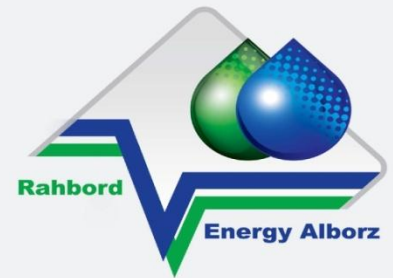
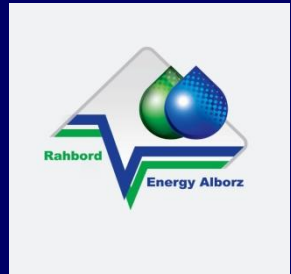


# Feasibility Study of Carbon Dioxide Capture from Ramin Power Plants And Injection In Khuzestan Oilfields

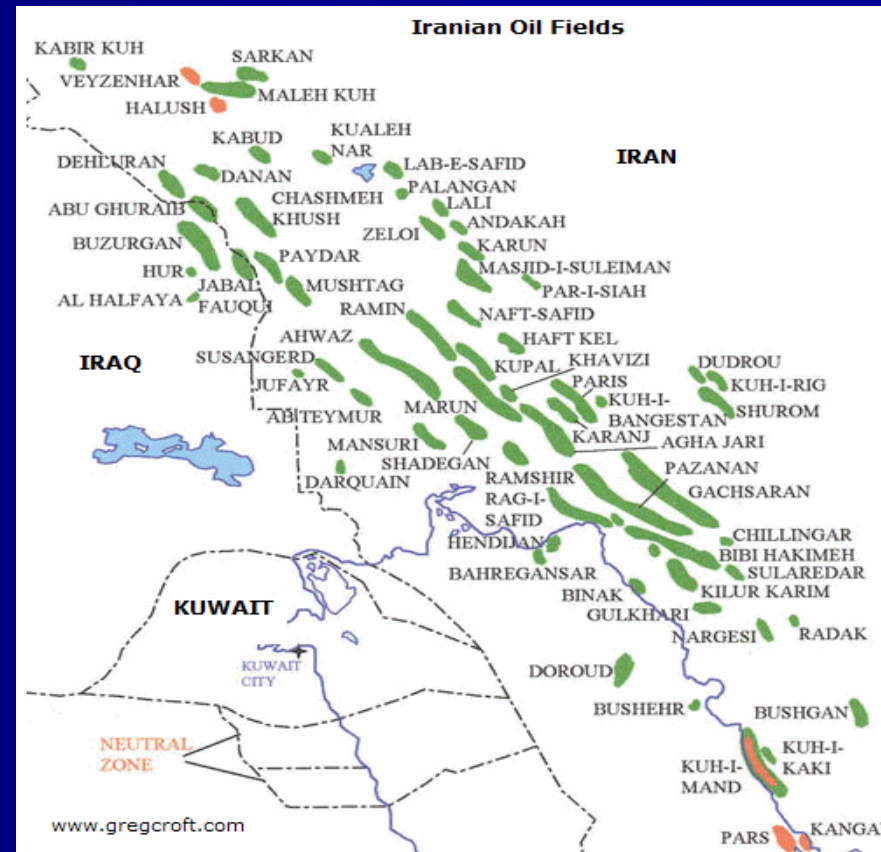


**Rahbord Energy Alborz**

# Khuzestan Oilfields



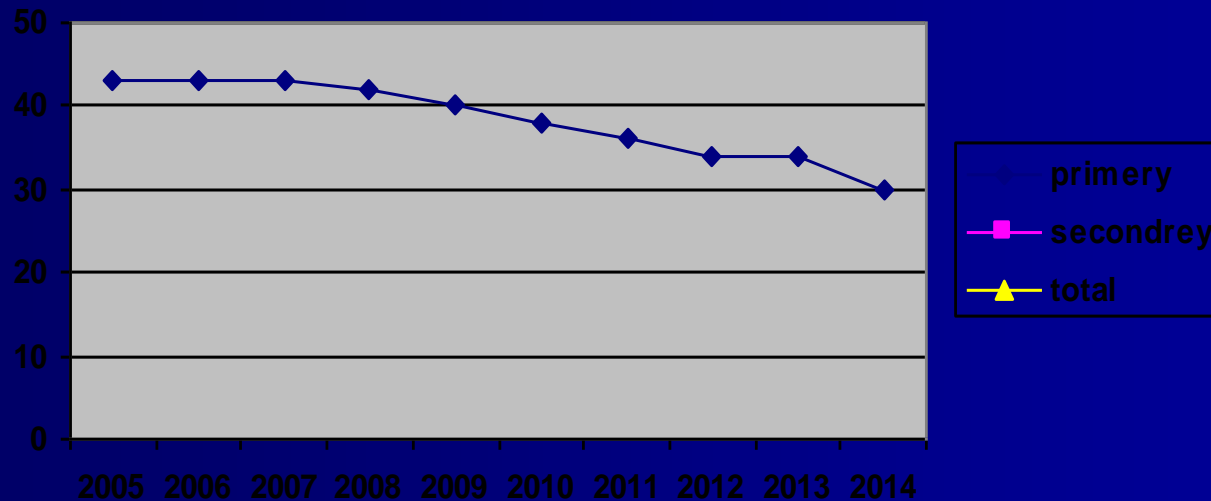
- 30 oil fields
- 47 reservoir



# Khuzestan Oilfields



## ■ One of fields production forecast 2005-2015



# Khuzestan Oilfields



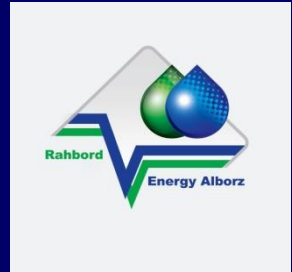
