate) U-tube bundle

**Both bundles can be fitted**


Challenge 2: corrosive medium on both sides of tube sheet

- Both sides of tube sheet require corrosion protection.
- Possibility leak detection

## Mechanical considerations pool reactor




## Agenda



1. Introduction and target
2. The "5XX" process
3. Specific "5XX" equipment
4. Mechanical considerations pool reactor
5. Conclusions

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## Conclusions



- Low energy urea melt plant extraction steam consumption as low as **558 kg/ton** (compared to benchmark plant 868 kg/ton).
- No hardware limitations from fabrication and safeguarding point of view for special equipment of this process concept.
- Better customization of future Stamicarbon plants with this low energy plant concept.

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## Conclusions



# Stamicarbon low energy "5XX" process now ready for licensing

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### Sittard - Headquarters

Mercator2  
6135 KW Sittard  
The Netherlands  
Ph. +31 46 4237000  
Fax +31 46 4237001  
info@stamicarbon.com

### Beijing

Room 3503, floor 35<sup>th</sup>, Jingcheng Mansion  
No.6 Xin Yuan Nan Road, Chao Yang District  
Beijing 100004  
People's Republic of China  
Ph. +86 10 84862886  
Fax +86 10 84862836  
chenggang.zhang@stamicarbon.com  
www.stamicarbon.cn

### Moscow

Zemlyanoy val 9, floor4, office 4008  
Regus Business Centry Citydel, LLC  
105064 Moscow  
Russian Federation  
Ph. +7 495 2871388  
Fax +7 495 9679700  
semen.evreinov@stamicarbon.com  
www.stamicarbon.ru

info@stamicarbon.com – www.stamicarbon.com



**Thank you**

**Stamicarbon**  
pure knowledge



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Session II**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Activities of BUE Centre For Renewable  
Energy CRE in the Field of Securing  
Renewable Energy Provision  
for Rural Areas**

**Mostafa Gouda  
Acting President  
BUE - Egypt**

# Efforts of the Centre For Renewable Energy CRE (British University in Egypt BUE) to Build a Renewable Energy Know-How

Submitted  
By

Prof Iman El-Mahallawi

## Vision and Mission of CRE

- To establish CRE as an internationally recognized centre of excellence that serves research and development communities in Egypt, the Middle East and beyond.
- Developing a BUE research strategy meeting challenges with respect to dissemination of renewable energy and sustainability, as well as, promotion international and local collaborative programs.

## Story of Progression and Building CRE

- 2006-2010 Building capacity: staff, labs, knowledge.
- 2010 Announcing the Centre.
- 2011 Start of an MSc Programme on renewable Energy and Advanced Materials.
- 2011-2012 Developing Lab and research Capacity.
- 2012 Building energy systems in rural areas.

## (Problem statement)

An expected shift in power sources in Egypt and the Arab World will take place during the coming decades. The Egyptian renewable energy sector aims at producing 20% of total power generation by 2020. Priority sectors are wind farms (the most cost-effective renewable energy source), followed by biodiesel production, and solar energy generation.

## (Problem statement)

- Current status is that only 10-15% of RE components and parts are locally manufactured and the remaining is imported.
- Driven by one of its main objectives the BUE CRE launches a continued programme starting by this workshop aiming at integrating societal efforts to help lead Egypt into the renewable energy era.

## (Action Plan)

Defining measures that need to be taken including:

- Legislations; Capacity building; Social awareness; Educational aims; Research strategies; And the most important Local manufacturing plans.
- Local manufacturing depends on: Vision; Technology; Investment; Education and training; And most important: Trained and educated labour.

## Recommendations

- Egyptian business sector should take the following steps immediately: Call for local and foreign investors to start business in RE manufacturing related activities.
- Egyptian investment sector should take the following steps immediately Prepare feasibility studies for various activities.
- Egyptian educational sector should take the following steps immediately : launch a nation wide campaign where renewable energy education is implemented in all related topics.

5/2/2013

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## Recommendations

- Egyptian research sector should take the following steps immediately : adopt research topics focusing on reducing prices and utilizing local materials.
- Egyptian labour sector should take the following steps immediately : design training and development programmes to provide trained staff for the expected industries.
- International community should understand that energy coming out of Egypt will feed the whole world but Egyptians have to be the main partners and the providers.

5/2/2013

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## BUE Work Plan

- Include RE topics in undergraduate education through support of curricular and extracurricular activities in the field of RE.
- Bridge the gap between academia and industry by organising workshops to local industrial communities paving the path for small business people and manufacturers to include RE parts in their plans.

## BUE Work Plan

- Working with professional bodies (Engineering syndicate and ASME Egypt) to open wide societal discussions on RE need, challenges, and options.
- Building a data base including all bodies, names, academic staff, research communities that can help in raising the RE profile in Egypt.

## BUE Work Plan

- Working on developing an Energy Road Map under the umbrella of ASME Egypt.
- Defining the immediate short term solutions and developing a BUE research strategy meeting these requirements: e.g using RE to meet part of the residential requirements, removing knowledge barriers for building stand alone energy systems, etc.

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## BUE Work Plan

- Defining the long term plan in view of the challenges: e.g. removing knowledge barriers for hybrid stand alone RE systems, finding solutions for climatic conditions affecting the efficiency of PV energy systems in Egypt, integrating local materials in the developed systems, etc..
- Building relations with national, regional and international societies for integration and raising the learning profile.

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## **Example Project Implemented by CRE**

### **Installing a Stand-alone RE Power System in Saydna Alkhedr and Saydna Moussa Villages Project**

## **Contents**

- Introduction
- Project Aim
- Project Objectives
- Roles of CRE
- Implementation

## Introduction

- The project is a charity project sponsored by Misr Elkheir Foundation.
- Dr. Tarek Hatem is the project manager and systems were designed and implemented by the CRE
- Two underprivileged villages at the suburbs of city of Fayoum are suffering from lack of electricity and services.
- Great solar potential at the two villages.

## Villages



**Mossa Village**



**Khidr Village**

## Project Aim

Solving local rural communities problems through sustainable and practical solutions



## Project Objectives

- Disassembly of unused PV solar panels from the lighting poles.
- Installation of PV solar systems atop of critical service and residential buildings.
- Empowering graduate and undergraduate students by involving them in the project and allowing them to learn about the fundamentals and applications of RE systems.

## Roles of CRE

- I. Design and components sizing of the PV systems.
- II. Preparing students academically through an intensive training before start of the project.
- III. Design and implement a prototype systems at the campus for practical training.
- IV. Implementation and supervision over associated machining and welding operations.
- V. Budget estimation for different system options and components combinations.

## Implementation



## Implementation

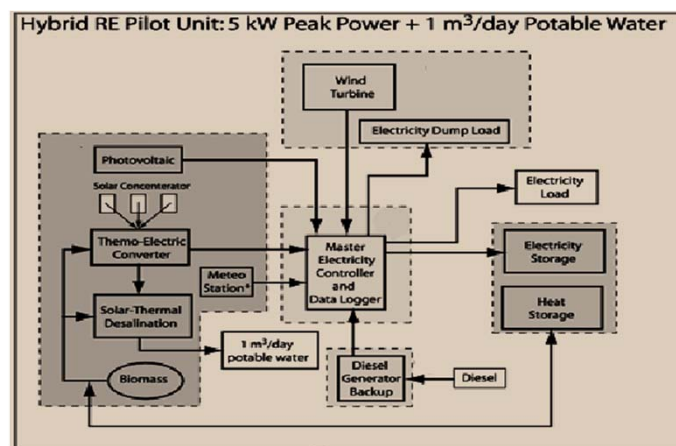


## Example Project In Preparation Stage by CRE

**Design and Development of a  
Low Cost Tailored Stand  
Alone Hybrid Power System**

- This action aims at offering innovative **scientific solutions** based on **joint industry/ academia** cooperation for the provision and supply of energy for **remote and rural areas**. Utilizing **Egypt's** natural resources is targeted by this proposal since the offered solutions will rely mainly on **renewable energy sources**. The **proposal also aims at empowering local people living in sub-serviced areas to work on finding solutions and options for self provision, and maintenance of their basic energy needs.**

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**Thank You for listening**




**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**GPIC Initiative to Renewable energy  
Adoption of Pioneering  
Technology Replacement of  
Urea High Pressure Stripper**

**Mohamed Jawad  
Urea Plant Engineer  
GPIC - Bahrain**






GULF PETROCHEMICAL INDUSTRIES COMPANY

## GPIC INITIATIVE TO RENEWABLE ENERGY & ENERGY AUDITING

### ADOPTION OF PIONEERING TECHNOLOGY REPLACEMENT OF UREA HIGH PRESSURE STRIPPER

Mohamed Jawad Jassim  
Urea Plant Graduate Engineer

AFA Workshop  
Renewable Energy in Fertilizer Industries  
and Energy Auditing  
April : 28-30, 2013 – Amman - Jordan



Beyond Excellence

## Introduction

- **Established in December 1979**
- **Joint-Venture between the Government of Bahrain, Saudi Arabia (SABIC) & Kuwait (PIC)**
- **Utilizes Natural Gas as raw material**
- **Produce: Ammonia, Methanol and Urea**
- **Started production in 1985**
- **Production Capacity : 1,500,000 Tonnes Annually**
- **Manpower : 475 Employees**
- **95% are Bahrainis including Trainees**









Beyond Excellence

## GPIC Urea Plant

GPIC Urea Plant was Commissioned in 1998.

- Synthesis Technology Licensor : Snamprogetti, Italy
- Granulation Technology Licensor : Uhde Fertiliser Technology, Germany.
- Engineering Contractor : Mitsubishi Heavy Industries, Japan

Design Capacity : 1700 MTPD of Granular Urea




 **Beyond Excellence**

## GPIC Urea Plant Production Performance

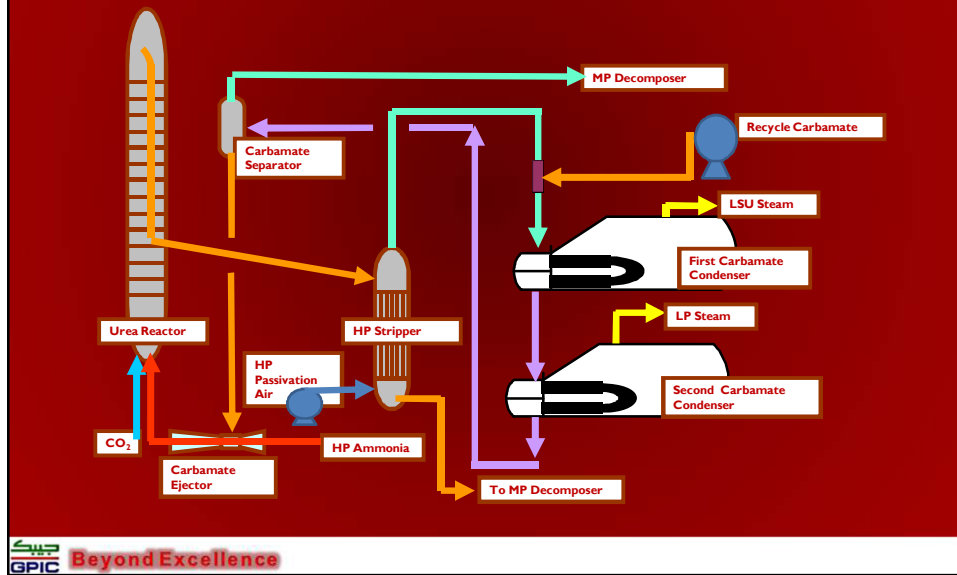
| Year | Production <i>MT</i> |
|------|----------------------|
| 1998 | 465769               |
| 1999 | 485559               |
| 2000 | 536900               |
| 2001 | 612742               |
| 2002 | 631110               |
| 2003 | 566984               |
| 2004 | 509776               |
| 2005 | 561058               |
| 2006 | 624682               |
| 2007 | 584763               |
| 2008 | 661443               |
| 2009 | 654016               |
| 2010 | 629371               |
| 2011 | 673681               |
| 2012 | 626985               |

Inception of  
OmegaBond  
stripper

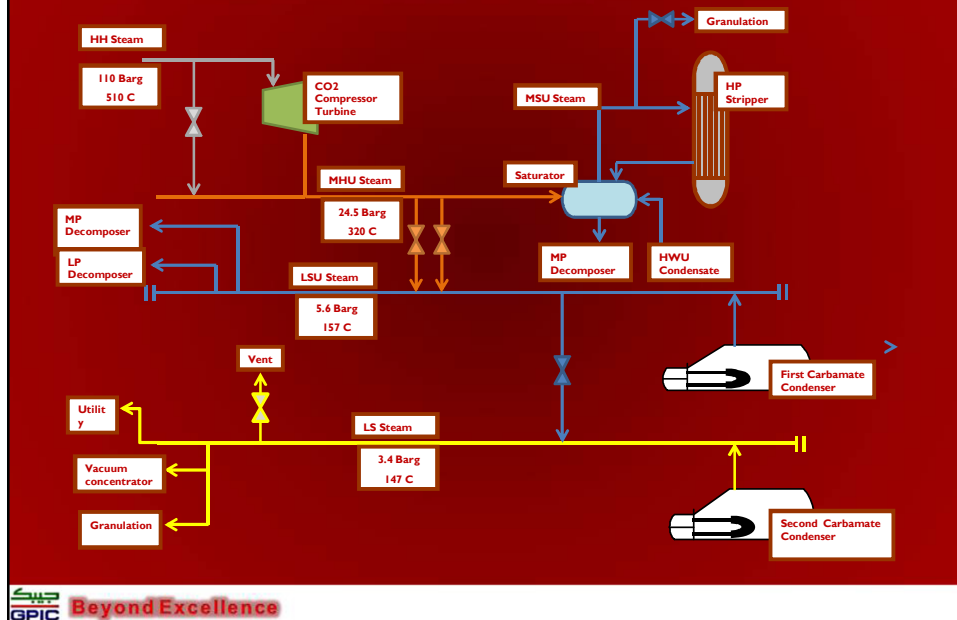


 **Beyond Excellence**

## Snamprogetti Ammonia Stripping Process



## Urea Plant Steam Network



## GPIC Urea Plant Bimetallic Stripper

### Design Features

- 25:22:2 Cr, Ni, Mo stainless steel outer tubes with inner tube of Zirconium.
- 25:22:2 lining on tube-sheet and channels
- Tubes have good Resistance against erosion.
- Good Resistance to corrosion when operated below 205 °C
- Assisted with Additional HP air for Passivation



## GPIC Urea Plant Bimetallic Stripper Experience

- Metallurgical concerns
  - SS:Zr Tube disbonding
  - Corrosion at tubes ends, tube-sheet cladding, channel & head lining

- Stripper was limited to a maximum temperature of 204 °C
- Increase of HP passivation air flow was required

Operation limitation at higher capacity

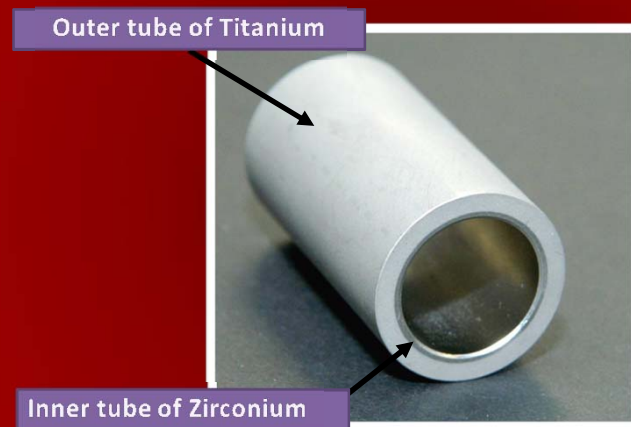
- Downstream MP and LP section were overloaded



## **Omegabond® Tubing Technology**

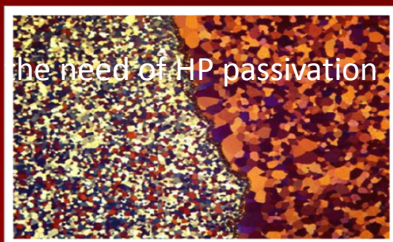
- In view of these issues and M/s Saipem's development of the HP stripper with Omegabond tubing technology, GPIC, as part of its strategic planning in regards to energy saving and resolving technical issues, decided to replace the HP stripper in March 2010.
- The new HP stripper is Titanium lined with Omegabond Tubes from ATI WahChang
- HP Stripper was fabricated at Luigi Resta, Italy

## **OmegaBond® Tubing**



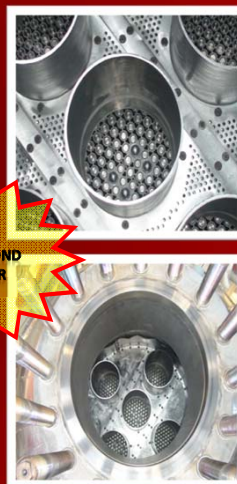
## OmegaBond® Tubing

- Allows more aggressive operating conditions
- Higher Integrity tubing due to Solid state joining technology utilized between Titanium and Zirconium.
- Eliminated the need of HP passivation air for the stripper.



GPIC Beyond Excellence

## Venturing into new Technology

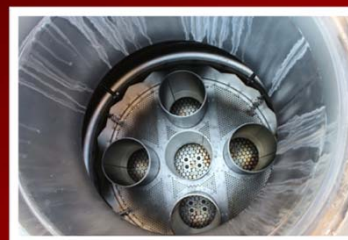


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## OmegaBond® Urea Stripper Inspection

- Detailed visual examination
- Ultrasonic Thickness Measurement
- Eddy current inspection
- Ultrasonic inspection



GPIC Beyond Excellence

## Operation Experience with using the OmegaBond® Tubes in GPIC's HP Urea Stripper

- **Metallurgical Advantages**
  - More stable in severe corrosive environment.
  - Ti/Zr OmegaBond tubing have better heat transfer coefficients than SS/Zr Bimetallic tubes.
  - Metal disbonding is eliminated with the
    - ✓ High integrity metallurgical bond
    - ✓ Similar thermal expansion coefficient of Ti and Zr
  - Weldability of tubes to tube sheets is achieved
  - Easy to maintain and have higher life cycle.

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## Operation Experience with using the OmegaBond® Tubes in GPIC's HP Urea Stripper

### • Plant Flexibility

- Operating the stripper at Higher bottom temperature (210-212°C), thus more Carbamate is decomposed by the stripper.
- Plant performance improved due to the reduction of inert to the system by removing the HP passivation air. In addition high maintenance cost of these compressors was eliminated.
- 85 kg LP steam per ton of urea product has become surplus that is used in the LS network of the complex.



## Operation Experience with using the OmegaBond® Tubes in GPIC's HP Urea Stripper

### • Energy Saving

- Heat recovery improved due to increase of stripper bottom temperature
- Generate more low pressure steam which is fed to steam network, reducing the load on boilers which lead to energy savings in regard to natural gas consumption.
- Reduced carbamate recycle which led to enhanced urea conversion and reduced energy consumption in the high pressure Carbamate pump.
- Downstream condensation and heating duties were reduced.
- HP Passivation air requirement for stripper was eliminated which saved energy in terms of power consumption by HP passivation air compressors.





## Overall Energy Evaluation of GPIC Urea Plant

- **Bimetallic stripper**

– HH Steam consumption was  $0.92 \frac{\text{Ton of Steam}}{\text{Ton of Urea}}$

- **OmegaBond Stripper**

– HH Steam consumption reduced to  $0.85 \frac{\text{Ton of Steam}}{\text{Ton of Urea}}$

**Which is around 7.5% reduction in the specific HH steam consumption**

## Overall Energy Evaluation of GPIC Urea Plant

- **Bimetallic stripper**

– Carbamate recycle Pump power  $24 \frac{\text{KW}}{\text{Kg of Urea}}$

- **OmegaBond Stripper**

– Carbamate recycle Pump power  $21 \frac{\text{KW}}{\text{Kg of Urea}}$

**Which is around 12.5% reduction in the recycle pump power consumption**

## Overall Energy Evaluation of GPIC Urea Plant

- **Bimetallic stripper**

- HP Passivation Air compressor power  $0.5 \frac{\text{KW}}{\text{Kg of Urea}}$

- **OmegaBond Stripper**

- No requirement of Passivation air.

**Additionally, 35 Nm<sup>3</sup>/H of Air were eliminated from the process**

## Conclusions

1. The overall capacity of GPIC's Urea plant equipped with the new stripper was increased more than 8% as a result of the OmegaBond® tubing.
2. The use of OmegaBond® tubing product is a highly desirable option for new Saipem urea strippers and future Saipem urea stripper revamps , **it is ideal option for energy saving and resolving technical issues related to material of construction.**
3. Return on investment projected at the time of the project initiation estimated a payback of 2 years, which was achieved **due to load increase and Energy savings attributed to OmegaBond tubes**

# Thank You For Your Kind Attention



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**BACTERIA /ALGAE REMOVAL FROM  
SAFCO-IV DEMINERALISATION UNIT**

**P.Balasubramanian & Hussain A. Al-Esmail  
SAFCO – Saudi Arabia**



# BACTERIA /ALGAE REMOVAL FROM SAFCO-IV DEMINERALISATION UNIT

By: Ponnambalam Balasubramanian and Hussain A. Al-Esmail

Process Engineering, SAFCO, Jubail, Kingdom of Saudi Arabia

Corresponding author.

E-mail address: [ponnambalamb@safco.sabic.com](mailto:ponnambalamb@safco.sabic.com) &  
[HEsmail@safco.sabic.com](mailto:HEsmail@safco.sabic.com)

## ABSTRACT

SAFCO 4 Utility Demin plant experienced a chronic problem in the demin system due to Aerobic Bacteria growth in the Cation, Degasifier and Anion Units. Due to this problem the demin unit throughput had fallen to 212 M<sup>3</sup>/h from both units against the requirement 340 M<sup>3</sup>/hr. This incident upset the water balance of the plant. In order to compensate the requirement of DM water, portable RO unit brought to the site and the remaining water taken from SAFCO3. For the last 6 years this issue caused severe **environmental** and cost impact adversely affecting water conservation and waste generation. Even though we had done the open backwashing of the resin, nozzle cleaning and chemical cleaning with caustic, they were not successful.

SAFCO Process Engineering team and after deep study and analysis, they proposed to do the Sterilization of the DM Unit to eliminate all the bacteria / Algae in the system using a new formulated Biocide and surfactant by special company. After implementation of the proposal during the Turnaround in April 2012, all the bacteria was eliminated as confirmed through tests/analysis. For the last one year, dP of the Anion and Cation unit came down to <0.5kg/cm<sup>2</sup> and the production of DM units increased up to 420 M<sup>3</sup>/hr. This enabled the sustainability effect to reduce the potable water consumption by around 55 m<sup>3</sup>/h and also bring down waste water generation by 55 M<sup>3</sup>/hr. Annual energy saving was 144,896 KWh

## INTRODUCTION

SAFCO, the World's largest producer of granular Urea fertilizer, operates four world class ammonia and Urea plants along with Urea formaldehyde and complex fertilizer plant. Each ammonia-urea complex has its own Utility plants serving steam, water and other utilities with tie in provisions for flexibility in operations.

SAFCO 4 (SF4) complex commissioned in 2006 consists of 3300 MTPD Ammonia plant based on UHDE's technology and 3250 MTPD Urea plant based on Stamicarbon technology.

The Demineralization(DM) plant attached to SF4 caters to the polished water requirement for the Utility Boilers and the waste heat boilers in the ammonia plant. The major intake of raw water from Marafiq is for the DM plant and the rest is for potable & irrigation, fire water and utility service points.

SAFCO 4 demin unit Cation and Anion vessels experienced high pressure drop since commissioning due to algae & bacteria growth. Several attempts were made to solve this problem online but were not successful. Also, cooling water leak in Urea Reflux Condenser worsened the situation leads to high growth of nitrifying bacteria resulted DM water production came down to 212 M<sup>3</sup>/hr. By January 2012 as against the required 340 M<sup>3</sup>/hr. Urea process condensate had to be dumped to the waste water system incurring huge water loss, energy loss and environment concern related to waste water management.

In order to solve the water issue one mobile R.O. unit was hired in Feb'12 and the remaining requirement was met from SAFCO 3.

SAFCO Process Engineering recommended sterilizing the demineralization unit of SAFCO 4 plant with reputed and experienced Water treatment Vendors as a permanent solution. Aim of this job was to completely remove all existing microbiological organisms during the turnaround in Apr 2012.

This paper intends to examine the origin of the problem and how the problem was solved. Sterilization was done on April 2012 using Biocide and Surfactant and after the sterilization the result shows that all bacteria were removed from the Unit and for the last one year DM unit is running normal with production rate of 420 M<sup>3</sup>/h and dP of the vessels were maximum 0.5 Kg/cm<sup>2</sup>.

## 2.0 DESCRIPTION OF DEMINERALIZATION UNIT

The DM plant in SF4 has a capacity to produce 800 M<sup>3</sup>/h of polished water to be used as Boiler feed water. The plant has two trains of DM unit that produces polished water of conductivity <0.2µS/cm which is suitable for boilers in Ammonia and Utility plant.

The service water facility provides make-up water to Demineralization unit and to process users. The demineralization unit, Figure 1, is composed of two identical lines, including activated carbon filters, cationic exchangers, Degasifier and anionic exchangers. In normal operation one line is working while the other one is on regeneration or stand-by. Service water is fed to the activated carbon filter to eliminate free chlorine.

Filtered water is collected in the mixing vessel where it is mixed with process condensate from ammonia and urea plant plus blow down of ammonia plant and auxiliary boiler water. These streams are cooled in heat exchangers at the plant side to keep the feed temperate at or below 50°C as this is required for proper operation of ion exchange.

From mixing vessel water is pumped to the Cation exchanger to remove ionic ammonia, calcium, sodium and iron etc. Acidic water is then passed through degassing column where dissolved carbon dioxide from carbonate and bicarbonate can be almost eliminated by air blown into the degassing column by fan. For process improvement, the column is filled with special hollow rings to provide a large surface for air contact with down flowing water.

From degassed water tank water is pumped to the anion exchanger where chloride, sulfate, silica and rest of carbonate are removed before demineralized water flows into the demineralization Tank. The ion exchanger shall be operated in fluidized packed bed where the water enters the vessel from bottom and leaves at top.(1)

The schematic diagram showing the DM plant configuration is given in Figure 01.

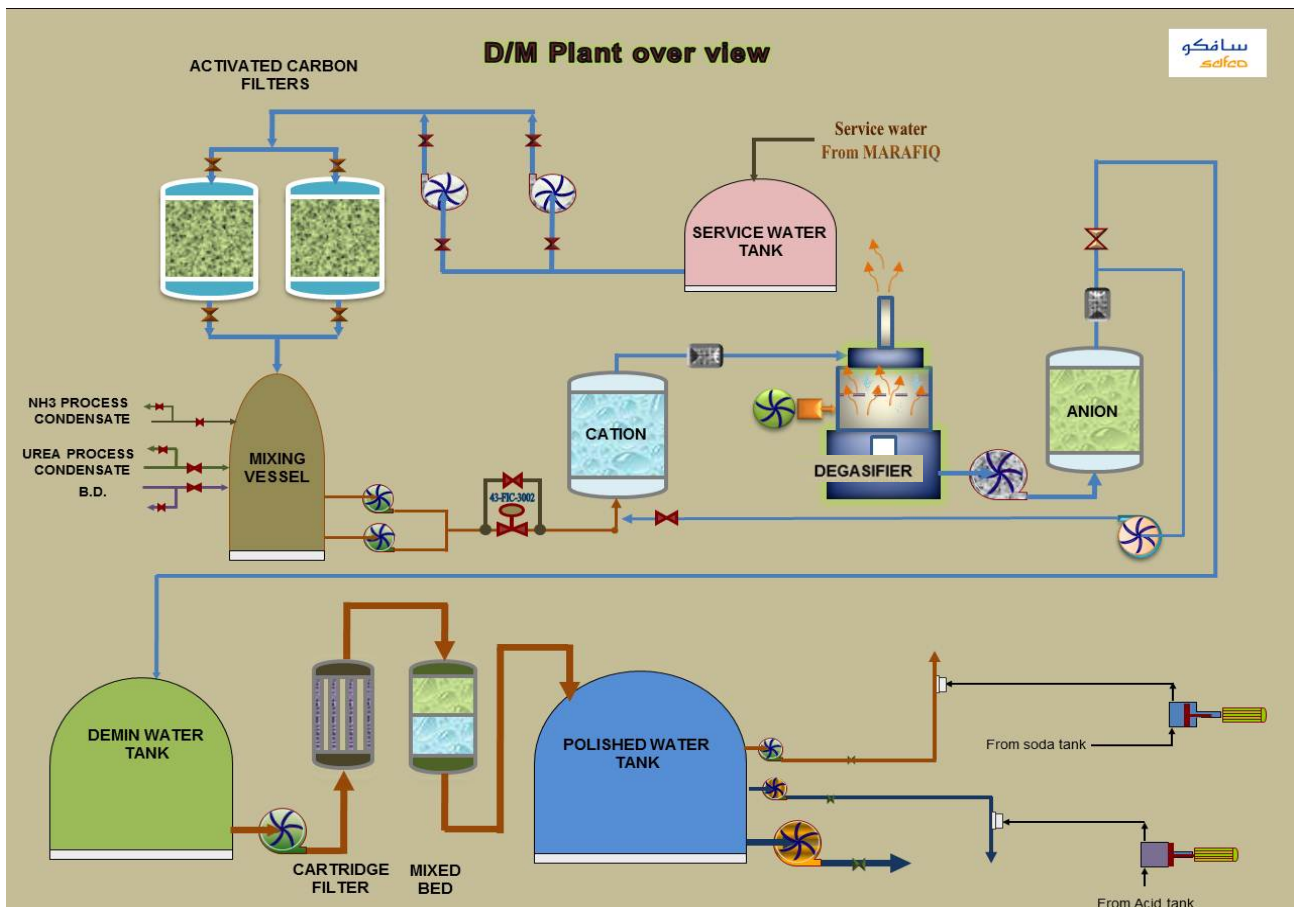


Figure 01: Block diagram of SF4 DM Plant

The output of the Anion exchange is 300 M<sup>3</sup>/hr. capacity with a conductivity of <2  $\mu$ S/cm. To meet the polished water demand, normally all the two DM trains and all three Mixed Beds are kept online except during regeneration period.(2)

In the DM tank (43-T301), as shown above, the various return turbine condensates around 540 M<sup>3</sup>/hr. from all plants mixed together. Demin tank water from DM tank pumped to mixed bed via cartridge filter and the mixed bed outlet quality is 0.2  $\mu$ S/cm conductivity.

### 3.0 EVENT CHRONOLOGY

**Resin Fouling:** Corrosion products, iron organic acids, suspended particles, oil and bacteria adsorption in the resin beads cause fouling. It has been reported that microbial resin fouling can be caused by *Pseudomonas abietaniphila* and *Zeogloea resinphilabacteria*. Another research group reported anion resin fouling by bacteria. One research team found filamentous bacterium, *Spaerotusnatan* on anion resin and in feed water to resins. The same team also identified



cyanobacteria (*Nostoc punctiformis*, *Anabena* sp, and *Oscillatoria* sp) and aquatic weeds in a flocculator's source H<sub>2</sub>O while investigating resin biofouling. The weeds release organic compound by metabolic activities and the decay helps bacteria growth by supplying nutrients. Idle, extended storage or remaining in neutral condition causes resin biological fouling, immersing resin in biostatic solutions minimises this potential.(3)

SAFCO 4 Demin unit experienced the problem of bacterial growth since commissioning in 2006. It might be due to the stagnant water present during the commissioning and also the input line leakage from Marafiq. SAFCO had done caustic cleaning for the resins but it was not successful.

**December 2008:** Degasifier packing rings came out through stack and Anion dP was also high due to Algae/ bacteria. Degasifier packing cleaning and Anion vessel nozzle cleaning done. After 2 weeks dP became high. Figure 02 illustrate the bacteria growth in degasifier rings.



Figure 02: Degasifier Packing with bacteria

**February 2009:** Both Anion and Cation open backwash done due to high dP. After that the production improved. Similar open backwashing exercise were done up to October 2010. Degasifier outlet strainer also opened for inspection. Figure 03 & Figure 04 illustrate the bacteria present in Degasifier strainer and Anion resin.



Figure 03: Degasifier outlet filter



Figure 04: Anion Resin

**October 2010:** Anion dP of both units came up to 2.0 Kg/cm<sup>2</sup> and the open backwashing and nozzle cleaning of both Anion vessels done. During open backwashing air scoring was also done as per the procedures from Resin vendor. Even after doing all, dP of both units were still high. Figure 05 illustrate the presence of bacteria in the nozzles and Figure 06 illustrate the bottom nozzle after cleaning and found good.



Figure 05: Bottom nozzles before cleaning

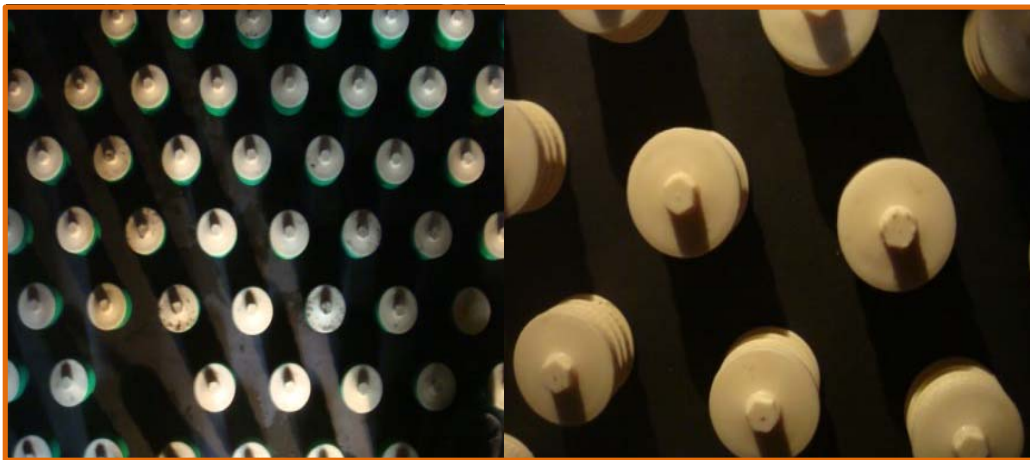


Figure 06: Bottom nozzles After cleaning

From the Degasifier sample, Heavy Aerobic Bacterial Growth has been observed. Mostly its Mold and Amorphous matter in flocks shape pattern. Bacterial Count is high.

**AEROBIC BACTERIA :** Total Viable Count @ 35° C 1 400 000 000 CFU/gram

**FUNGI :** Mold 5 400 000 est. CFU/gram

- SAFCO along with Chemical provider analyzed the source of Bacteria from all condensate samples. The source of algae from the condensate coming from the process Air compressor separator condensate. Also Algae / Bacteria growth seen mainly in Degasifier and in 42-T-617(Waste water tank.)
- The possible cause for more algae/bacterial growth is the presence of ammonia, methanol in the water (process Condensate) and oxygen that is available in Degasifier along

with bacteria already in the system. **SAFCO Process Engineering recommended for Sterilization of the whole unit.**

- Process air compressor condensate dumped (4M<sup>3</sup>/hr) and 42-T-617 waste water not to taken to the system. Regular open backwashing was done every month to all cation and Anion resins.
- **January 2012:** Demin water production suddenly came down to 212 M<sup>3</sup>/hr. due to nitrifying bacteria presence in the system might be due to cooling water leak. Urea process condensate was started dumping due to high conductivity and also cooling water loss from the system was 900 lits/hr. Cooling water was continuously lost from the closed loop system and make up was done with Polished water . Also, chemical make up for corrosion protection (N-39LS/N –Nitrite chemical) was done frequently as the weekly analysis showed reduction. Even though Urea process condensate dumped, the algae growth was more, high dp in both Anion and Cation and reduce the production.
- Several ways of identifying the leak sources in the exchangers in Ammonia , Urea and Utilities did not help. Finally tracer test done for 52 exchangers and identify the leak in Urea plant reflex condenser (42-E-804).

## 4.0 PROCESS IMPACT AND ACTION PLAN

### 4.1 Impact of the Bacteria growth, C.W. leak and condensate dumping

The above problem led to the following issues in the plant:

- Due to the above problem on the average production of the Demin unit came down to 212 M<sup>3</sup>/hr.
- The water balance in the SAFCO 4 got severely affected with a shortage of 108M<sup>3</sup>/h in Demin water since February 2012.
- From January 2013 onwards, weekly open backwash done to both Anion Resins. 60 M<sup>3</sup> of polished water required for every backwash.
- Additional 55M<sup>3</sup>/h of waste water had to be disposed due to the dumping of Urea condensate and the waste water from R.O unit. This, apart from energy loss, cost impact for disposal, led to high retention levels in waste water section leading to waste water management issues
- Constraint to sustain plant loads due to the limitation in Demin water generation causing difficulty to meet polished water demand in the plant

- The operation of the DM plant with frequent open backwash due to high dP, coordination between other plants etc caused severe stress on the Utility operation personnel.

#### **4.2 Energy and Cost implication**

Significant cost impact entailed due to the dumping scenario which is worked out as below:

Yearly 144,896 KWh additional energy required for regeneration water pump and waste water pump.

Additional raw water drawal from Marafiq due to loss of condensate -55 M<sup>3</sup>/hr

Waste water disposed – 55 M<sup>3</sup>/hr

Rental cost for R.O. Unit - 0.5 million per month.

#### **4.3 Temporary Remedial measures**

The following mitigation steps were immediately to sustain plant operations

- 40 M<sup>3</sup>/hr of DM water from SF3 DM plant.
- 15 M<sup>3</sup>/hr of Polished water was transferred in tankers from Ibn Al Baytar.

#### **4.4 Additional setback and interim measures**

While the Utility units were struggling to combat the dumping scenario, an additional problem cropped up in January 2013 when SF4 Ammonia plant suffered a setback due to a leak in 41-E-612 (Syn.loop waste heat boiler) that resulted in dumping of blow down water and frequent regeneration of mixed bed.(Maximum cycle time of 30 hr./cycle against 72 hrs./cycle).

A quick fix solution was explored and a portable RO unit of 60m<sup>3</sup>/h capacity was installed on rental basis to treat raw water and supply DM water suitable as feed to Mixed bed polisher in SF3 DM plant. This measure incurred a high expenditure of SR 500,000/month.

### **5.0 STERILIZATION DURING TURNAROUND AS SUSTAINABILITY ALTERNATIVE**

Extensive brainstorming was done and interactions with external agencies and experts were carried out to evolve a suitable solution to eliminate Bacteria permanently from the DM unit, conserve the energy, water and sustain plant operation. Water Processing and Technology companies were called and consulted and proposals were received and studied.

Finally after the series of in house analysis followed by chemical provider and SABIC T & I corrosion team support , SAFCO Process Engineering assured to proceed for Sterilization with Oxidizing Biocide and Surfactant during Turnaround.The details of causes and remedies are mentioned in Table 01.

**Table 01: DM UNIT BACTERIA ISSUES AND REMEDIES**

| Sl.No. | Possible causes  | Remedy by SAFCO Process Engineering  |
|--------|--|--|
| 1      | Bacteria Already present in the system   | Sterilization during T/A   |
| 2      | Bacteria from the incoming sources, (Water quality pipeline contamination)                           | <p>Bacteria coming from the following areas identified</p> <ol style="list-style-type: none"> <li>1. Service water inlet line already replaced in 2010.</li> <li>2. Process Air compressor inter stage cooler condensate found bacteria and diverted.</li> <li>3. 42-T-617 waste water tank had bacteria and diverted.</li> <li>4. Close monitoring of the inputs are to be closely monitored.</li> <li>5. Open backwash of Resins to be done once in every three months.</li> </ol> |
| 3      | Air coming from the Air blower to Degasifier containing Bacteria coming from nearby waste water tank | Cover the waste water basin or Treat the waste water basin with Oxidizing bacteria (NaOCl)   |

### 5.1 STERILIZATION PROCESS SUMMARY

As previously mentioned, the aim of this sterilization job was to completely remove all existing microbiological organisms during this turn around by using Oxidizing Biocide and Surfactant. Sterilization came as a part of the solution for high pressure drop issues in the demineralization unit vessels due to algae & bacteria growth. Figure 07 illustrate the detailed schematic drawing for the Sterilization.



