Scope of Tight Gas Reservoir In Pakistan

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Agenda

- Definition of Tight Gas Reservoir
- Required Technology to Develop TGR
- Tight Gas in Pakistan
- Tight Gas USA Experience
- Conceptual Development of TGR in Pakistan
- Economic Modeling of TGR
- Conclusion

Definition of Tight Gas Reservoir

i. Reservoir is designated as tight if:
   1. The effective permeability is less than 1 md and generally the un-stimulated gas flow rates is less than 1.0 mmscfd

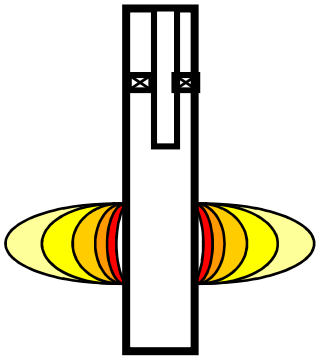
ii. In the TGR's, there are lots of uncertainty regarding:
   1. Irreducible water saturation and the connate gas saturation,
   2. Overburden correction factor that has a big impact on the low permeability range value
   3. Net pay of the formation
   4. Presence or absence of natural fractures

Required Technology for TGR Development

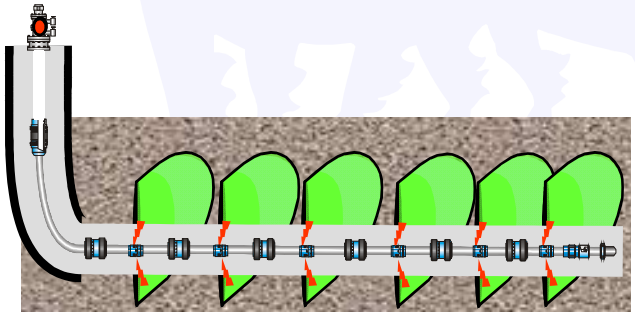
i. Wells productivity pre-stimulation is less than 1.0 MMscf/d.

ii. To improve the wells productivity, stimulation technique should be applied

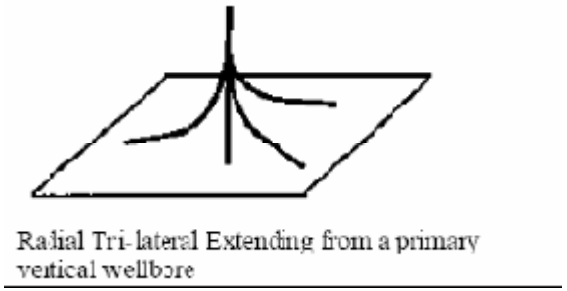
1. hydraulic fracture, (there are some examples in Pakistan)
2. multi-fractured horizontal wellbore (No application to date in Pakistan)
3. multi-lateral wellbores, (No application to date in Pakistan)