- **Gas injection and pressure maintenance plan:**
- **Ahvaz bangestan**
- **Aghajari**
- **Kupal**
- **Binak**
- **Maroon**
- **Naft sefid**
- **Bibi Hakimeh**

# Khuzestan Oilfields



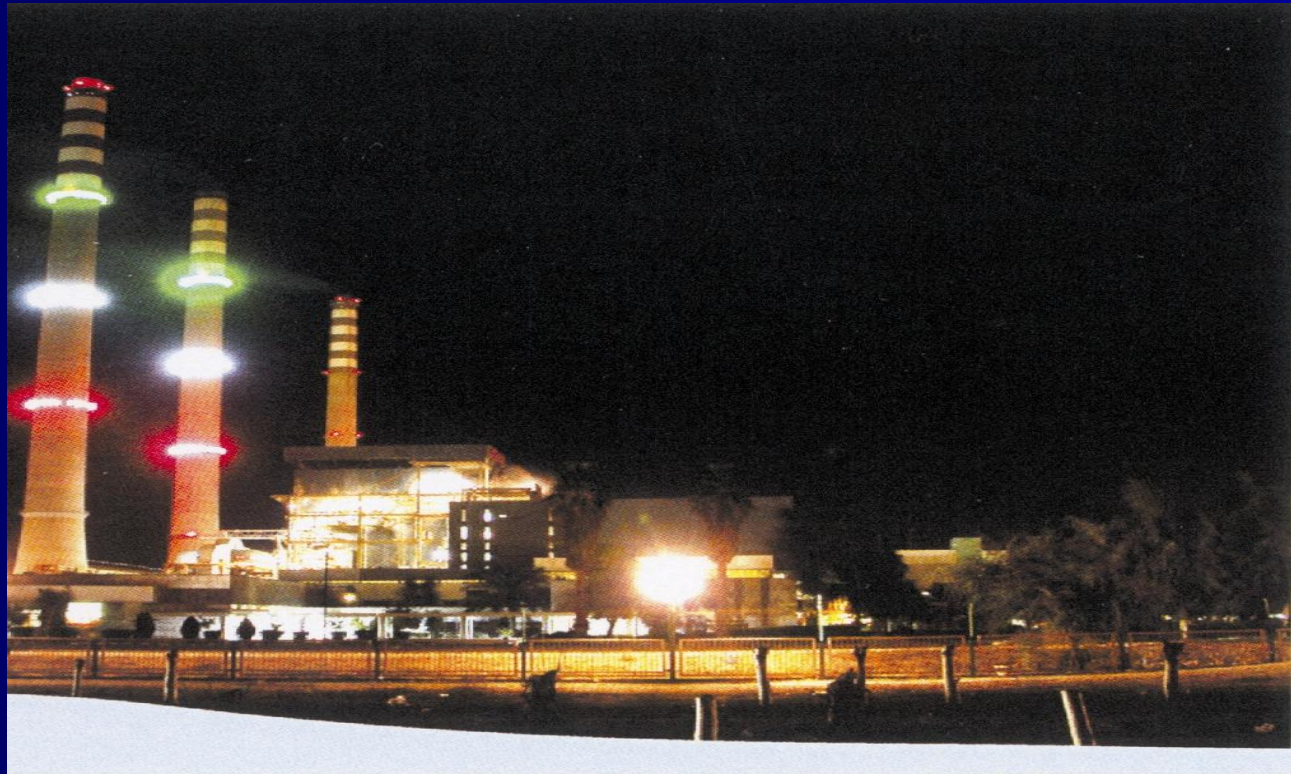
- **Gas required:**
- **217 MSCMD 2014**
- **Total: 79.205 BSCM Y 2014**
- **Total 1355 SBCM Y 2005-2015**
- **Gas will supply from :North Pars ,South Pars ,Pazanan, Aghar ,Dalan, Sahand ,Ghaleh nar**