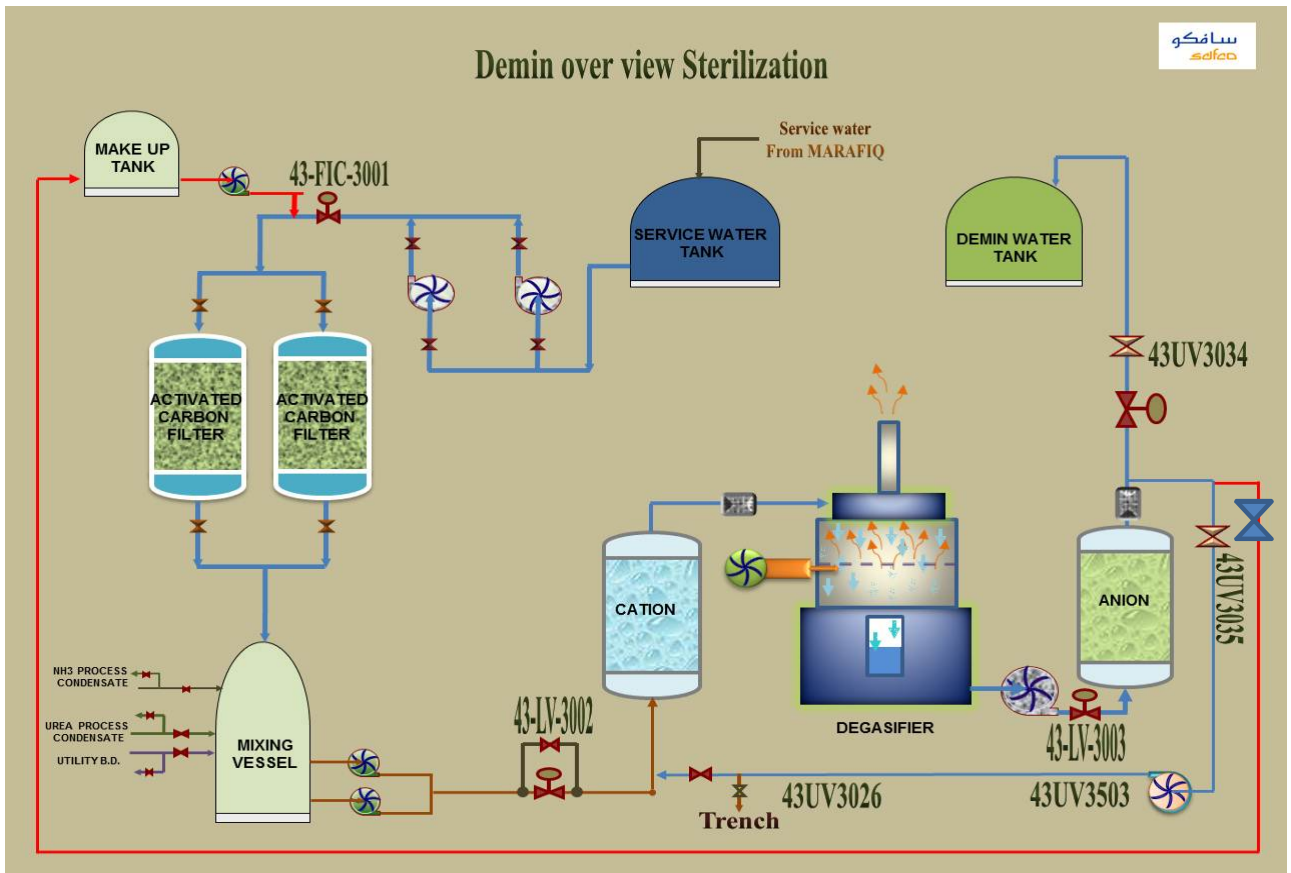


Figure 07: Schematic flow diagram for Sterilization prepared by Process Engineering

After emptying the carbon filter, mixed bed, cation, Degasifier & anion vessels, surfactant solution was circulated for few hours to remove all oils, mud & silt, resins and any suspensions in order to keep clean vessels before applying the biocide.

One flushing step with demin water was taken to remove surfactant, and then biocide 1% solution was circulated for few hours. Vessels were kept soaked with biocide solution for three hours for disinfection, before disposing the biocide solution.

Finally, two flushing steps with demin water were undertaken to remove any biocide traces from the vessels.

Entire job was done effectively within the specified time frame without any incidents or chemicals spillage.

Bacteria test was done on the final flushing water from both trains, and the result was nil bacteria counts, which indicates the successful completion of the sterilization process.

The waste water internally treated and was disposed as per RC regulations and reduces the disposable cost.

## 5.6 Resultant benefits

The implementation of the Sterilization Technology with Biocide and surfactant proved to be a successful Energy conservative and sustainability drive story as it culminated in huge potable water conservation, reduction in material waste in the form of waste water and reduction in energy.

Benefits occurred mentioned in Table 02.

Table 02: Energy saving By Sterilization:

| Description   | Annual Energy saving, KWh |
|---|---------------------------|
| By not running Regeneration water pump additionally         | 19240                     |
| By not running Industrial waste water pump additionally     | 75479                     |
| By not running neutralization waste water pump additionally | 50177                     |
| Total Energy saving   | 144896                    |

By Sterilization and by rectifying leak in Urea process condensate Reflex condenser, enabled reduce the potable water consumption by around 55 M<sup>3</sup>/h and also bring down waste water generation by 55 M<sup>3</sup>/h

## 6.0 CONCLUSION

After implementation of the sterilization process during the Turnaround in April 2012, all the bacteria was totally eliminated as confirmed through test/ analysis. By this approach dp of the Anion and Cation are within control and energy consumption was brought down by 144896 KWh.

Conceptual innovation often proves to be a valuable tool in trouble shooting and circumventing critical issues in the process industries. Innovative cleaning techniques can improve Energy savings, productivity and service factor of the plant. It gave faith in experimenting with new chemical cleaning method to tackle plant problems. The leak detection by Tracer method as an effective solution for identifying the leak. As DM Unit exists in all SABIC Units, this method can be adopted if similar operational problem encountered.

## ACKNOWLEDGMENTS

Nabeel Al Marzouk , Manager (Process Engg), Dhiya Taher Al-Khaleefa, (Process Superintendent) , PGR Nair (Process Staff Engineer), Faisal Fahad Al-Shahrani (SF4 Operation Manager), Salah Dawood Al-Homoud, Supdt. Operations (SF4 Utilities), Dr. Zuhair Yaseen Al-Taha, (Leader, Innovation & Sustainability), Nalco and SABIC T & I for their advisory services.

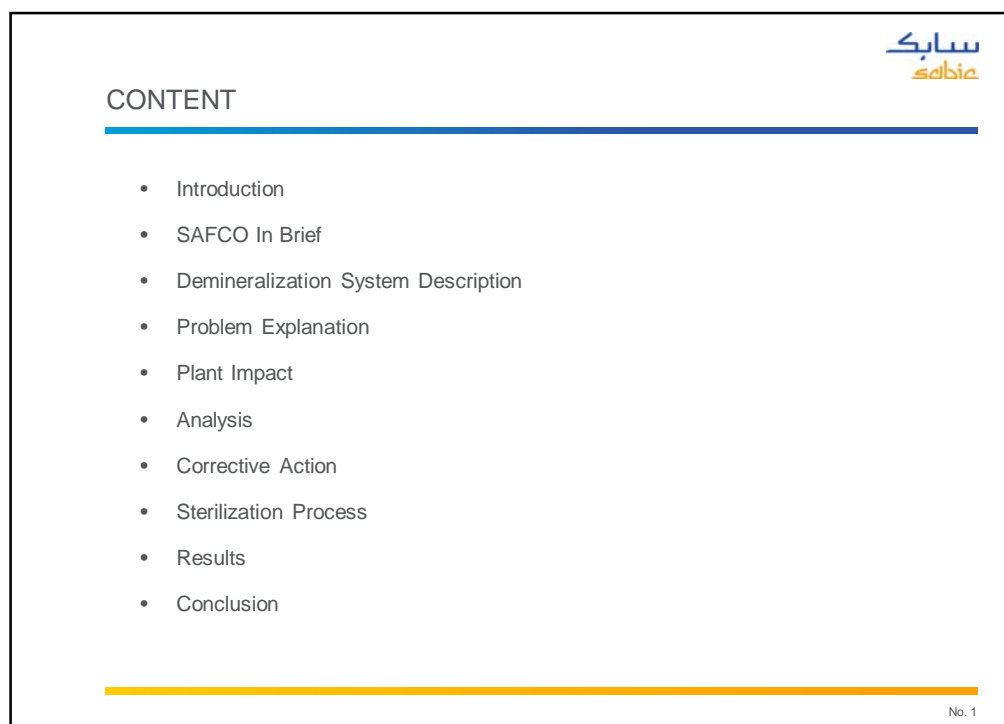
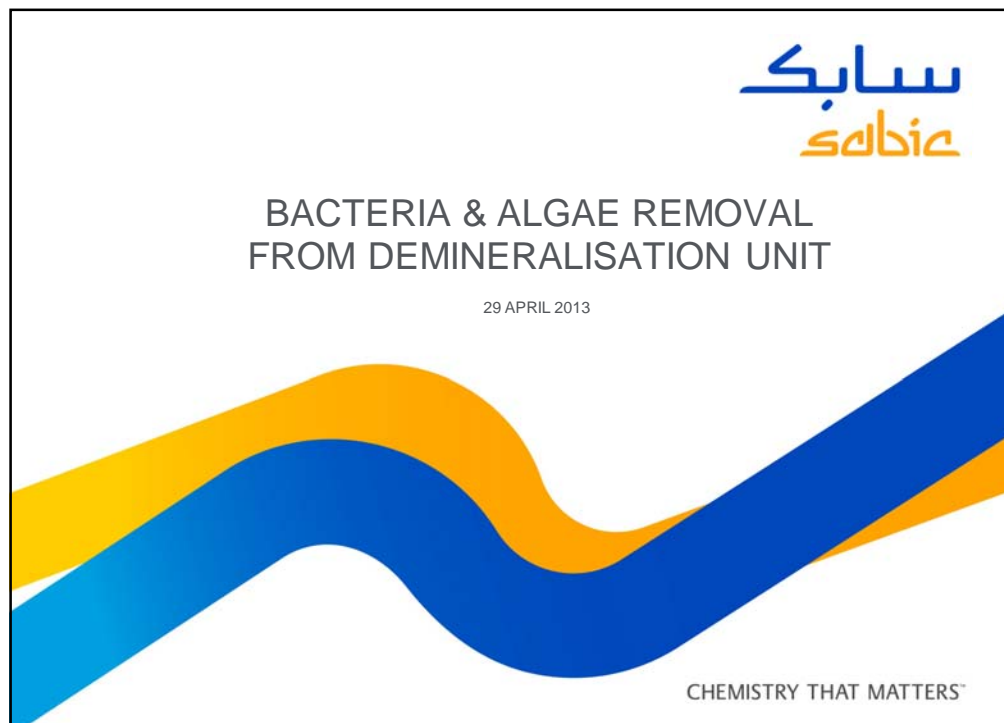
## AUTHORS' BIOGRAPHY

- P.Balasubramanian, B.Sc (Chemistry), Madurai University and B.E (Chemical Engg),Jadavpur University, India working as Process Engineer in SAFCO, Jubail.E mail : [ponnambalamb@safco.sabic.com](mailto:ponnambalamb@safco.sabic.com)
- Hussain A.Al-Esmail, B.S (Chemical Engineering), KING SAUD UNIVERSITY (KSU), KSA, working as Process Superintendent in SAFCO, Jubail, E mail: [HEsmail@safco.sabic.com](mailto:HEsmail@safco.sabic.com)

## REFERENCES

- 1) UHDE Manual for DM plant Operations –Book No.1 OF 4
- 2) SAFCO4 Utility Operations Manual
- 3) Article in Hydrocarbon processing, December 2006 by Sirajur Rahman (Protect anion resin from bio fouling)





## INTRODUCTION

---

Since Plant commissioning in 2006, Utility Demin plant experienced a chronic problem of frequent increase in Demin unit vessels pressure drop which led to fallen down Demin units production drastically and increase in maintenance frequency.

The problem caused by growth of **Aerobic Bacteria** and Algae formation in cation, degassing column and anion vessels led to reduce the unit throughput to 212m<sup>3</sup>/hr against the requirement 340 m<sup>3</sup>/hr. Also effected the plant sustainability due to additional consumption of power , water and extra generation of waste water.

After deep study and analysis, Sterilization process was done using a new formulated Biocide and surfactant , resulted on total elimination of Bacteria from the system and increase in Demin plant production.

This paper intends to examine the origin of the problem and how the problem got solved.

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No. 2

## SAFCO IN BREAI F

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SAFCO, one of the World's largest producer of granular Urea fertilizer, operates four world class ammonia and Urea plants along with Urea formaldehyde and complex fertilizer plant.

Each ammonia-urea complex has its own Utility plants serving steam, water and other utilities with tie in provisions for flexibility in operations.




---

No. 3

## SAFCO PLANTS

|                          |                      |                   |                 |                |
|--------------------------|----------------------|-------------------|-----------------|----------------|
| IBN ALBYTAR<br>1987-1990 | Ammonia<br>1500 MTPD | Urea<br>1500 MTPD | CF<br>3070 MTPD |                |
| SAFCO-2<br>1993          | Ammonia<br>1500 MTPD | Urea<br>1800 MTPD |                 |                |
| SAFCO-3<br>2000          | Ammonia<br>1500 MTPD | Urea<br>1800 MTPD |                 |                |
| SAFCO-4<br>2006          | Ammonia<br>3300 MTPD | Urea<br>3250 MTPD |                 | UFC<br>90 MTPD |
| Total                    | Ammonia<br>7800 MTPD | Urea<br>8350 MTPD | CF<br>3070 MTPD | UFC<br>90 MTPD |
| SAFCO-5<br>2014          |                      | Urea<br>3250 MTPD |                 | UFC<br>90 MTPD |

No. 4

## DEMINERALIZATION SYSTEM DECECRIPTION

The Demineralization Plant contains Demin unit and Polishing Unit.

Demin unit is composed of two identical lines, each consist of Activated Carbon Filter, Cation Exchanger, Degassing Column and Anion Exchanger.

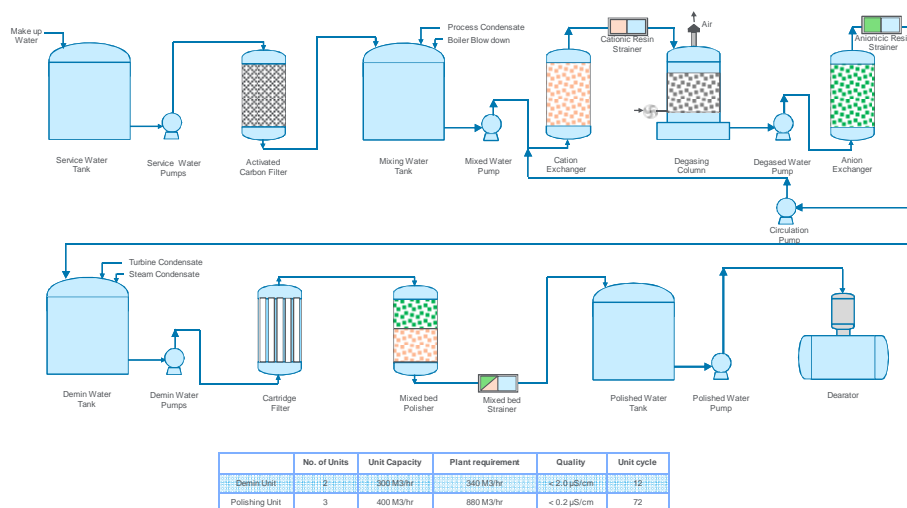
The Demin unit Shall treat process condensate and Boiler blowdown of less quality than the required for polishing, and service water as make up water to compensate process losses. Demin water is stored in Demin water tank and therein mixed with low polluted turbine and steam condensate.

Polishing Unit is composed of three trains each consist of cartridge filter and mixed bed filter.

The treatment by Mixed bed filter provides fully demineralized water, so called polished water to be used for medium pressure and high pressure boilers. The purified water is collected in the polished water tank.

No. 5

## DEMIN PLANT DESCRIPTION

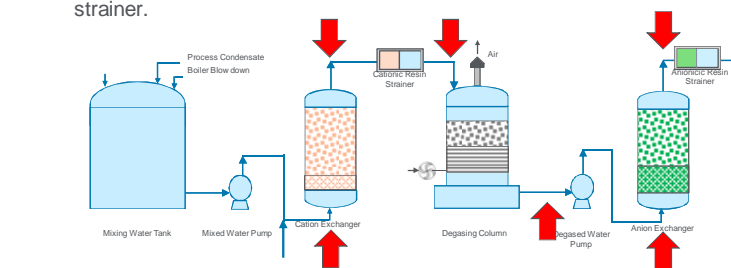


No. 6

## PROBLEM EXPLANATION

For around six years , by reason of Bacteria & algae formation the following problems occurred frequently in the Demin unit :

- High pressure drop in Cation and Anion vessels.
- Fouling of Cation and Anion Resin.
- Restriction of water flow in Degassing column led to push out rings through stack.
- Chocking of Anion & Caion bottom nozzles and Degassing Column pump suction strainer.



No. 7

## AFFECTED PARTS BEFORE & AFTER



Pump Strainer



Bottom Nozzles



Degassing column Packing



Anion Resin

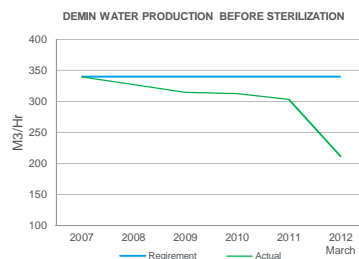


No. 8

## PLANT IMPACT

Due to the problem the following are impacted the plant :

- Severe shortage of Demin water as the average unit production came down to 212M<sup>3</sup>/hr.
- Sustainability extremely effected due to high intensity of Energy , Water and Waste water caused by frequent back wash and increase number of regenerations.
- Cost impact in maintenance, rent of temporary RO unit , energy ,raw water and waste water disposal.
- Overloading of other plants Demin units to compensate this unit shortage.



No. 9

## ANALYSIS

The main sources of Bacteria and algae were defined as follow:

1. Water stagnancy during commissioning.
2. Recycling of atmospheric humidity condensate from Ammonia Process air inter-stage cooler to process condensate line.
3. Air coming from the Air blower to Degassing Column containing Bacteria coming from nearby waste water tank.
4. In January 2012, Urea Reflux Condenser started leaking cooling water to process condensate which worsened the situation and led to high growth of **Nitrifying Bacteria** resulted Demin water production came down drastically to 212 M<sup>3</sup>/hr as against the required 340 M<sup>3</sup>/hr. After the cause finding, Urea process condensate had dumped to the waste water system incurring huge water loss, around 108 m<sup>3</sup>/hr.



Microsoft  
Word Presentation

No. 10

## CORRECTIVE ACTION

### Short Term :

Eliminate Bacteria source by:

- Divert Ammonia Process air inter-stage cooler to waste water system.
- Avoiding water stagnancy for long time in waste water Tank and use biocide treatment for the same.
- Dump Urea process condensate from Urea Reflux Condenser to the waste water system and compensate it with rented RO Unit.( Jan 2012 to April 2012)

### Permanent Solution:

- During Plant Turnaround Carry out Sterilization of all Demin circuit starting from Activated Carbon Filter including Mixing Tank, Cation exchanger , Degassing Column and ended with Anion Exchanger along with all connected piping and pumps.

No. 11

## STERILIZATION PROCESS

The aim of the sterilization was to completely remove all existing microbiological organisms by using Oxidizing Biocide and Surfactant. The Lab. was monitoring the Bacteria analysis regularly.

### Preparations:

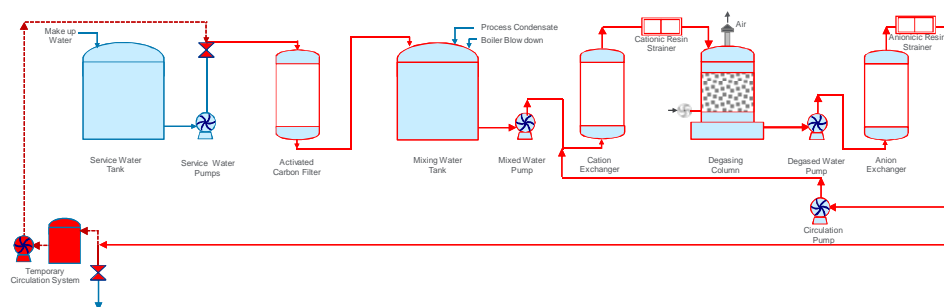
- The Unit shut down and isolated, temporary circulation arrangement prepared.
- Empty carbon filter, cation and anion vessels.
- Degassing column rushing rings removed cleaned and put back.
- Blind the system and remove critical instruments.
- Prepare both chemicals solution

### Sterilization Steps

1. Surfactant solution circulated for three hours to remove all oils, mud & silt.
2. System flushed with Demin water to remove surfactant.
3. Circulation of Biocide 1% solution three hours, then soaking for another four hours for disinfection purpose. The process continued until assuring the total elimination of all microbiological organisms through Lab. analysis.
4. Finally, two flushing steps with Demin water were undertaken to remove the Biocide.

No. 12

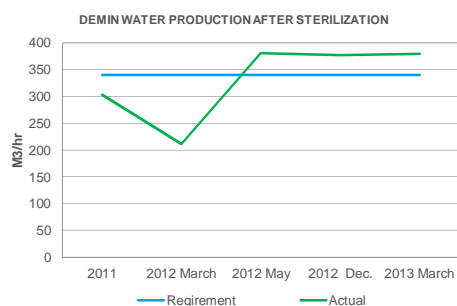
## STERILIZATION DESCRIPTION



No. 13

## RESULTED SAVING IN WATER

1. After the start up in May 2012, Demin unit operated smoothly and its production reached to 6606 M3/Cycle against the requirement 4080 M3/Cycle.
2. As a result of the sterilization process, all the bacteria had eliminated totally from the system as confirmed through Lab. analysis.
3. Accordingly the bacteria being continuously analyzed on weekly basis, it did not appear in the system even after one year of operation.



No. 14

## CONCLUSION

The implementation of the Sterilization Technology with Biocide and surfactant proved to be a successful Energy conservative and sustainability drive story as it culminated in energy reduction, huge potable water conservation and also enormous waste water saving.

Sustainability Yearly Accomplishment by Sterilization:

| Power Saving KWh | Raw Water Saving M3 | Waste water disposal M3 |
|------------------|---------------------|-------------------------|
| 144896           | 477168              | 477168                  |

Conceptual innovation often proves to be a valuable tool in trouble shooting and circumventing critical issues in the process industries. Innovative cleaning techniques can improve energy savings, productivity and service factor of the plant. The leak detection by Tracer method as an effective solution for identifying the leak.

As Demin Unit exists in most of fertilizer industry, this method can be adopted if similar operational problem encountered.

No. 15



# Questions

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

# **Recent PV activities at RSS**

**Firas Mohammad Alawneh  
Head of Photovoltaics (PV) Division  
NERC / RSS- Jordan**



الجمعية العلمية الملكية  
Royal Scientific Society



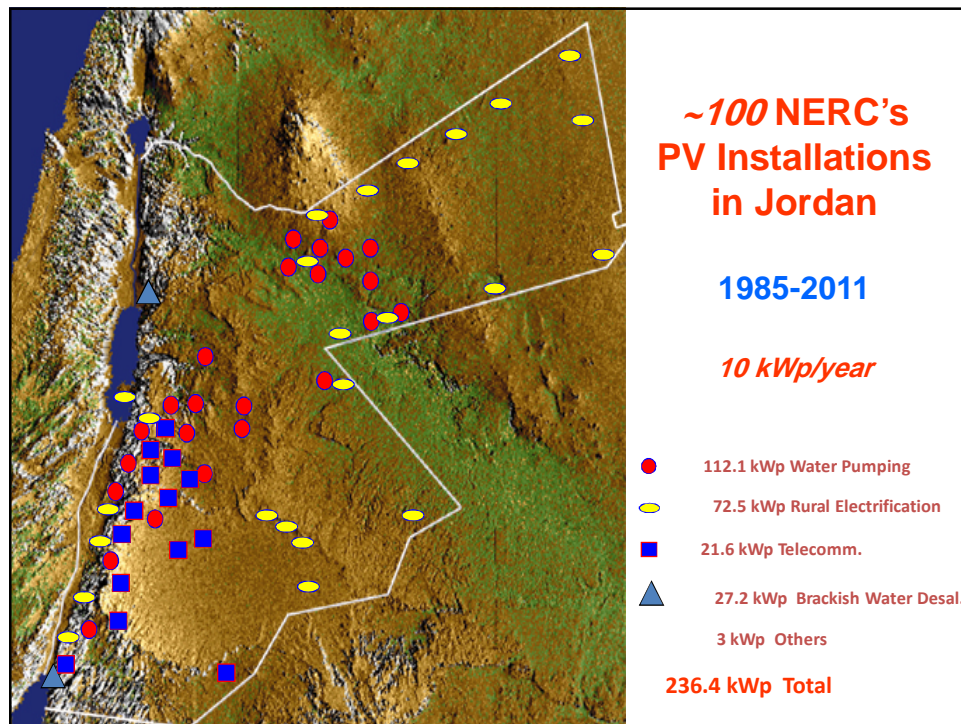
## Recent PV Activities at NERC/RSS

Prepared by:  
Eng. Firas Alawneh  
Head of PV Division / National Energy Research Center  
[firas.alawneh@nerc.gov.jo](mailto:firas.alawneh@nerc.gov.jo)  
Royal Scientific Society  
[firas.alawneh@rss.jo](mailto:firas.alawneh@rss.jo)  
Amman - Jordan

AFA Workshop: Renewable Energy in Fertilizer Industries & Energy Auditing  
Amman, Jordan 28-30 April, 2013

## Outline

- **PV Division at NERC**
- **Past PV Experience**
- **New Net-Metering Law for Small-scale RE systems (Mainly for PV Rooftop Installations)**
- **Recent grid connected PV Installations done by NERC**
- **Testing PV modules and PV inverters at PV Systems Laboratory of NERC**
- **Conclusions**



### Site Photos for some NERC's PV Installations in Jordan



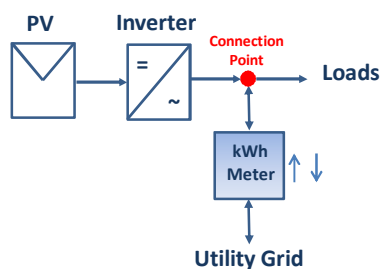
## New Net-Metering Law for Small-scale RE systems (Mainly for PV Rooftop Installations)



شركة الكهرباء الأردنية المساهمة العامة المحدودة  
Jordan Electric Power Company



شركة كهرباء إربد محافظة إربد المساهمة العامة المحدودة  
Irbid District Electricity Company L.T.D.



Source: NERC / RSS

## Recent Grid Connected PV Installations done by NERC

- 288 kWp PV power plant at RSS in Amman
- 240 kWp Tafila Rooftops PV Project
- 10 kWp PV Evaluation Field in Ma'an (South)
- 6 kWp PV Evaluation Field in Irbid (North)

Source: NERC / RSS

## 288 kWp PV Power Pant at RSS in Amman

- In November 2011, NERC designed and installed through a Japanese grant a 288 kWp grid connected PV system within the campus of the Royal Scientific Society (RSS) where NERC exists.
- The utility operator at that time was not obliged to receive any electricity form the system as the connection and feed-in instructions were not issued yet by the Electricity Regulatory Commission (ERC), so the system was equipped with a utility reverse power protection.

Source: NERC / RSS

## 288 kWp PV System at RSS



Site Photo

GUI, monitoring system

Source: NERC / RSS

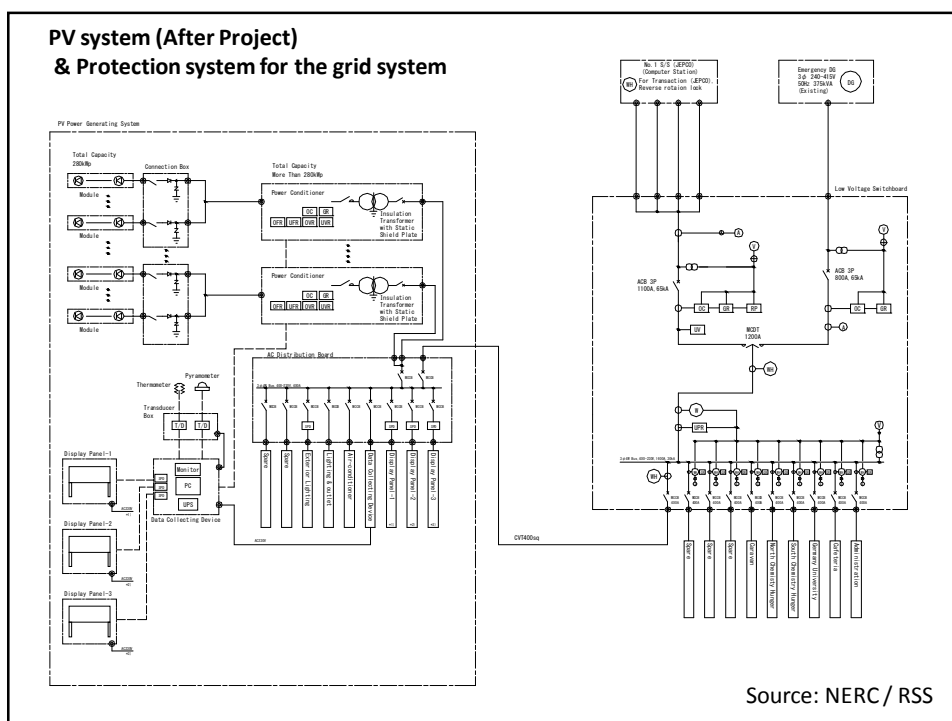
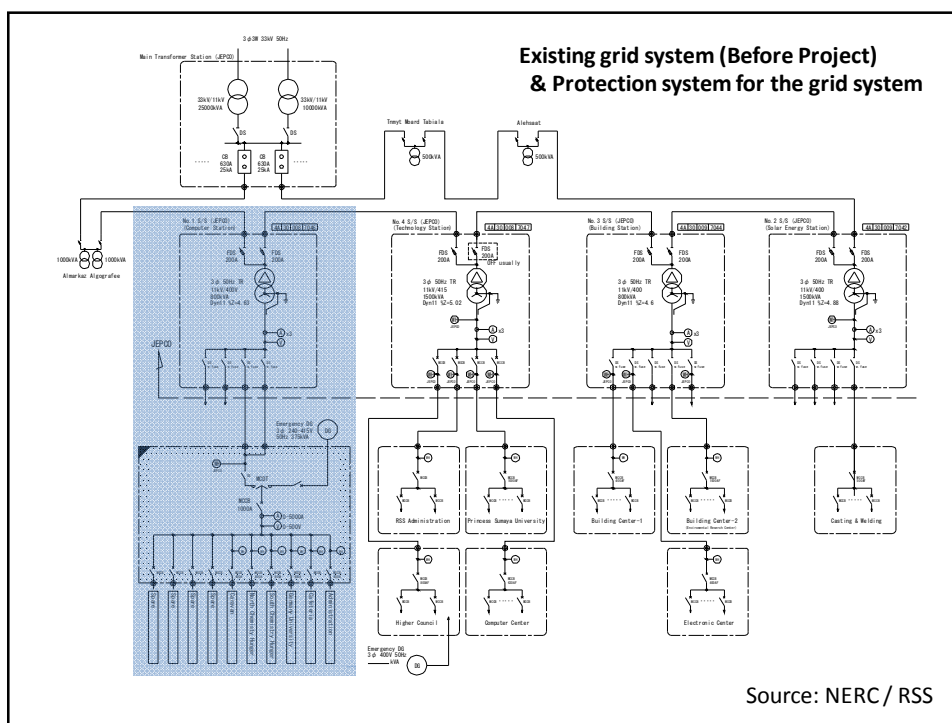
## Site Analysis



## Site Evaluation Criteria

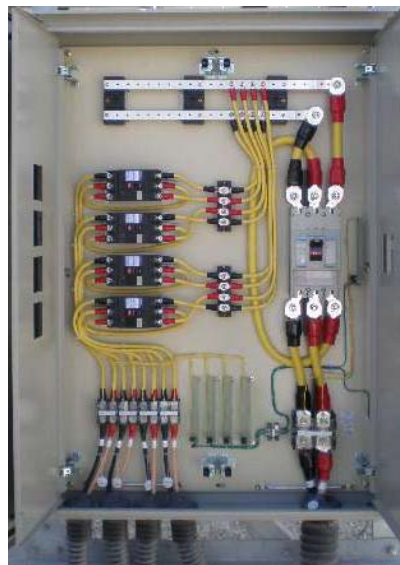
| Condition   | Rating | Comments  |
|---|--------|---|
| 1 Land geography of the site  |        |   |
| The site is not influenced by natural disaster like a flooding, strong wind, sand storm, etc. | ○      |   |
| The strength of the ground stands up to the weight of PV array and wind pressure.             | ○      |   |
| 2 Direction (South)   | ○      |   |
| 3 Situation of around site (Obstruction etc.)   |        |   |
| No shadow by building, trees, poles and so on   | △      | The deirection of the slope is up to South (Recovered by Land leveling) |
| No burglary   | ○      | Security by the Fence of EHSC   |
| 4 Power consumption of the site facility.   | ○      | Consumed by EHSC  |
| 5 Visibility of PV system   | ○      |   |

Source: NERC / RSS





## DC Connection Boxes for PV Strings and Arrays



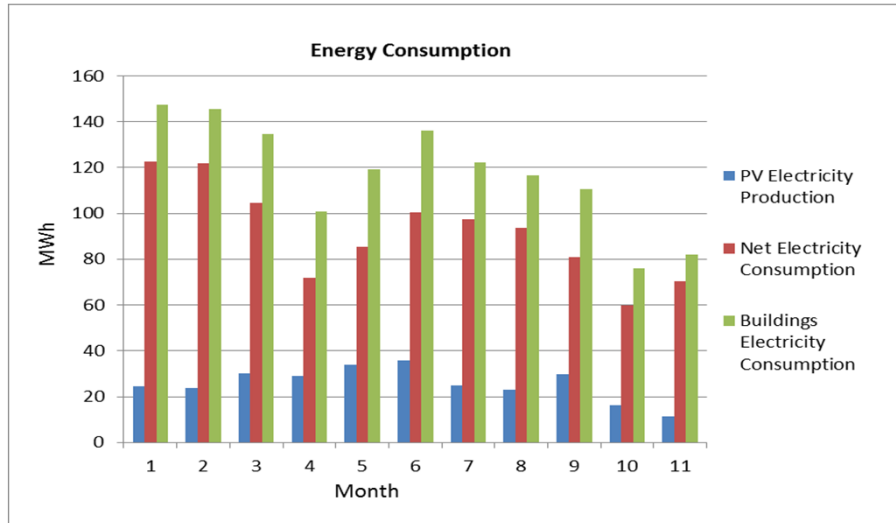
Source: NERC / RSS

## Control Room for Inverters and Monitoring System



Source: NERC / RSS

**Net electricity consumption = Building electricity consumption - PV electricity production**  
**Year 2012**



Source: NERC / RSS

## RSS Participation in “Let Jordan Shine” Initiative 240 kWp Tafila Rooftops PV Project



RSS in cooperation with Jordan Enterprise Development Corporation (JEDCO) and Petra Solar, Inc. announced a mutual agreement to mobilize the first phase of the national Smart Solar Energy plan which was announced at the Jordan- U.S. Business Forum held in May, 2011 under the Royal patronage of His Majesty King Abdullah II.

The plan, called Let Jordan Shine, will help create a more sustainable future for Jordan with Smart Solar Energy solutions. It will help Jordan diversify its energy generation sources in order to reduce its reliance on external sources for power generation.

Smart Solar systems were installed in the first phase of the project at 1,000 homes of the Tafila Project. The target of the project is to install smart solar systems at 20,000 homes across the governorate.

Residents of Tafilah who participate in the program will reap the benefit of a reduced electric bill, as each Smart Solar system installed on a rooftop will feed electricity directly into that home. The systems will generate clean, safe renewable energy, plus they will build a wireless smart grid communication network throughout Tafilah, which will help make the electric infrastructure more stable, efficient and energy independent.

Project Size, Type  
and Coverage  
Area



## PV Evaluation Field in Ma'an (South)

- In year 2011, NERC signed an agreement with a Jordanian company, aiming to invest in solar electricity generation, to install different PV systems with different cell technologies and evaluate the technical performance of them under the climatic conditions of a site located in the southern part of Jordan. The nominal capacity for each PV system is around 1 kWp or more.
- 8 systems are installed in the evaluation field till the moment.

Source: NERC / RSS

## Site Photos



A Photo during Installation



A Photo after Installation

Source: NERC / RSS

## PV Evaluation Field in Irbid (North)

- In October 2012, NERC installed 5 grid connected PV systems on the rooftop of one of the buildings located within the campus of a University in the northern part of Jordan. The nominal capacity for each PV system is around 1 kWp or more.
- This project was funded by the Regional Center for Renewable Energy and Energy Efficiency (RCREEE) as a research project.
- A central monitoring system was installed. Data is accessible offline and online via the internet.

Source: NERC / RSS

## Site Photos



A Photo during Installation



A Photo after Installation

Source: NERC / RSS



## Testing PV modules and PV inverters at PV Systems Laboratory of NERC

- **Outdoor Testing of PV Modules and Arrays:**
  - Testing up to 100 kWp PV arrays (NERC received recently a new IV curve tracer, the only one in Jordan)
  - Testing according to IEC 60904-1 entitled “Photovoltaic devices-Part 1: Measurements of PV current-voltage characteristics”
  - Correction according to IEC 60891 standard entitled “Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic (PV) devices”
- **Measurement of PV inverter efficiency:**
  - Testing up to 10 kVA
  - Testing according to IEC 61683 standard entitled “Photovoltaic systems- Power conditioners-Procedure for measuring efficiency”

Source: NERC / RSS



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Session III**



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Energy Saving projects at  
APC/Case Study**

**Jamal Amira**

**Technical Department Manger**

**APC- Jordan**

**Ala'a Al Omari**

**Senior Process Engineer**

# **Energy Saving Projects Case Study**

**Jamal Amira/ Technical Department Manager**  
**Eng. Ala'a Omari /Senior Process Engineer**

**The Arab Potash Company**



**SUBMITTED TO**

**The Arab Fertilizer Association**



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## **SECTION ONE**

### **QMS - APC ACCREDITATION**

APC management recognizes that Safety, Quality & Environment are crucial for assuring business sustainability, profitability and growth. Therefore, a Quality Assurance Department was established to ensure the establishment, effective implementation and continual performance improvement of an Integrated Safety, Quality & Environment Management System according to the relevant updated local and international standards. As a result of management commitment at all levels, the cooperation of all departments through active participation in internal audits and management review processes, and the effectively implemented awareness programs, APC successfully achieved certificates of compliance of the following international and local standards:

1. Occupational Safety and Health Management System Standard –OHSAS -18001 on May-15 -2004, being the second company in Jordan to achieve this certification.
2. Environmental Management System Standard (EMS) -ISO -14001:2004 on May-18 -2005, being the first company in Jordan to achieve this certification.
3. Quality Management System Standard (QMS) - ISO -9001:2000 on June - 07-2001, being one of the pioneers companies in Jordan to implement this standard.
4. Quality Management System Standard (QMS)- ISO- 9001:2000 on August-05-2004 for our APC Hospital and Clinics.
5. “General requirements for the competence of testing and calibration laboratories” standard-ISO-17025:2005 on September-23-2008, as a result of which our APC laboratory was certified as an accredited laboratory at local and international levels.
6. Jordan Quality Mark on March-18 -2004.

## Section Two

### Introduction

#### About APC

The idea of the Potash project was based on the Potash Plant located on the north-western shores of the Dead Sea during the British Mandate. The old plant was destroyed but the idea remained alive and a Pan Arab company was formed in 1956 to implement a project for the production of Potash using the minerals of the Dead Sea.

The site is located 110 kilometers south of Amman and 200 kilometers north of Aqaba. The site is a Solar Evaporation Pond System of an area of 150 square kilometers and processing plants for the ore.

The investment in the original project, including substantial infrastructure was nearly 480 Million USD. Financing was obtained through loans from international finance institutions and aid agencies as well as Arab development funds. The project began in 1976 with tests and experiments to determine the parameters of various technologies and ideas in a very hostile environment. Construction began in 1979 and was completed in 1982. At the end of construction, about (117) kilometers of seepage proof dykes were built (other dykes built later on). These were more than 8 meters wide at the top and were an engineering challenge to be built on top of a non- stable sea bed. The excavation carried out during the construction period was of a colossal magnitude, 16 million cubic meters of earth material was displaced.

Potash production began in 1983 and has since progressed with various schemes aimed at optimizing and expanding this production. The initial plant was built to a capacity of 1.2 million tones of product.

This was expanded in the late eighties to handle 1.4 million tones and key modifications were undertaken with the Solar System to enhance the production of the ore accordingly. A second plant based on different technology and of a capacity of 0.4 million tones was built in 1994 and this brought the total production capacity to 1.8 million tones. Then another cold crystallization plant of 0.45 million tones was built in 2010 and this brought the total production capacity to 2.45 million tones. Further expansion is currently under evaluation to bring the total potash capacity to 3.2 MMTP.

The capital of the Arab Potash Company is 83.3 million Jordanian Dinars. It has a concession from the Jordanian Government to exploit, manufacture, and market the mineral resources of the Dead Sea, until 2058.

The Arab Potash Company employs over 2000 personnel and has offices in Amman, Safi and Aqaba. It owns extensive housing and recreational facilities near its plants, and in addition, it provides the surrounding region with assistance in social, medical, economic and vocational development.

## **Section Three**

### **Background**

Energy poverty constitutes one of the fundamental challenges that Jordan, like many developing countries, is facing in its struggle for economic development and betterment of life its citizens. Energy is going to get more costly. Jordan is planning to manage energy over the coming decades by set an energy mission to ensuring the required energy supply, for sustainable development, with the least cost and best quality through development and implementation of proper policies, legislation and programs.

Up till now, the government is trying to reduce the country's energy bill, both in the shorter and longer term, through the harnessing of its domestic energy resources and reserves.

Most likely, 2013 will witness a new cycle of increasing regional and international needs and fertilizer trade movement accompanied by a heightened international demand on agricultural products according to the current and expected indicators.

As well as, Fertilizers are an important factor in modern-day agriculture. They are responsible for substantial increases in crop yields, and allow crops to be planted in soil that would otherwise be nutrient deficient.

Therefore, the challenges facing fertilizer industry and the rise in demand rate, compared to last year, and consequently the necessity of providing the required amounts of different fertilizers and related raw materials will be handled positively through the additional capacities.

Inorganic fertilizers are major consumers of energy in the agricultural sector; most fertilizer energy use is attributable to the production of nitrogen fertilizers with natural gas.

Fertilizers are characterized as an indirect energy consumer on the farm. Other indirect energy consumers include chemical pesticides, hybrid seeds, and special feed supplements for livestock. Indirect energy consumers differ from direct energy consumers, such as tractors, irrigation pumps, and other types of agricultural equipment, in that the majority of the energy consumption associated with fertilizers is accomplished away from the farm.