Vertical Well
Hydraulic fracture

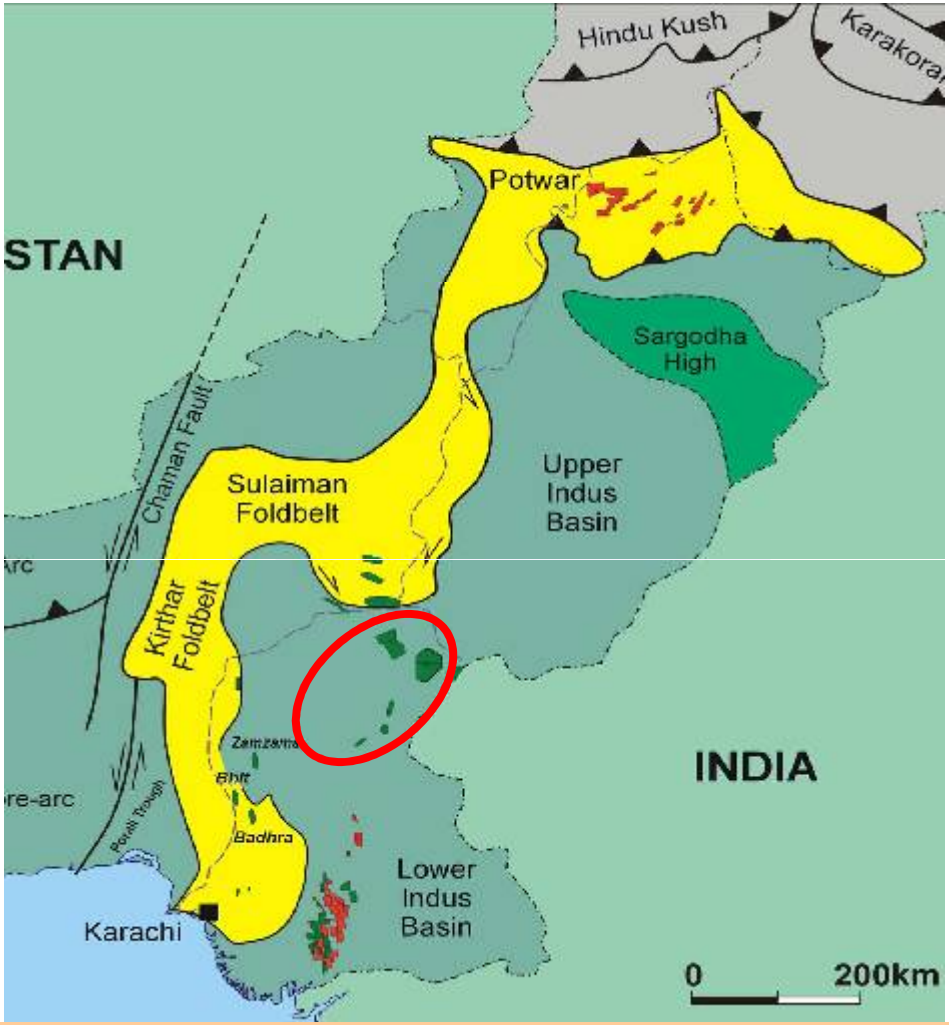


Horizontal Well
Multi fractured



Multi Lateral Well

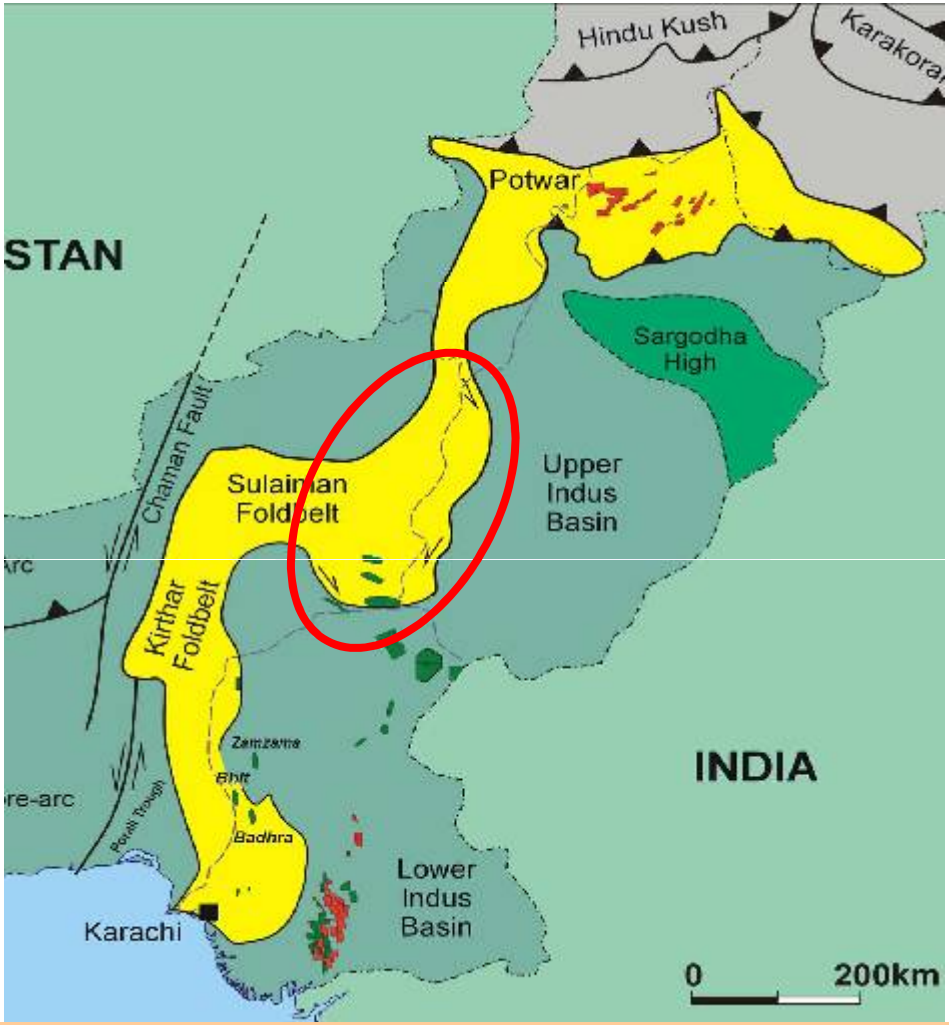
Tight Gas in Middle Indus Pakistan