# Khuzestan Main stationary CO2 Sources

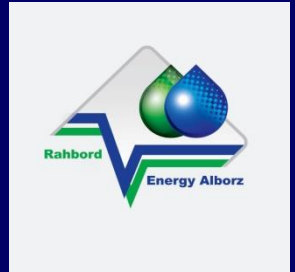


- **Power Plants: Ramin, Zargan, Abadan**
- **Refineries: Abadan**
- **Petrochemical: BIPC, Razi,...**
- **Industries: Cement factory, Ahvaz steel company**

# Ramin Power plant



# Ramin Power plant



- Ramin power plant located 25 KM north east of Ahvaz city
- Start of power generation :1979
- Ramin contains 6 unit with 350 MW capacity
- Steam boiler cycle
- 3 stage 1 shaft steam turbine each 350 MW
- Steam pressure:245 Kg/cm<sup>2</sup>
- Steam Temperature :545 C
- Steam production: 1070 ton/hour
- Wet cooling tower
- Cooling water consumption :36000 M<sup>3</sup>/hour



# Ramin Power plant



- **Real capacity:1748 MW**
- **Efficiency:37.2%**
- **Total units shut down per year :84**
- **Capacity factor:65%**
- **% excess air:100%**
- **Fuel consumption:**
  - **Each unit:70000 m<sup>3</sup>/hour natural gas**
  - **70 m<sup>3</sup>/hour fuel oil**

# Ramin Power plant



- **CO2 production:**
- **4793980 ton per year with Natural gas**
- **7085471 ton per year with heavy fuel oil**
- **Flue gas temperature:120-140C**
- **Total flue gas flow rate:7798000 m3/hour**
- **Flue gas temperature:4.27 Kg/m2**
- **Stack :3 stacks**

# Capturing plant Designing



- **Flue gas analysis**
- **Combustion analysis according to fuel composition**
- **Feed gas characterization**
- **Plant conceptual design**
- **Process basis: Amine cycle**
- **Obtain data from simulator**
- **Stream specs setting**
- **PFD & P&ID**
- **Equipment sizing**