The challenges of high and volatile energy prices, decreasing conventional energy resources, aging and constrained infrastructure, growth in energy demand and growing environmental concerns can be successfully overcome through a modern energy supply which follows the guiding objective of sustainable development. Planning wisely for our energy needs is one of the most important challenges our generation faces.

The implementation of energy-efficiency measures in the production and use of fertilizers will help curb the effects of rising oil costs, as well as the effects of energy cost in general. These measures to Increase the Energy Efficiency are replace process equipment with high-efficiency models, improve process controls to optimize chemical reactions, recover process heat and maximize the recovery of waste materials. Moreover we have to address the energy consumption during the application of fertilizers to crops which is farmer responsibility.

## **Section Four**

### **Potash Production Process Description**

The Dead Sea is located in the Dead Sea Rift, which is part of a long fissure in the Earth's surface called the Great Rift Valley. The 3,700 mile (6,000 km) long Great Rift Valley extends from the Taurus Mountains of Turkey to the Zambezi Valley in southern Africa. The Dead Sea lies 426.78 m below sea level, making it the lowest elevation and the lowest body of water in the world. To prepare

**The Raw Material is prepared** at 112 km<sup>2</sup> solar evaporation ponds system and ore processing plants. The brine from the Dead Sea is pumped where the initial concentration process is undertaken at the salt ponds where NaCl deposits. The remaining brine is pumped into the Carnallite ponds, to precipitate the raw Carnallite ( $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ ) and NaCl. This bed is harvested as a slurry from beneath the brine and pumped to the existing and new refineries.

The original plant employs hot leach technology to process the Carnallite to extract potash, but the newer facilities employ cold crystallization. In the hot leaching unit, the Carnallite slurry is received, dewatered and decomposed in two stages in an agitator tanks. The resulting solids from the decomposition are a mixture of potassium chloride and sodium chloride: this mixture (known as sylvinite) is dewatered and washed. The resulting cake is conveyed to the sylvinite processing stage.

In the next sylvinite processing stage, the sylvinite cake is leached using agitator tanks in a two-stage process. Heated lean brine, returned from the crystallization process, is used for leaching the KCl solids. The hot brine, now saturated with KCl, is clarified in a hot thickener. The thickener's overflow is pumped to the crystallization process, and the underflow slurry containing NaCl crystals is dewatered, repulped with waste brine and then pumped to the tailings area.

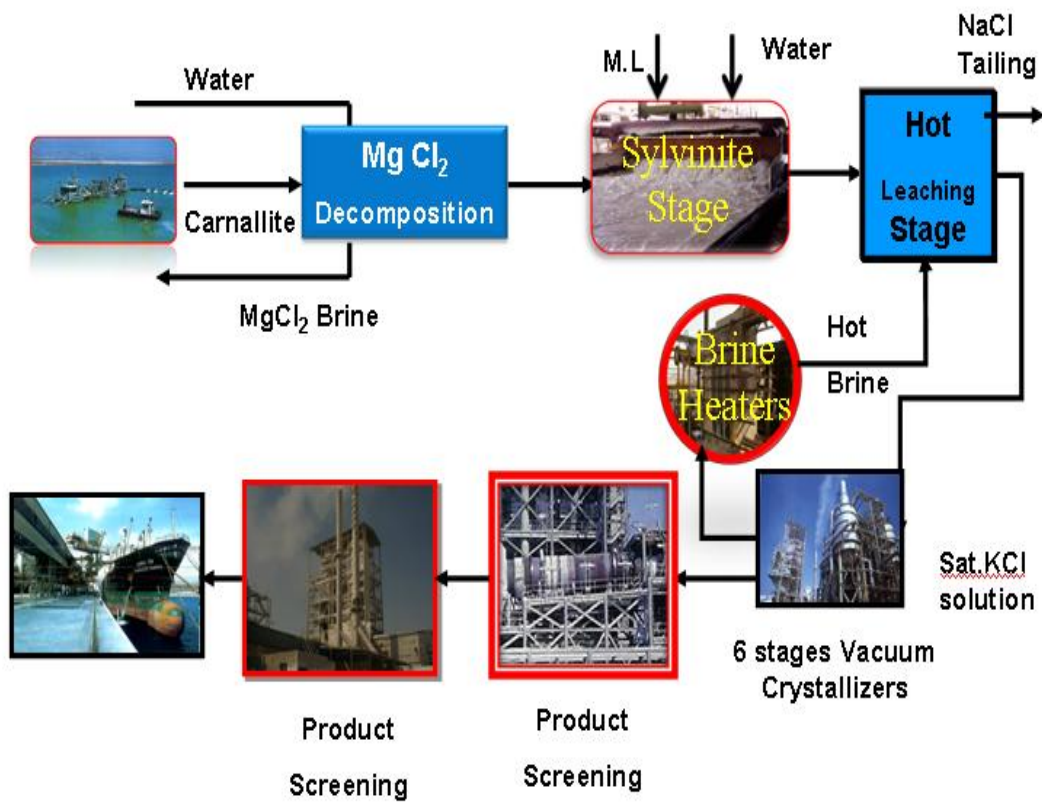
The hot brine from the thickener overflow, which is saturated with sodium and potassium chlorides, is cooled successively in a six-stage vacuum crystallizing system from 93°C to 42°C. Upon cooling, KCl decreases in solubility and crystallizes under controlled conditions.

The potash slurry from the last-stage crystallizer is directed to the product hydro\_ cyclones, where partial dewatering takes place. The underflow of the cyclones is sent to centrifuges for further dewatering. In the drying stage, the cake from the centrifuges is conveyed to an oil-fired rotary dryer to remove the last traces of moisture entrained with the crystals. From the dryer, the product is sent to a fluidized bed cooler and then to the screening system, while the dust is collected, using a cluster of high-efficiency cyclones.

The product coming from the dryer goes to the screening unit, where it is segregated into two product grades: standard and fine. Standard potash is cooled by using a fluidized bed cooler, but an alternative is under implementation to use a column cooler for this purpose. An anti-caking agent is added in carefully controlled amounts to minimize the natural tendency of potash to agglomerate during storage and shipment. Free-flowing properties are thus ensured to facilitate handling of these products by the customer.

To ensure a clean environment and to minimize potash losses as dust, APC has installed several de-dusting systems, such as bag filtration units and high-efficiency cyclones.

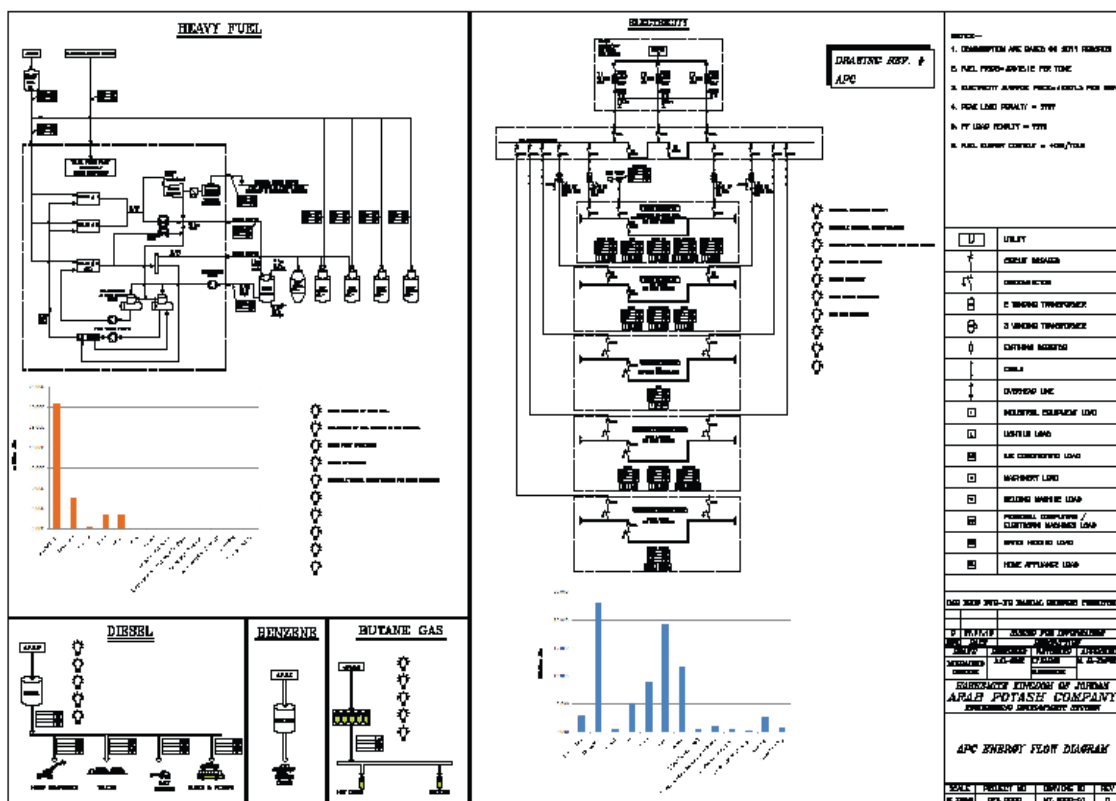
## Hot Leach Process



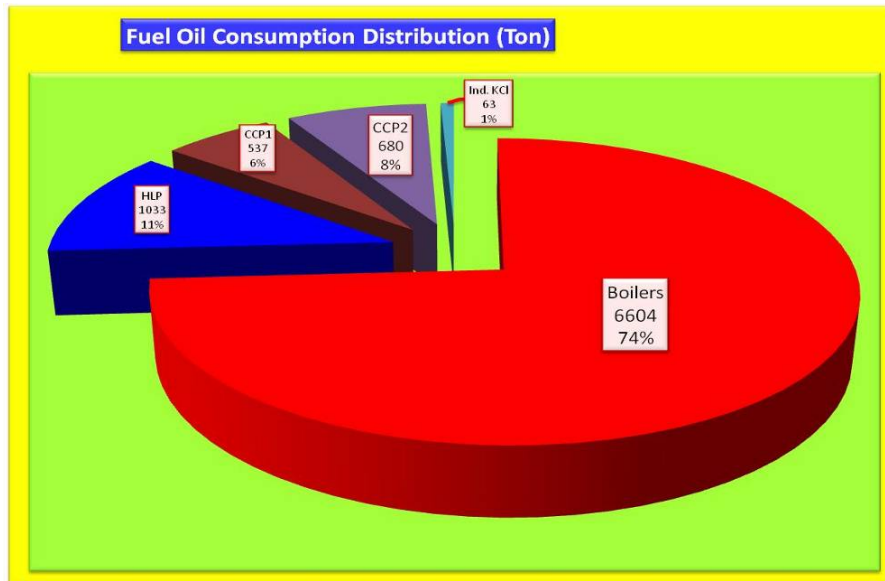


## **Methodology**

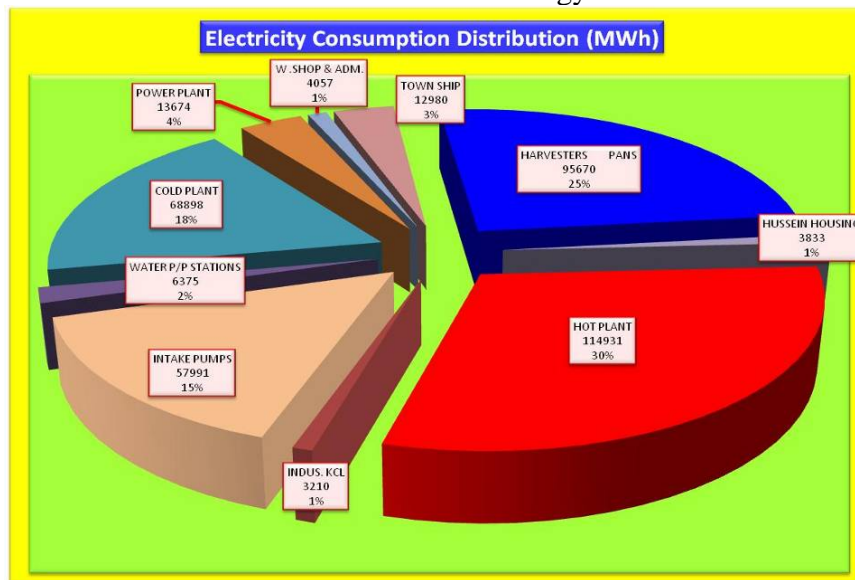
APC is one of the leading and large companies in Jordan that consumed energy, preliminary four main forms of energy are used in APC as per below energy flow diagram, namely: -



- **Diesel fuel:** it is widely used at APC for different applications. However, trucks are major consumer with a sharing ratio of about 70%
- **Gasoline:** it is mainly used in transportation sector.
- **Heavy fuel oil:** HFO is the chief energy source being used at APC in terms of equivalent energy content with a sharing ratio of 71% of annual energy needs, it is used mainly to supply the cogeneration power station, which produces electricity and heat in the form of low and/or medium pressure steam; also it is used at the plants combustors.



- **Electricity:** It is consumption represents the core of the annual energy bill; it is represents about 20% of the total consumed energy.



The principal goal of the Arab Potash Company, as any other industrial companies, is to attain the best performances, efficiencies and recovery of individual equipment and units respectively. Consequently intensive studies had been carried out to figure out the major bottlenecks and utilities high consumption in the plants, then an optimization study to resolve all bottlenecks and obstacles in refineries in order to save energy, increasing equipment reliability and improving the Environment.

APC has meanwhile continued to undertake energy saving at their plants and utility services and freshly completing energy conservation projects. The energy conservation projects are focused on energy saving projects taken into account potash production expansion and the overall plant performance improvements.

The following chapter will highlight on the major energy saving projects, equipment reliability and environment improvements projects at APC plants: -

- New Falling film heat exchanger at HLP.
- New mineral separator at HLP.
- Reduction of transportation diesel fuel.

## **Section Five – One**

### **Project One: Falling Film Heat Exchanger**

APC is used to heat the lean brine by two parallel plate-and-frame heat exchangers in which circulating brine is heated from 78 °C to 108 °C via low-pressure steam (2.4 bar (g)). Heated brine flows out of the top of heaters by gravity and is divided into two streams, one to hot-leach tank #1 and the other to hot-leach tank #3.

#### **Problem:**

After 28 years of operation, APC experienced low performance of the plate heat exchangers used in the hot leach plant to heat up the circuit brine, and becoming expensive in terms of maintenance. The existing plate heat exchangers are failed to maintain operational readiness > 95%, and this failures occurs always during start up/ pumps switching and wear and tear in rubber since it became fragile as a result of high temperature and long service. This also results in increasing the running cost as a result of losses of steam and frequent maintenance.

Plate Heat Exchangers

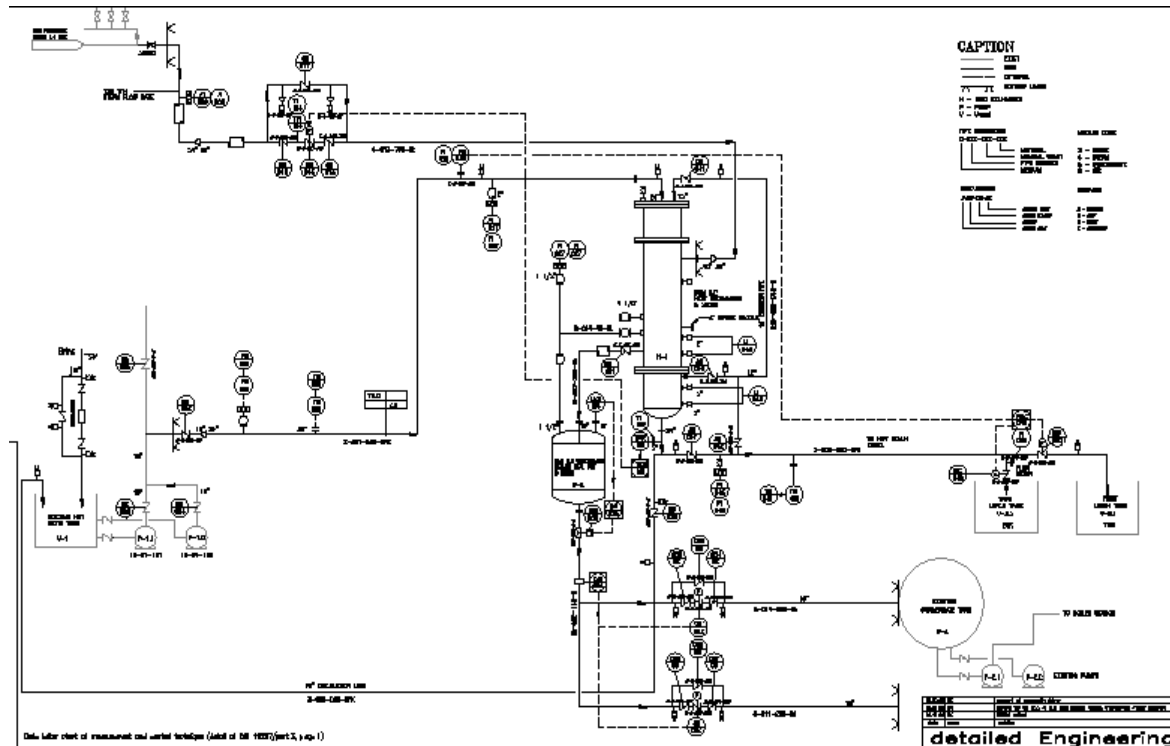


### Solution:

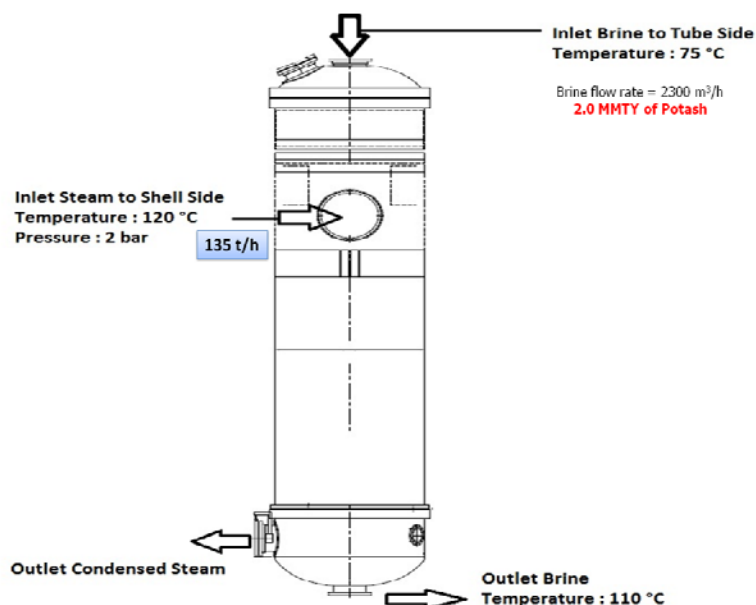
Three alternatives have been studied to increase reliability of the heat exchangers, maintain the current plates, replacement the existing type with other different types and replace the material of construction.

The finding is to replace the existing plate heat exchanger with falling film heat exchanger. This will reduce the maintenance cost, the operation cost by saving around 10 TPH of steam, and avail more safety working area.

The Falling film heat exchanger has put successfully, safely and smoothly into service on May 6<sup>th</sup>, 2011.

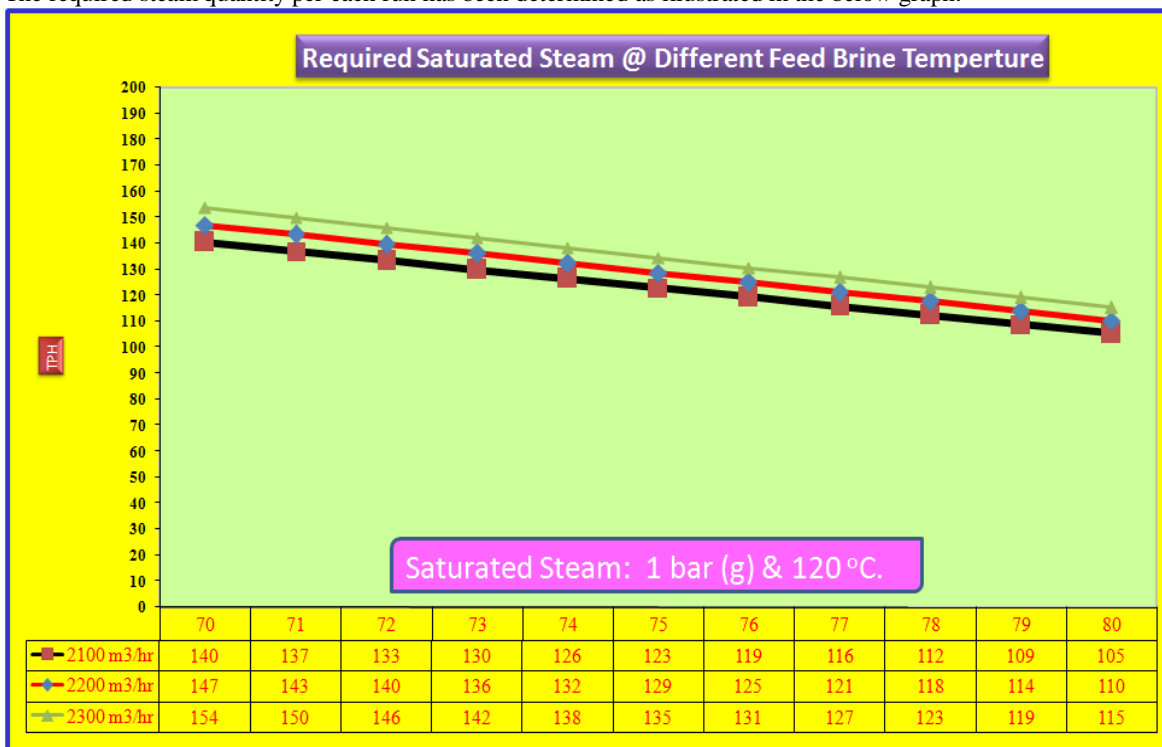


- DT = temperature difference between shell side (condensing steam) and tube side (brine temperature).

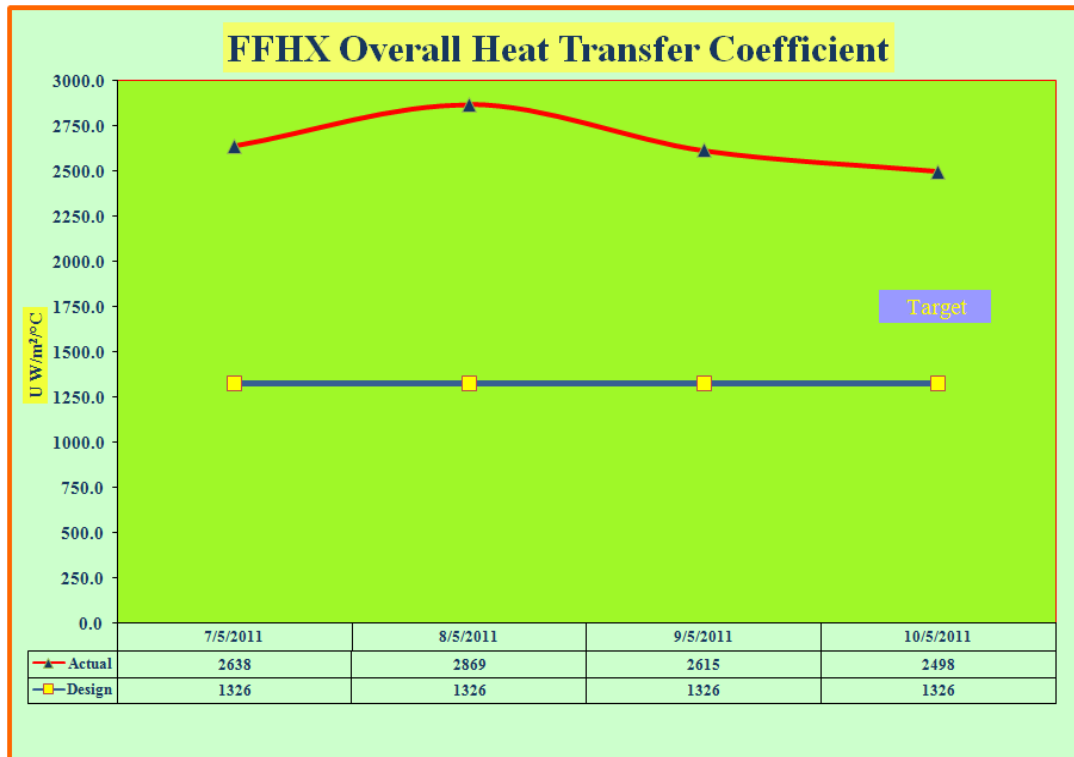


The process data has been simulated to calculate the overall heat transfer coefficient at different operation conditions by changing the feed flow rate from 2100 m<sup>3</sup>/hr to 2300 m<sup>3</sup>/hr, brine feed temperature from 70 °C to 80 °C at saturated steam (1 bar (g) & 120 °C): -

The required steam quantity per each run has been determined as illustrated in the below graph: -



The current values of “overall heat transfer coefficient” are higher than the designed value; that because the FFHX works below the designed capacity.



- Reduce the steam consumption by 6%, ensuring the brine feed to crystallizers is always saturated, thus increasing their KCl content and thus crystallizers are operated at their optimum, with the proper control of brine temperature.

#### Energy Saving

| Fuel Oil (kg fuel/ ton KCl) | Steam (kg steam/ ton KCl) |
|-----------------------------|---------------------------|
| 2.94                        | 35                        |

- The specific consumption of fuel with respect to HLP potash production (kg fuel/ ton KCl) was reduced by 2.94 Kg/ Ton (Positive effect).
- The specific consumption of steam with respect to HLP potash production (kg steam/ ton KCl) was reduced by 35 Kg / Ton (over the respective periods mentioned above). (Positive effect)
- Reduce the maintenance cost.
- Avail more safe working area (high-quality insulation).
- Decrease the downtime which is resulted of using old and deteriorated equipment.
- Improve the housekeeping by decreasing leaks.



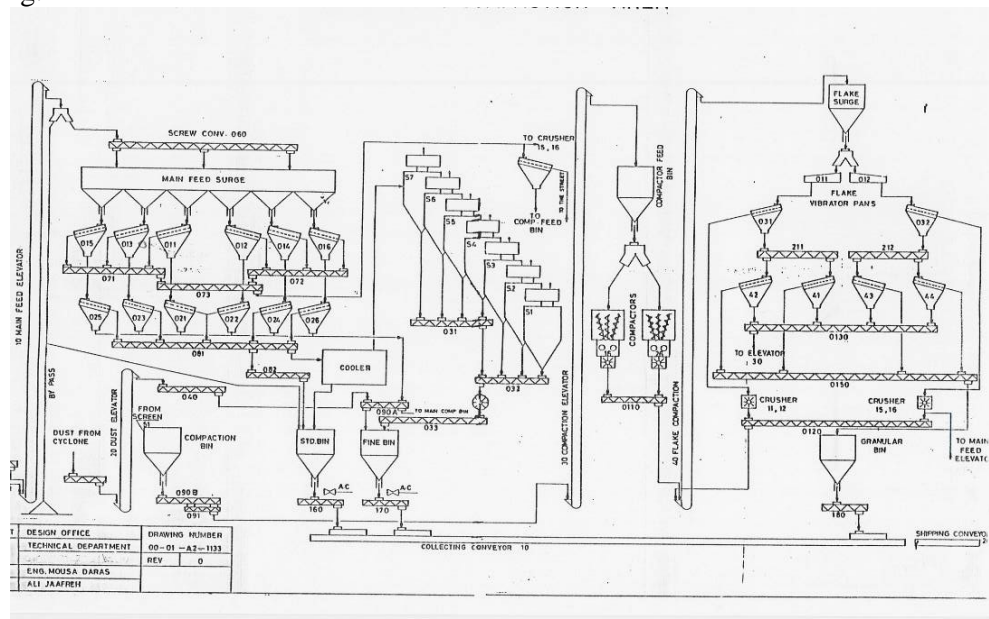
## Section Five – Two

### Project Two: New mineral separator at HLP.

APC product Handling area operates with various solids handling equipment, including bucket elevators, screw conveyors, screens, product cooler equipment, bins, etc.

The product at the exit of the dryer is conveyed to the screening section where it is classified into different grades, i.e., standard, and fine, while part of standard, fines and dust are directed to the compaction unit where they are compacted to produce a granular product.

To achieve desired sizes of the fine and standard potash, dryer product is sieved and screened first in six parallel screens in which extra coarse particles are separated from the dried product. The remaining dryer product is sent to another six parallel secondary screens for further screening.



### Problem:

The old screens were built on 1982 with a capacity of 1.2 MMTPY, in 1987; HLP production capacity was increased from design Capacity of 1.2 to 1.4 MTPY and no modification has been carried out on the screening unit and till the time of replacement no major modification has been carried out on the screens themselves to increase the capacity.

The most significant problem which has an adverse effect on the screens' performance is the critical condition of the frame, body and cover of the screens. The screens cover show signs of deterioration as a result of corrosion and erosion.

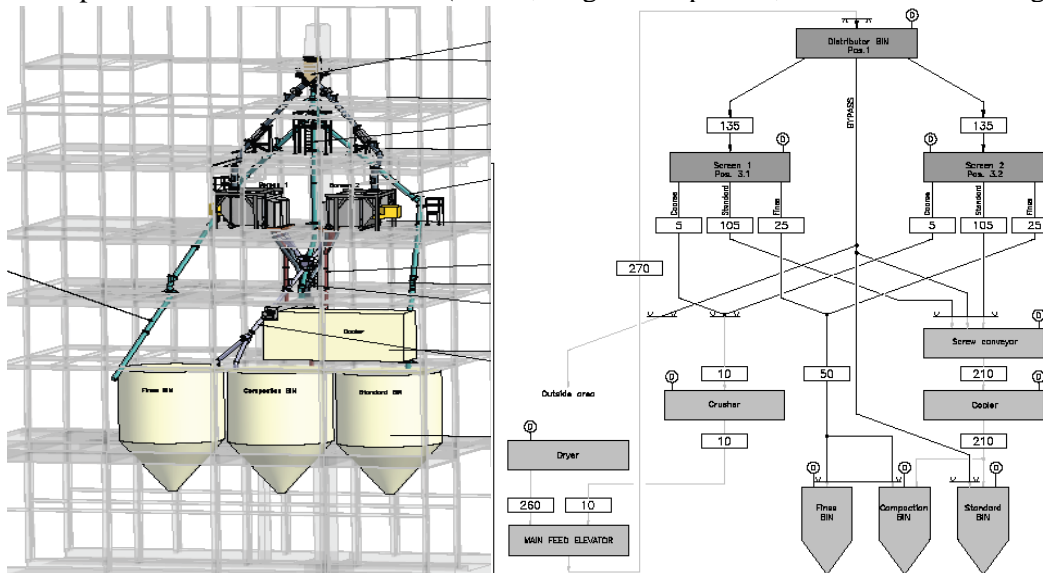
The high number of the used screeners and conveying equipments results in high consumption of power.

### Solution:

Project alternatives have been studied, and a comparison between the proposed screens drawings and the field is carried out, the findings are: -

- The main feed bins will be replaced by two chutes.
- Three main screw conveyers will be removed and use chute for fine material to feed fine bin.

- Replace six primary screens model Rotex 81 and six secondary screens model 521 by two new screens mineral multi-deck screens model 4240-2 of a capacity of 135 TPH per each with their auxiliaries (chutes, magnetic separator, and automatic slide gates).



The project had been executed within 75 calendar days and the new mineral separators have put successfully and smoothly into service.





### **Performance Evaluation:**

The benefits of this modification include better quality (particle size distribution) to cope with international requirements, the physical analysis of standard potash is within the accepted range; the difference between Tyler Mesh (10 - 65) is above 90%.

| Screen # | SAMPLE           | TYLER MESH (%cum.) |      |      |      |      |      |      |      |      |      |
|----------|------------------|--------------------|------|------|------|------|------|------|------|------|------|
|          |                  | 8                  | 10   | 14   | 20   | 28   | 35   | 48   | 65   | 100  | 150  |
|          | Dryer Product    |                    | 0.73 | 3.7  | 15   | 55.2 | 78.1 | 89.4 | 95.6 |      |      |
|          | Standard Product |                    | 0.4  | 8.0  | 26.7 | 61.3 | 85.1 | 94.3 | 97.3 |      |      |
|          | Fine Product     |                    |      |      | 4.1  | 10.4 | 16.8 | 40.3 | 80.2 | 88.0 | 94.6 |
|          | Oversize         | 19.7               | 70.5 | 83.0 |      | 92.2 |      |      |      |      |      |

And up-to-date, the main achieved benefits are: -

- Decrease the electrical running cost of the screening units by decreasing the number of operated equipments such as screens and screw conveyers. The total energy saved is 66 Kw.hr which represent 55%.
- Increase the standard grade potash production by 6%.
- Decrease the down time which is resulted from using old and deteriorated equipment.
- Improve the product quality by increasing the efficiency of the screens.
- Obtain more free area.
- Safe the environment by decreasing dust emission.
- Improve the housekeeping by decreasing leaks.
- Avail more safe working area.

## Section Five – Three

### Project Three: Reduction of Transportation Fuel Diesel

The final potash product can either go to the plant product storage warehouse, or it can be conveyed to shipping bins from which it can be loaded into specially made bottom- dump trucks for delivery to the storage warehouse at the port of Aqaba.

A fleet of trucks, with a capacity of 50 tons each, daily transport Potash via the Safi-Aqaba road (225 km) to the storage and loading facilities at Aqaba for ocean shipment.

The storage capacity in Aqaba was recently expanded from 160,000 tons to 260,000 tons.

The Aqaba facilities are among the most efficient and modern in the Potash industry. The reclaiming system ensures physical uniformity, guarantees reduced segregation and prevents caking. Dedusing, oil treatment and new screening units are installed to remove any fine particles and to reduce dust emissions during loading vessels at rates up to 1000 tons/hr. Aqaba affords professional inspection services and excellent shipping communications.

#### Potash specification that put on the market is: -

| Physical                               |           |          |          |       |
|--|-----------|----------|----------|-------|
| Tyler Mesh Typical Percentage Retained |           |          |          |       |
| Mesh No.                               | Open (mm) | Granular | Standard | Fine  |
| +5                                     | 4.00      | <10      |          |       |
| +6                                     | 3.35      | 15-25    |          |       |
| +8                                     | 2.36      | 50-70    |          |       |
| +10                                    | 1.70      | >80      | 1-3      |       |
| +12                                    | 1.40      | >90      |          |       |
| +14                                    | 1.18      |          | 8-15     |       |
| +20                                    | 0.85      |          | 20-40    |       |
| +28                                    | 0.60      |          | 40-60    | 0-4   |
| +35                                    | 0.425     |          | 65-85    | 7-12  |
| +48                                    | 0.30      |          | 88       | 20-40 |
| +65                                    | 0.212     |          | 95       | 45-65 |
| +100                                   | 0.150     |          |          | 75-85 |
| +150                                   | 0.106     |          |          | 80-90 |

| Guaranteed (Tyler Mesh) (mm)      | $\leq 10\%$ (+5) (4.00)<br>$> 90\%$ (+12) (1.40) | 90% min. Between<br>(10-65) (1.70-0.212) | 70% min. Between<br>(35-150) (0.425-0.106) |
|-----------------------------------|--|--|--|
| Stowage Factor                    | 38   | 36                                       | 34   |
| Angle of Repose                   | 32-34  | 28.5-29.5                                | 29-30                                      |
| Bulk Density (MT/m <sup>3</sup> ) | 1.063-1.180                                      | 1.299-1.358                              | 1.174-1.331                                |
| S.G.N                             | 250-300  |  |  |
| % Degradation (max)               | 10   |  |  |

| Chemical               |        |          |          |      |
|------------------------|--------|----------|----------|------|
| Element                | Units  | Granular | Standard | Fine |
| K <sub>2</sub> O (min) | %      | 61.0     | 61.0     | 60.7 |
| KCl (min)              | %      | 96.5     | 96.5     | 96.0 |
| NaCl (max)             | %      | 2.50     | 2.60     | 2.80 |
| Mg <sup>++</sup> (max) | %      | 0.15     | 0.13     | 0.20 |
| Ca <sup>++</sup> (max) | %      | 0.02     | 0.02     | 0.02 |
| Moisture (max)         | %      | 0.20     | 0.35     | 0.35 |
| Anti Cake/Amine (max)  | Kg/ton | -        | 0.25     | 0.25 |

| Industrial Grade |  |  |  |  |
|------------------|--|--|--|--|
|------------------|--|--|--|--|

| Chemical                            |       |            |
|-------------------------------------|-------|------------|
| Element                             | Units | Guaranteed |
| K <sub>2</sub> O (min)              | %     | 62.70      |
| KCl (min)                           | %     | 99.20      |
| NaCl (max)                          | %     | 0.50       |
| Moisture (max)                      | %     | 0.20       |
| Mg <sup>++</sup> (max)              | PPM   | 100        |
| Ca <sup>++</sup> (max)              | PPM   | 50         |
| SO <sub>4</sub> <sup>++</sup> (max) | PPM   | 20         |
| Water Insolubles (max)              | PPM   | 200        |

| Physical   |  |  |
|--|--|--|
| The Physical Size is 95% Minimum Over 150 (0.106mm) Tyler Mesh |  |  |

APC owns and operates large number of different types and models of ground vehicles, which can be classified into two main categories: -

- Passengers and general services: saloon cars, pickups, buses, tankers, service trucks and special equipment.
- **Potash Trucks:** there are 94 heavy duty road trucks, they are equipped with diesel engine 6 cylinders in line, turbocharged and gear box is 10 forward speeds.



### **Problem**

High consumption of diesel fuel oil.

### **Solution**

- Using Alum Light Weight Trailers instead of steel trailers, the capital cost of an Alum set of trailers is 56% over the capital price of a Carbon price set of trailers.
- Install a flat tilted sheet fitted on roof of the driver cabin, wind deflector in order to reduce overall drag.

- Replace the old trucks of 50 tons payload type MAC R612.ST and R688.S with 80 tons payload MAC type R612.ST to reduce the horse power consumption by 1.82 hp/transferred ton.
- Use a speed limiter to cut off the injection beyond a predetermined setting point
- Set a management program to follow up and average the fuel oil consumption per vehicle/type/model.
- Set a bounce formula that increase productivity and improve fuel efficiency without running vehicle fast especially on return trip.
- Improve maintenance by carrying out schedule preventive maintenance.
- Replace the steel trucks trailer by Aluminum low tare weight trailers.
- These trailers, when put into operation this will allow 10 more Tons in the net tonnage per trip.

Carbon Steel Trailer




Alum Trailer




### **Performance Evaluation:**




- Increase the total load out from 47 Tons to 57 Tons per trip (20% more per trip). That means APC hauls the same tonnage by 36,000 Trips per annum instead of 43,660 trips (7,660 less trips per year/ 17.5% less in operational costs).
- Therefore; the net percentage of the annual operational save by using Alum trailers instead of the traditional carbon steel trailers is = 11.9% for the advantage of the Alum trailers.
- Less transportation costs due to: -
  - Reduction in specific fuel consumption.
  - Less trucks' maintenance.
  - Reduce the public traffic rush on the road.
  - Improve the surrounding environment
  - Less accidents' possibility.



## Energy Saving Projects Case Study

### The Arab Potash Company





### Presentation Contents

- History and location.
- Process Description (HLP Process).
- APC Energy Saving Projects.
- Case Studies.
  - Heat Exchangers : -
    - Plate HXs'
    - FFHX.
  - Screening Unit Revamp
    - Type 81 & 521.
    - Multi\_deck mineral separator.
  - Potash Transportation.

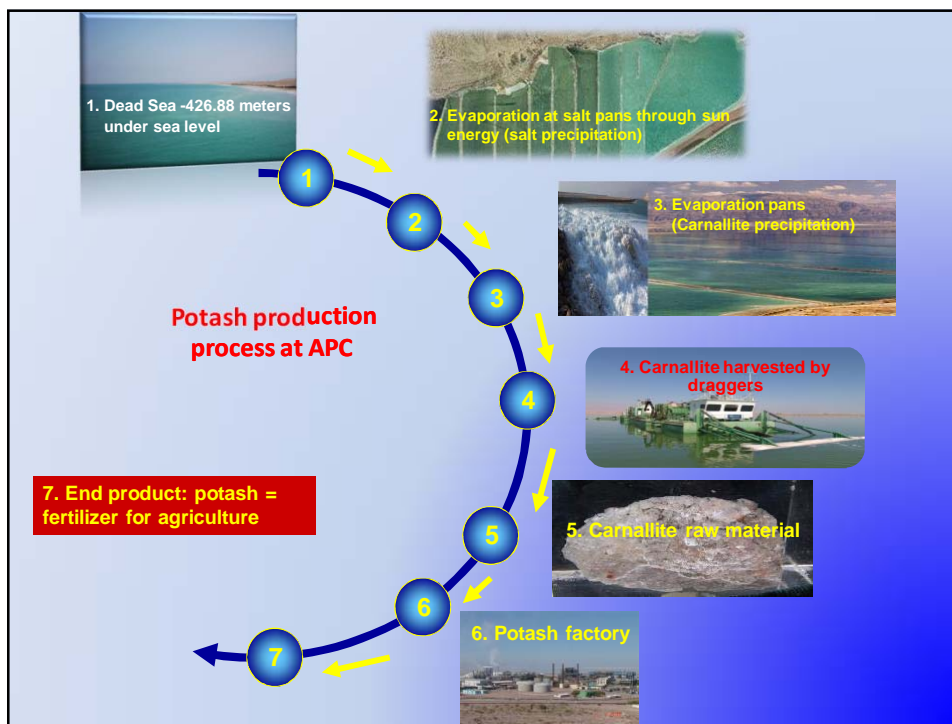
## History and Location



- First extraction of Potash from the Dead Sea was In 1930 by British-Palestinian Co. .
- APC Founded in 1956 by Jordan Government .
- Given a Concession for 100 years to exploit the Dead Sea minerals.
- Started commercial production in 1983.
- Total current capacity of Fertilizers grade potash is 2.5 MMTPY.
- APC plans to bring total capacity from 2.5 to 3.2 MMTPY through existing plants debottlenecking's.