Block	No. of Prospects	Reservoir	GIIP(bcf)
8	11	7	7,400

With the courtesy of Eni, OMV

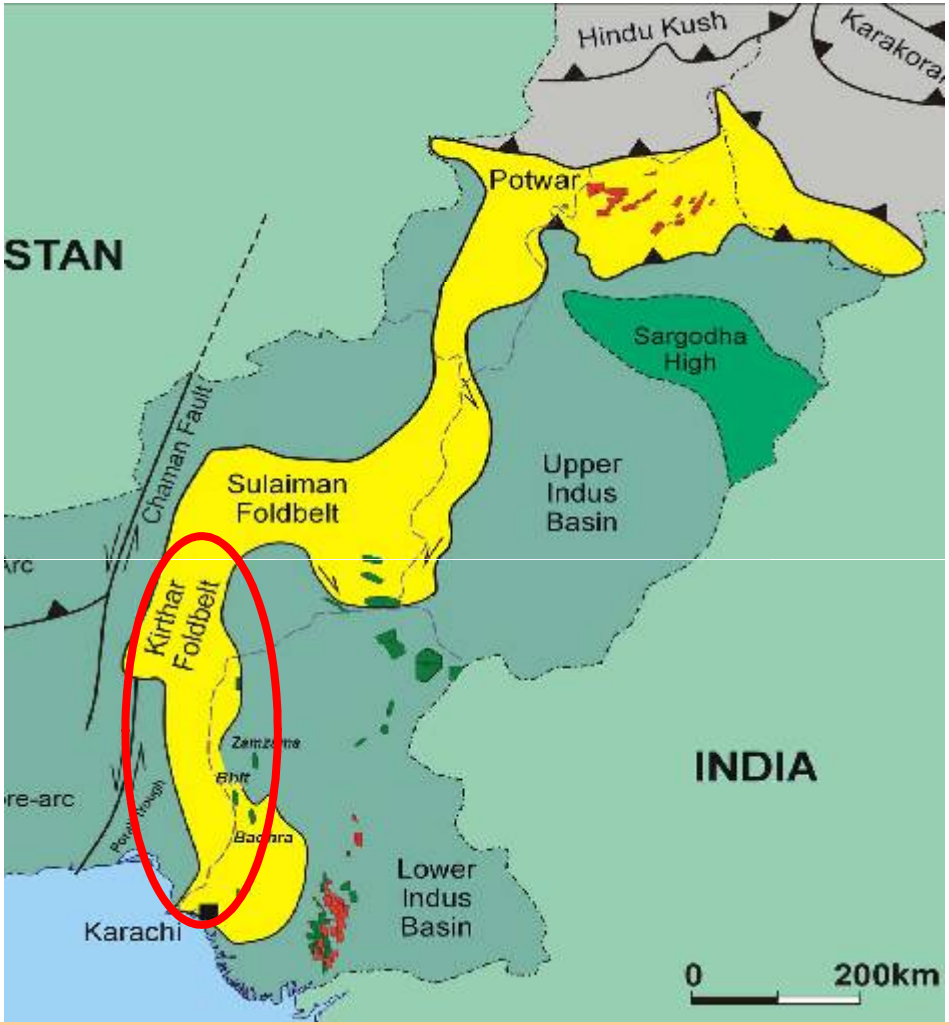
Tight Gas in Sulaiman FB of Pakistan



Block	No. of Prospects	Reservoir	GIIP(bcf)