# Capturing plant

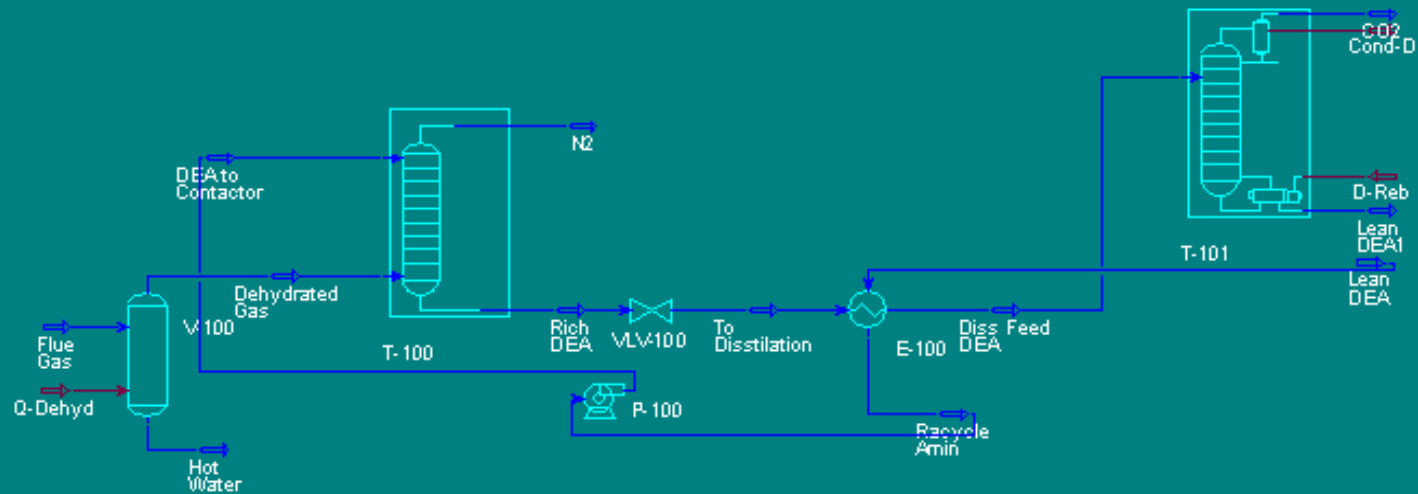


# Process description



- **Use MEA 28% as absorbent**
- **SO<sub>2</sub> washing unit (for fuel oil)**
- **Flue gas cooler and gas dehydrator**
- **Absorption column T-100**
- **Absorption in low Temperature, high Pressure**
- **Reducing pressure of rich Amine stream**
- **Amine Regeneration in 90 C, low pressure**
- **Recycling lean Amine**
- **Make up water**
- **Removing NO<sub>x</sub> (ppm tower)**
- **CO<sub>2</sub> cooling dehydration**

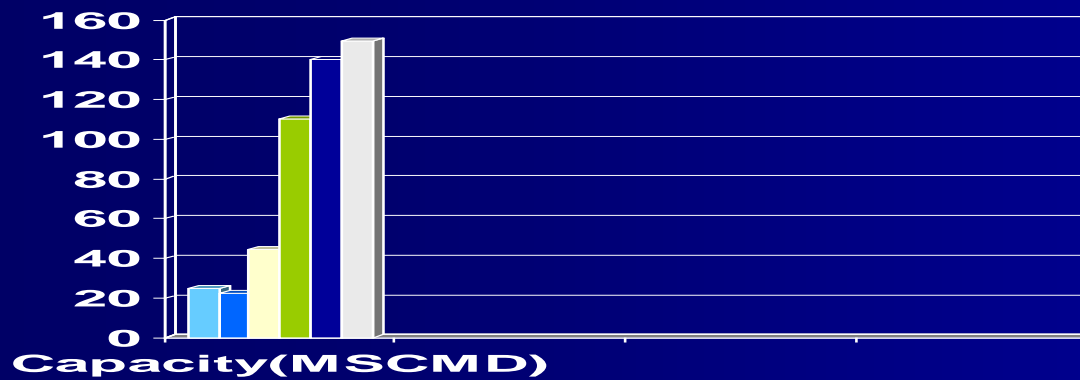
# Process description



# Capturing plant



- CO2 flow rate :178.6 Ton/hour
- CO2 purity :more than 98%
- Plant capacity:149.6 M cubic meter day