**Potash Process**





## Dead Sea - General Info.

**Age Around .....12,000 Years Old**

**Total length ..... 55 km.**

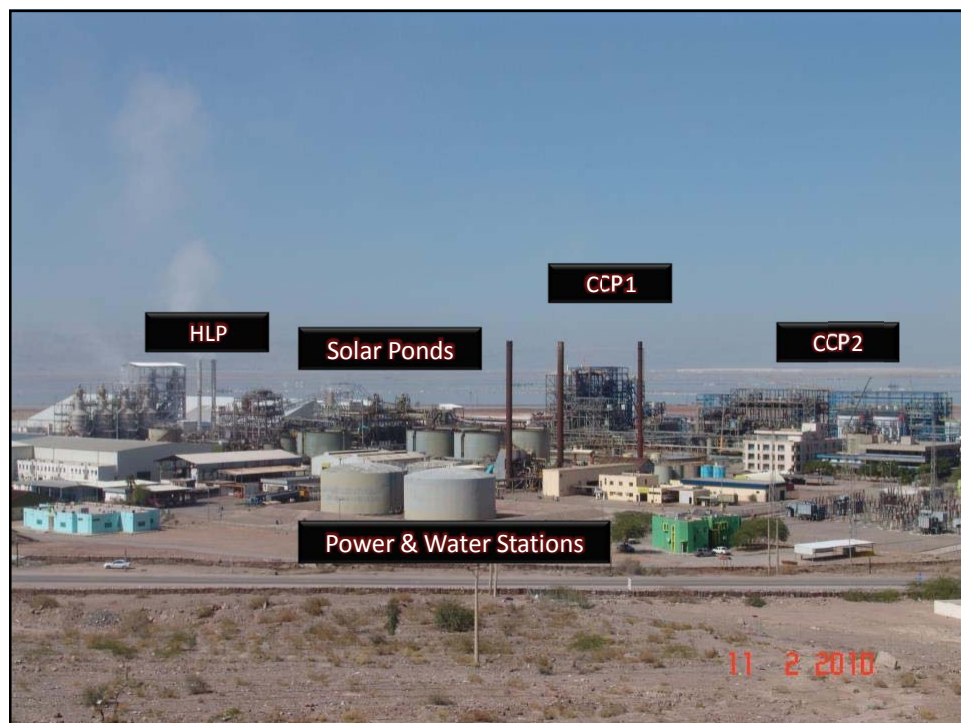
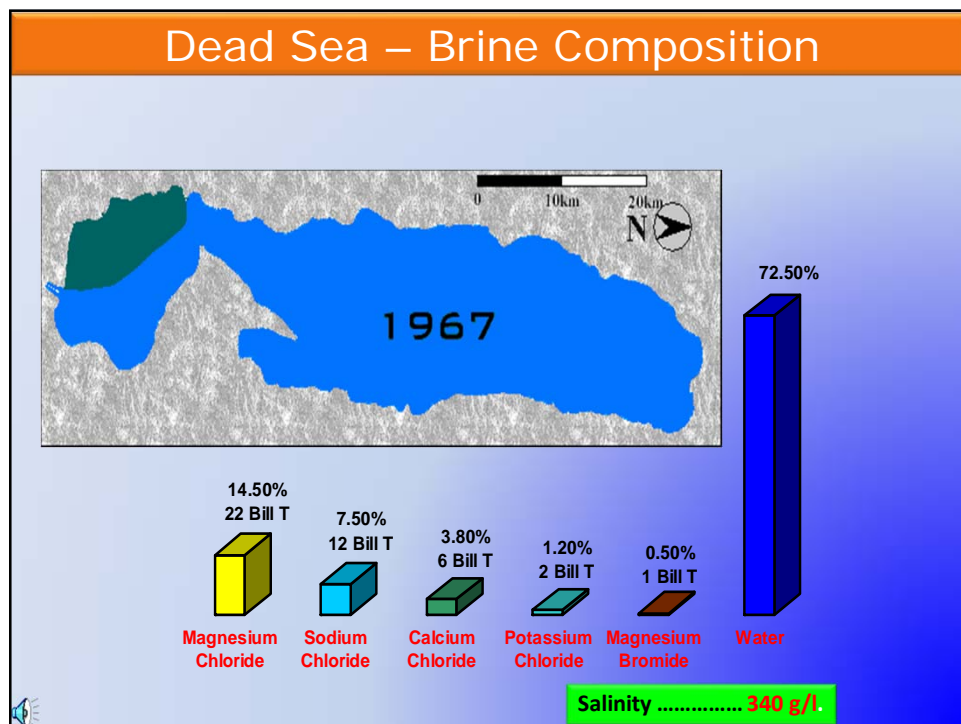
**Width range ..... 12-17 km.**

**Total Area ..... 650 km<sup>2</sup>.**

**Max. Depth ..... 360 m.**

**• Rate of fall of the dead sea .... 1.0 m/yr .**

**Elevation .... -426.88 m below sea level (April 15<sup>th</sup>, 2013)**





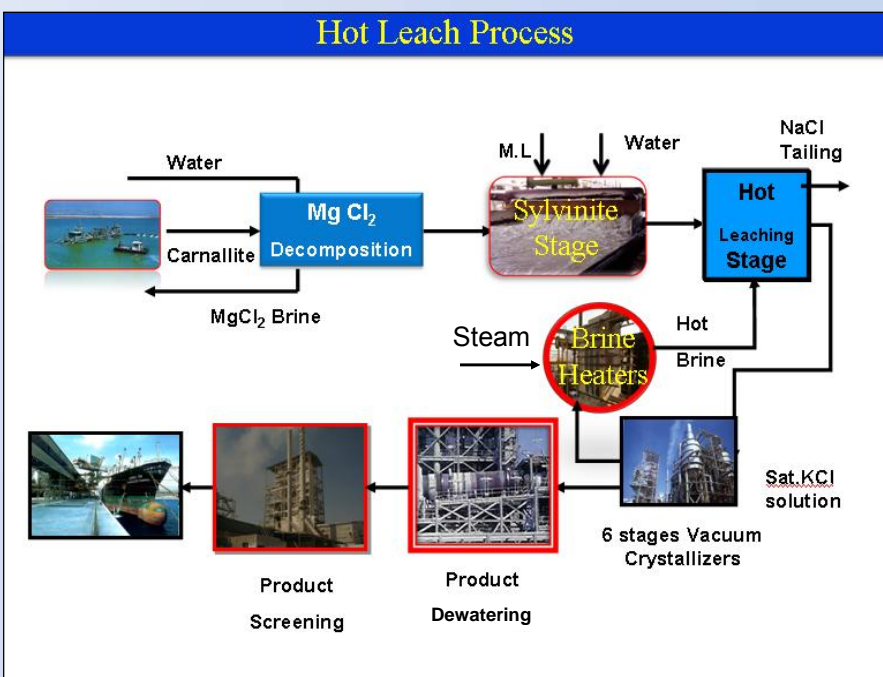
## APC Production Plants

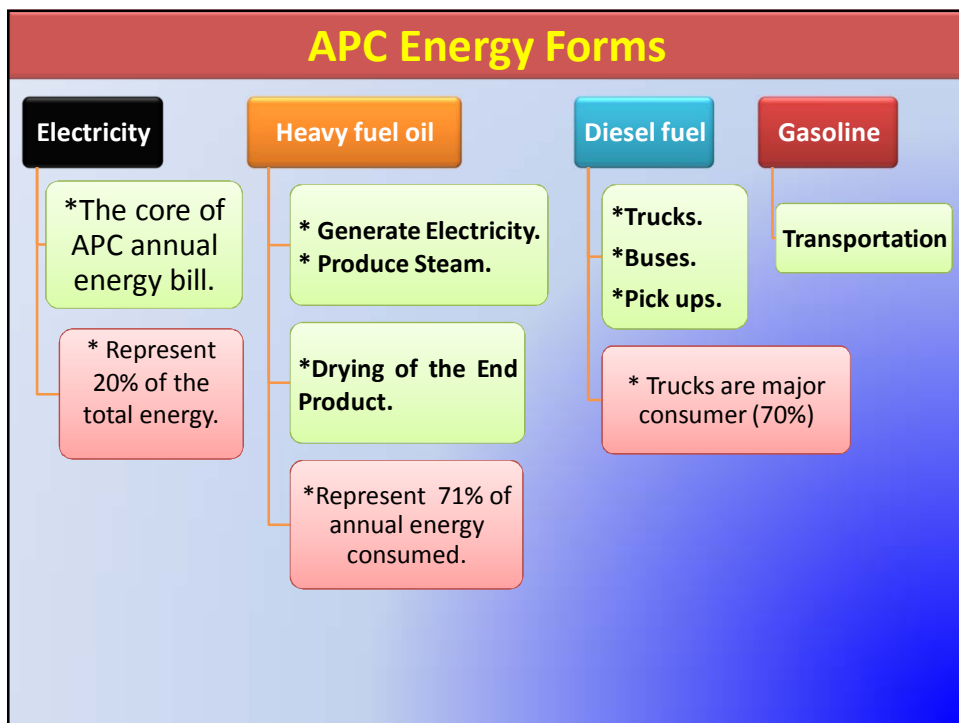
|                               |                  |      |
|-------------------------------|------------------|------|
| Hot Leach Plant               | 1.4 MMTPY        | 1982 |
| Cold Crystallization Plant I  | 0.6 MMTPY        | 1994 |
| Cold Crystallization Plant II | 0.5 MMTPY        | 2010 |
| <b>Total</b>                  | <b>2.5 MMTPY</b> |      |

## Other Production Plants

|                                      |  |
|--------------------------------------|--|
| Industrial Potash                    | 0.1 MMTPY<br>Capacity included above         |
| Compaction Unit<br>(Granular Potash) | 350,000 Tons/year<br>Capacity included above |

## Hot Leach Process



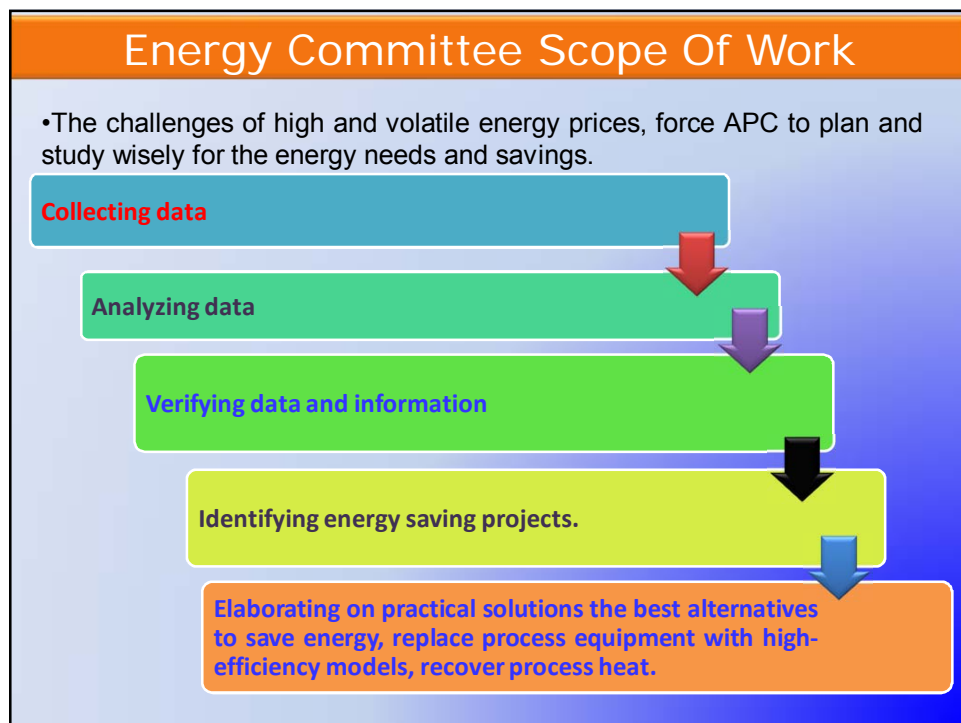
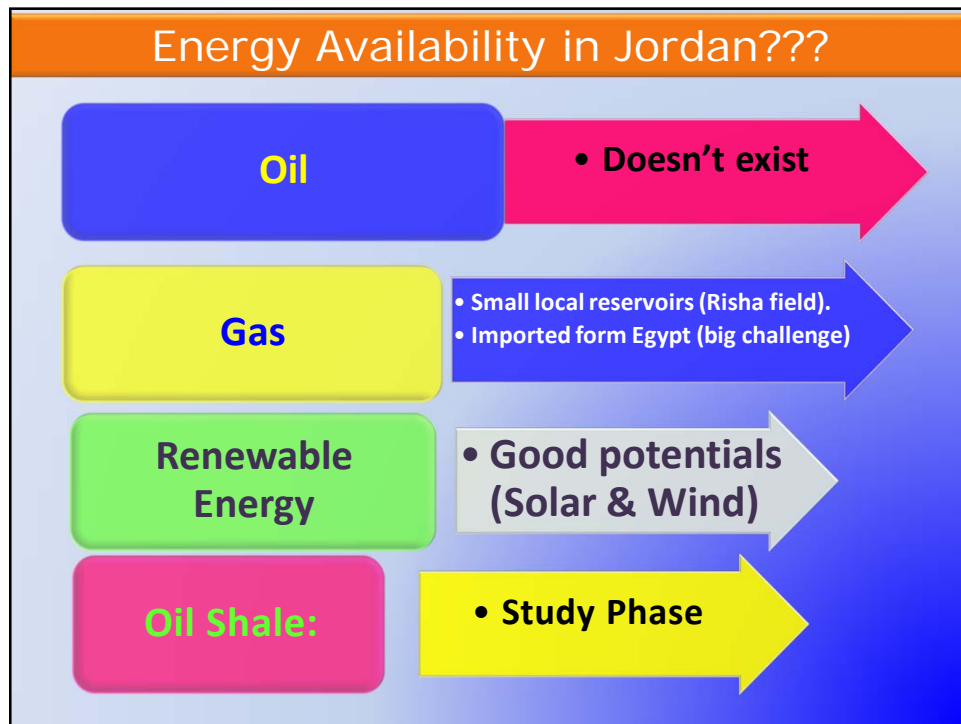


## APC POWER GENERATION & CONSUMPTION

|                                 |                                 |
|---------------------------------|---------------------------------|
| <b>Steam Co. Generation</b>     | <b>650 Kg Steam/ Ton Potash</b> |
| Boiler No. 1                    | 110 Tons/hr at 63 bars          |
| Boiler No. 2                    | 110 Tons/hr at 63 bars          |
| Auxiliary Boiler                | 46 Tons/hr at 15 bars           |
| <b>Power Generation</b>         |                                 |
| Steam Power Plant               | 15.0 MWH                        |
| <b>Power From National Grid</b> | 45 MWH                          |
| Total Electricity Requirements  | 60 MWH                          |
| Fuel Oil Consumption            | ~90,000 Tons/year               |

## APC External Energy Sources

- APC is one of the leading and large companies in Jordan that consumed energy.
- APC imports Energy from: -
  - Jordan Petroleum Company.
  - Jordan National of Electricity.
  - Private Sector.
- Energy poverty constitutes one of the fundamental challenges that Jordan is facing.



## Energy Saving Projects/ Case Study

APC has meanwhile continued to undertake energy saving at their plants and utility services and recently completing the succeeding energy conservation projects.

New Falling film heat exchanger at HLP.



New Multi-deck mineral separator at HLP.



Reduction of transportation diesel fuel.



## Case Study

### Heat Exchanger



## Plate Heat Exchanger Problem

- The plate heat exchangers are failed to maintain operational readiness > 95%.
- This failures occurs always during pumps start up due to wear and tear in rubber since it become fragile as a result of high temperature.
- This also results in steam losses and frequent maintenance.



## Solution

Three alternatives have been studied to increase reliability of the heat exchangers: -

- Maintain the current plates.
- Replace the existing type with other different types.
- Replace the material of construction



### Findings

Replace the existing plate heat exchangers with falling film heat exchanger.



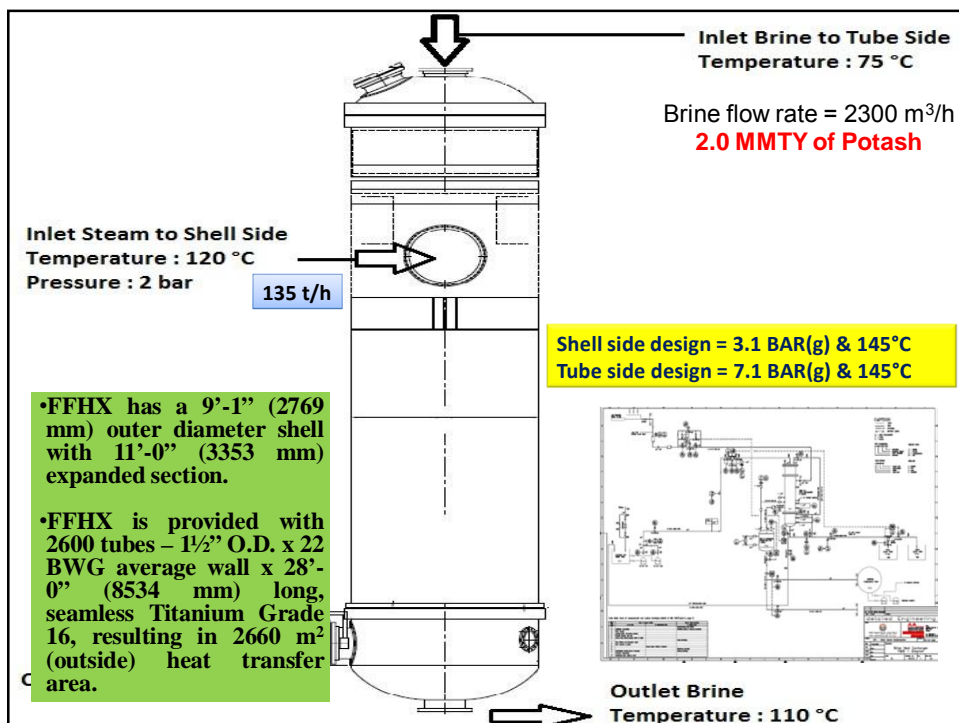
## Selection of FFHX Why???

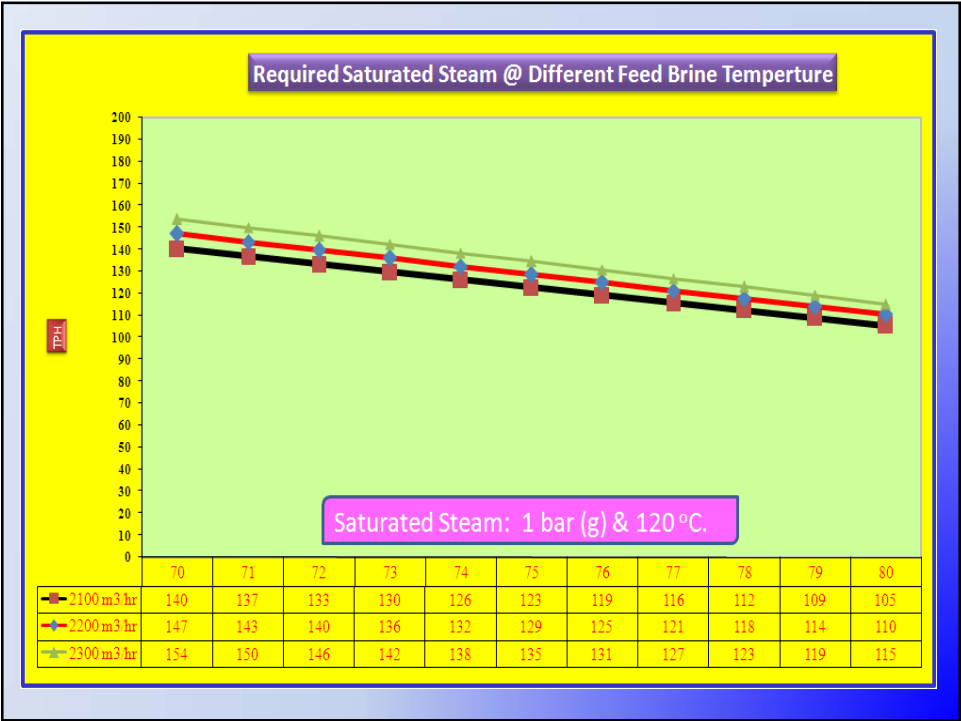
### 1) Improve the Safety & Environment Conditions:

- I. Replace the existing deteriorated Plate Heat Exchanger.
- II. New equipment (more safe).
- III. Less operating equipment.

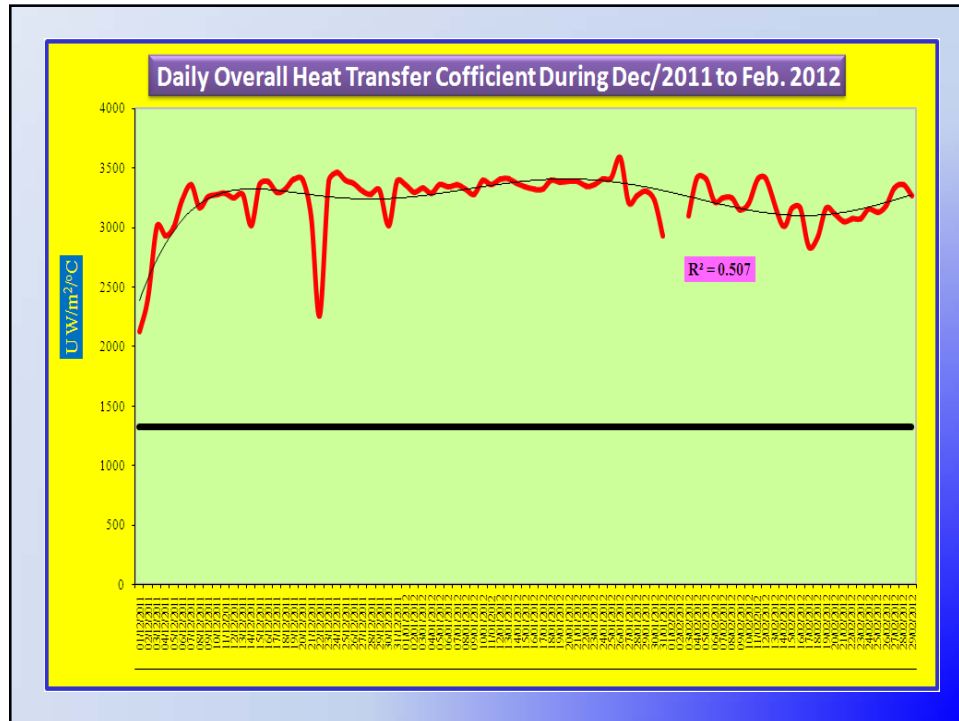
### 2) Improve plant heat recovery: -

- i. Less Heat losses.
- ii. Automation.
- iii. More process options (according to production needs).
- iv. Improve leaching control.
- v. Lower operating and maintenance cost









### Process Evaluation

- The current values of “ **Overall Heat Transfer Coefficient** ” are higher than the designed value. **(Positive effect).**
- The specific consumption of steam with respect to HLP potash production has reduced by 6% <from **557** to **522** (kg steam/ ton KCl) >. **(Positive effect).**
- The specific consumption of fuel with respect to HLP potash production has reduced by 6.2% (from **47.4** to **44.46** (kg fuel/ ton KCl)) . **(Positive effect).**



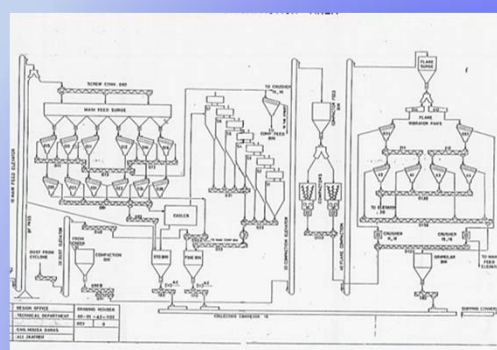
## Problem

- The old screens were built on 1982 with a capacity of 1.2 MMTPY.
- In 1987; HLP production capacity was increased from design Capacity of 1.2 to 1.4 MTPY and no modification has been carried out on the screening unit.

The most substantial problems of screening unit are Low screening efficiency due to: -

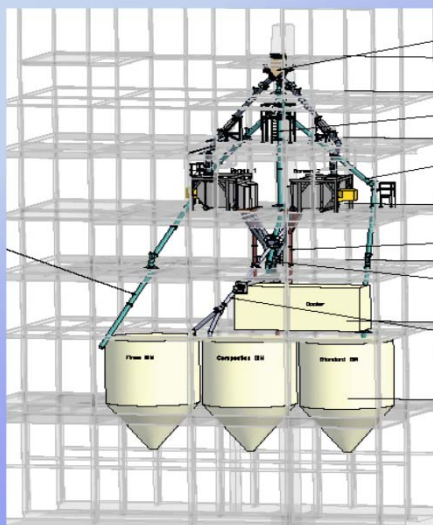
Critical condition of the frame, body and cover of the screens.

High number of screeners and conveying equipment (high power consumption).



### Solution:

Replace the existing 12 Rotex machines, 4 screws conveyers and 6 feed bins by two Rotex multi-deck screens of 135 TPH capacity each.  
(Gravity flow).



Project Execution has been completed and successfully commissioned.



### Major Achieved Benefits

1) Potash Physical Specifications have been remarkably improved

- I. (97% cumulative weight on -10 + 65 Tyler Mesh).
- II. (>70% cumulative weight on -35 +150 Tyler Mesh).

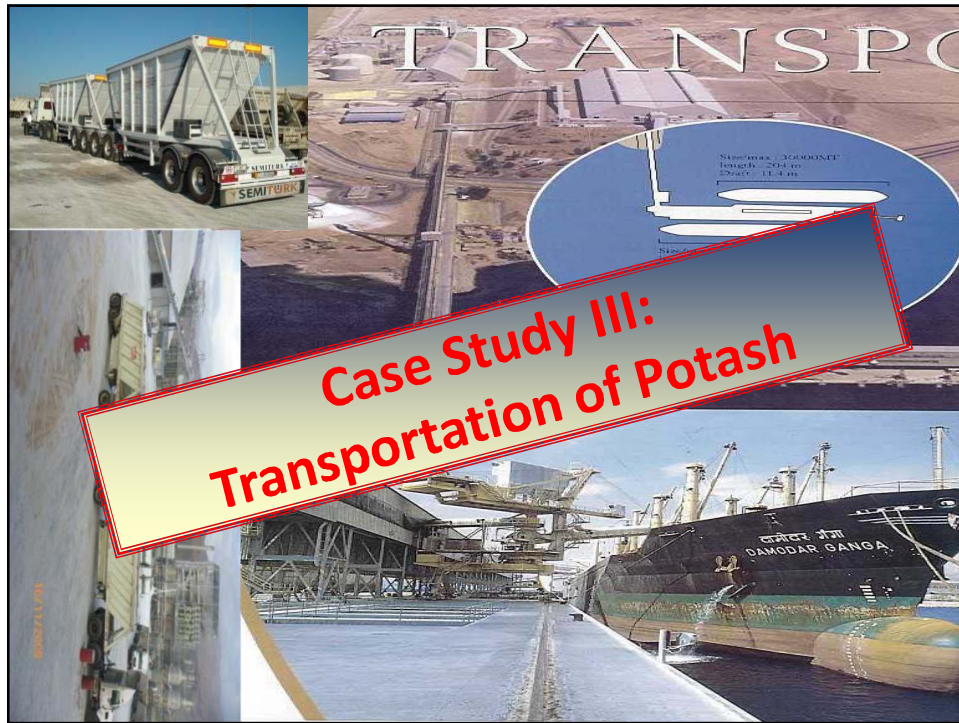
(very efficient screening)

| SAMPLE           | TYLER MESH (%cum.) |      |      |      |      |      |      |      |      |      |
|------------------|--------------------|------|------|------|------|------|------|------|------|------|
|                  | 8                  | 10   | 14   | 20   | 28   | 35   | 48   | 65   | 100  | 150  |
| Dryer Product    |                    | 0.73 | 3.7  | 15   | 55.2 | 78.1 | 89.4 | 95.6 |      |      |
| Standard Product |                    | 0.4  | 8.0  | 26.7 | 61.3 | 85.1 | 94.3 | 97.3 |      |      |
| Fine Product     |                    |      |      | 4.1  | 10.4 | 16.8 | 40.3 | 80.2 | 88.0 | 94.6 |
| Oversize         | 19.7               | 70.5 | 83.0 |      | 92.2 |      |      |      |      |      |

### And up-to-date, the main achieved benefits are: -

- Decrease the electrical running cost of the screening units by 55% (66 KW.hr).
- The number of operated equipment have been reduced.
- Increase the standard grade potash production by 6%.
- Decrease the down time which is resulted from using old and deteriorated equipment.
- Improve the product quality by increasing the efficiency of the screens.
- Obtain more free area.
- Safe the environment by decreasing dust emission.
- Improve the housekeeping by decreasing leaks.





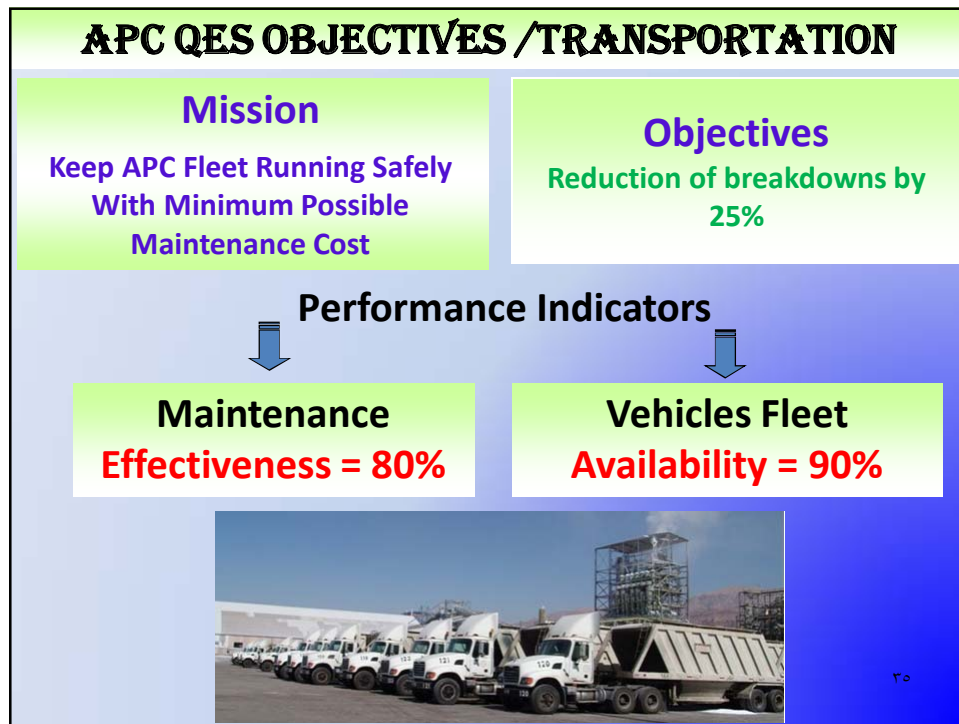
## Storage & Shipping

Storage **capacity at plant site:** 120 thousand tons  
& Open Yard is also used.

Storage **capacity at Aqaba:** 260 thousand tons.

Potash **transported from plant site to Aqaba:** 5500 tons daily (94 trucks).

Aqaba Ship loading **capacity:** 1 thousand ton/hr



**Problem**

- High consumption of diesel fuel oil.



### Main Solution:

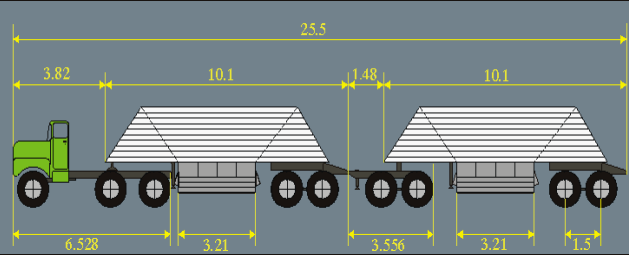
## Replace the Carbon-steel Trailers with Aluminum Trailers.

☐ Use Alum Light Weight Trailers instead of steel trailers.

☐ New Aluminum Trailers are provided with Tubeless Tires for Fuel saving and serve as Anti-Sudden Flatness.

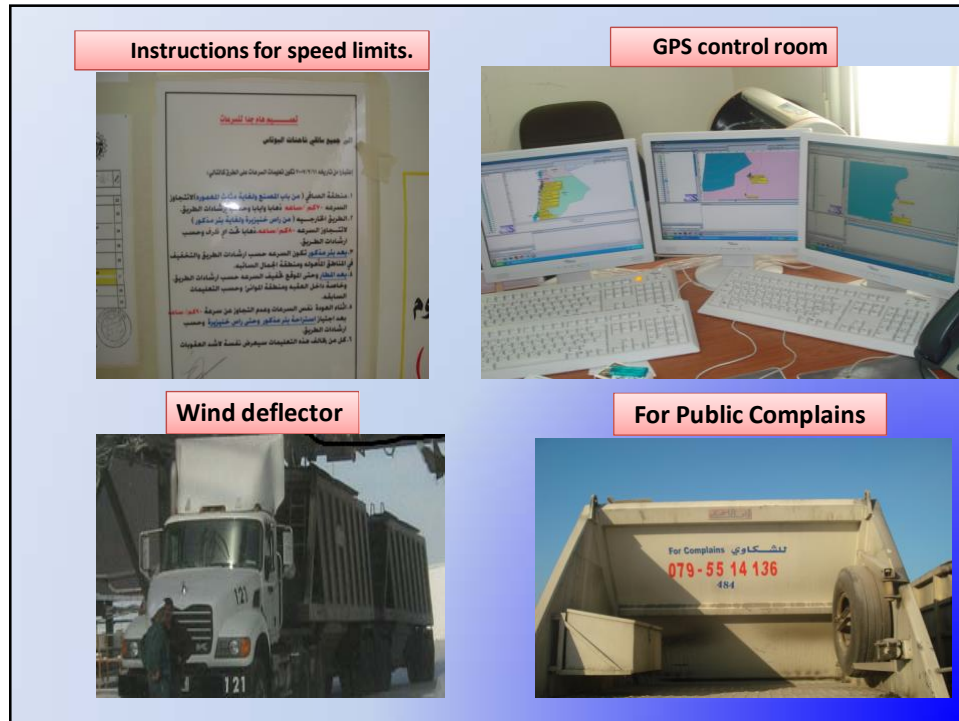
☐ Aluminum trailers are provided with sliding dump gates fulfilling better sealing than the existing clamshell gates to prevent potash spillage (cost) to the local environment.

|                         |  |
|-------------------------|--|
| TRUCK WEIGHT            | 8 TON  |
| FRONT TRAILER WEIGHT    | 7.5 TON  |
| REAR TRAILER WEIGHT     | 10 TON   |
| GROSS WEIGHT (UNLOADED) | 25.5 TON                                       |
| CARGO WEIGHT (2X25)     | 50 TON   |
| TOTAL GROSS WEIGHT      | 75.5 TON                                       |
| OVERALL MAXIMUM LENGTH  | 25.5 METER                                     |
| OVERALL WIDTH           | 2.45 METER                                     |
| NUMBER OF AXLES         | 9 AXLES (4 DOUBLE AXLES AND SINGLE FRONT AXLE) |



## Complementary Solutions

- Install a flat tilted sheet fitted on roof of the driver cabin, wind deflector in order to reduce overall drag.
- Use a speed limiter to cut off the injection beyond a predetermined setting point.
- Set a management program to follow up and average the fuel oil consumption per vehicle/type/model.
- Set a bounce formula that increase productivity and improve fuel efficiency without running vehicle fast especially on return trip.
- Improve maintenance by carrying out schedule preventive maintenance.



## Performance Evaluation

- Increase the total load out per trip by 20% (from 47 Tons to 57 Tons per trip).
- Reduce the annual trips by 7,660 trips per year which represent 17.5%.
- Therefore; the net percentage of the annual operational save is = 11.9%.
- Less transportation costs also due to: -
  - Reduction in specific fuel consumption (Diesel oil handling).
  - Less trucks' maintenance.
  - Reduce the public traffic rush on the road.
  - Improve the surrounding environment
  - Less accidents' possibility.





**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Energy Conservation in  
Modern Plants-Alexfert's View.**

**Mohamed Hassan Mowena  
ALEXFERT  
Egypt**

# Energy Conservation in Modern Plants- Alexfert's View.

*Fertilizer production consumes approximately 1.2 % of the world's total energy on an annual basis of which ammonia production accounts for 87 % of the industry's total energy consumption. Continual improvements are ongoing for improving the energy efficiency of ammonia plants by implementing various energy saving schemes and adopting efficient technologies for the new plants. This paper summarizes two case studies implemented in Alexfert's ammonia plant along with some different ways for energy conservation in ammonia plants.*

*Author(s):*

*Eng. Khaled El-Sayed Mohamed*

*Dr. Eng. Mohamed Hassan Mowena*

*Alexandria Fertilizers Company, Alexandria, Egypt*

## Introduction

Continual engineering efforts are ongoing to study the energy conservation possibilities for the ammonia plants. Most of these efforts aims in reducing the gap in energy consumption for the old established plants with the modern ones. Energy efficiency in the manufacture of nitrogen-based fertilizers has significantly improved. The average net specific consumption for modern plants approaches 5.9 – 7.0 Gcal/mt, while still some plants are working on the level of 7.88-13.9 Gcal/mt, and this suggests that revamping less efficient existing plants would increase energy efficiency, and reduce production costs.

**Energy Conservation Efforts in Alexfert's Ammonia plant:** Alexandria Fertilizers Company (Alexfert) was established as a joint stock company in Oct. 2003 on the coast of Abu Qir bay, on the Mediterranean coast of Egypt. The company consists of an ammonia plant with a capacity of 1200 MTPD, and urea granulation plant with a capacity of 2000 MTPD, in addition to the necessary Offsites and utilities.

The plants were commissioned in Aug. 2006 with the main contractor for the whole complex is UHDE Company. One of the objects of the company quality and environmental policy is to continually improve the process execution and resources management including the energy conservation.

Since the plant establishment was based on the latest proven technology, the average net specific consumption for the plant was designed as 7.288 Gcal/mt, while continual efforts aims in optimizing such figure as much as possible.

Recently, two cases were improved the performance in two different locations within the ammonia plant which shall be illustrated as follows:

➤ **Case One: The use of highly effective ACT-1 activator, which shows substantial benefits over DEA in CO<sub>2</sub> removal unit.**

The CO<sub>2</sub> removal unit incorporates the use of traditional benfield solution based on 30 % potassium carbonate (K<sub>2</sub>CO<sub>3</sub>) in addition to an activator (DEA) and corrosion inhibitor (Vanadium pentaoxide). The activator concentration is 3 %, which is added to the carbonate solution for improving the absorption rate of CO<sub>2</sub>. For many years DEA (diethanolamine) has been the standard activator and is still used in many operating plants.

However, the unit suffers from the following problems:

- i. Thermal degradation of DEA.
- ii. Chemical degradation of DEA due to reaction with reoxidizing agents used to oxidize the corrosion inhibitor (vanadium) from V<sup>+4</sup> to V<sup>+5</sup>, along with the formation of non regenerable large molecular weight polymeric chemicals and heat stable salts. This results in system foaming and increasing the corrosion products along with H<sub>2</sub> slippage from desorber which limiting the operation of urea plant.

Recently, ACT-1 (an alternative product developed by UOP Co.) proves as a more-stable molecule that is more resistant to degradation.

The features of the benfield unit designed for activation with ACT-1 instead of DEA could be summarized as follows:

- i. Potential for capacity increases of up to 5 % in the CO<sub>2</sub> removal unit.
- ii. Potential reduction in regeneration heat from 5 -8 %.
- iii. Potential reduced solution pumping requirements by up to 10 %.

The above mentioned benefits along with overcoming the problems in the unit's operating parameters were considered, and decision was taken to change the benfield solution activator to be ACT-1 instead of DEA, the job was held during turnaround performed for year 2011. The results could be illustrated as follows:

1. Increase in the absorption capacity by 20 % decrease in the CO<sub>2</sub> slippage.
2. Reduction in regeneration heat for the benfield solution by 20 %, in other hand the specific consumption is reduced by almost 0.025 Gcal/ mt ammonia.
3. Reduction in pumping rates by 5 % due to significant decrease in the absorption solution circulation flow rates.
4. The net saving in low pressure steam consumption could be used in the following areas:
  - Increasing the fuel temperature to boiler.
  - Increasing the Deaerator pressure using low pressure steam which increase the boiler feed water temp. with the potential saving in the boiler feed water as well.
  - Increasing the combustion air temperature to primary reformer box which aids in maximizing the combustion efficiency in the burners, thus saves fuel.

➤ **Case Two: Replacement of W.H.B. in Ammonia Synthesis unit.**

The waste heat boiler installed downstream of the ammonia converter is an Uhde designed Fountain type vertical WHB. It consists of 400 freely movable U-tubes, and is located downstream the ammonia converter to cool down the gases outlet the Converter from 456 °C to 306 °C against boiler feed water. The boiler feed water is preheated to be close to the boiling point in especially pre-heating part and saturated steam with 329 °C is generated in the evaporating part. The converted gases are introduced in the tube side at a design pressure of 184.8 bar abs, and the steam is generated in the shell side at 127 bar abs.

One year after the initial start-up, the boiler suffers from two repeated failures, of which the synthesis section operating conditions were optimized.

The in house comprehensive studying for the similar cases along with the continual successful communications with the designer (UHDE) revealed the need to modify some of the equipment design parameters along with increasing the boiler capacity by 10 % for the ease of maximizing the HP-steam production with maintaining safe and stable operation.