9	14	3	19,000

With the courtesy of Eni, OGDCL

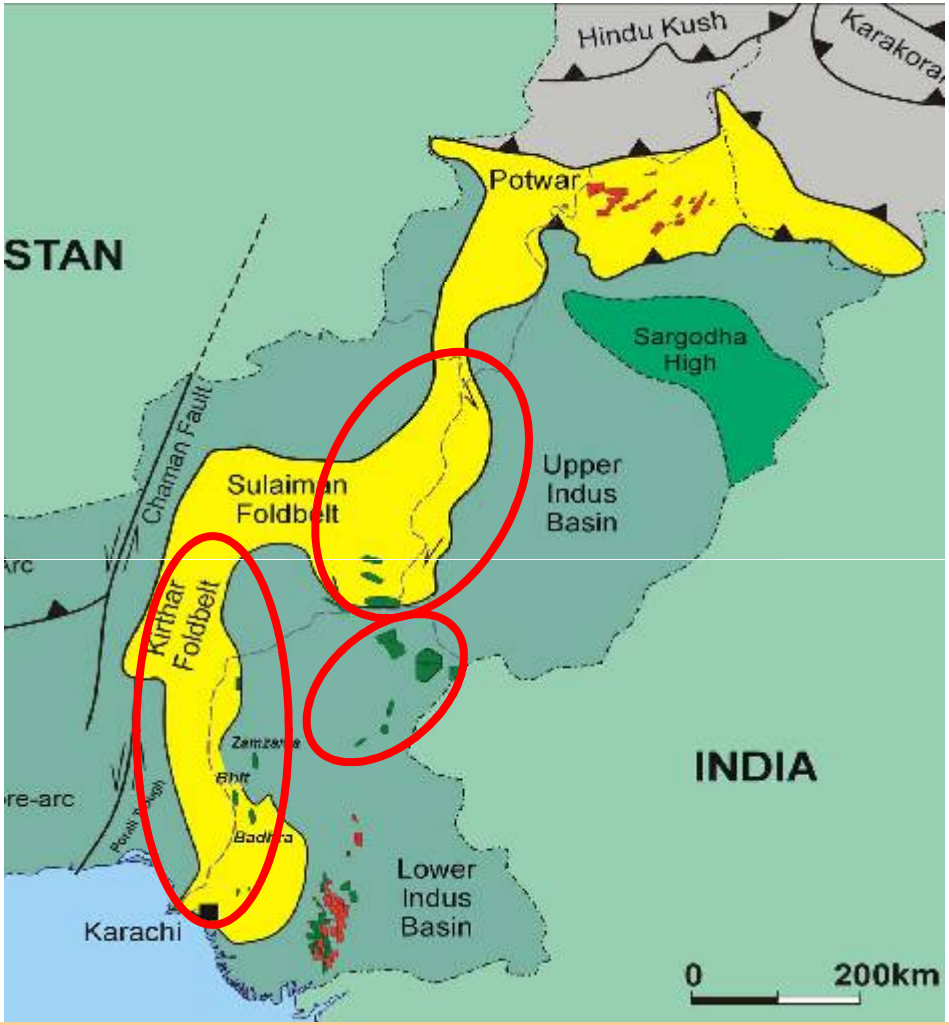
Tight Gas in Kirthar FB of Pakistan



Block	No. of Prospects	Reservoir	GIIP(bcf)
7	8	2	7,300

With the courtesy of Eni, OGDCL