# Site Selection



- **Criteria:**
- **Reservoir history**
- **Reservoir Capacity**
- **Crude density and viscosity**
- **Distance from power plant**
- **Reservoir pressure**
- **Geology and safe storage**



# Site Selection: with MEC



File Screening Option Exit

Reservoir Name  Unit:  SI Units (Metric)  Imperial Units (Field)

Screening Type

Screen Results

Co2 Weighting Nitrogen Weighting Methane Weighting

Depth  Meter

Oil Density  Meter

Temperature  M<sup>2</sup>

Oil Viscosity  Meter

Oil Saturation  Meter

Save Changes Default Values Close

Fracturing:  Meter

Horizontal Permeability:  Degrees C°

Vertical Permeability:  kPa

Active Water Drive:  kPa

kPa

kPa

mD

mD

# Site Selection: with MEC



InfoFrm

File Screening Option Exit

Reservoir Name  Unit:  SI Units (Metric)  Imperial Units (Field)

Screening Type

**Screen Results**

Reservoir and Rock Properties | Fluid Properties | OOIP, Production and Injection Plan | Calculated Values | Production Priority

<input type="text" value="CO2"/>	Reservoir Length:	<input type="text"/>	Meter
<input type="text" value="Nitrogen"/>	Reservoir Width:	<input type="text"/>	Meter
<input type="text" value="Methane"/>	Reservoir Area:	<input type="text"/>	M <sup>2</sup>
<input type="text" value="Ranking"/>	Reservoir Thickness:	<input type="text"/>	Meter
	Porosity:	<input type="text"/>	
	Depth:	<input type="text"/>	Meter
	Formation Type:	<input type="text" value="Carbonate"/>	
	Reservoir Temperature:	<input type="text"/>	Degrees C°
	Current Oil Saturation:	<input type="text"/>	
	Initial Water Saturation:	<input type="text"/>	
	Residual Oil Saturation:	<input type="text"/>	
	Initial Pressure:	<input type="text"/>	kPa
	Bubble Point Pressure:	<input type="text"/>	kPa
	Current Pressure:	<input type="text"/>	kPa
	Fracturing:	<input type="text" value="No"/>	
	Horizontal Permeability:	<input type="text"/>	mD
	Vertical Permeability:	<input type="text"/>	mD
	Active Water Drive:	<input type="text" value="No"/>	
	Wet Type:	<input type="text" value="Water wet"/>	

# Site Selection: with MEC



	Screening Criteria	Reservoir Data	
<b>PASS</b>	Depth 2624 <	10100	Foot
<b>PASS</b>	Reservoir Temperature 77 <	213	Degree F°
<b>FAIL</b>	(Oil Density) surface 25 <	24	API
<b>PASS</b>	Dead Oil Viscosity 10 >	2.8	cp
<b>PASS</b>	Current Oil saturation 0.25 <=	0.38	fraction

Active Water Drive

(CO2 Minimum Miscibility Pressure: (MMP  PSI

CO2 MMP was estimated for pure CO2 using Cronquist correlation, without correction for molar fraction of CH4 and N2 in the reservoir oil (correlation for Live oil)

When there is NOT an Active Water Drive, The CO2 MMP must be less than the Fracturing Pressure.

**PASS** MMP <  Fracturing Pressure:  PSI

Success degree 150

War1 : hold energy penalty,oil trapping problem temporary miscibility.