The new equipment was successfully installed during turnaround held in October 2009, with the following performance main features:

- i. The synthesis section is running over its name plate capacity (almost 103 %).

- ii. Steam production increased by 10 % over the old one, which is equivalent to almost 0.05 Gcal/ton ammonia.
- iii. The new boiler outlet temperature decreased from 306 to 289 °C.

➤ **Energy Conservation results due to application of the two cases, results in reducing energy per to ammonia to 0.1 Gcal/mt ammonia, which equivalent to 900,000 \$/year.**

## **Developments and opportunities:**

Developments in the ammonia production technologies runs simultaneously with the idea of revamping or modifying the existing plants for the ease of increasing their efficiencies, maximizing economics or elimination bottlenecks in order to match with modern technologies and reduce energy consumption to remain competitive. Continuous developments in process technology, catalyst and design and material of construction for equipments offered opportunities to all existing plants to improve energy efficiency, while selecting the proper development is governed by each plant own case, technology used, and the management review of the resources with the evaluation of the process capital and operating investment costs. Of the possible points to be considered, we can illustrate the following points of which should be studied carefully prior to selecting the applicable one or more as follows:

- **Reforming Section:** the main object is to reduce the steam to carbon ratio, which could be through various ways as follows:
  - i. Establishment of modern reformer tubes with better metallurgy, higher strength, and thinner wall that allow higher heat transfer, larger inner space for catalyst packing, and saving energy.
  - ii. Energy conservation through the utilization of excess heat in flue gases liberated from reformer box through new coil in preheating of other streams depending on stack temperature.
  - iii. Installing pre-reformer which reduces significantly the firing duty in the primary reformer to be installed in a new convection coil or as a separate heater.
  - iv. For secondary reformer, short catalyst loading improving the combustion zone and the reforming zone, respectively.
- **CO Shift converters:** the utilization of better designed exit nozzles for the two reactors markedly improves the vessels pressure drop which in turn aids in synthesis gas turbine power saving.

- **CO<sub>2</sub> removal:** Changing the packing in absorption and desorption columns for better mass transfer efficiency along with the proper selection for the absorption activator for reducing energy paid per CO<sub>2</sub> extracted. One of the attractive points is the replacement of the single stage flash drum with multi-stage one aiming in decreasing the steam requirements.
- **Methanator and synthesis gas suction:**
  - i. Drying of the synthesis gas allows the gas to be fed directly to the inlet of the converter rather than being fed into the loop before ammonia separator.
  - ii. Chilling of make-up synthesis gas helps in saving the synthesis compressor power by 9 % per 30 °C, to be utilized for increasing plant rate or decreasing power consumption for synthesis gas turbine.
- **Ammonia Synthesis:** Modifying the ammonia converter basket, aiming in enhancing the flow direction from axial to radial or axial-radial, thus led to the possibility of using more active catalyst of finer particle size without increasing the pressure drop through the reactor led to potential saving of 0.2-0.3 Gcal/mt. The proper design for waste heat recovery from synthesis gases exit converter also aims in recovering the excess heat and improving the heat duty for ammonia refrigeration cycle.
- **Purge gas recovery:** aims in the selective recovery of ammonia and hydrogen from the purge gas where the hydrogen is recycled to the synthesis loop and ammonia increases the plant productivity, the idea reduces the specific energy consumption from 0.15-0.25 Gcal/mt.
- **Catalyst used:** the selection of the catalyst to be used in the overall process stages is of great importance, since selecting higher activity catalyst, with the lowest possible pressure drop and high conversion rates significantly improves the productivity and energy needs.
- **Steam system:** the effective control of leaked points from steam system vents significantly improves the process efficiency. This could be managed by applying the modern control systems.

## Conclusions

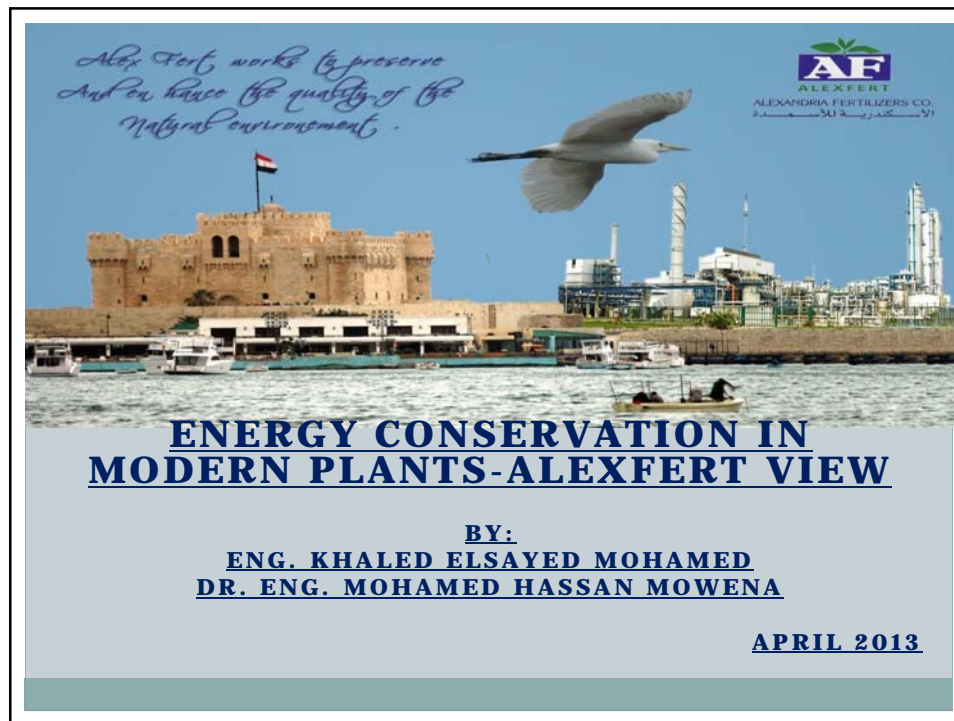
The energy conservation philosophy became an essential for making the ammonia manufacturing competitive, taking into account the following points:

- i. The great opportunity for revamping the old plants which has a great marginal limits, in comparison with the new plants, to improve their performance by selecting one or more of the energy conservation techniques.
- ii. The continual increase in the prices of the energy resources pulls the manufacturers to enable and promote further technological advancements that will reduce energy consumption.

## References

1. F. Kessler, D. Hoberg and S. Hruby, First Application of Uhde's dual pressure ammonia process for revamping of the Duslo Ammonia plant, Nitrogen Conference and Exhibition , Austria (2006).
2. Retrofits for ageing ammonia plants, Johnson Matthey Catalyst Seminar, Egypt (2008)
3. S.K. Furukawa and R.K. Bartoo, Improved Benfield Process for Ammonia Plants, UOP, USA, (1997).
4. J. J. de Wit, A. Riezebos, Upgrading a 25 year old Ammonia plant resulting in
5. Lower Energy Consumption and Higher Production Capacity, AIChE (1998).
6. S. NAND and M. Goswami, Recent Effort in Energy Conservation in Ammonia and Urea plants, Indian J. Fert., Vol. 4 (12), pp. 17-20 (2008).
7. Benchmarking of IFA Ammonia Plants, 2009.





### Introduction: Fertilizer Industry and Community development



- Nitrogen fertilizers contributes to producing close to 50 % of the food grown world wide.
- Fertilizers production consumes 1.2 % of the world's total energy on an annual basis, of which 87 % used for ammonia production.
- About 98 % of the nitrogen fertilizers are derived from synthetically produced ammonia.
- The ammonia production is an energy-intensive process.

## Ammonia as an energy –intensive



- Economically, natural gas is the main hydrocarbon feed stock used in ammonia synthesis, i.e., the processes that use less natural gas per unit of Ammonia contributes to a significant reduction in the production costs.
- Environmentally, the energy-efficiency improvements led to a reduction in the generated CO<sub>2</sub> emissions from both process and fuel combustion that saves environment.

**Minimize energy Consumption and/or maximize production capacity.**

- According to latest surveys, the average net specific consumption for modern plants approaches 5.9-7 Gcal/mt NH<sub>3</sub>, but still some plants at the figure of 8-13 Gcal/mt, based on age, capacity and technology.

## Alexandria Fertilizers Company -Introduction



- Alexfert was established in October 2003 on the coast of Abu Qir bay, south Mediterranean at Alexandria, Egypt.
- Commissioned by August 2006.
- Consisted of:



Ammonia Plant  
1200 MTPD  
Uhde Design



Urea Plant  
1925 MTPD  
StamCarbon  
Design



Utilities Section



Ammonium  
Sulphate Plant  
720 MTPD  
Under  
commissioning

## Alexfert Policy



- To continually improve the process execution, and resources management including the energy conservation.
- Based on that, the plants establishment comprising the use of latest proven technologies, while continual efforts aims in improving and optimizing the energy consumption issues.
- Present average net specific consumption is 7.3 Gcal/MT Ammonia.

## Recent Efforts in Ammonia plants:

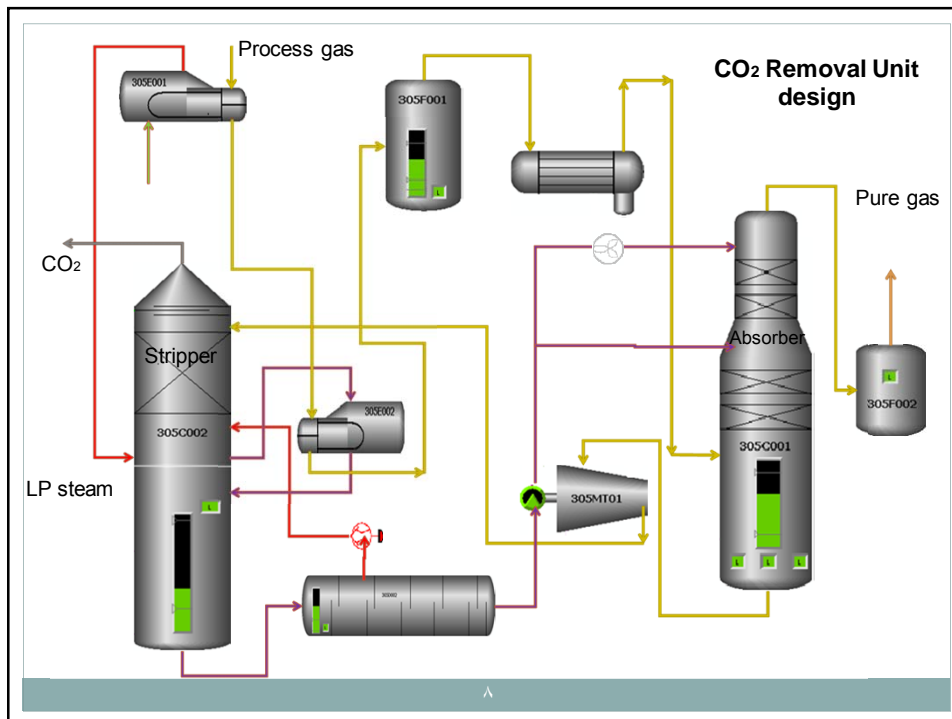


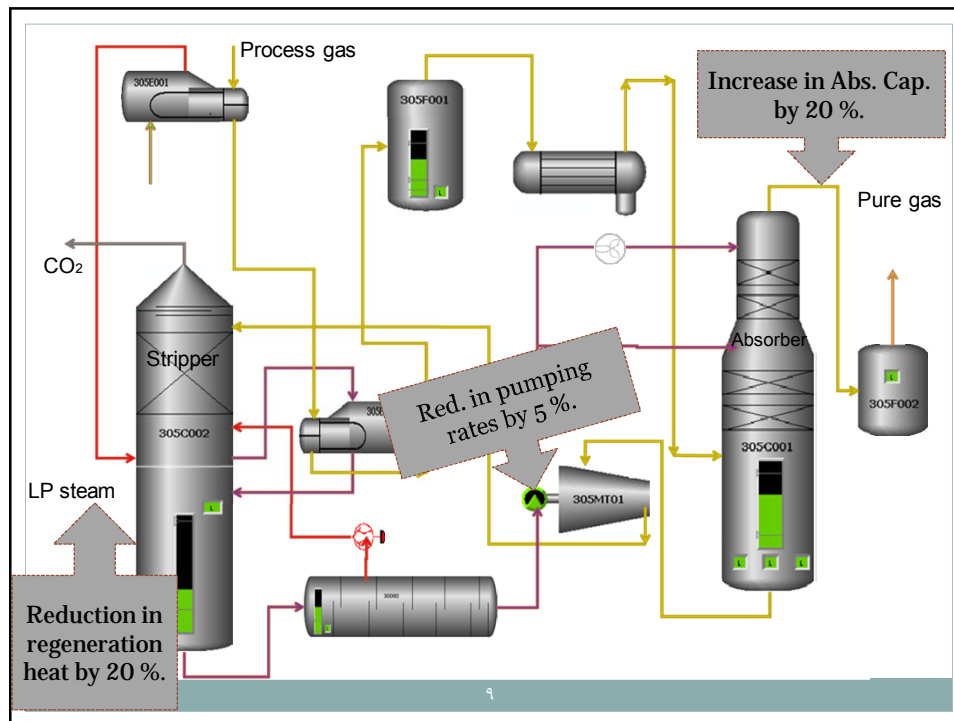
- Two cases could be considered which improves the use of energy resources:
  1. The use of an effective activator “ACT1”, which shows substantial benefits over DEA in CO<sub>2</sub> removal unit.
  2. Improvement of W.H.B. in Ammonia Synthesis unit.

## Case one: the use of ACT-1 Activator.

- Benfield solution is used based on 30 %  $K_2CO_3$ , 3 % DEA and corrosion inhibitor “Vanadium pentaoxide”.
- Rule of activator is to improve the absorption rate of  $CO_2$ .
- Problems:
  1. Thermal degradation of DEA.
  2. Chemical degradation of DEA due to reaction with reoxidizing agents and formation of non regenerable polymeric chemicals and heat stable salts.

Foaming, corrosion products, and hydrogen slippage from desorber that limits the operation of urea plant.





### Case one: the use of ACT-1 Activator.

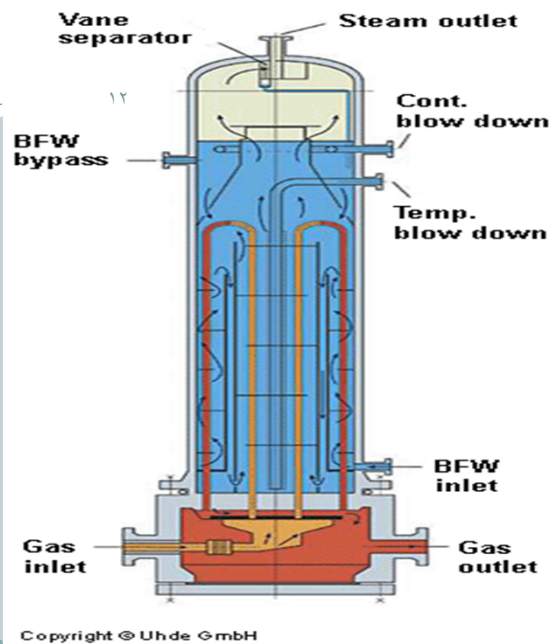
- The net saving in low pressure steam consumption could be used in the following areas:
  1. Increasing the fuel temperature to boiler.
  2. Increasing the deaerator pressure using LP-steam which increase the B.F.W temperature and decrease consumption.
  3. Increasing the combustion air temperature to reformer box which maximizes the combustion efficiency in the burners.

## Case Two: Improvement of W.H.B. in Ammonia plant



- Uhde designed fountain type vertical W.H.B.
- Cool down the gasses down stream Amm. Converter from 456 to 306 °C, with design pressure of 184.8 bar.
- B.F.W is preheated and saturated steam is generated in the evaporating part, with pressure of 127 bar.
- 400 U-tubes with two passes.

## Case Two: Improvement of W.H.B. in Ammonia plant



### Case Two: Improvement of W.H.B. in Ammonia plant

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- One year after initial start-up, the boiler suffers from two repeated failures, of which synthesis section operating conditions optimized.
- In-house comprehensive studying for the similar cases along with communication with the designer “UHDE” revealed the need to modify some design parameters with increasing the boiler capacity by 10 %.

### Case Two: Improvement of W.H.B. in Ammonia plant

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- Some features of the modification:

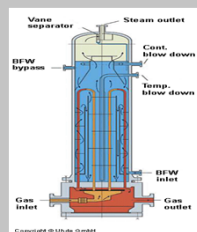
**This as well as ferrule insertion length and baffle spacing positively improve the W.H.B. circulation rate, heat flux in the hot zone and boiler capacity.**

| Item                    | Old design | New design |
|-------------------------|------------|------------|
| No. of tubes            | 400        | 320        |
| Tube length             | 5760       | 7550       |
| Tube OD                 | 25         | 30         |
| Pitch                   | 45         | 50         |
| No. of baffles          | 27         | 23         |
| Shell diameter “inside” | 1390       | 1430       |
| No. of drain points     | 2          | 4          |

## Net Saving

15

**Energy conservation by 0.1 Gcal/mt Ammonia, which is equivalent to 900,000 S/year.**



## General guide for developments and opportunities

16

- Developments runs simultaneously with the idea of revamping or modifying the existing units for the ease of increasing their efficiencies, maximizing economics, or eliminating bottlenecks to match with modern technologies and reduce energy consumption so as to remain competitive.







### Consider carefully:

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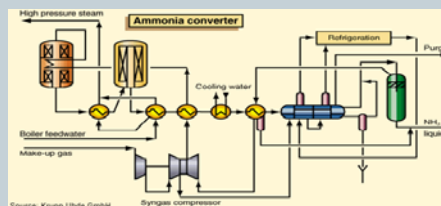
- CO shift converters:  
Better design exit nozzles “improves pressure drop”.
- CO<sub>2</sub> removal unit:
  1. Packing selection for absorption and stripping columns.
  2. Selecting proper activator.
  3. Replacement of single stage flash drum to multi-stages one.

Thus, improve absorption efficiency per extracted CO<sub>2</sub>, decrease steam requirements.

### Consider carefully:

٢٠

- Methanator and synthesis gas suction:
  1. Drying of the synthesis gas allows the gas to feed directly to converter instead of synthesis loop before separator.
  2. Chilling of make-up synthesis gas reduces synthesis gas compressor power by 9 % per 30 °C “increase plant rate”.



### Consider carefully:

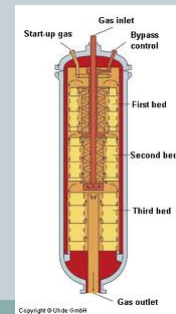
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- **Ammonia Synthesis:**

1. Modifying the ammonia converter basket aiming in enhancing the flow direction “axial to radial or axial-radial”.
2. Proper design for waste heat recovery from synthesis gases exit converter “excess heat recover & improve heat duty of ammonia refrigeration cycle”.

- **Purge gas recovery:**

Selective recovery of ammonia and hydrogen from the purge gas “hydrogen to synthesis & ammonia productivity improved”



### Consider carefully:

٢٢

- **Catalyst used:**

Use of higher activity catalyst with lowest pressure drop & high conversion rates improves the productivity and energy needs.

- **Steam system:**

Effective control of leaked points from steam system vents as well as application of the modern control systems, all of which improves the process efficiency and saves energy.

## Conclusions

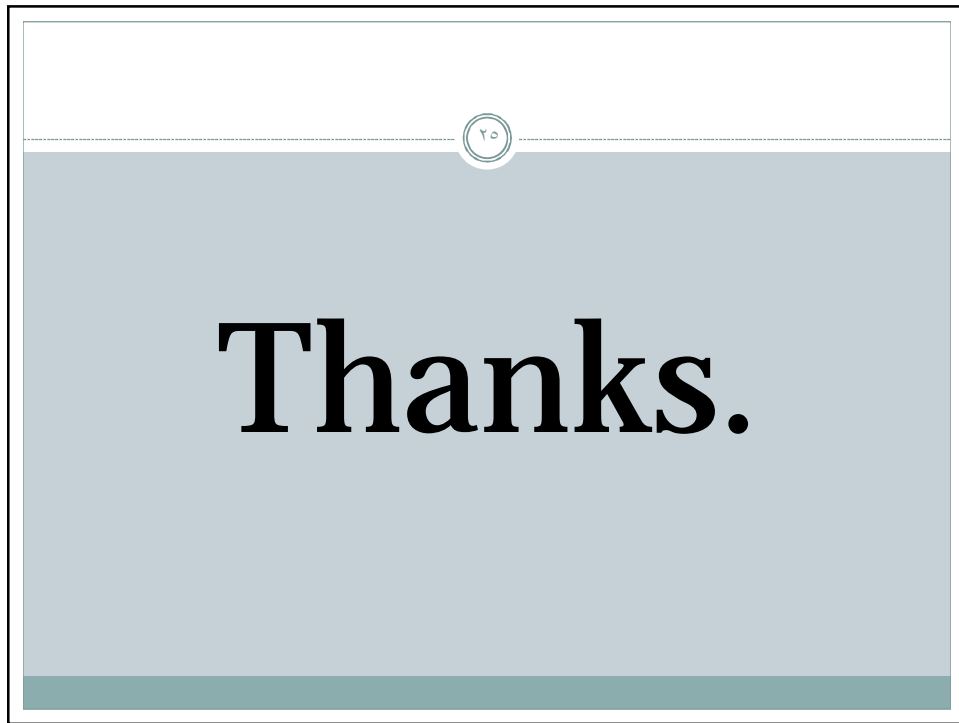
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- The energy conservation philosophy is an essential for ammonia manufacturing competition taking into account:
  1. Great opportunity for revamping old units “great design margin”, to improve their performance.
  2. Continual increase in the energy resources prices that pulls manufacturers to reduce energy consumption.

## References

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- F. Kessler, D. Hoberg and S. Hruby, First Application of Uhde's dual pressure ammonia process for revamping of the Duslo Ammonia plant, Nitrogen Conference and Exhibition , Austria (2006).
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- Benchmarking of IFA Ammonia Plants, 2009-2012.



**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Prospects of Energy Savings in the  
Jordanian Fertilizer Industry**

**Hassan Al-Seaf  
Marketing Engineer  
Eta-Max Energy &  
Environmental Solutions**

**Ahmed M. Al-Ghandoor  
Associate Professor -  
The Hashemite  
University**

# Feasibility of on-grid Solar Photovoltaic Systems

AFA Work Shop

Renewable Energy in Fertilizer Industries & Energy Auditing

29<sup>th</sup> April 2013

Eng.Hassan Al-Seaf. *Technical Consultant*



## Introduction to PV Technology

ETA-max Energy & Environmental Solutions 2/27/2012



ETA-max Energy & Environmental Solutions 2/27/2012

## Solar Photovoltaics

- The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for direct electric current (DC).
- Photovoltaic power generation employs solar panels composed of arrays of solar cells containing a photovoltaic material.
- Materials presently used for photovoltaics include monocrystalline silicon, polycrystalline silicon, and amorphous silicon.

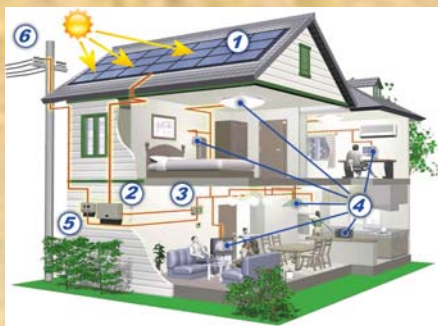


## Solar Photovoltaic Applications



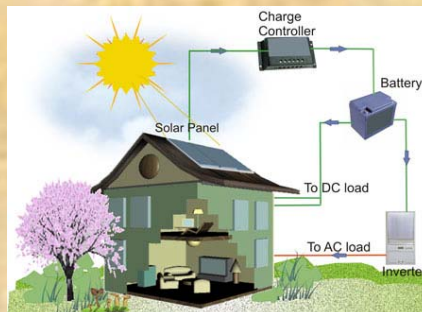
## On-grid Solar Photovoltaics

- Solar photovoltaic systems can be grid connected (on-grid) systems or stand alone (off-grid) systems.
- A typical on-grid system requires the employment of DC/AC inverter to convert direct current to alternating current that can be synchronized with the grid power and used in conjunction with it.



## Solar Photovoltaics

- An off-grid system typically relies on the use of re-chargeable batteries with a charge controller to optimize the charging and discharging processes, in addition to an off-grid DC/AC inverter.



## Advantages of PV Systems

Expected working life over 25 years.

Zero running cost.

Zero GHG emissions.

Minimum maintenance requirements.

Minimum infrastructure requirements.

## Solar Panels

- A solar panel (also solar module, photovoltaic module or photovoltaic panel) is a packaged, connected assembly of solar cells, also known as photovoltaic cells.
- The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity.
- There are three general families of photovoltaic (PV) solar panels on the market today. They are mono-crystalline silicon, polycrystalline silicon, and thin film.

## Solar Panels

- Monocrystalline and Polycrystalline represent the "traditional" technologies for solar panels.
- They can be grouped into the category of "crystalline silicon".
- Monocrystalline is the original PV technology invented in the fifties, while polycrystalline entered the market in the early eighties.
- They are very similar in performance and reliability.

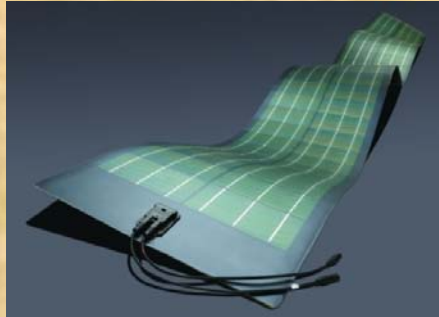


## Solar Panels

- On the other hand, thin film panels can be made flexible and light weight by using amorphous silicon deposited on plastic glazing.
- Thin film panels can perform slightly better than crystalline modules under low light conditions.
- They are also less susceptible to power loss from partial shading of a module.
- The main disadvantages of the thin film technology are lower efficiency and uncertain durability.
- Lower efficiency means that more space and mounting hardware is required to produce the same power output.

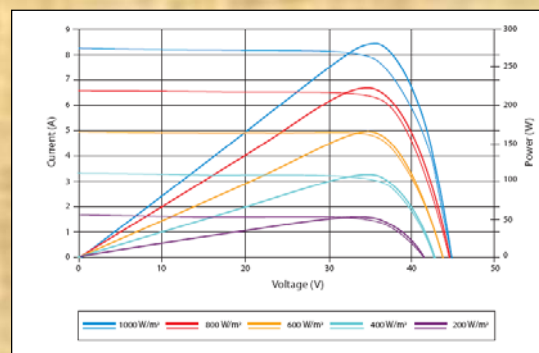


## Solar Panels



## Solar Panels

- Solar panels are usually rated in kWp, which is the peak output under standard test conditions (irradiance of 1,000 W/m<sup>2</sup>, and module temperature at 25°C).



## Solar Panels

- Solar panels are robust and durable.
- They are designed to withstand severe climatic conditions including heat, rain, and snow with expected operating life of 20-25 years.
- In fact, many crystalline silicon module manufacturers offer a warranty that guarantees electrical production for 10 years at 90% of rated power output and 25 years at 80%.
- The most efficient mass-produced solar panels have energy density values around of 140 W/m<sup>2</sup>.

## Solar Inverters

- A solar inverter or PV inverter is a critical component in a Photovoltaic system.
- It performs the conversion of the variable DC output of the Photovoltaic modules into a utility frequency AC current that can be fed into the commercial electrical grid.
- On-grid inverters, match phase with a utility-supplied sine wave.
- Grid-tied inverters are designed to shut down automatically upon loss of utility supply, for safety reasons.
- They do not provide backup power during utility outages.

## Solar Inverters



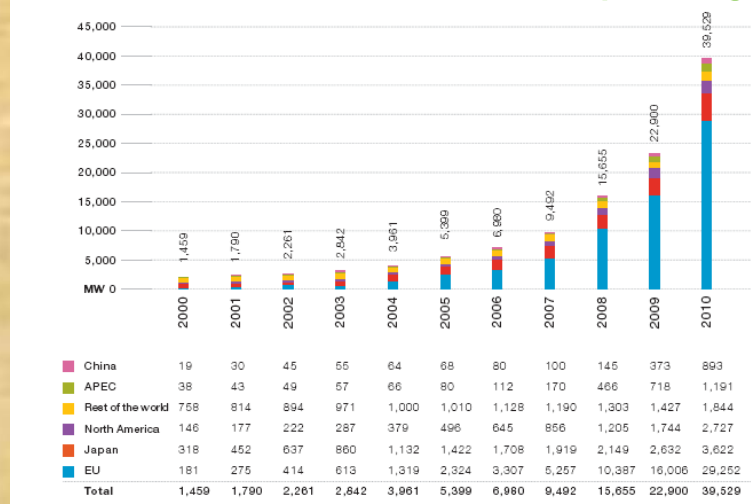
## Solar Inverters

- Most grid-tie inverters have peak efficiencies of over 94%, some as high as 96%.
- The energy lost during inversion is for the most part converted into heat.
- This means that in order for an inverter to put out the rated amount of power it will need to have a power input that exceeds the output.
- Inverters that are capable of producing power at different AC voltages may have different efficiencies associated with each voltage.

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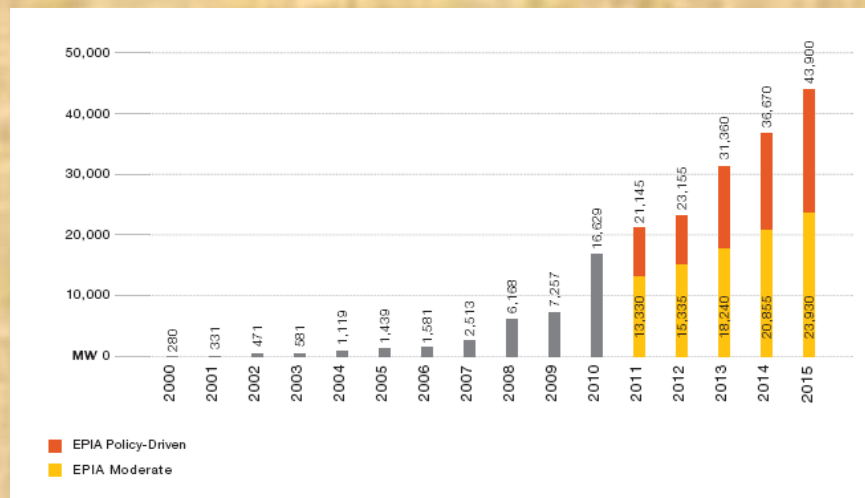
## Global PV market Status

## Global PV Installed Capacity

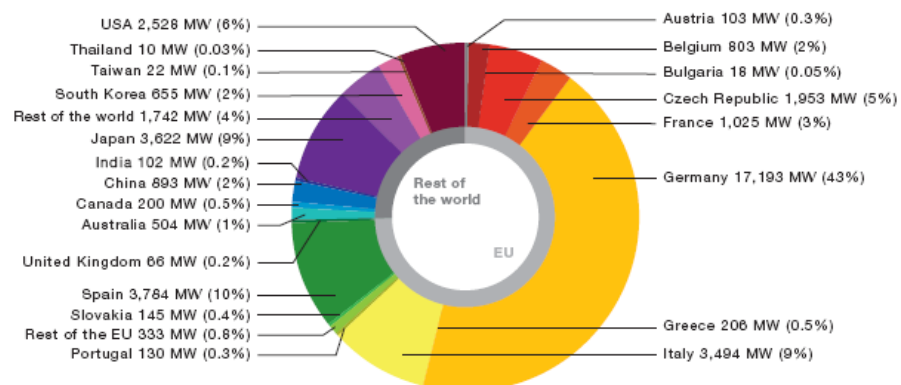




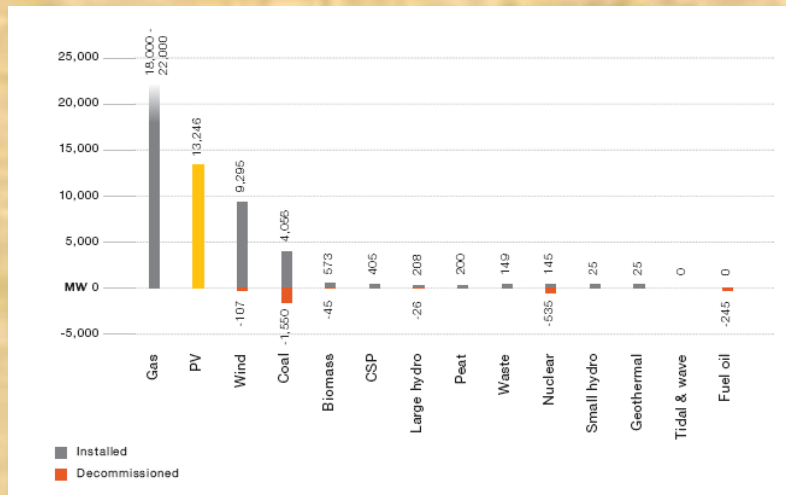
## Global PV Market Demand



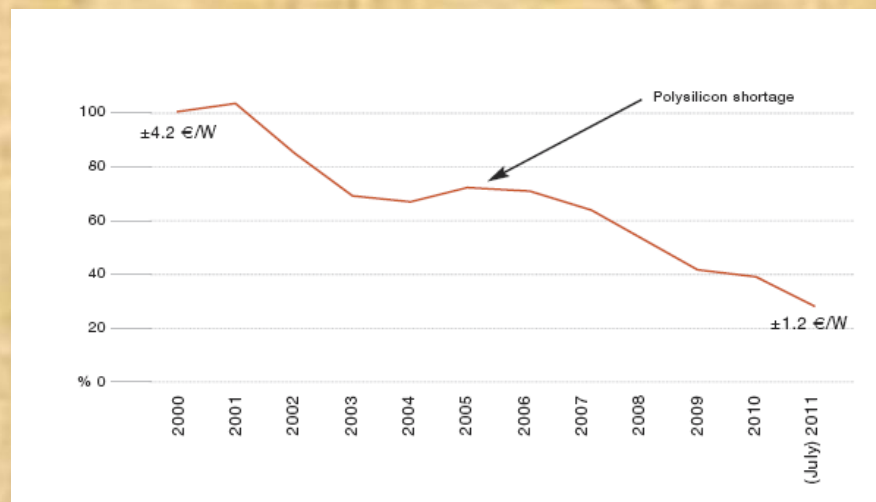
## Global PV Market – by Country

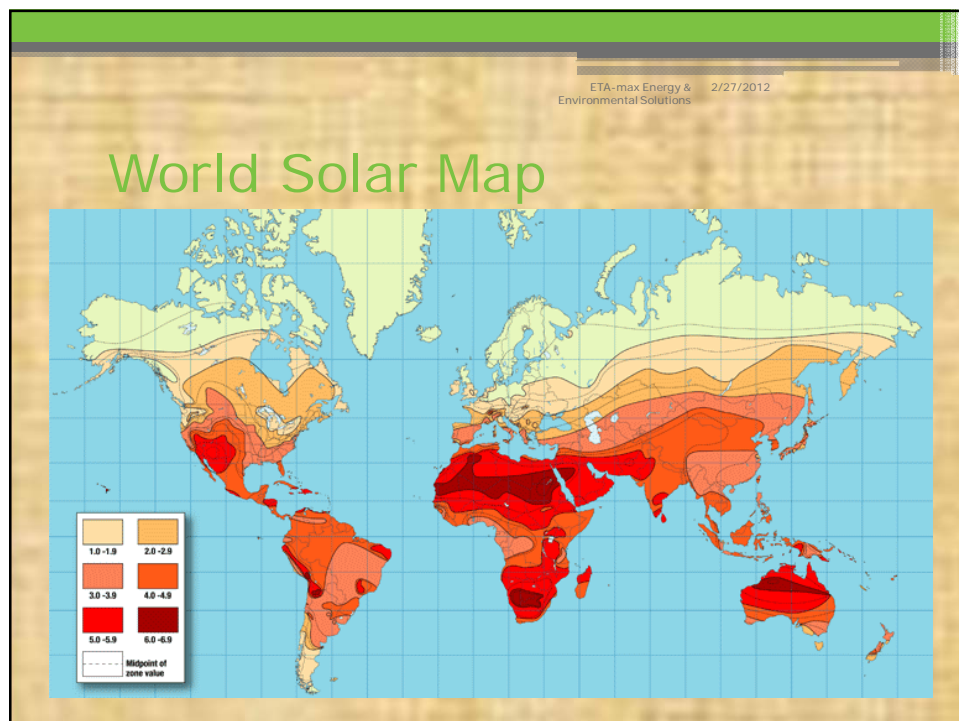
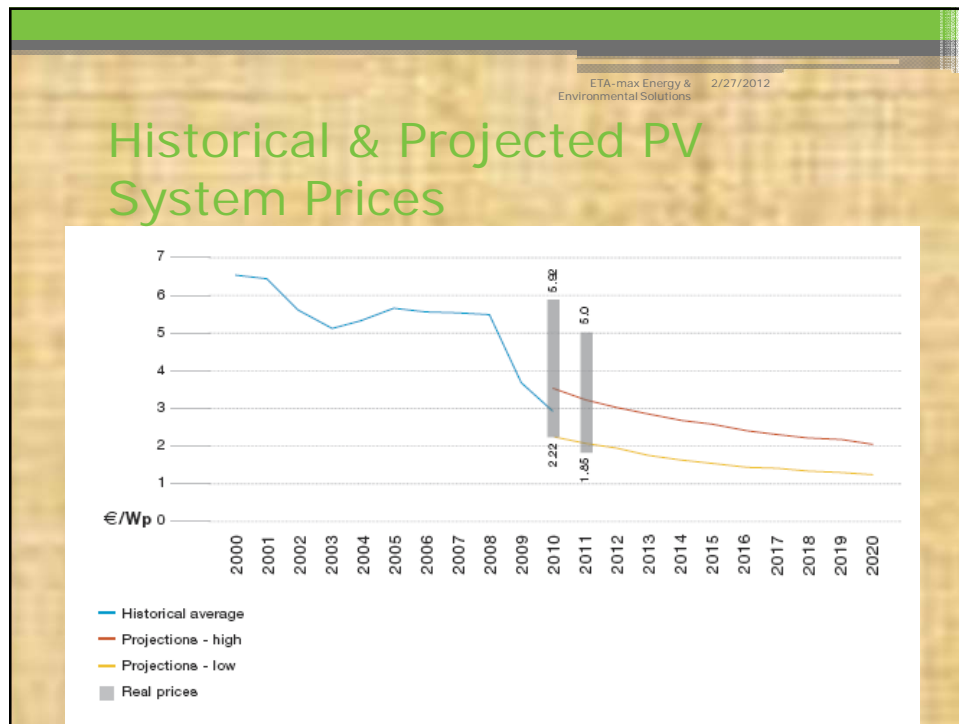


## Power Projects in Europe (2010)



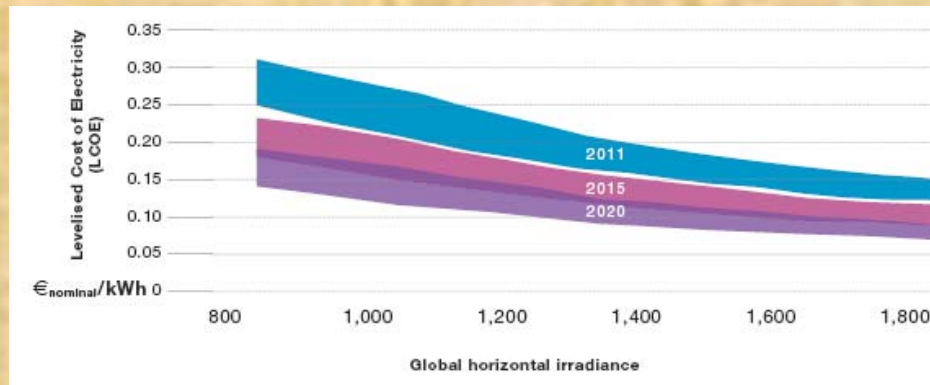
## Historical PV Module Prices





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## Current & Projected End-User Electricity Cost



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## Current Electricity Crisis in Jordan

## Energy Crisis in Jordan

- Nearly 98.4% of energy consumption came in the form of crude oil, petroleum products and natural gas.
- Only 3.7% of which coming from indigenous sources while the remaining being imported from neighboring Arab countries.
- The cost of consumed energy represents over 22% of the national GDP.

## Energy Crisis in Jordan

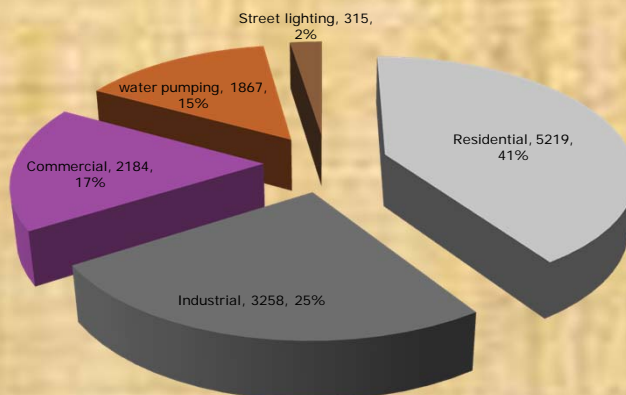
- Electricity generation in Jordan has been mainly dependent on natural gas, imported from Egypt.
- Over the past few months, and due to repeated cuts in natural gas supplies, Jordan has been forced to revert to diesel fuel and heavy fuel oil to compensate for gas shortages.
- This resulted in losses of over JD 1030 million for the electricity sector.