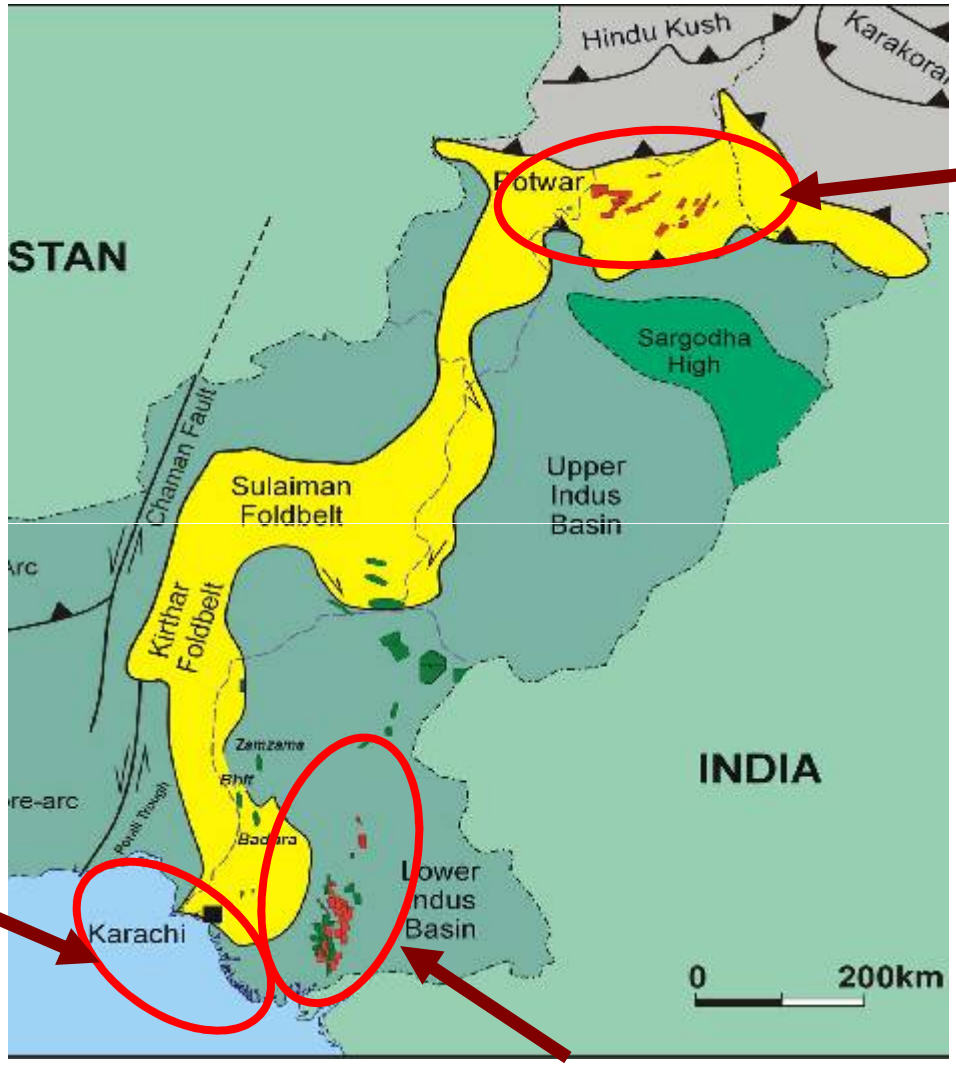
Total Known Tight Gas in Pakistan



Block	No. of Prospects	Reservoir	GIIP (bcf)
19	26	8	33,700

With the courtesy of Eni, OGDCL, OMV

Tight Gas in other parts of Pakistan ?