**Result**  
**PASS**

# Bangestan



- Major Bangestan Reservoirs are located in vicinity.
- These reservoirs have been explored in the period between 1958 to 1968.
- Production from these filed started on 1971
- Initial pressure of this reservoir was more than 5500 psig
- Porosity:0.14
- Viscosity:1. CP
- API:25.5
- Temperature:220F
- Primary recovery factor:0.11

# One of Bangestan Reservoirs



# Transfer



- **16 inch carbon steel**
- **Internal epoxy coating**
- **Pipe line pressure 90 bar**
- **Pipe line length:25 KM**
- **Compressor station: just in start point**

# Compressor station



- **1 unit start point of pipeline**
- **Max pressure :90 bar**
- **1 unit in injection site**
- **Max pressure:387.5 bar**
- **Total capacity:56.95**

# Cost estimation



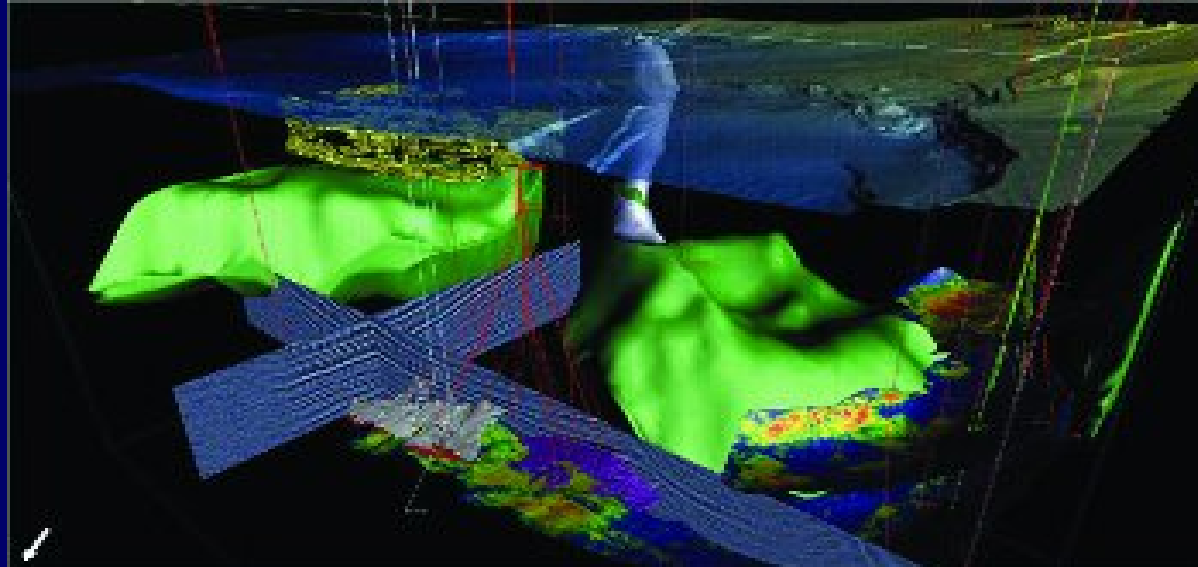
- **Capturing plant :920 M\$**
- **Pipe line:75 M\$**
- **Compressor station:150 M\$**
- **Drilling completion & Surface facilities:170 M\$**
- **Total:1248 Million \$**
- **Operating costs:3% per year**
- **Steam 1400 Tons per hour**
- **Electrical Power : 392 MW**



# Oil production



- Increase in production 70000bbl day
- Based on CO2 Injection Simulation



# Economic evaluation



- **Project economy evaluated in different level of oil price**
- **Oil prices considered at 28\$,35\$,45\$,55\$,70\$,85\$ per barrel**
- **Investment recovery estimated In each oil price level**

# Economic evaluation



- **Return time changes between 6.5 years at price 28\$/bbl to 1.9 years at price 85\$/bbl in low production scenario**
- **Return time changes between 3.5 years at price 28\$/bbl to 1.1 years at price 85\$/bbl in high production scenario**
- **Carbon dioxide avoided cost: 49 \$/ton CO<sub>2</sub>**

# Economic evaluation



- **Economy can be improved by Environmental aids**
- **CDM facilities can improve economy between 15-30% depend on oil price level**

# Recommendation:



- **More detailed design and feasibility study should be defined about Ramin project to obtain better economical outlook**
- **Reservoir study should be defined for clear site selection**

# Thanks for attention