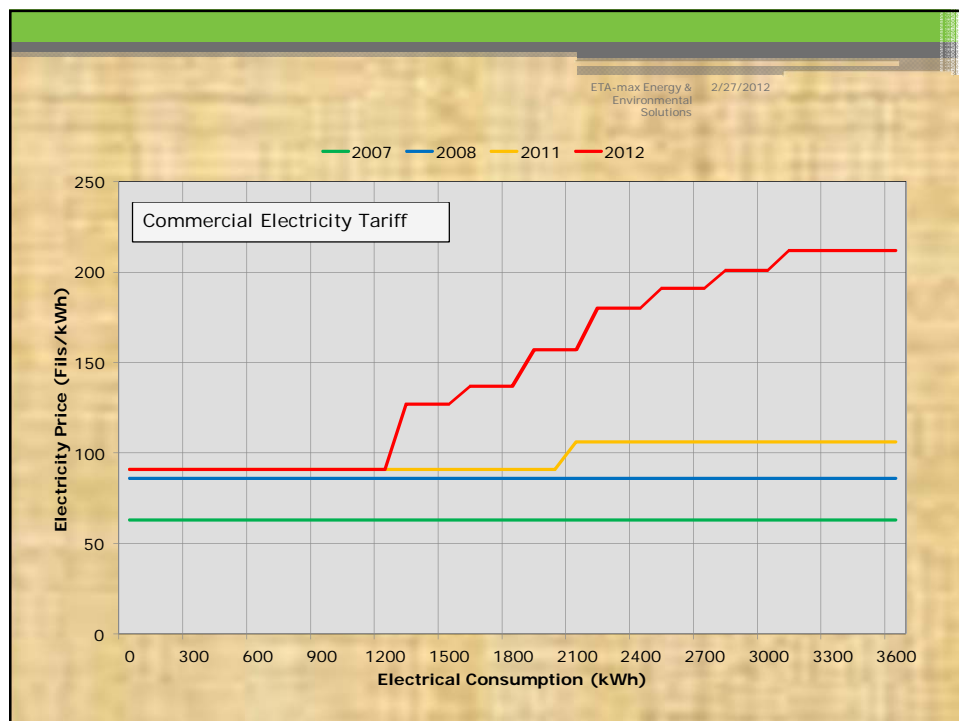
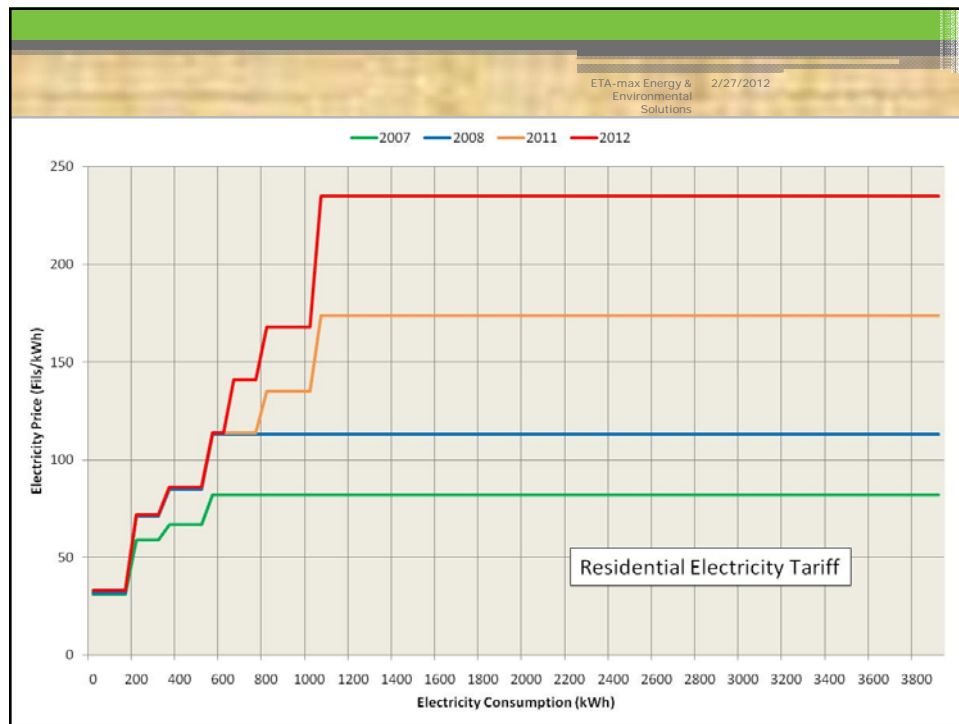


## Energy Crisis in Jordan

- This was due to the increase in the average cost of generation to more than JD 0.12/kWh.
- The cost is expected to rise to over JD 0.15/kWh in 2012.
- Imported electricity increased at a rate of around 300%.
- As a result, electricity prices witnessed a historical increase in 1 February following another increase in July 2011.

## Electricity Consumption in Jordan by Sector





## Can on-grid PV systems be part of the solution?

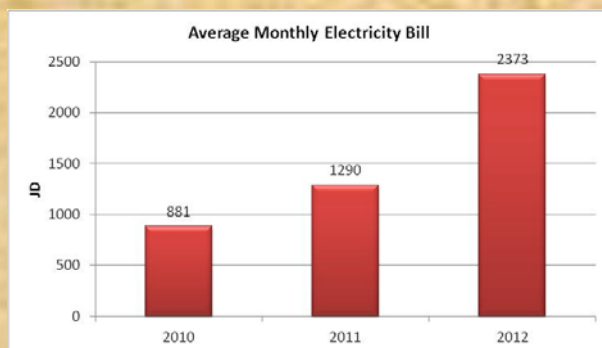
### Why on-grid?

- A grid connected system is the most suitable in the presence of grid power.
- Such system can work in synchronization with the conventional grid where the power from the solar system will be complemented by the grid.
- This will reduce the consumption of conventional power and can therefore be regarded as an energy saving measure.
- Another advantage of such system will be avoiding extra expansions in conventional grid infra-structure.



## Case Study 1: School

- Assuming a school having an average monthly consumption of 10000 kWh.

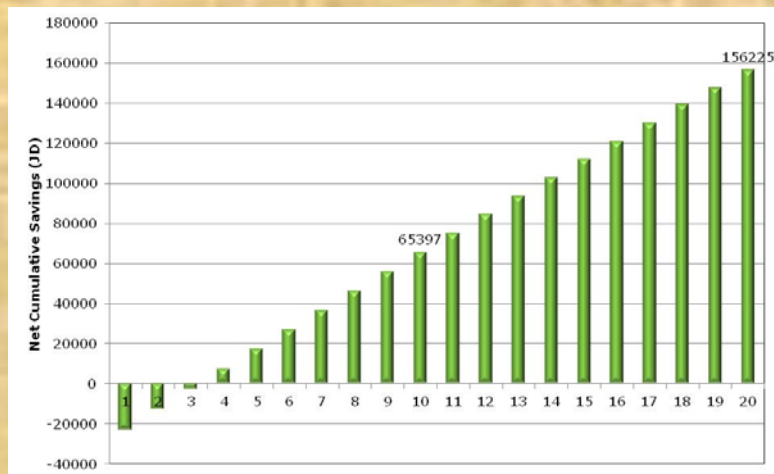


## Case Study 1: School

- If a 20 kWp system is proposed:

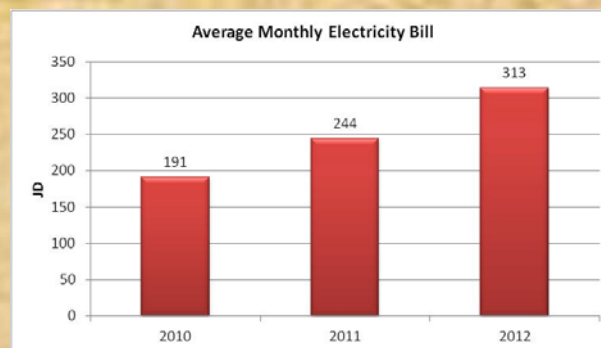
|                        |        |
|------------------------|--------|
| New Bill (JD)          | 2373   |
| Savings (JD)           | 841    |
| Reduced Bill (JD)      | 1532   |
| Produced Energy (kWh)  | 3166.7 |
| System Cost (JD)       | 33000  |
| Payback Period (Years) | 3.3    |

## Case Study 1: School



## Case Study 2: Residential Villa

- For a residential villa with an average monthly consumption of 1800 kWh:

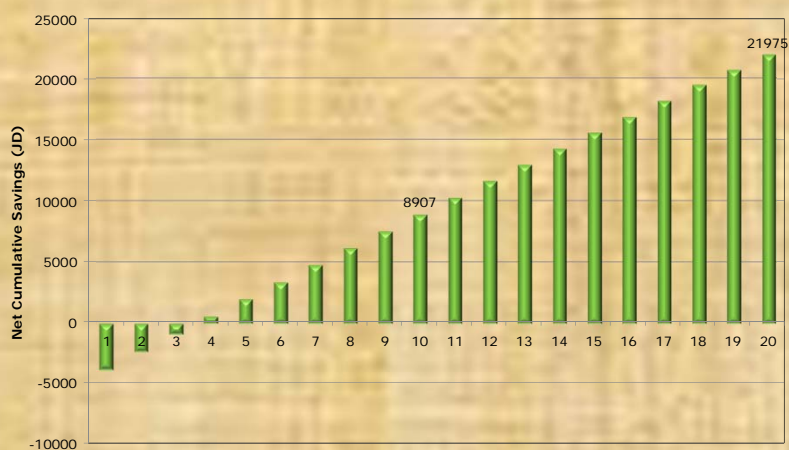


## Case Study 2: Residential Villa

- If a 3 kWp system is proposed:

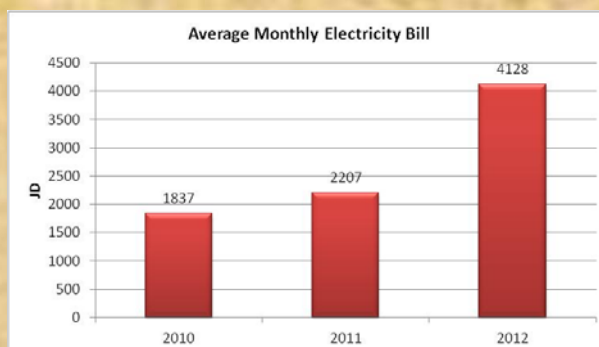
|                        |      |
|------------------------|------|
| New Bill (JD)          | 313  |
| Savings (JD)           | 121  |
| Reduced Bill (JD)      | 192  |
| Produced Energy (kWh)  | 475  |
| System Cost (JD)       | 5250 |
| Payback Period (Years) | 3.7  |

## Case Study 2: Residential Villa



## Case Study 3: Large Supermarket

- For a supermarket with an average monthly consumption of 20000 kWh:



## Case Study 3: Large Supermarket

- If a 40 kW system is proposed:

|                        |       |
|------------------------|-------|
| New Bill (JD)          | 4128  |
| Savings (JD)           | 1381  |
| Reduced Bill (JD)      | 2747  |
| Produced Energy (kWh)  | 6333  |
| System Cost (JD)       | 66000 |
| Payback Period (Years) | 4.0   |

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## Case Study 3: Large Supermarket



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## Thank You !

Hassan AlSeaf Mechanical Engineer  
 ETA-max Energy & Environmental Solutions  
 509 Caracas Center, Amman  
 +962 6 5333 559  
 Al-seaf@eta-max.com  
 www.Eta-max.com

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Enhancing Energy Efficiency  
of Ammonia Synthesis Section**

**Bashar Jaffar Al-Aradi  
Designated Senior Process Engineer  
GPIC- Bahrain**

# **Enhancing Energy Efficiency of Ammonia Synthesis Section**

**Prepared by: Bashar Mohsen Al-Aradi**

**Designated Senior Process Engineer**

**AFA Workshop**

**Renewable Energy in Fertilizer Industries and Energy Auditing**

**April : 28-30, 2013 – Amman - Jordan**

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## **1.0 Abstract:**

In an Ammonia plant, the performance of the Ammonia Synthesis Converter is considered to be a hallmark of the plant's efficient operation. The Synthesis Converter of GPIC Ammonia Plant had three axial beds when plant was first commissioned in 1985. During the revamp in 1989, the configuration of the Ammonia Synthesis Converter was changed to Axial-Axial-Radial Beds.

The last Ammonia Synthesis Catalyst replacement was carried out in 1996. Since, the current charge of catalyst of the converter was in service for around 16 years, it was decided to replace the catalyst during the Turnaround in November 2012.

Since, at the time of replacement of the catalyst the Converter Basket would have completed an active service life of 23 year, a proactive initiative was taken to replace the Converter Basket otherwise the next replacement was only possible after 39 years of operation since 1985.

A conscious decision was taken to go for an improved converter basket design, with a view to reduce energy consumption besides maintaining reliability of the Ammonia Synthesis Converter.

The converter basket was replaced during Turnaround in November, 2012. Besides improving reliability of the plant following additional benefits were obtained:

- Operating pressure of the Synthesis loop was lowered from 312 barg to 281 barg.
- The pressure drop across the converter was lowered from 5.1 bar to 2.5 bar.
- Reduction in Specific Energy consumption of 0.17 Gcal/MT of ammonia was achieved.

This paper discusses various steps in the implementation of this Energy Efficiency Improvement project.

## **2.0 A Brief Outline of the Stages of Ammonia Process:**

1. The following stages constitute the front end of Ammonia Plant:
  - Natural Gas is converted into Hydrogen & CO in the reformation process.
  - CO in the gas is converted to CO<sub>2</sub> in the HT and LT Shift converter.
  - The CO<sub>2</sub> is removed from the gas in the CO<sub>2</sub> removal step
  - Traces of CO/CO<sub>2</sub> left in the gas are converted to methane in the methanator.
  - Nitrogen required for the synthesis of Ammonia is provided by introduction of air in the reformation process.
2. The gas is compressed from 27 barg to 310 barg in a centrifugal, steam turbine driven SynGas compressor. Some details of the Ammonia converter and synthesis loop:
  - The catalyst was supported in a catalyst basket made of SS347.
  - The catalyst charge in the basket was of Ammonia conventional Catalyst type (Iron Oxide ) of a size of 1.5-3mm, 6-10mm, 12-21mm, 16-23 mm.
  - Typical parameters under of Ammonia synthesis loop:
    - I. Pressure of synthesis loop: 312 barg
    - II. Temperature at the inlet /outlet of the converter: 150 degC /~380 degC
    - III. Concentration of ammonia at the outlet of the converter: 18.5%
    - IV. Circulation rate: 555 KNm<sup>3</sup>/hr
    - V. Inert purge from the synthesis loop: 9%.
3. The following stages constitute the backend of the Ammonia Plant
  - The synthesis loop where the Ammonia is synthesised using the compressed synthesis gas in the Ammonia converter.

- The required refrigeration utility using ammonia refrigeration.
- The tail gas scrubbing unit for removal of Ammonia from the purge gases.

### **3.0 Ammonia Plant Capacity Enhancement:**

Ammonia Plant was commissioned in 1985 with an initial plant capacity of 1000 MTPD with Ammonia Converter Basket of Axial-Axial-Axial type. A major revamp of Ammonia plant was undertaken in 1989 to increase the plant capacity to 1200 MTPD. Part of the revamp was replacing the Ammonia basket with Axial-Axial-Radial type. The actual Ammonia production was in range of 1220-1280 MTPD depending on the weather conditions. In 2007, the Secondary Reformer was replaced with new improved design which helped in increasing Ammonia Plant capacity to 1347 MTPD during the favorite weather. However, Carbon Dioxide Recovery Plant (CDR) was commissioned during December 2009 to increase Methanol and Urea production by 100 MTPD and 80 MTPD respectively. This had caused Ammonia production to reduce to 1290-1300 MTPD due to less hydrogen recovery from Methanol Purge. The basket was inspected in 1996 along with the catalyst replacement after 7 years being in service. The basket was in good condition at that time.

As per the catalyst replacement schedule, the Ammonia Converter catalyst was to be replaced during the scheduled Turnaround in November 2012 because of completing 16 years being in service. Since the Ammonia Converter Basket was completing 23 years in service since 1989 and in case, if it had not been replaced in 2012, then it would have been in service for another 16 years which makes its total life as 39 years. This would have made the basket vulnerable to failure.

Therefore, in order to enhance the reliability of the Ammonia Plant, a decision was taken to replace the Ammonia Converter Basket along with the catalyst replacement schedule.

Next, the question was whether to replace the Ammonia Basket with:

- 1- One to one replacement (similar design).
- 2- Replace with one of improved design.

#### **4.0 Options for new Ammonia Converter Basket:**

Two design options were available and were evaluated by GPIC as mentioned below:

##### **4.1: 1<sup>st</sup> Design Option:**

Indicated that a benefit of 1% conversion increase and a drop of 1 bar pressure in the synthesis loop could be achieved in case the old Ammonia Converter basket replaced with an improved design of Radial-Radial-Radial type. This means that the plant shall be operated under the old operating regime as there was no significant benefit in changing the design.

##### **4.2: 2<sup>nd</sup> Design Option:**

Indicated the following benefits in case the old Ammonia Converter basket replaced with the new improved design basket of two radial beds type:

- 1- The loop pressure shall drop to  $\sim 276 + 5$  barg from the present 310 barg.
- 2- Pressure drop across the converter shall be around 2.5 barg.
- 3- Outlet temperature of the converter shall not exceed 383 DegC.
- 4- The circulation flows shall remain almost similar.
- 5- The overall heat duty on the cooling water network and the refrigeration system shall remain almost similar.

- 6- No major modifications to the Ammonia Converter shell.
- 7- New fresh catalyst is part of the supply with the Ammonia basket.
- 8- No addition of equipment was envisaged.
- 9- Carrying out feasibility study for Ammonia Plant backend for a production of 1,347 MTPD. The study shall be divided into two engineering packages and shall also:
  - A. Help GPIC to decide whether or not to proceed with basket replacement.
  - B. Ascertain whether all the equipment parameters will be well within the design limits.
- 10- Carry out feasibility study of Ammonia Plant frontend to check the reliability and safety of the front-end. Also, to identify the most attractive revamp scheme to produce 1347 MTPD of Ammonia during summer that will result in reduction in the energy consumption.
- 11- Information about the reference plant was submitted that underwent the basket replacement with similar operating conditions to GPIC. It is worth mentioning that experienced engineers from GPIC had visited the reference plant to exchange knowledge about the replacement prior to finalizing the appropriate option.

After a comprehensive study, GPIC decided to go with the 2<sup>nd</sup> Design option.

## **5.0 Feasibility Study Findings of 2<sup>nd</sup> Option:**

The study revealed the following:

- 1- No modification was required for any equipment.
- 2- For Synthesis Compressor, the recycle stage shall operate close to its limits but no problems were expected.
- 3- The load on the Refrigeration section shall increase by 0.6%.
- 4- The control valves capacities were sufficient for the revamp case.
- 5- The PSV's capacity were sufficient for the revamp case.
- 6- Velocities increased but were within the acceptable limits.

## **6.0 Main difference between old and new convertor basket:**

The main differences between the two baskets are summarised in the below table:

| Description              | UOM  | Old Convertor Basket             | New Convertor Basket      |
|--------------------------|------|----------------------------------|---------------------------|
| No. of beds              | no.  | 3                                | 2                         |
| Beds configuration       | ---- | Axial-Axial-Radial               | Radial-Radial             |
| No. of Heat Exchangers   | no.  | 3                                | 2                         |
| Temperature control      | no.  | 3 Quenches                       | One Quench and Cold shot  |
| Material of Construction | ---- | SS 347                           | SS 321                    |
| Catalyst Loaded          | ---- | Unreduced & Pre-reduced Catalyst | Only Pre-reduced Catalyst |
| Catalyst Quantity        | m3   | 21.4                             | 20.8                      |
| Catalyst size            | mm   | 1.5-3, 6-10, 12-21, 16-23        | 1-3                       |

## **6.1 Gas flow pattern in old Ammonia Basket**

(refer to sketch in page 10):

The main gas inlet enters the reactor from the bottom and joins with the shell cooling gas that distribute from the top around the whole basket for cooling of the pressure shell. Both gases mix and go into the shell side of the 1st heat exchanger for heating up. The gas after that goes through the center pipe to the 2nd heat exchanger shell side for heating up again, but before that the 3rd bed quench is introduced to the gas. Increasing the amount of quench gas will cool down the tube gas exit. The gas after mixing and heating up will go through the center pipe again to the 3rd heat exchanger shell side for further heating, and similar as before, a quench gas will be introduced before the gas goes into the 3rd heat exchanger for same reason as before. After that the gas after heating will continue flowing through the center pipe until it reaches the top of the basket, the gas will then be forced to go through the first catalyst bed but prior to that, a quench will be introduced to the gas for cooling and controlling the temperature inlet of the 1st bed. The gas due to the reaction will gain heat in the first bed and since it is an exothermic reaction, cooling is required. The gas will exit the 1st bed and will go through the tube side of the 3rd heat exchanger where it will be cooled down by the gas in the shell side and will enter the 2nd bed. The 2nd bed inlet temperature can be controlled by controlling the amount of quench gas introduced in the shell side of the 3rd heat exchanger. The gas similar like before will gain heat and cooling is required again for the same reason, and so the gas will go through the 2nd heat exchanger where it will be cooled down by the gas in the shell side and will enter the 3rd catalyst bed. Similar as the 2nd bed, the 3rd bed inlet temperature can be controlled by controlling the amount of quench gas introduced in the shell side of the 2nd heat exchanger.

The gas will flow in the 3rd bed in a radial direction and will gain heat again. The gas will finally be cooled down in the 1st exchanger tube side and will exit the convertor.

## **6.2 Gas flow pattern in new Ammonia Basket**

(refer to sketch in page 10):

The basket consists of two catalyst beds, one interbed heat exchanger placed in the centre of the first catalyst bed and one feed/effluent exchanger located below the second catalyst bed.

All converter inlet and outlet nozzles are re-used.

The main gas stream is introduced into the converter through the inlet at the bottom of the converter. There the gas mixes with the pressure shell cooling gas introduced from top, and it flows to the shell side of the feed/effluent heat exchanger and is preheated by heat exchange with effluent from the 2nd catalyst bed.

The main gas stream leaving the shell side of the lower heat exchanger is transferred to the top of the catalyst section through the transfer pipe placed in the centre of the converter.

The cold bypass gas is introduced through the inlet going to the mixing arrangement at the top of the converter basket. The amount of cold bypass gas controls the gas temperature at the inlet of the first catalyst bed.

The remaining part of the gas is introduced through the inlet at the top of the converter and is transferred to the basket through a flexible connection. It passes to the bottom tube sheet of the interbed heat exchanger through the concentric transfer pipe in the interbed heat exchanger and passes the tubes in upward direction thereby cooling the first catalyst bed effluent to the proper inlet temperature to the second catalyst bed.



After passing the tube side of the interbed exchanger, the interbed heat exchanger gas is mixed with the main gas stream and the cold bypass gas in the mixing arrangement above the interbed heat exchanger and 1st catalyst bed. The mixed gas stream then flows to the inlet panels around 1st catalyst bed. From the inlet panels, it passes the 1st catalyst bed in a radial inward direction and flows to the annulus between the centre screen of the 1st catalyst-bed and the interbed heat exchanger. Appropriate perforation of the walls of the catalyst bed ensures a uniform gas distribution in the catalyst bed.

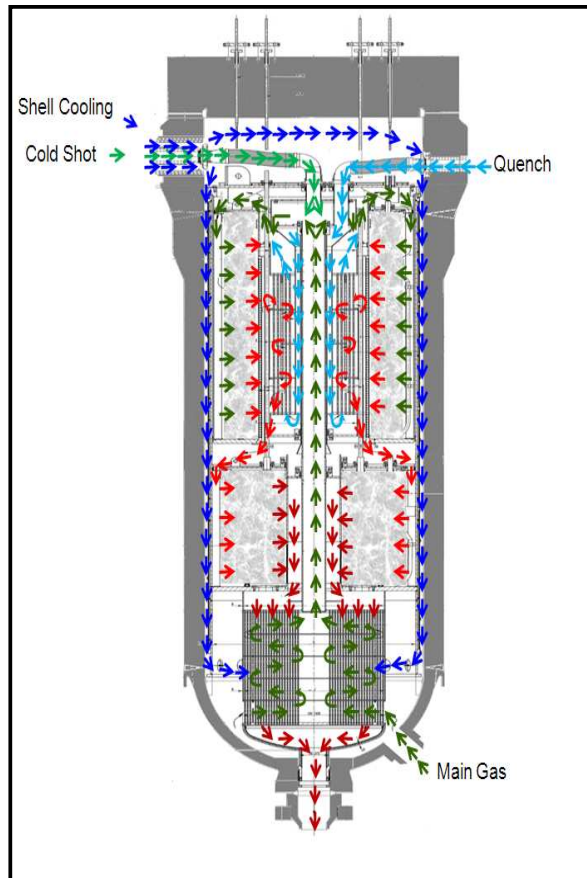
The effluent from the 1st catalyst bed passes the shell side of the interbed heat exchanger for cooling to the inlet temperature of the 2nd catalyst bed by heat exchange with the interbed heat exchanger gas, as described above.

From the shell side of the interbed heat exchanger, the gas is transferred to the 2nd catalyst bed via the inlet panels surrounding the catalyst bed. The 2nd catalyst bed is passed in a radial inward direction. The gas distribution is again ensured by appropriate perforation of the catalyst bed walls.

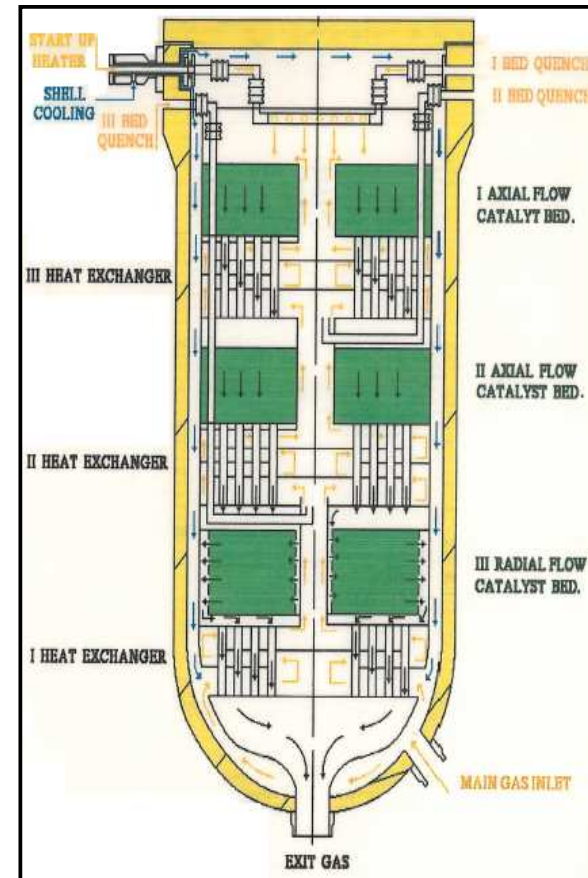
The effluent from the 2nd catalyst bed flows via the annular space between the centre screen of this catalyst bed and the transfer pipe to the tube side of the lower heat exchanger for heat exchange with the main gas stream introduced through the inlet at the bottom of the converter. From the tube side of the lower heat exchanger, the gas is transferred to the converter outlet.

During start-up, hot gas from the external start-up heater is introduced through the cold bypass inlet at the top of the converter.

Following sketches illustrates the difference graphically and the process gas patterns:



**New basket**



**Old basket**

## **7.0 Installation of the new basket:**

The new basket was installed during GPIC scheduled turnaround in November 2012 under the supervision of two mechanical engineers representing the supplier of the new Ammonia Basket.

The installation process was almost smooth and when the plant was started, the expected reduction in synthesis loop pressure was achieved.

## 8.0 Performance of the new basket:

Following table summarizes the operating condition with the new basket against the highest production of Ammonia.

| Description                              | UOM                 | Prior to turnaround with "Old Converter Basket" when the production was the highest | Post turnaround with "New Converter Basket" |
|--|---------------------|---|---|
| Date                                     |                     | 05-04-2012  | 24-12-2012                                  |
| Ammonia Production                       | MTPD                | 1,347   | 1,375                                       |
| Frontend Load                            | %                   | 103.8   | 107.6                                       |
| Backend Load                             | %                   | 108.2   | 110.4                                       |
| Make up flow                             | Nm <sup>3</sup> /hr | 157,172   | 159,200                                     |
| Compressor Speed                         | rpm                 | 11,271  | 11,230                                      |
| Hydrogen gas flow from PSA               | Nm <sup>3</sup> /hr | 17,619  | 17,200                                      |
| Tail gas flow to PSA                     | Nm <sup>3</sup> /hr | 8,488   | 8,980                                       |
| Synthesis loop circulation flows         | Nm <sup>3</sup> /hr | 551,800   | 545,000                                     |
| Synthesis loop operating pressure        | barg                | 312.2   | 281   |
| Pressure drop across Ammonia Converter   | bar                 | 5.4   | 2.5   |
| Inlet temperature of the converter       | °C                  | 158   | 143.3                                       |
| Outlet temperature of the converter      | °C                  | 376   | 384   |
| Synthesis loop ΔP                        | bar                 | 16.6  | 14.2  |
| Ammonia concentration @ converter inlet  | %                   | 3.10  | 3.50  |
| Ammonia concentration @ converter outlet | %                   | 18.50   | 20.1  |

Following points can be concluded from above table:

1. The new Ammonia basket was designed for an Ammonia production of 1,347MTPD. However, with new basket, the actual production achieved was 1,375MTPD.
2. The synthesis loop operating pressure came down to 281 barg from 312 barg.
3. Pressure drop across Ammonia Converter reduced by 2.7 bar i.e before basket replacement was 5.4 bar and became 2.5 after the replacement.
4. Ammonia concentration at converter outlet was 20.1% at 1,375 load compared to 18.5% at 1,347 MTPD load.

#### **9.0 Main Lessons Learned:**

1. Purge paper that was used for welding purpose was not removed.
2. Contingency plan should be available to lift the basket with full weight.
3. Tripartite meetings between supplier, site contractor & GPIC helped in trouble free installation.
4. Advanced NDT techniques like Phased Array, TOFD, Velocity Ratio were used based on RBI Study to investigate hydrogen embrittlement on Ammonia multilayer shell.

## **10.0 Conclusion:**

1. The replacement of the Ammonia converter basket was successfully implemented during the scheduled turnaround period.
2. Exchanging knowledge and experience with our similar plant helps in taking appropriate decisions.
3. The Ammonia converter basket replacement led to cross check and re-evaluate the frontend and backend equipment including but not limited to pipelines velocities, control valves and PSVs.
4. The new Ammonia basket was designed for an Ammonia production of 1,347MTPD. However, with new basket, the actual production achieved was 1,375MTPD.
5. Operating pressure of the Ammonia Synthesis loop reduced to 281 barg from 312 barg.
6. Pressure drop across Ammonia Converter reduced by 2.7 bar.
7. Overall reduction in Specific Energy consumption of 0.17 Gcal/MT of ammonia was achieved.
8. Ammonia concentration at converter outlet was 20.1% at 1,375 load compared to 18.5% at 1,347 MTPD load.
9. Before boxing up, all process lines where fabrication job were done, must be thoroughly inspected and cleaned.

# Enhancing Energy Efficiency of Ammonia Synthesis Section

Presented by: Bashar Mohsen Al-Aradi  
Designated Senior Process Engineer

AFA Workshop  
Renewable Energy in Fertilizer Industries and Energy Auditing

April : 28-30, 2013 – Amman - Jordan

Gulf Petrochemical Industries Co.

شركة الخليج للصناعات البترولية والكيمياويات

## Agenda

- ❖ Introduction to GPIC
- ❖ Ammonia Process
- ❖ Background about Ammonia convertor basket
- ❖ Decision to replace Ammonia converter basket
- ❖ Installation
- ❖ Actual Performance
- ❖ Main lessons learned
- ❖ Conclusion

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شركة الخليج للصناعات البترولية والكيمياويات

## Introduction - GPIC

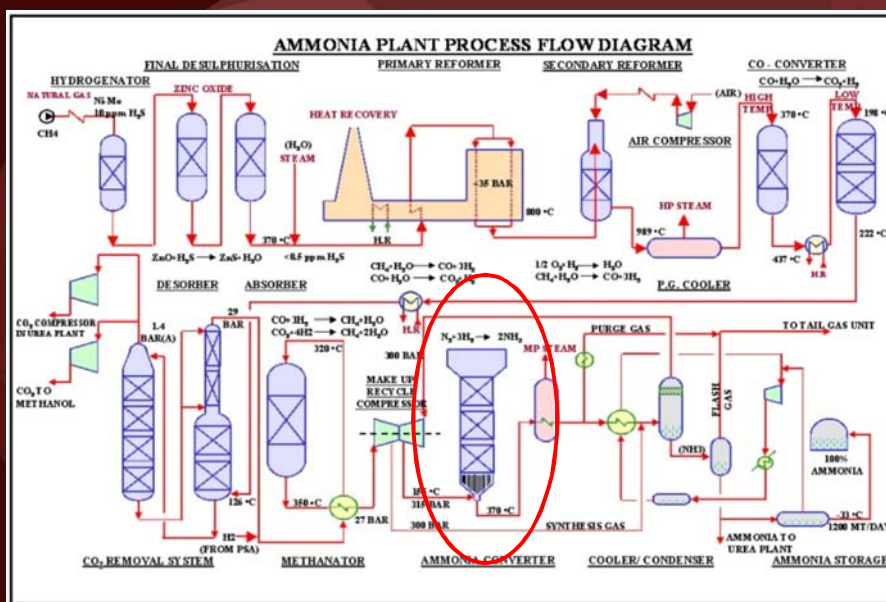
- ❖ GPIC is the Gulf Petrochemical Industries Company.
- ❖ Established in December 1979.
- ❖ Joint-Venture between the Government of Bahrain, SABIC & PIC.
- ❖ Utilizes Natural Gas as raw material.
- ❖ Production : Ammonia , Methanol and Urea.
- ❖ Production Capacity : 1,500,000 Tonnes Annually.
- ❖ Manpower : 474 Employees ( 95% Bahrainization).



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شركة الخليج لصناعة البتروكيماويات

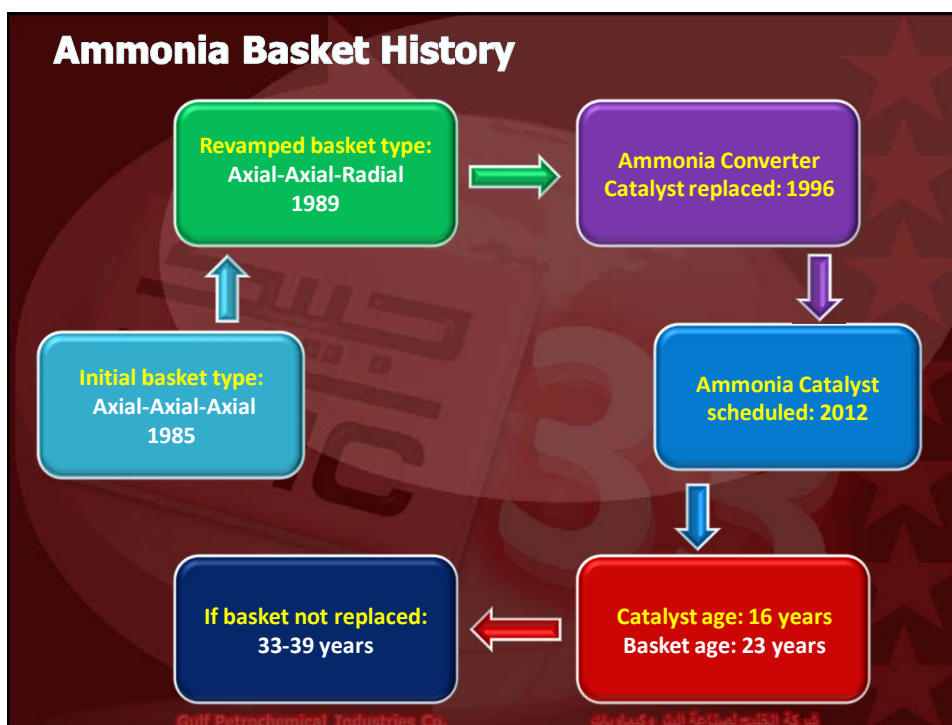
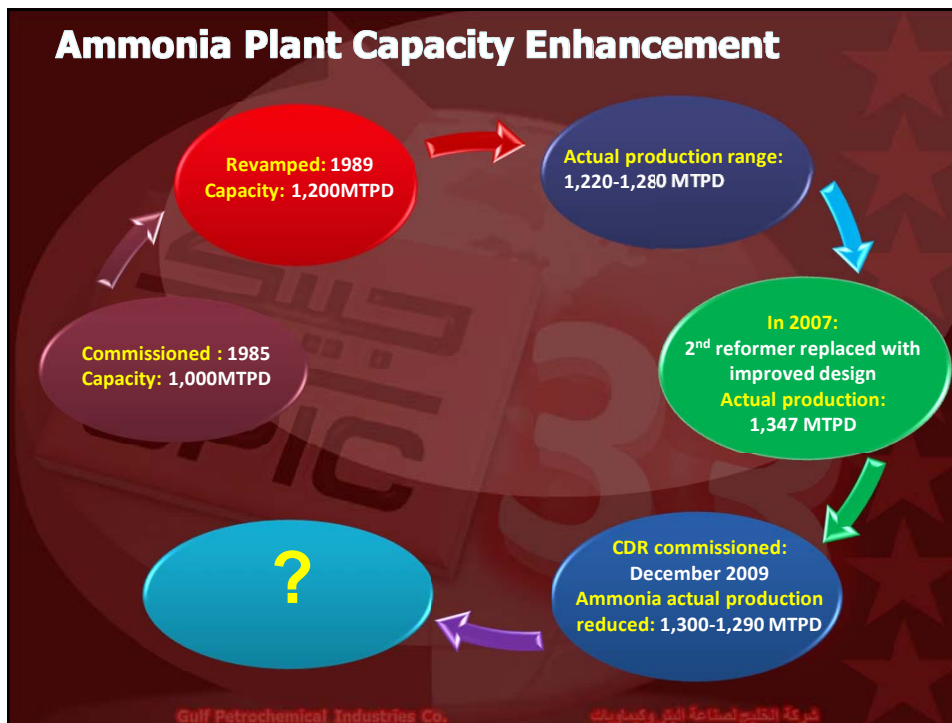
## Ammonia Process



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شركة الخليج لصناعة البتروكيماويات





## Decision to replace Ammonia Converter Basket

- ❖ Ammonia reliability.
- ❖ Catalyst replacement optimization.
- ❖ Limited inspection of inter beds exchangers “Nitriding”.

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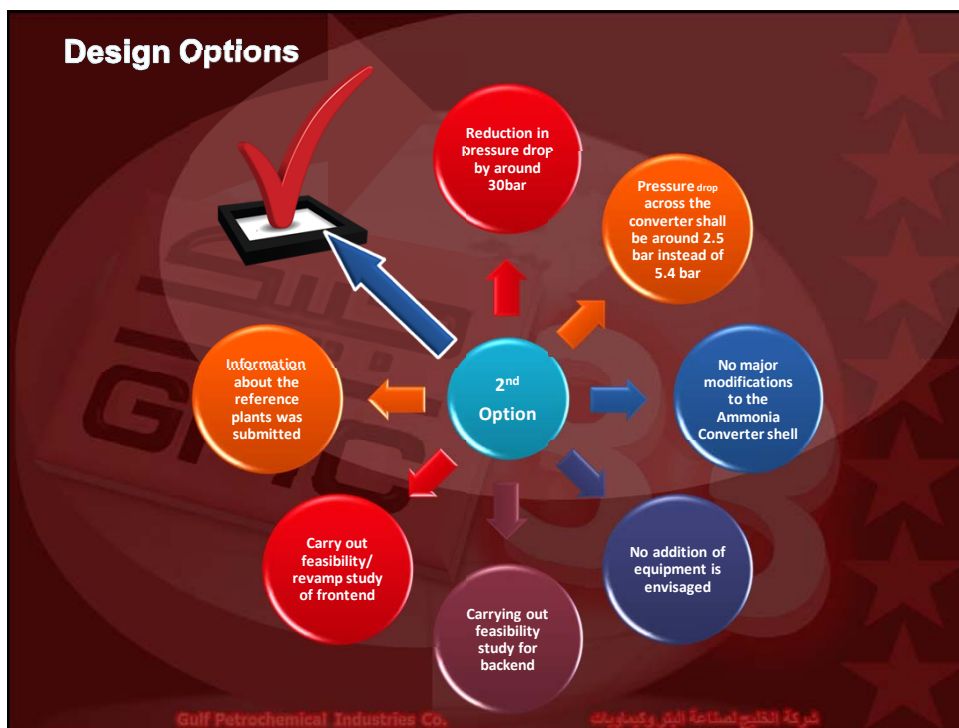
شركة الخليج للصناعات البتروكيماويات

## Options of Ammonia Basket replacement

- ❖ Option #1: One to one replacement (similar design)
- ❖ Option #2: Replace with one of improved design

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## Feasibility Study Findings of Option 2

- 1 • No modification was required for any equipment.
- 2 • For Synthesis Compressor, the recycle stage shall operate close to its limits but no problems were expected.
- 3 • The load on the Refrigeration section shall increase by 0.6%.
- 4 • The control valves capacities were sufficient for the revamp case.
- 5 • The PSV's capacity were sufficient for the revamp case.
- 6 • Velocities increased but were within the acceptable limits.

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شركة الخليج للصناعات البتروكيماويات

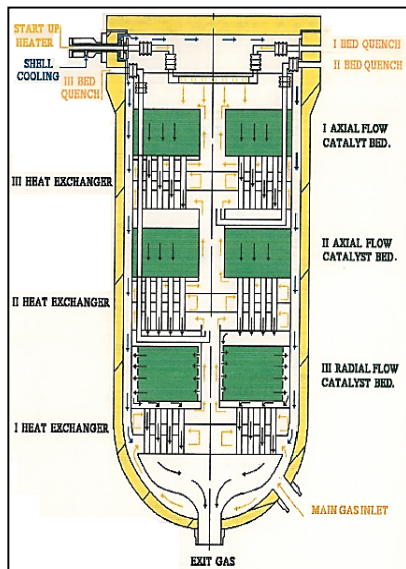
## Old vs. New Ammonia Converter Basket Comparison

| Description                     | OLD Basket                        | NEW Basket                |
|---------------------------------|-----------------------------------|---------------------------|
| Loop pressure                   | 312.2 barg                        | 276+5 barg                |
| $\Delta P$ across the converter | 5.4 bar                           | 2.5 bar                   |
| No. of beds                     | 3                                 | 2                         |
| Beds configuration              | Axial-Axial-Radial                | Radial-Radial             |
| No. of Heat Exchangers          | 3                                 | 2                         |
| Temperature control             | 3 Quenches                        | One Quench and Cold shot  |
| Material of Construction        | SS347                             | SS321                     |
| Catalyst Loaded                 | Unreduced & Pre-reduced Catalyst  | Only Pre-reduced Catalyst |
| Catalyst Quantity               | 21.4m <sup>3</sup>                | 20.8m <sup>3</sup>        |
| Catalyst size                   | 1.5-3mm, 6-10mm, 12-21mm, 16-23mm | 1-3mm                     |

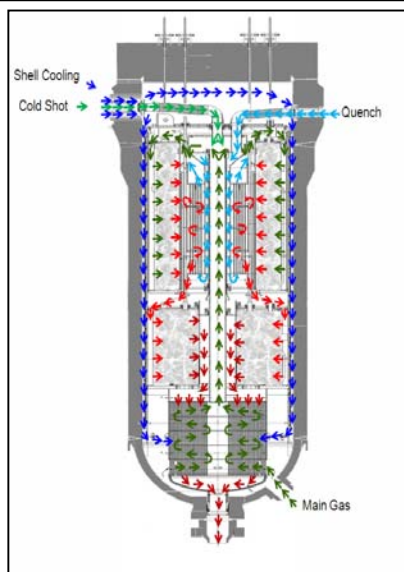
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شركة الخليج للصناعات البتروكيماويات

## Gas pattern for the old Ammonia Basket



## Gas pattern for the new Ammonia Basket





## Installation

- ❖ The new basket was installed during GPIC scheduled turnaround in November 2012
- ❖ The installation process was almost smooth

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شركة الخليج للصناعات البتروكيماويات











### Actual Performance

| Description                            | UOM     | OLD Basket | NEW Basket |
|--|---------|------------|------------|
| Ammonia Production                     | MTPD    | 1,347      | 1,375      |
| Specific Energy                        | Gcal/MT | 8.81       | 8.64       |
| Synthesis loop operating pressure      | barg    | 312.2      | 281        |
| Pressure drop across Ammonia Converter | bar     | 5.4        | 2.5        |
| Inlet temperature of the converter     | degC    | 158        | 143.3      |
| Outlet temperature of the converter    | degC    | 376        | 384        |

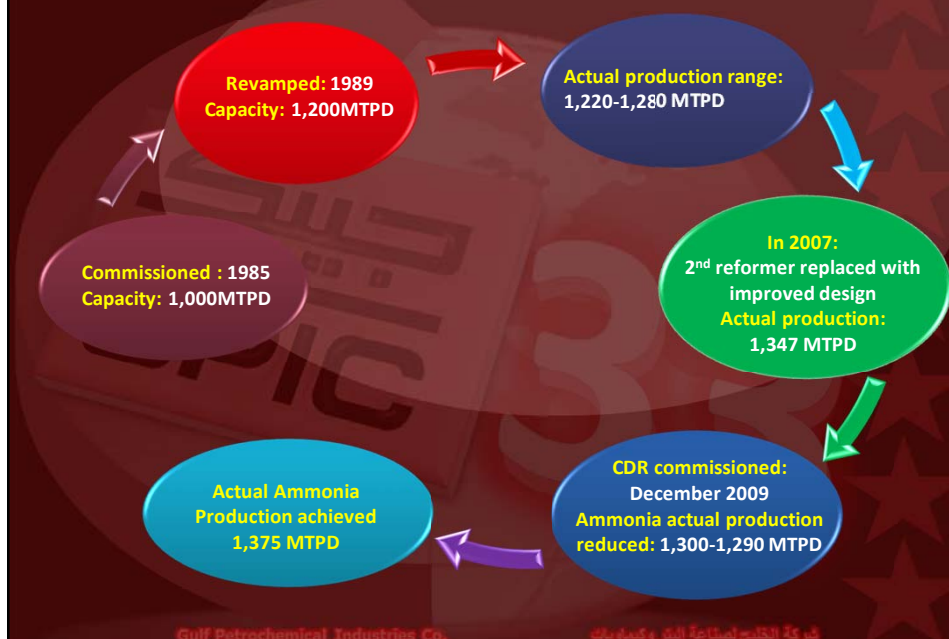
## Actual Performance

| Description                              | UOM    | OLD Basket | NEW Basket |
|--|--------|------------|------------|
| Make up flow                             | Nm3/hr | 157,172    | 159,200    |
| Compressor Speed                         | rpm    | 11,271     | 11,230     |
| Hydrogen gas flow from PSA               | Nm3/hr | 17,619     | 17,200     |
| Synthesis loop circulation flows         | Nm3/hr | 551,800    | 545,000    |
| Synthesis loop $\Delta P$                | bar    | 16.6       | 14.2       |
| Ammonia concentration @ convertor inlet  | %      | 3.10       | 3.50       |
| Ammonia concentration @ convertor outlet | %      | 18.50      | 20.1       |

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## Ammonia Plant Capacity Enhancement



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شركة الخليج للصناعات البتروكيماويات

## Main Lessons Learned

- ❖ Purge paper that was used for welding purpose was not removed
- ❖ Contingency plan should be available to lift the basket with full weight
- ❖ Tripartite meetings between supplier, site contractor & GPIC helped in trouble free installation
- ❖ Advanced NDT techniques like Phased Array, TOFD, Velocity Ratio were used based on RBI Study to investigate hydrogen embrittlement on Ammonia multilayer shell

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شركة الخليج للصناعات البتروكيماويات

## Conclusion

- ❖ The new Ammonia basket was designed for an Ammonia production of 1,347MTPD. However, with new basket, the actual production achieved was 1,375MTPD.
- ❖ The synthesis loop operating pressure came down to 281 barg from 312 barg.
- ❖ Pressure drop across Ammonia Converter reduced by 2.7 bar.

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شركة الخليج للصناعات البتروكيماويات

## Conclusion

- ❖ Ammonia concentration at converter outlet was 20.1% at 1,375 load compared to 18.5% at 1,347 MTPD load.
- ❖ Reduction in Ammonia specific energy by 0.17Gcal/MT was achieved.
- ❖ Before boxing up, all process lines where fabrication job were done, must be thoroughly inspected and cleaned.

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# Thank You

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شركة الخليج للصناعات البترولية

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Session IV**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Energy Conservation Program/ Case  
Study: Load Management at APC**

**Hussein Shorman  
Power Plant Superintendent  
APC - Jordan**



# Arab Potash Company

## AFA Workshop- Case Study 28- 30 April, 2013.

Hussein Shorman  
Power Plant Superintendent

## Contents:

---

- Energy Conservation Program in APC.
- Case Study: Load Management in Intake Pumping Station.
  - Operation Modes.
- Operation Without Load Management :
  - Principle of Operation.
  - Energy Cost Per Month for 2013.
- Operation With Load Management.
  - Principle of Operation.
  - Electrical Energy Pricing.
  - Selecting the Optimum Operation Mode.
  - Energy Cost Per Month for 2013.
- The Expected Saving With Load Management in 2013.

# **Energy Conservation Program in APC**

## **Energy Conservation Program in APC:**

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An Energy Conservation Committee was formed in April, 2012. Its mandate was to seek opportunities for energy saving in APC, carry out the related studies, and evaluate opportunities and make the necessary recommendations for improvement.



## **Energy Conservation Program in APC:**

---

- **Identified Areas for Minimizing APC Energy Bills:**
  - **Load Management.**
  - Lighting.
  - VFD motors.
  - Efficiency of Steam Cycle.
  - Trucking Fuel.
  - Optimizing Process Parameters.
  - Renewable Energy.

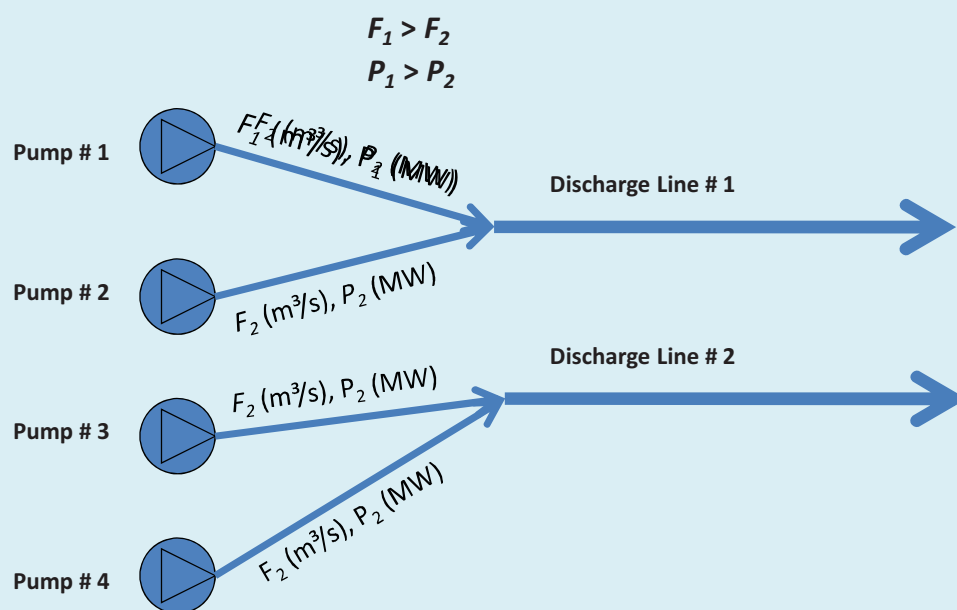
### **Case Study:**

## **Load Management in the Intake Pumping Station**

# Operation Modes

## Operation Modes:

---



# Operation Modes:

---

|    | Operation Modes              |
|----|------------------------------|
| 1. | 1 Pump to 1 Discharge Line   |
| 2. | 2 Pumps to 2 Discharge Lines |
| 3. | 2 Pumps to 1 Discharge Line  |
| 4. | 3 Pumps                      |
| 5. | 4 Pumps                      |

# Operation Without Applying Load Management

## Operation Without Applying Load Management:

### Principle of Operation:

The Intake Pumps used to be operated with the least possible number of pumps around the 24 hours to achieve the required pumped quantity per month.

## Operation Without Applying Load Management:

### Energy Cost Per Month for 2013:

| Month | No. of Working Pumps | No. of Working Days | Peak Period Penalty (JD) | Energy Cost (JD) | Total Cost (JD) |
|-------|----------------------|---------------------|--------------------------|------------------|-----------------|
| Mar   | 1                    | 5                   | 0                        | 72,480           | 72,480          |
|       | 2                    | 15                  | 17880                    | 434,880          | 452,760         |
| Apr   | 3                    | 27.23               | 26,224                   | 1,157,863        | 1,184,087       |
| May   | 3                    | 27                  | 26,224                   | 1,148,083        | 1,174,307       |
| Jun   | 4                    | 24.47               | 34,568                   | 1,371,573        | 1,406,141       |
| Jul   | 4                    | 25.3                | 34,568                   | 1,418,095        | 1,452,663       |
| Aug   | 4                    | 25.85               | 34,568                   | 1,448,924        | 1,483,492       |
| Sep   | 3                    | 29.28               | 26,224                   | 1,245,032        | 1,271,256       |
| Oct   | 3                    | 25.81               | 26,224                   | 1,097,482        | 1,123,706       |
| Nov   | 2                    | 24.71               | 17,880                   | 716,392          | 734,272         |
| Dec   | 2                    | 19.37               | 17,880                   | 561,575          | 579,455         |
| Total |                      |                     | 262,240                  | 10,672,380       | 10,934,620      |

# Operation With Applying Load Management

## Operation With Applying Load Management:

---

### Principle of Operation:

We are looking for the operation mode/s that result in pumping the monthly required quantity with the lowest cost.

# Electrical Energy Pricing

## Electrical Energy Pricing:

| Period |                     | Price (JD/MWh) |
|--------|---------------------|----------------|
| Night  | 11:00 PM – 07:00 AM | 164            |
| Day    | 07:00 AM – 11:00 PM | 220            |

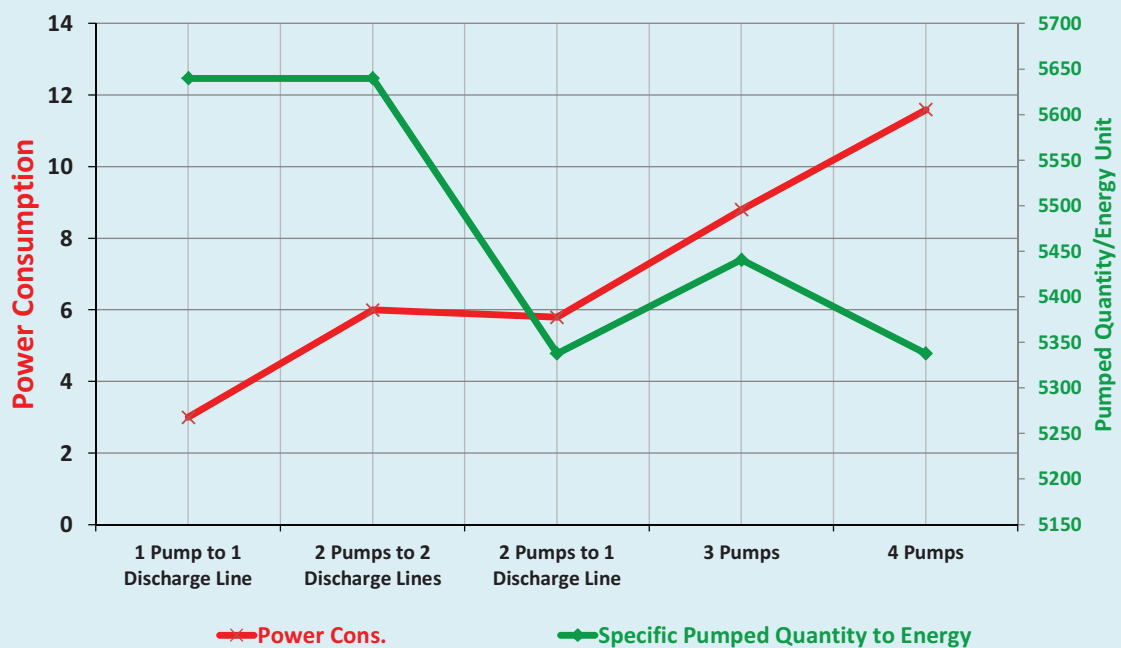
| Peak Period  | Penalty (JD/kW) |
|--------------|-----------------|
| 3 hours/ day | 2.98            |

**Peak Period Penalty** = 2.98 JD/kW/ month for the maximum monthly load.

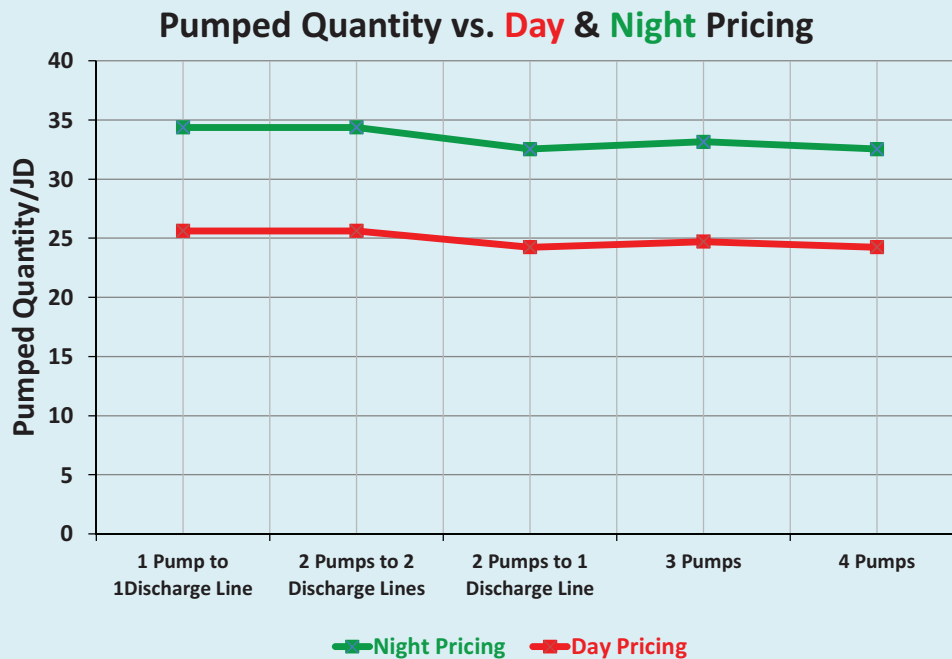
**The maximum monthly load** is the maximum value of the average load per half an hour measured in kW during the peak period.

# Selecting the Optimum Operation Mode

## Selecting the Optimum Operation Mode:



## Selecting the Optimum Operation Mode:



## Selecting the Optimum Operation Mode:

We conclude that the optimum operation mode that achieves the lowest cost is the one that meets the following conditions:

- Avoiding the operation of pumps during the peak periods to avoid penalties.
- The selected operation mode should be the one with the highest Pumped Quantity/Energy Unit.
- The adopted operation should result in the highest Pumped Quantity/JD. That is; minimizing the running hours during the day periods.



## Operation With Applying Load Management:

---

### Energy Cost Per Month for 2013:

(Table on the Next slide)

| Month | No. of Working Pumps | No. of Working Days | Night Running Hours | Day Running Hours | Total Cost (JD/Month) |
|-------|----------------------|---------------------|---------------------|-------------------|-----------------------|
| Mar   | 1                    | 5                   | 8                   | 0.48              | 62,374                |
|       | 2                    | 15                  | 8                   | 8.96              | 433,382               |
| Apr   | 3                    | 26                  | 8                   | 13                | 1,145,889             |
|       | 4                    | 4                   | 8                   | 12.78             |                       |
| May   | 3                    | 26                  | 8                   | 13                | 1,129,540             |
|       | 4                    | 5                   | 8                   | 7.75              |                       |
| Jun   | 3                    | 9                   | 8                   | 13                | 1,346,722             |
|       | 4                    | 21                  | 8                   | 13                |                       |
| Jul   | 3                    | 6                   | 8                   | 13                | 1,391,882             |
|       | 4                    | 25                  | 8                   | 12.4              |                       |
| Aug   | 3                    | 6                   | 8                   | 13                | 1,425,058             |
|       | 4                    | 25                  | 8                   | 12.92             |                       |
| Sep   | 3                    | 18                  | 8                   | 13                | 1,239,444             |
|       | 4                    | 12                  | 8                   | 12.93             |                       |
| Oct   | 3                    | 25                  | 8                   | 13                | 1,072,853             |
|       | 4                    | 6                   | 8                   | 4.16              |                       |
| Nov   | 3                    | 30                  | 8                   | 5.97              | 693,106               |
| Dec   | 3                    | 31                  | 8                   | 2.6               | 513,955               |
|       |                      |                     |                     |                   | 10,454,203            |

## The Expected Saving With Load Management in 2013

### The Expected Saving With Load Management in 2013:

|       | Total Cost<br>(JD/Month)       |                            |                              |
|-------|--------------------------------|----------------------------|------------------------------|
| Month | Load Management<br>Not Applied | Load Management<br>Applied | Monthly Saving<br>(JD/Month) |
| Mar   | 525,240                        | 495,757                    | 29,483                       |
| Apr   | 1,184,087                      | 1,145,889                  | 38,199                       |
| May   | 1,174,307                      | 1,129,540                  | 44,768                       |
| Jun   | 1,406,141                      | 1,346,722                  | 59,419                       |
| Jul   | 1,452,663                      | 1,391,882                  | 60,782                       |
| Aug   | 1,483,492                      | 1,425,058                  | 58,434                       |
| Sep   | 1,271,256                      | 1,239,444                  | 31,813                       |
| Oct   | 1,123,706                      | 1,072,853                  | 50,853                       |
| Nov   | 734,272                        | 693,106                    | 41,167                       |
| Dec   | 579,455                        | 513,955                    | 65,500                       |
| Total | 10,934,620                     | 10,454,203                 | 480,417                      |

**The Expected Saving in 2013 is**  
**JD480,417**

*Thank You*

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Reduction in Regeneration Heat duty by  
Using New Generation Activator in  
Benfield System of SAFCO3  
Ammonia Plant**

**Anosh K Thomas and Saad Maymouni  
SAFCO – S. Arabia**

# REDUCTION IN REGENERATION HEAT DUTY BY USING NEW GENERATION ACTIVATOR IN BENFIELD SYSTEM

April 2013



CHEMISTRY THAT MATTERS™

## CONTENTS

---

- About SAFCO
- Process description and chemistry
- History of problems
- Immediate actions
- Results
- Future plan and conclusions

## INTRODUCTION

---

### **SAFCO/IBB**

Saudi Arabian Fertilizer Company (SAFCO) is one of SABIC affiliates.

- Established in 1965 with Ammonia-Urea complex in Dammam City.
- SAFCO Operates 4 Integrated Ammonia –Urea Complexes in Jubail
  - 2.3 million ton  $\text{NH}_3$
  - 2.6 million ton Urea
  - 0.5 million tons of CF
- SF-V standalone urea project is under construction.
  - Capacity: 3250 MTPD.
  - Production Date: 2014.

---

No. 2

## AMMONIA PLANT

---

- KBR purifier technology.
- Commissioning in 2000.
- Capacity: 1500 MTPD.
- $\text{CO}_2$  removal unit – Benfield process.

---

No. 3

## PROCESS DESCRIPTION

- This ammonia plant employs a UOP Benfield process for CO<sub>2</sub> absorption from process gas. Benfield process is a thermally regenerated cyclic process that uses an activated, inhibited hot potassium carbonate (HPC) solution to remove CO<sub>2</sub>.

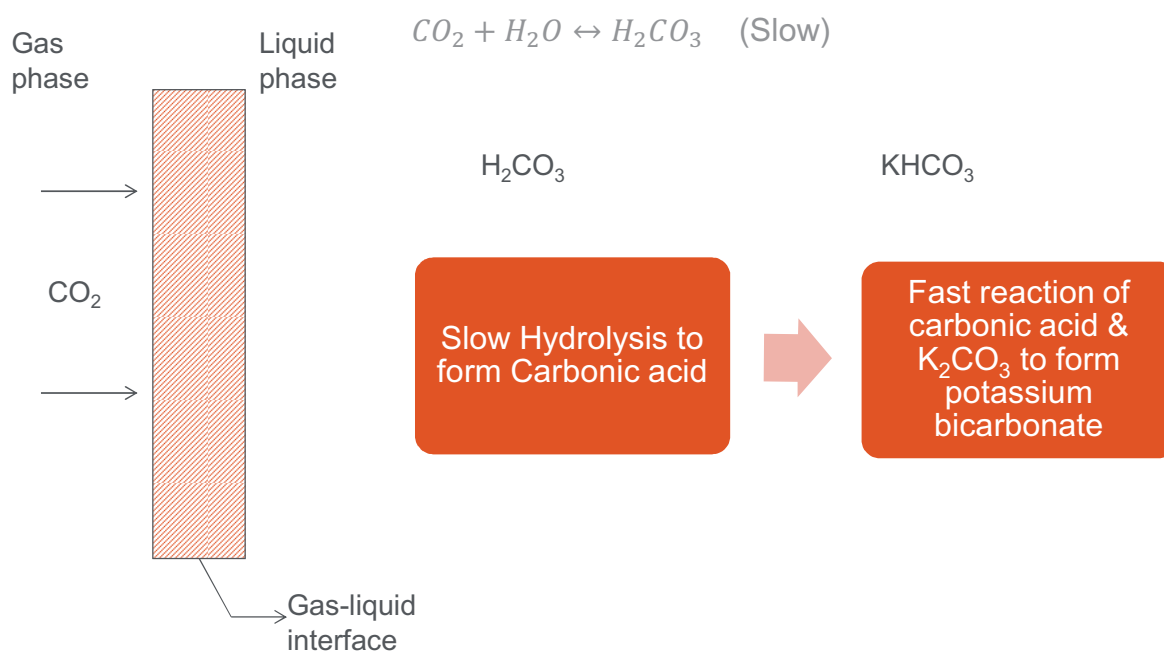
Overall reaction:



- An activator di-ethanolamine (DEA) is added to the solvent to catalyze the absorption rate.
  - 67% by wt. water.
  - 30% by wt. K<sub>2</sub>CO<sub>3</sub>.
  - 2-3% by wt. DEA.
  - 0.9% by wt. V<sub>2</sub>O<sub>5</sub> (corrosion inhibitor).
- The absorbed CO<sub>2</sub> is released from HPC by stripping it in a regenerator column using regeneration heat and pressure reduction.

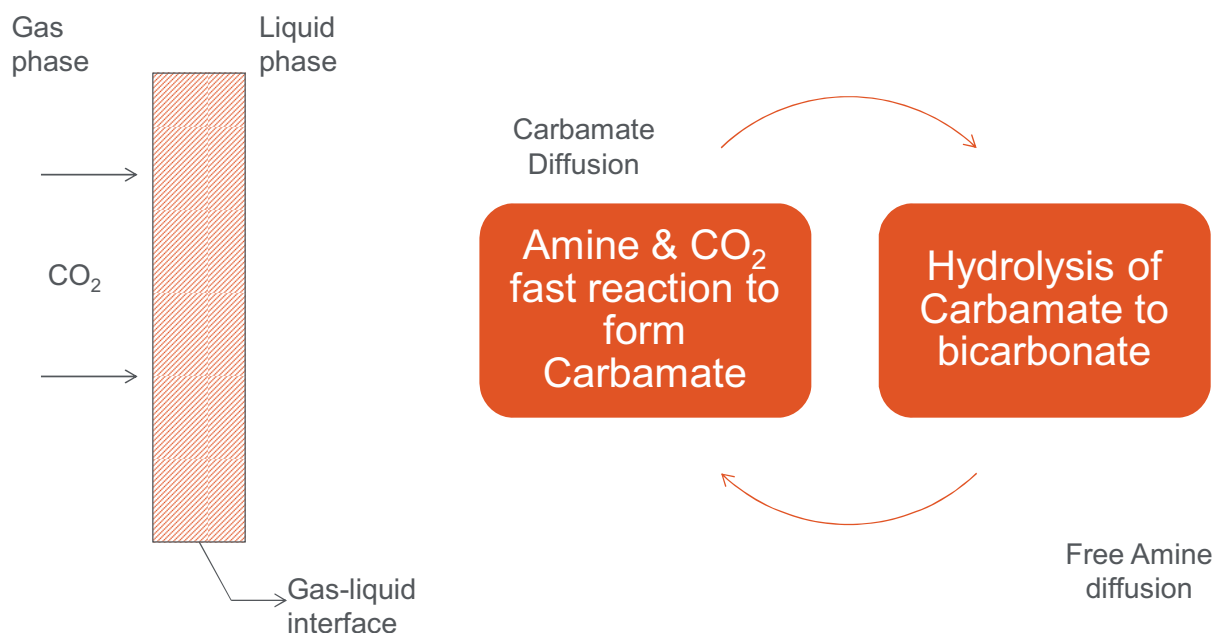
No. 4

## UN-ACTIVATED CO<sub>2</sub> ABSORPTION



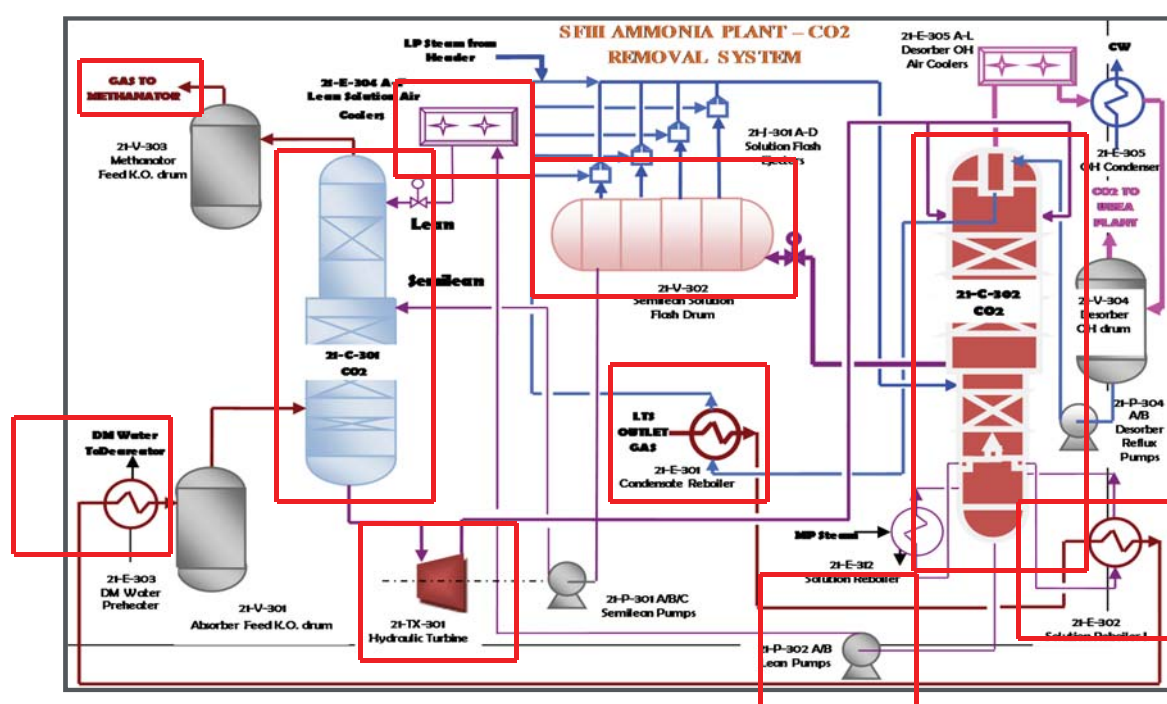
No. 5

## AMINE ACTIVATED CO<sub>2</sub> ABSORPTION



No. 6

## PROCESS FLOW DIAGRAM



No. 7



## HISTORY OF PROBLEMS

---

In 2010, CO<sub>2</sub> removal unit started showing some performance challenges. These challenges include:

- Higher solution circulation rate.
- Higher CO<sub>2</sub> slippage.
- Higher H<sub>2</sub> slippage out of stripper.
- Frequent foaming in the solution.
- High consumption of chemicals (K<sub>2</sub>CO<sub>3</sub>, DEA, antifoam).

After thorough investigation and analysis, it was concluded that the problems are the result of DEA degradation. Degradation products include large (polymers) and small (acetates, formates) degradation products.

---

No. 8

## ACTION PLAN

---

Short term actions taken:

- External Mechanical filtration: Additional 5 microns mobile filter was installed to reduce total dissolved solids in HPC solution.
- Commissioned activated carbon filter: after commissioning, reduction in DEA degradation products was observed.

Long term action must be taken to resolve performance difficulties!

- Convert to aMDEA based CO<sub>2</sub> removal unit.
- Change the activator from DEA to ACT-1.

### ACTIVATOR REPLACEMENT

---

No. 9

## WHAT IS ACT-1

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ACT-1 is a proprietary activator formulated by UOP. It is a Polyalkylamine (about 40- 70 Wt %) and is completely miscible in water. It can be used instead of DEA in all Benfield CO<sub>2</sub> Absorption system.

---

No. 10

## ANTICIPATED RESULTS

---

- Reduction in regeneration heat duty.
- Reduction in CO<sub>2</sub> slip from Absorber.
- Low H<sub>2</sub> slippage in the CO<sub>2</sub>.
- Better vapor-liquid equilibrium.
- More chemical stability.
- Less activator make-up.
- Less foaming tendency.
- Lower operating cost.
- More stable operation.

---

No. 11

## ACTIVATOR REPLACEMENT

- The “HYGIENE” of the Benfield solution was affected severely . The deterioration was so bad to replace ACT-1 online. The following measures were taken prior to preparation of fresh solution:
  - Old solution was discarded.
  - CO<sub>2</sub> system was flushed with DM water.
  - Stripper (regenerator) was cleaned from deposits (including packing).
- ACT-1 comes in hydrate form (68 wt.% ACT-1).
- Miscible in hot water and HPC solution.
- ACT-1 activated HPC contains:
  - 30 wt.% K<sub>2</sub>CO<sub>3</sub>.
  - 0.5-1.0 wt.% ACT-1.
  - 0.8 wt. % V<sub>2</sub>O<sub>5</sub>.

No. 12

## RESULTS

After start-up, significant performance improvements were noticed.

| Parameter                        | Unit | DEA  | ACT-1 |
|----------------------------------|------|------|-------|
| Reduction in regeneration energy | %    | -    | 10    |
| Activator consumption            | MT   | 8.2  | 3     |
| CO <sub>2</sub> slippage         | ppm  | 1400 | 700   |
| H <sub>2</sub> slippage          | %    | 1.1  | 0.55  |
| Plant load increase              | %    | -    | 0.4   |
| Reduction in circulation rate    | %    | -    | 12    |

No. 13

## FUTURE PLAN

---

In order to further improve CO<sub>2</sub> system performance, it is planned to replace the packing of both absorber and stripper. This is expected to increase the absorption capacity of the existing system.

| Current packing | Proposed alternative |
|-----------------|----------------------|
| Pall rings      | Raschig super ring   |

## CONCLUSION

---

- DEA degradation caused operational challenges, plant load increase difficulties and production losses.
- Benefits of the new activator:
  - 10% reduction in solution regeneration energy was achieved with new activator .
  - 12% reduction circulation rate.
  - 50% reduction in CO<sub>2</sub> and H<sub>2</sub> slippage.
  - 0.4% plant load increase.

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THE END

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**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Saving Energy Consumption  
in Semadco**

**Eng El-Sayed OWIDAT  
Consultant Electric  
Semadco - Egypt**



## **El Nasr Company for Fertilizers & Chemical Industries (Semadco / Suez )**

**“Case study”**

**Saving Energy Consumption in Semadco**

**Pre.: Eng. El-Sayed Owidat**

**Consultant Electric**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES &  
ENERGY AUDITING**

**Amman/Jordan : April 28-30, 2013**

1



## **El Nasr Company for Fertilizers & Chemical Industries**



2



Semadco

## El Nasr Company for Fertilizers & Chemical Industries

Egyptian contributing company belonging to the Holding Company for Chemical Industries and the Ministry of Investment

locating in Suez Arab Republic of Egypt was established in 1946

The company works in the field of production and marketing of nitrogenous fertilizers, liquid and solid, chemicals

The authorized capital of 500 million and paid 221 million

**Solid fertilizers :**

**Granular ammonium nitrate fertilizer (Granulated) 33.5% nitrogen.**

**Ammonia Sulfate 20.6% nitrogen.**

**Liquid fertilizers:**

- **Ammonium Sulfo-nitrate 18% nitrogen, 2% sulfur.**

- **Calcium Nitrate, 10.5% nitrogen, 13.6% calcium.**

**Secondary products:**

- **Nitric acid .**

- **sulfuric acid .**

- **liquid ammonia .**

- **aqua ammonia.**

3



Semadco

**Address: Ataka - Suez - Arab  
Republic of Egypt.**

**Telephone :-**           002 062 336 0041  
                                  002 062 336 0042  
                                  002 062 336 0043

**Fax:-**                 002 062 336 0047

**E-mail: [semadco@semadco.com](mailto:semadco@semadco.com)**

**Web site:- [www.semadco.com](http://www.semadco.com)**

4





Semadco

## **Cairo Office**

**Address:** Egypt's housing reconstruction behind the Sheraton Airport Area 8 - Building No. 8.

**Tel:** 002 02 2266 3142

**Fax:** 002 02 2266 7325

## **Alexandria Office**

**Address:** 23 Tahrir Square, Building insurance.

**Tel:** 002 03 486 3490

**Fax:** 002 03 487 5121

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## **Overview history of the company:**

- 1946 company established with a capital of 4 million pounds and increased to 7 million pounds in 1956 and now stands at 221 million pounds.
- In 1947 the implementation of a project calcium nitrate 15.5% nitrogen capacity of 200 thousand tons per year, then increased to 250 thousand tons and 270 thousand tons / year.
- 1999 was scrapping the dry part of the calcium nitrate.
- In 1961 the establishment of sulfuric acid units and ammonia sulfate.
- 1989 contract to establish a unit 400 tons of ammonia / day.
- 1990 a contract to build two production units ammonium nitrate fertilizer capacity 1000 - 1200 tons / day.
- April 2009 start experimenting calcium nitrate fertilizer production 15.5% nitrogen granulated.

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## The company's products and design capacity for each of them separately:

| <b>• Main products:</b>                     |             |                           |
|---|-------------|---------------------------|
|   | product     | prod. capacity / ton Year |
| - Ammonium nitrate                          | 33.5% azote | 200.000                   |
| - Ammonia sulfate                           | 20.6% azote | 100.0000                  |
| <b>• Intermediate products:</b>             |             |                           |
| - Calcium nitrate liquid                    | 11% azote   | 10.000                    |
| - Nitric acid                               | 52% - 55%   | 162.000                   |
| - Sulfuric acid                             | 98.5%       | 170.000                   |
| - Liquid ammonia                            | 99.9%       | 120.000                   |
| <b>• The raw materials used in company:</b> |             |                           |
| 1- Natural gas                              | local       | 143,000,000m3/Year        |
| 2- Sulfur raw                               | imported    | 57000 tons / year         |

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## I. Economies improve the Power factor

### **• Introduction: -**

It is known that 50 to 60% of the electrical grid loads by Electric motors, usually have the power factor for these motors less than 0.9, the power factor is the relationship between the reactive power and active power withdrawn from the network.

This is illustrated by Figure (1):

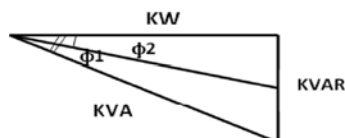


Figure it is clear that the greater the power factor can take the largest power from the network and thus can reduce losses.

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## **Benefit of improving the power factor: -**

### **1. reduce the cost of electrical power: -**

Installation of capacitors provides the necessary powers to improve the power factor can reduce electric consumption bill for the consumer and kept reactive power at a lower level than the contracted value to be agreed upon with the electricity company.

### **2. technical and economic benefits: -**

Improving the power factor client can use transformers, circuit breakers and smaller cables. In addition to reducing energy loss and drop in voltage which will benefit material on both the consumer and the product.

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### **• Reduce the Electrical losses in cables:-**

The power losses is proportional with the value of the current square  $P = I^2 R$ .

I.e. Result in reduced current value 10%, for example, a reduction in the electrical energy is reduced by up to 20%.

### **• Reduce the drop in voltage:-**

Reduced (or canceled) power factor improvement capacitors reactive current pass-through conductors on the source of feeding and then reduced (or disposed of) drop in voltage.

### **• Increase the power capacity available:-**

With improving the power factor loads of feeder transformer. Reduced the value of the current flowing through the transformer and then you can add new loads.

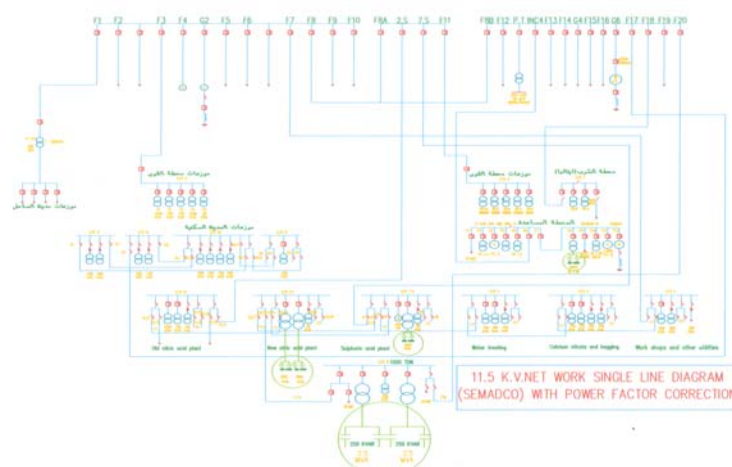
10

**A study on the internal network of Al-Nasr Fertilizers and Chemical Industries and found the following: -**

الشكل رقم (٢) يوضح تغذية اقسام المصنع المختلفة قبل تركيب المكثفات



**Second:** - Figure (3) shows the SLD to feed various sections of the factory after installing capacitors.



الشكل رقم (٣) يوضح تغذية اقسام المصنع المختلفة بعد تركيب المكثفات



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**Third: - Studying electricity bills for the year 2007 until 2011 We found a penalty because of the power factor less than 0.9 and where the contract between El-Nasr fertilizers and electricity company provided that in the case of low power factor for 0.9 increases the price of energy by 2% per 0.01 lower in the power factor. In the case of increasing the power factor 0.92 less than the price of energy by 0.5% for each 0.01 increase in the power factor and maximum 0.95.**

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**A review of billing showing the following: -**

| year      | return on or penalties |             | Power factor |
|-----------|------------------------|-------------|--------------|
|           | return on              | the penalty |              |
| 2007/2008 | -----                  | 855884      | 0.6          |
| 2008/2009 | -----                  | 336643      | 0.76         |
| 2009/2010 | -----                  | 144571      | 0.88         |
| 2010/2011 | -----                  | -----       |              |
| 2011/2012 | 56192                  | -----       | 0.93         |

**attachment a copy of billing.**

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[illegible]

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شركة القناة للتوزيع الكهربائية  
الاطاعات المالية والتجارية

مطالبة الاقساط الثابتة ومقابل القدرة  
للعام المالي ٢٠١٠ / ٢٠١١ (مائل)

نوم / الوسي  
قسم المحيل / شركة النصر للاستثمار

أكتوبر من ٥٠٠ كد

| تسوية اقسى حمل             |           |
|----------------------------|-----------|
| نوم حمل في ٢٠١٠/٦/٣٠       | ١٦٥٠٠ ك و |
| جنيه                       | ٢٣٧٠٠٠٠٠٠ |
| نوم حمل اقسى حمل ٢٠١٠/٦/٣٠ | ١١٢٣٣ ك و |
| جنيه                       | ١٦٦٦٦٦٠٠  |
| جنيه                       | ٧٨٨٨٨٠٠٠  |

إجمالي المستحق للأجل من التسوية ٧٨٨٨٨٠٠٠ جنيه

سيحالة وتسعة وخمسون ألف وثمانمائة وثمانون وخمسة مئة لا غير

مستول كهرباء المشتركين  
اسم :  
التوزيع

رؤوس :  
اسم :  
التوزيع

مختتم

٢٠١٠/٦/٣٠

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**شركة الكهرباء لتوزيع الكهرباء**  
**القطاعات الجالية والتجارية**

**مطالبة القسمة الثالث و معايل القدرة**  
**للعام المالي ٢٠١١ / ٢٠١٢ (مائل)**

رقم / السوس : أشهر من ٥٠٠ ك  
 اسم العميل / شركة الناصر للاستشارات


| تسوية الأحمال   | تسوية معايل القدرة   |
|---|--|
| <b>تسوية الأحمال</b><br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢<br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢<br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢ | <b>تسوية معايل القدرة</b><br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br><b>فرق سعر الطاقة المستحق للعميل</b><br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠<br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠<br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠ |
| <b>تسوية الأحمال</b><br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢<br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢<br>القيمة احمال في ٢٠١١/٢٠١٢ : ١١١٢٢ | <b>تسوية معايل القدرة</b><br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br>[معايل القدرة المطلوبة التسوية احمال] : ١٧٢٣١٢٨<br><b>فرق سعر الطاقة المستحق للعميل</b><br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠<br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠<br>الفرق سعر الطاقة المستحق للعميل : ٥٦١٩٢,٠٠ |

**إجمالي المستحق للعميل**  
 ١٨١٩٣,٠٠

مائة وواحد وثلاثون ألف و تسعة مائة وخمسة و ثلاثون جنيه مصري لا غير

رقم : مستقر  
 الاسم : مستقر  
 التوقيع : مستقر

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**What has been done: -**

**1. The installation of the fixed capacitors with transformers power suitable with the capacity of each transformer in accordance with the following schedule:-**

| Transformer KVA | Capacitor KVAR |
|-----------------|----------------|
| 630             | 12.5           |
| 800             | 15             |
| 1000            | 20             |
| 1250            | 25             |
| 1600            | 35             |
| 2000            | 40             |

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2. **Installation variable capacitor bank with MCC suitable with load withdrawn of the panel so it works automatically.**

After installation of capacitors and power factor operation became larger than 0.92 and therefore the Semadco recovered 56192 Egyptian pounds.

And attached bills showing the values of penalties as well as value of the company's recovery of penalties because of the high power factor.

And is now completing the installation of capacitors to access the 0.95 in order to improve network performance in factories.

It is expected to recover 1.5% of the annual bill value (approximately 30 million pounds) as 450000 pounds annually as of 01/07/2013.

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### Case study

- **Installed (3) units operate automatically capacity 3×120 = 360KVAR**
- **Installed (3) units operate automatically capacity 3×250 = 750KVAR**

The cost of the units according to the existing supply orders as follows: -

|              | Statement capacitors | Cost of capacitors in LE |
|--------------|----------------------|--------------------------|
|              | 3×120                | 48977.60                 |
|              | 1×250                | 22516.55                 |
|              | 2×250                | 50345.00                 |
| <b>Total</b> | <b>1110 KVAR</b>     | <b>121839.15</b>         |

attachment a copy of Supply orders for these units.

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[illegible]

23



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[illegible]

24



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[illegible]

25



سیمادکو

[illegible]

27



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From the previous tables, according to the existing electricity bills yield was attached 56192.00 Egyptian pounds during the year 2011/2012  
Then the capital cost can be paid back in about 2.5 years.

Below are some pictures of improving the power factor units that have been installed

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## II. Use AC Drives in Drinking Water Stations For Energy Conservation

**• Introduction:**

Due to the changing pattern of consumption of the water over 24 hours and even have electricity consumption throughout the day is linked to water consumption and therefore it must control the water pressure, according to periods of low consumption to suit the amount of water needed.

The system was controlled by the bypass and control valve in delivery line manually and this has its problems.

To solve this problem was to use (AC DRIVE) to control the pressure and the amount of water needed during the day to suit the daily consumption.

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### Advantages of using AC Drives in operating pumps

1. Maintaining a constant pressure in water lines throughout the day.
2. Saving the electrical energy equal to 10:20% as The relationship between power and speed are:

$$\frac{p1}{p2} = \left( \frac{n1}{n2} \right)^3$$

Where, P: power, n: speed

3. Prevented the pumps from mechanical shock at startup.
4. Protection of pipe lines from sudden shock, water hammering and increasing the pressure at night.

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5. Reducing wearing of circuit breakers and contactors of motor.
6. Improving the power factor reaching more than 0.9 .
7. Reduce the starting current for motors.
8. When the motor is running at a lower speed of rated speed prolongs his age because of (low motor temperature and thus lower temperature of winding and bearings).
9. Using this system cost can be recovered within 3 years.

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## Case study

Specifications drinking water station of El-Nasr Fertilizers and Chemical Industries are as follows: -

There are 4 Siemens Motor data as follows:

$P = 132 \text{ KW}$ ,  $3 \times 380 \text{ Volt}$ ,  $1500 \text{ R.P.M}$ ,  $0.86 \text{ P.F}$ ,  $F = 50 \text{ Hz}$

And pumps data as follows:

$Q = 560 \text{ m}^3/\text{h}$ ,  $H = 60 \text{ m}$ ,  $\text{BHP} = 130 \text{ HP}$

Normally operate 2 pumps is controlled manually by the bypass and valve in delivery line this method is ineffective in water consumption (pressure, quantity) and electric power as the motor were operating at nearly full load.

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After installing AC Drive and installation pressure switch on delivery line to control the water pressure over the 24-hour, found that the first motor reached to rated speed without access to the required pressure, then the second motor is operating through (AC Drive) to get the required pressure, and speed in this case less than rated speed, power is drawn according to the following formula: -

$$\frac{p1}{p2} = \left( \frac{n1}{n2} \right)^3$$

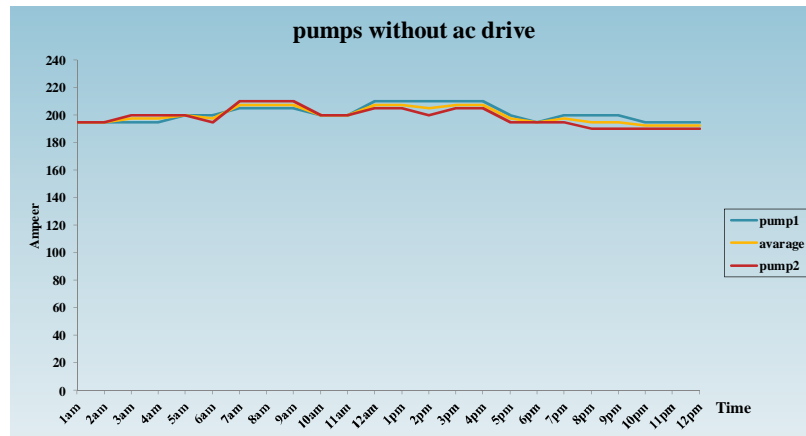
The following statement shows the value of power consumption before and after using AC Drive, accounts and curves the following: -

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### Consumption before using AC Drive:



$$P = 2 * \sqrt{3} * V * I * \cos \phi$$

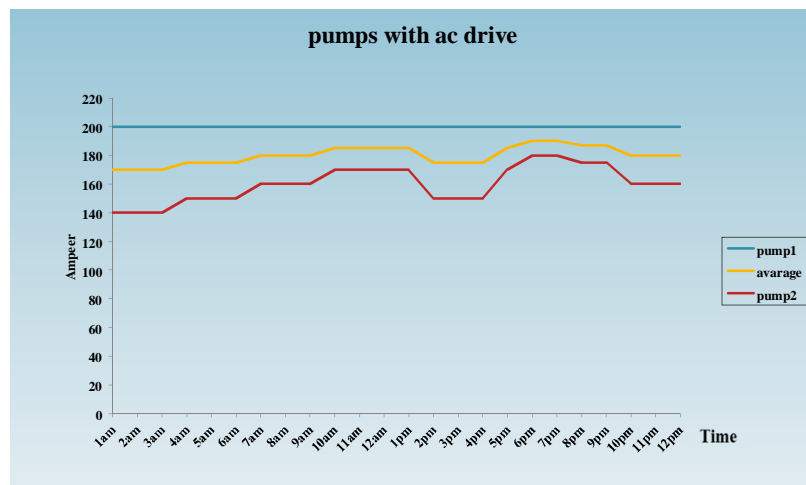
$$P = 2 * \sqrt{3} * 380 * 200 * 0.86 = 226.41 \text{ KW}$$

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### Consumption after using AC Drive:



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$$P = \sqrt{3} * V * I * \cos \phi$$

$$P1 = \sqrt{3} * 380 * 200 * 0.86 = 113.2 \text{ KW}$$

$$P2 = \sqrt{3} * 380 * 168 * 0.93 = 102.83 \text{ KW}$$

$$Pt = P1 + P2 = 216.03 \text{ KW}$$

Saving in power / hour = P – Pt

$$= 226.41 - 216.03 = 10.38 \text{ KW/h}$$

$$\text{Saving in power / year} = 10.38 * 365 * 24 = 90928.8 \text{ KW}$$

Since the price of a kilo-watt company contracted 0.42 pounds, then your account is the cost of energy, which was provided as follows

$$0.42 \times 90928.8 = 38190.096 \text{ LE}$$

And where the unit price as supply orders number 765/2011-2012 valued 131449 pounds.

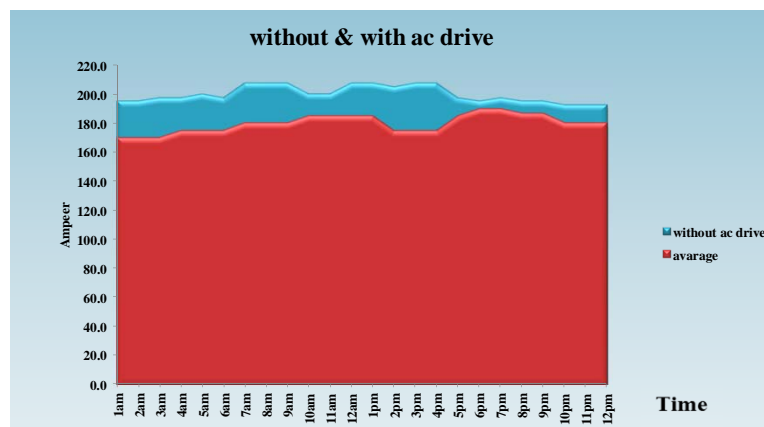
Then the capital cost can be paid back in **3.44 years.**

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The following figure shows how savings in energy consumption before and after the use of AC Drive



The following are some of the images of AC Drive, which was installed

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شركة النصر للأسمدة والصناعات الكيماوية

• ٦٢/٢٣٦٠٠٠٢١ / ٢٢ / ٢٢ تقيشون  
• ٦٢/٢٣٦٠٠٠٢٧ فاكس

— 22 —

المسويين - عثمان قسمة

القطاع التجاري

الإدارة العامة للمشتريات  
بالمسؤولين

بالمسؤولين

شركة الجمال للتجارة العامة  
عنوان ٩١٤٧١١٠٤٦٤  
القرى ٩١٤٦٢١١  
أمر توريد رقم ٩٠٨٠-٩١١٧٦٥  
طلب شراء رقم ٩٠٨٠-٩١١٤٦٤  
شروط عامة  
١-

(١) للشركة الحق في رفض البضاعة وإعادة تأجيل لكم على حسابكم إذا عاينت الوصفات النصوص عنها في أمر التوريد.

(٢) التوريد: ٧.٢.٢٠١١ / ١٠.٠٥.٢٠١١ (تاريخ تقديم)

(٣) طريقة التسداد: ١٠.٠٥.٢٠١١ (تاريخ التسداد)

بالإشارة إلى: (طريقة التسداد) ١٠.٠٥.٢٠١١ / ١٠.٠٥.٢٠١١ (تاريخ التسداد)

بإجراء التوريد الآتي

| اسم   | الوظيفة | نوع البطاقة |
|-------|---------|-------------|
| حماية | تحويل   | بطاقة       |

الهدف من هذه البطاقة هو حماية النظام من التلف  
بواسطة التيار الكهربائي

(ac driving) الحماية من التيار الكهربائي

- Frequency converter :  
- input frequency : 165 ohms 9.9 Hz  
- power : 160 W  
- Built-in switcher - it protect from radio waves  
- built-in filter - C and MC voltage  
- built-in AC (no ohmic inductor) to protect the system from supply harmonics and transient voltage -  
- The maximum length of the meter cable up to 3m m.  
- The device can't be separated from the central unit  
- safe ready with the low static noise .  
- standard multi (input/output) any needed function could be adding anytime with only option I/O Card .  
- Easy hardware communication and - alphanumeric keypad with RS232C communication .  
- All in one application packaging / standards applications .  
Manufacturer : Vacon  
origin : Finland

(ما عدا اليوم والجمعة)

القسم الطالب ..... الكورس .....

.....

الفصل فی شرح

المؤرخون

39



**Semadco**

شركة النصر للأسمدة والصناعات الكيماوية

٢٢/٢٢٦٠٠٤٦ / ٤٢ / ٤٢  
٢٢/٢٢٦٠٠٤٧

١٠٠-١١٠

المسؤولين - عتائق

القطاع التجاري

المجلة العالمية للعلوم

الجامعة المستنصرية

القادر على: ٢٠١٤/٧/١١  
 المرفوع رقم: ٢٠١٤-٢٠١١/٧٦٥  
 مكتب شراء رقم: ٢٠١١/١٩٤٤

(1) الشركة الحق في رفض الشفعة وأما إذا لم يرد على حسابكم (2) خالفت التواضعات المتضمنة في أمر التوريث  
(2) التوريث 3 1 أسبوع (3) طريقة السلام (4) طريقة السلام  
بإشارة إلى (طريقة الشفعة) سلامة عام 14/11/2018  
يرجاء التوريث الأسبق

| العدد | الاسم | الوظيفة             | العدد | الاسم | الوظيفة             |
|-------|-------|---------------------|-------|-------|---------------------|
| 19    | CT    | Current Transformer | 20    | CT    | Current Transformer |
| 21    | CT    | Current Transformer | 22    | CT    | Current Transformer |
| 23    | CT    | Current Transformer | 24    | CT    | Current Transformer |
| 25    | CT    | Current Transformer | 26    | CT    | Current Transformer |
| 27    | CT    | Current Transformer | 28    | CT    | Current Transformer |
| 29    | CT    | Current Transformer | 30    | CT    | Current Transformer |
| 31    | CT    | Current Transformer | 32    | CT    | Current Transformer |
| 33    | CT    | Current Transformer | 34    | CT    | Current Transformer |
| 35    | CT    | Current Transformer | 36    | CT    | Current Transformer |
| 37    | CT    | Current Transformer | 38    | CT    | Current Transformer |
| 39    | CT    | Current Transformer | 40    | CT    | Current Transformer |
| 41    | CT    | Current Transformer | 42    | CT    | Current Transformer |
| 43    | CT    | Current Transformer | 44    | CT    | Current Transformer |
| 45    | CT    | Current Transformer | 46    | CT    | Current Transformer |
| 47    | CT    | Current Transformer | 48    | CT    | Current Transformer |
| 49    | CT    | Current Transformer | 50    | CT    | Current Transformer |
| 51    | CT    | Current Transformer | 52    | CT    | Current Transformer |
| 53    | CT    | Current Transformer | 54    | CT    | Current Transformer |
| 55    | CT    | Current Transformer | 56    | CT    | Current Transformer |
| 57    | CT    | Current Transformer | 58    | CT    | Current Transformer |
| 59    | CT    | Current Transformer | 60    | CT    | Current Transformer |
| 61    | CT    | Current Transformer | 62    | CT    | Current Transformer |
| 63    | CT    | Current Transformer | 64    | CT    | Current Transformer |
| 65    | CT    | Current Transformer | 66    | CT    | Current Transformer |
| 67    | CT    | Current Transformer | 68    | CT    | Current Transformer |
| 69    | CT    | Current Transformer | 70    | CT    | Current Transformer |
| 71    | CT    | Current Transformer | 72    | CT    | Current Transformer |
| 73    | CT    | Current Transformer | 74    | CT    | Current Transformer |
| 75    | CT    | Current Transformer | 76    | CT    | Current Transformer |
| 77    | CT    | Current Transformer | 78    | CT    | Current Transformer |
| 79    | CT    | Current Transformer | 80    | CT    | Current Transformer |
| 81    | CT    | Current Transformer | 82    | CT    | Current Transformer |
| 83    | CT    | Current Transformer | 84    | CT    | Current Transformer |
| 85    | CT    | Current Transformer | 86    | CT    | Current Transformer |
| 87    | CT    | Current Transformer | 88    | CT    | Current Transformer |
| 89    | CT    | Current Transformer | 90    | CT    | Current Transformer |
| 91    | CT    | Current Transformer | 92    | CT    | Current Transformer |
| 93    | CT    | Current Transformer | 94    | CT    | Current Transformer |
| 95    | CT    | Current Transformer | 96    | CT    | Current Transformer |
| 97    | CT    | Current Transformer | 98    | CT    | Current Transformer |
| 99    | CT    | Current Transformer | 100   | CT    | Current Transformer |

[illegible]

القسم الطالب الكورس

..... مناقشة فسرية

**الفصل الثامن**

.....

40



**Semadco**

شركة النصر للأسمدة والصناعات الكيماوية

• ٦٢/٢٣٦٠٠٢١ / ٢٢ / ٢٣ تشرين  
• ٦٢/٢٣٦٠٠٢٧

ش - ت م م  
الموسم - مناقشة

القطاع التجاري  
إدارة العامة للمشتريات  
بالسويس

بالسويين

الرقم: ٥٠٤١٣١١١  
أمر توريد رقم ٥٠١١١٧٦٥  
طلب شراء رقم ٥٠١١١٩٩٥

میر تھریڈ  
شرائط عامہ

السادة  
عنوان

١) الشركة الحق في رفض الشراكة وإعادة لها لكم على حسابكم إذا عاينت التوافقات المتصور عنها في أمر التوريد  
٢) التوريد ٤٠٣٠٠٠٠  
٣) طريقة الحساب ١٠٠٠٠٠٠  
٤) طريقة الحساب ٥٠٠٠٠٠٠  
٥) طريقة الحساب ١٠٠٠٠٠٠٠  
٦) طريقة الحساب ١٠٠٠٠٠٠٠  
٧) طريقة الحساب ١٠٠٠٠٠٠٠  
٨) طريقة الحساب ١٠٠٠٠٠٠٠  
٩) طريقة الحساب ١٠٠٠٠٠٠٠  
١٠) طريقة الحساب ١٠٠٠٠٠٠٠

| الرقم | التاريخ | الموضوع   | الاسم |
|-------|---------|---|-------|
| 11900 | -       | 1 output : 4-20 MA<br>1 Conn : 24   |       |
| 11910 | -       | Such As Data sheet<br>↓ Manufacture : aplissers<br>• level switch    23 - 1   |       |
| 11915 | -       | Such As Drawing<br>that is example for 4-20MA auto - change<br>so that optimal the best way to connect<br>the AC Drive to the system also it can<br>change it if between all forums not only<br>for one of them that will be able for<br>system to work even if the AC drive<br>down. |       |
| 11920 | -       | AC Drives 2 # NIM 21134   |       |
| 11925 | -       |   |       |

القسم الثالث

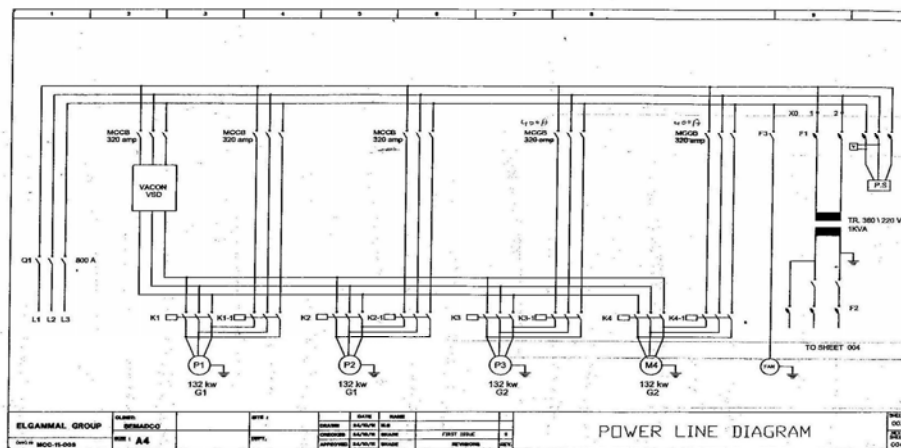
(ماعنا المشو والخطا)

.....محافظة شربينة  
.....محافظة شربينة  
.....محافظة شربينة

.....


Figure 6. *Continued*

41



POWER LINE DIAGRAM

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Semadco

**The above and from the date of establishment of the company since 1946.**

**Due to the aging of all the equipment, the company is currently rehabilitating the basic units:-**

- **Revamping the electricity system at a cost of 15 million pounds.**
- **Feed factories voltage 66 kV instead of 11 kV to ensure stability and continuity of the production process and provide the equivalent of 25% of the bill value of electric power annually at a cost of 10 million pounds.**

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Semadco

# Thank you

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**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**Saving Energy Consumption  
in Semadco**

**Eng El-Sayed OWIDAT  
Consultant Electric  
Semadco - Egypt**

**RENEWABLE ENERGY IN FERTILIZER INDUSTRIES  
& ENERGY AUDITING**

Amman Jordan  
April 28-30, 2013

**List of Delegates**

## RENEWABLE ENERGY IN FERTILIZER INDUSTRIES &amp; ENERGY AUDITING

| #  | COUNTRY | NAME                | POSITION   | COMPANY                           | TELEPHONE               | FAX              | E-MAIL                        |
|----|---------|---------------------|--|-----------------------------------|-------------------------|------------------|-------------------------------|
| 1  | Bahrain | Mohamed JAWAD       | Urea Shift Supervisor                                  | GPIC                              | +973 39734991           | +973 17733377    | MJzzzz@hotmail.com            |
| 2  | Bahrain | Bashar AL-ARADI     | Designated Senior Process Engineer                     | GPIC                              | +973 39613818           | +973 17731047    | balaradi@gpic.net             |
| 3  | Egypt   | Mahmoud SALEH       | Vice Chairman for Instrumentation & Electrical Affairs | Abu Qir Fertilizers Company (AFC) | +203 5603053            | +203 5603086     | afctrainingcenter@yahoo.com   |
| 4  | Egypt   | Moustafa AHMED      | Deputy Electrical Sectors                              | Abu Qir Fertilizers Company (AFC) | +203 5603053            | +203 235603086   | afctrainingcenter@yahoo.com   |
| 5  | Egypt   | Shafik ASHKAR       | Secretary General                                      | AFA                               | +202 23054464           | +202 23054466    | info@afa.com.eg               |
| 6  | Egypt   | Mohamed EL-SHABOURY | Finance & Adminstration Manager                        | AFA                               | +202 23054467           | +202 23054466    | info@afa.com.eg               |
| 7  | Egypt   | Mohamed M. ALI      | Studies Manager  | AFA                               | +202 23054464           | +202 23054466    | info@afa.com.eg               |
| 8  | Egypt   | Wael MAZEN          | Manager, Admin. Section                                | AFA                               | +202 23054464           | +202 23054466    | info@afa.com.eg               |
| 9  | Egypt   | Marwa MOHSEN        | Head, Executive Secretary Section                      | AFA                               | +202 23054464           | +202 23054466    | info@afa.com.eg               |
| 10 | Egypt   | Mohamed MOWENA      | Process Senior Engineer                                | ALEXFERT                          | +203 5603775            | +203 5603024     | waleed.khattab@alexfert.com   |
| 11 | Egypt   | Hossam MOUSTAFA     | Electrical Senior Eng.                                 | ALEXFERT                          | +203 5603775            | +203 5603024     | waleed.khattab@alexfert.com   |
| 12 | Egypt   | Mohamed EL TRAWY    | Ammonia Process Shift Eng.                             | ALEXFERT                          | +203 5603775            | +203 5603024     | waleed.khattab@alexfert.com   |
| 13 | Egypt   | Ahmed SADAWEY       | Piping Maintenance Eng.                                | ALEXFERT                          | +203 5603775            | +203 5603024     | waleed.khattab@alexfert.com   |
| 14 | Egypt   | Moustafa METWALY    | Ammonia Process Supervisor                             | ALEXFERT                          | +203 5603775            | +203 5603024     | waleed.khattab@alexfert.com   |
| 15 | Egypt   | Mostafa GOUDA       | Acting President                                       | BUE                               | +202 26890000 ext. 1475 | +202 26300010/20 | MGouda@Bue.edu.eg             |
| 16 | Egypt   | Iman EL MAHALLAWI   | Director Centre for Renewable Energy                   | BUE                               |                         |                  | ielmahallawi@Bue.edu.eg       |
| 17 | Egypt   | Alaedin ABBAS       | Managing Director                                      | COME                              | +201223163695           | +203 5556147     | alaedin.abbas@comeconsult.com |
| 18 | Egypt   | Axel Ceglie SWOBODA | Business Development Manager                           | Consukorra                        | +201003234433           | +202 27869730    | axel@consukorra.com           |
| 19 | Egypt   | Saber ABU KHADRA    | Chairman   | EGYTRAIN                          | +201000464727           |                  | saym_00@hotmail.com           |



|    |       |                      |                                 |              |               |               |                         |
|----|-------|----------------------|---------------------------------|--------------|---------------|---------------|-------------------------|
|    |       |                      |                                 |              |               |               |                         |
| 20 | Egypt | Ahmed SABER          |                                 | EGYTRAIN     |               |               |                         |
| 21 | Egypt | Ehsan ABDEL LATIF    | Managing Director, Technical    | El Delta Co. |               |               |                         |
| 22 | Egypt | Mohamed AL-HADIDI    | Head Sectors, Production        | El Delta Co. |               |               |                         |
| 23 | Egypt | El-Sayed MUSBAH      | Head Sector, Maintenance        | El Delta Co. |               |               |                         |
| 24 | Egypt | Samir M. HASABO      | GM Urea Machines                | El Delta Co. |               |               |                         |
| 25 | Egypt | Salah Gamal EL-SARAF | GM Maintenance                  | El Delta Co. |               |               |                         |
| 26 | Egypt | Bassem IBRAHIM       | Urea Production                 | El Delta Co. |               |               |                         |
| 27 | Egypt | Mohamed AL-KHOULY    | Urea Machines                   | El Delta Co. |               |               |                         |
| 28 | Egypt | Hossam ABDEL MAKSOUD | Urea Maintenance                | El Delta Co. |               |               |                         |
| 29 | Egypt | Assem A. ATTA ALLAH  | Urea Maintenance                | El Delta Co. |               |               |                         |
| 30 | Egypt | Gamal ISMAIL         | Managing Director, Technical    | KIMA         | +20972314500  | +20972314505  | info@kimaegypt.com      |
| 31 | Egypt | Ahmed ABDEL AZIZ     | Head Sector, Labs               | KIMA         | +20972314500  | +20972314505  | info@kimaegypt.com      |
| 32 | Egypt | Saad HUSSEIN         | Head Sector, Electricity        | KIMA         | +20972314500  | +20972314505  | info@kimaegypt.com      |
| 33 | Egypt | Mohsen AHMED         | GM, Hydrogen                    | KIMA         | +20972314500  | +20972314505  | info@kimaegypt.com      |
| 34 | Egypt | Essam EL-Din AHMED   | GM, Ammonia                     | KIMA         | +20972314500  | +20972314505  | info@kimaegypt.com      |
| 35 | Egypt | Waleed EL ZOGHBY     | Urea Production Dept. Head      | MOPCO        | +202 26731184 | +202 26731181 | w.elzoghby@mopco-eg.com |
| 36 | Egypt | Mohamed KHALAF       | Maintenance Engineer            | MOPCO        | +202 26731184 | +202 26731181 | m.khalaf@mopco-eg.com   |
| 37 | Egypt | Ibrahim ABDEL HAI    | Chairman & Managing Director    | SEMADCO      | +20623360272  | +20623360047  | semadco@semadco.com     |
| 38 | Egypt | Mohamed AL-DESOKI    | Managing Director - Technical   | SEMADCO      | +201154020497 | +20623360047  | semadco@semadco.com     |
| 39 | Egypt | Ahmed Gharib KHISSM  | Head Sectors, Economic          | SEMADCO      | +201154008301 | +20623360047  | semadco@semadco.com     |
| 40 | Egypt | Abdel Nasser BEKHEET | Head Sector, Production         | SEMADCO      | +201154008307 | +20623360074  | semadco@semadco.com     |
| 41 | Egypt | Sayed AWAYDAT        | Consultant - Electricity Sector | SEMADCO      | +201003677758 | +20623360047  | semadco@semadco.com     |
| 42 | Egypt | Ahmed AL-KAREEM      | Head Sector, Finance            | SEMADCO      | +201003179805 | +20623360047  | semadco@semadco.com     |
| 43 | Egypt | Ahmed Abu Bakr       | Engineer,                       | SEMADCO      | +201112220163 | +2062 3360047 | semadco@semadco.com     |

| Sl. No. | Country | Name                    | Position                                | Company                    | Mobile No.      | Phone No.      | Email                      |
|---------|---------|-------------------------|---|----------------------------|-----------------|----------------|----------------------------|
| 44      | Egypt   | Tamer Eid EL-SAYED      | Engineer, Electronics                   | SEMADCO                    | +201142620874   | +2062 3360047  | semadco@semadco.com        |
| 45      | Egypt   | Mohamed EL-SAYED        | Engineer, Mechanical                    | SEMADCO                    | +201065876957   | +20623360047   | semadco@semadco.com        |
| 46      | Egypt   | Sami A. AHMED           | Manager, Production                     | SEMADCO                    | +201002748929   | +20623360047   | semadco@semadco.com        |
| 47      | Egypt   | Abdel Moniem A. EL-GHAR | Head Sectors, Engineering               | SEMADCO                    | +201224812694   | +20623360041   | semadco@semadco.com        |
| 48      | Egypt   | Aisha Ali SALEM         | Head Sector                             | SEMADCO                    | +201147614360   | +20623360047   | semadco@semadco.com        |
| 49      | Egypt   | Hoda Hashim EL-SAYED    | Consultant                              | SEMADCO                    | +20623360272    | +20623360047   | semadco@semadco.com        |
| 50      | Egypt   | Mahmoud YOUSSEF         | GM                                      | SEMADCO                    | +20222667336    | +20222667325   | semadco@semadco.com        |
| 51      | Egypt   | Sayed Ahmed HELMY       | Head Sector, Medical                    | SEMADCO                    | +201001851684   | +20623360047   | semadco@semadco.com        |
| 52      | Iraq    | Abdulhadi AL ASADI      | Deputy Manager                          | SCF/South Region           | +964 7806029010 |                | hadisaad2009@yahoo.com     |
| 53      | Iraq    | Ali Khalaf MOHAMED      | Chief of Engineer                       | State Co. For Phosphate    | +964 7808930317 | +964 24612901  | ali_kmuhammed@yahoo.com    |
| 54      | Iraq    | Hamid HAMEED            | Fertilizer Manager                      | State Co. For Phosphate    | +964 7903316860 | +964 24612901  | phosphate_qaim@yahoo.com   |
| 55      | Jordan  | Bilal AL-HMOUD          | Chairman's Business Development Advisor | Arab Potash Company (APC)  |                 |                | Bilal.a@arabpotash.com     |
| 56      | Jordan  | Fuad ZOUBI              | Power & Water Dept. Manager             | Arab Potash Company (APC)  |                 |                | fuad.z@arabpotash.com      |
| 57      | Jordan  | Hussein SHORMAN         | Power Plant Superintendent              | Arab Potash Company (APC)  |                 |                | hussein.sh@arabpotash.com  |
| 58      | Jordan  | Faisal JARAH            | CCP Mechanical Superintendent           | Arab Potash Company (APC)  |                 |                |                            |
| 59      | Jordan  | Abdel Salam ODAT        | Senior Electrical Engineer              | Arab Potash Company (APC)  |                 |                |                            |
| 60      | Jordan  | Khalid DARHAMAD         | CCP Production Superintendent           | Arab Potash Company (APC)  |                 |                |                            |
| 61      | Jordan  | Khalil O'SHOOSH         | HLP Production Superintendent           | Arab Potash Company (APC)  |                 |                |                            |
| 62      | Jordan  | Alaa OMARI              | Senior Process Engineer                 | Arab Potash Company (APC)  |                 |                | alaa.o@arabpotash.com      |
| 63      | Jordan  | Jamal AMIRA             | Technical Dept. Manager                 | Arab Potash Company (APC)  |                 |                | jamal.amira@arabpotash.com |
| 64      | Jordan  | Bassam FAKHOURI         | Vice President/MD                       | Chemicals & Mining Ind. Co | +962 79 5538988 | +962 6 5336110 | manager.cmi@gmail.com      |
| 65      | Jordan  | Hassan AL-SEAF          | Marketing Engineer                      | ETA-MAZ                    | +962 795693310  | +962 65343555  | al-saif@eta-max.com        |

|    |        |                        |                                    |                           |                   |                |                              |
|----|--------|------------------------|------------------------------------|---------------------------|-------------------|----------------|------------------------------|
| 66 | Jordan | Ibrahim ALRAWASHDEH    | General Manager                    | Indo-Jordan Chemicals Co. | +96265512872 / 74 | +96265512871   | mdoffice@ijcltd.com          |
| 67 | Jordan | Rajabather THANIGAIVEL | First Process Engineer             | Indo-Jordan Chemicals Co. | +962 6 5512872/4  | +962 6 5512871 | mdoffice@ijcltd.com          |
| 68 | Jordan | Anwar AL TAMIMI        | Acting Plant Engineer              | Indo-Jordan Chemicals Co. | +962 6 5512872/4  | +962 6 5512871 | mdoffice@ijcltd.com          |
| 69 | Jordan | Omar AL GSOUS          | Engineer                           | Indo-Jordan Chemicals Co. | +962 6 5512872/4  | +962 6 5512871 | mdoffice@ijcltd.com          |
| 70 | Jordan | Munther HADDADIN       | Chairman                           | JAFCCO                    | +962 6 5851809    | +962 6 5851824 | hinad.ibrahim@jafco.com      |
| 71 | Jordan | Samir A. RAHIM         | Assistant CEO                      | JAFCCO                    | +962 799767762    | +962 65851809  | hinad.ibrahim@jafco.com      |
| 72 | Jordan | Zaid MA'TOUK           | Technical Manager                  | JAFCCO                    | +962 799707762    | +962 6 5251827 | hinad.ibrahim@jafco.com      |
| 73 | Jordan | Ahmad ABU SAULIK       | Production Auditing Superintendant | JAFCCO                    | +962 799767762    | +962 6 5851824 | hinad.ibrahim@jafco.com      |
| 74 | Jordan | Emad AL-MADADHA        | CEO                                | JPMC                      | +962 65697795     | +962 65652917  | e.madadha@jpmc.com.jo        |
| 75 | Jordan | Ayman AL AGHA          |                                    | JPMC                      |                   |                |                              |
| 76 | Jordan | Lna AL DABBAS          |                                    | JPMC                      |                   |                |                              |
| 77 | Jordan | Khetam HAWAMDEH        |                                    | JPMC                      |                   |                |                              |
| 78 | Jordan | Bassam HADDAD          |                                    | JPMC                      |                   |                |                              |
| 79 | Jordan | Ghada BASYOUNI         |                                    | JPMC                      |                   |                |                              |
| 80 | Jordan | Shawqi AL MOMANI       |                                    | JPMC                      |                   |                |                              |
| 81 | Jordan | Jaser ATAWARA          |                                    | JPMC                      |                   |                |                              |
| 82 | Jordan | Abed AL ADAILEH        |                                    | JPMC                      |                   |                |                              |
| 83 | Jordan | Mahmoud AL-SARAYREH    |                                    | JPMC                      |                   |                |                              |
| 84 | Jordan | Faisal AL TURSHAN      |                                    | JPMC                      |                   |                |                              |
| 85 | Jordan | Ashraf AL MUBAIDEEN    |                                    | JPMC                      |                   |                |                              |
| 86 | Jordan | Bassam ZOOMOT          | General Manager                    | KEMAPCO                   | +962795250011     | +96264601995   | bassam.zoumot@kemapco.com.jo |
| 87 | Jordan | Ahmad MAHAMID          | Maintenance & Planning Manager     | KEMAPCO                   | +962 797449777    | +962 32017188  | ahmad.mahamid@kemapco.com    |
| 88 | Jordan | Nabeel MHAI DAT        | Production Manager                 | KEMAPCO                   | +962 797449566    | +962 32017188  | nabeel.mhaidat@kemapco.com   |
| 89 | Jordan | Ramzi SINNO KROT       | Technical Manager                  | KEMAPCO                   | +962 797313486    | +962 32017188  | ramzi.sinnokrot@kemapco.com  |
| 90 | Jordan | Yousif QATAWNEH        | Loading & Yard Supervisor          | KEMAPCO                   | +962 797313447    | +962 2301788   | yousifqatawneh@kemapco.com   |
| 91 | Jordan | Yacoub MARAR           | Solar Energy Section Head          | MEMR                      |                   |                | yacoub.marmar@MEMR.gov.jo    |

|     |                      |                       |   |                              |                |                |                                |
|-----|----------------------|-----------------------|---|------------------------------|----------------|----------------|--------------------------------|
| 92  | Jordan               | Firas ALAWNEH         | Head of Photovoltaics (PV) Division                     | NERC                         |                |                | firas.alawneh@nerc.gov.jo      |
| 93  | Jordan               | Muhieddin TAWALBEH    | Head of Rational Use of Energy & Solar Thermal Division | NERC                         |                |                |                                |
| 94  | Jordan               | Ahmad AL-ROUSAN       | Studies & Consultation Specialist                       | NERC                         |                |                | a.rousan@nerc.gov.jo           |
| 95  | Jordan               | Karim HALASEH         | General Manager   | Nippon Jordan Fertilizer Co. | +962 6 5691708 | +962 6 5684127 | karim.halaseh@njfc-jo.com      |
| 96  | Jordan               | Amin KABARITI         | Maintenance Manger                                      | Nippon Jordan Fertilizer Co. | +962-32017112  | +962-32017104  | amin8@njfc-jo.com              |
| 97  | Jordan               | Ahmed AL-GHANDOOR     | Associate Professor                                     | The Hashemite University     | +962 796535999 | +962 5 3826348 | gandoor2002@yahoo.com          |
| 98  | Kuwait               | Lutfi NAYFEH          | Senior Specialist "Process Eng."                        | Petrochemical Industries Co. | 0096597250747  | 0096523260678  | lutfi_nai@pic.com.kw           |
| 99  | Kuwait               | Husain ASHOUR         | Senior Planning & Coordination Engineer                 | Petrochemical Industries Co. | +965 99393901  | +965 23260512  | Hussain_Ashour@pic.com.kw      |
| 100 | Kuwait               | Waleed ALFADHLY       | Senior Engineer   | Petrochemical Industries Co. | +965 99012167  | +962 23211000  | walfadhli@pic.com.kw           |
| 101 | Kuwait               | Mishal ALALI          | Maintenance Engineer                                    | Petrochemical Industries Co. | +965 23212317  |                | mishal_alali@pic.com.kw        |
| 102 | Netherlands          | Jo MEESEN             | Principal Engineer                                      | Stamicarbon bv               | +31 464237055  | +31 464237001  | jo.meessen@stamicarbon.com     |
| 103 | Netherlands          | John OOSTVEEN         | Process After Sales Engineer                            | Stamicarbon bv               | +31 464237058  | +31 464237001  | john.oostveen@stamicarbon.com  |
| 104 | Saudi Arabia         | Meshal AL-MUWALLAD    | Process Engineer  | ALBAYRONI                    | +966 503885572 | +966 33406092  | mueslladms@albayroni.sabic.com |
| 105 | Saudi Arabia         | Shams AL-SHAMMASI     | Director Planning & Economics                           | SABIC                        | +966 505904573 | +966 33422929  | shammasisa@sabic.com           |
| 106 | Saudi Arabia         | Anosh THOMAS          | Process Engineer, Author                                | SAFCO                        | +966 588916493 |                | thomasahk@safco.sabic.com      |
| 107 | Saudi Arabia         | Hussain AL-ESMAIL     | Utilities Process Superintendant, Process Eng. Dept.    | SAFCO                        | +966 33406647  | +966 33418029  | HEsmail@safco.sabic.com        |
| 108 | Saudi Arabia         | Saad MAYMONI          | Chemical Engineer, Co-Author                            | SAFCO                        |                |                | maymonisa@safco.sabic.com      |
| 109 | Saudi Arabia         | Bala PONNAMBALAM      | Process Engineer, Author                                | SAFCO                        | +966 545250645 |                | ponnambalamb@safco.sabic.com   |
| 110 | Saudi Arabia         | Ahmad AL KATEB #10428 | Shift Engineer II                                       | SAFCO                        | +966 1 2258183 |                | AKateb@safco.sabic.com         |
| 111 | United Arab Emirates | Yazan HAROUN          | Sales Engineer  | Pall Corporation-ME FZE      | 00971566763543 | 0097148849420  | yazan_haroun@europe.pall.com   |