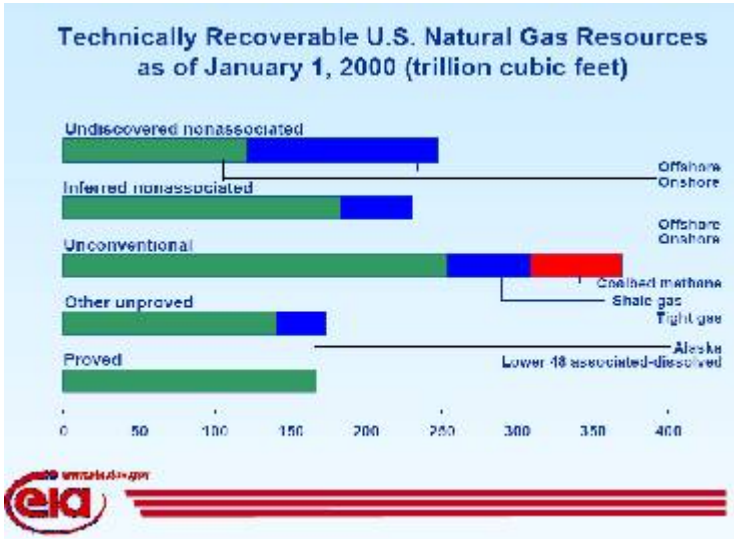
Potwar

Offshore

L- Indus Basin

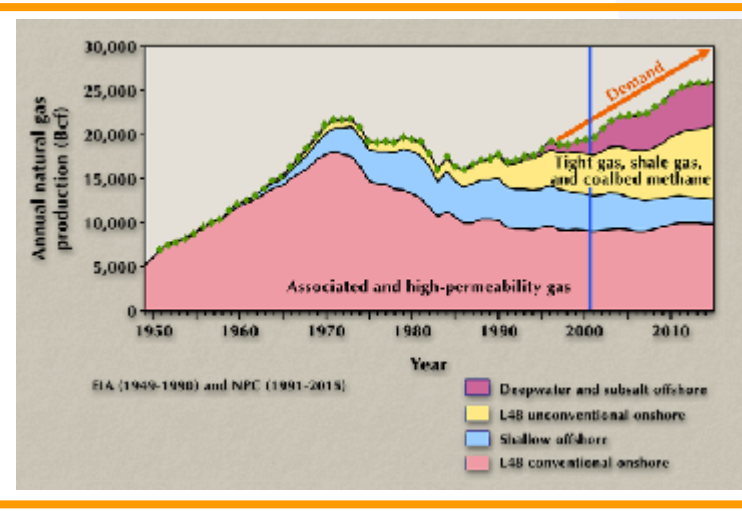
US Gas Resources and Tight Gas Production

Resource



Technical Recoverable U.S. Natural Gas Resources as of Jan. 1, 2000. The largest category is unconventional resources with 370 Tcf, with most of that from Tight Sandstone at 69 %.

Production

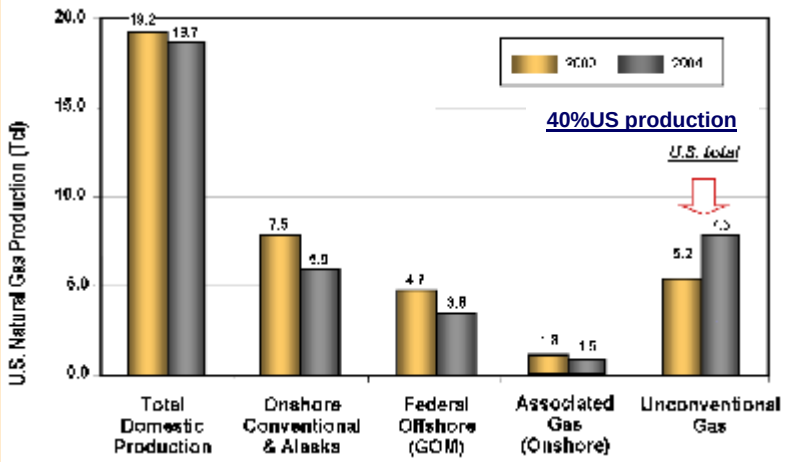


Annual Natural Gas production in the United States since 1949, showing the major components of the natural gas production curve (Sources: EIA from 1949-1990 and NPC from 1991-2015).

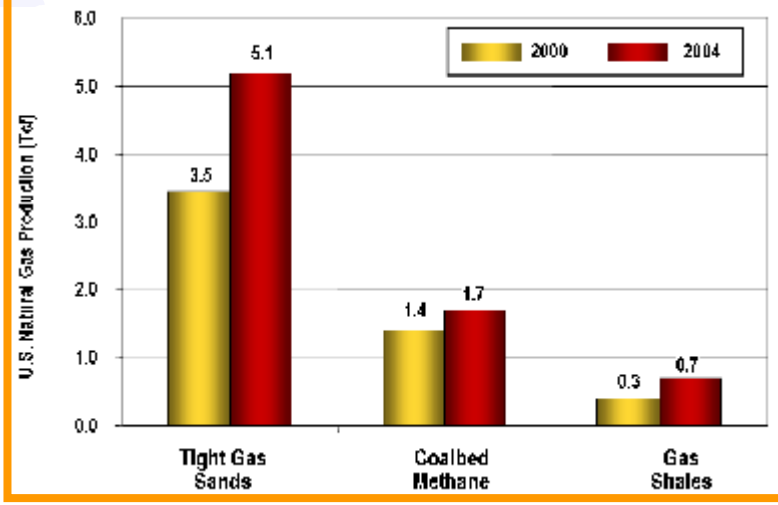
EIA: Energy Information Administration
NPC: National Petroleum Council

US Gas Production in 2000 Vs 2004

U.S Natural Gas Production, 2000-2004



U.S Unconventional Gas Production, 2000-2004



Unconventional Gas accounts, in 2004, 40% of the U.S. Natural Gas Production. All three unconventional gas resources have experienced increased production.

Advanced Resources International, Inc

Unconventional Gas Resources in US (Case Histories)

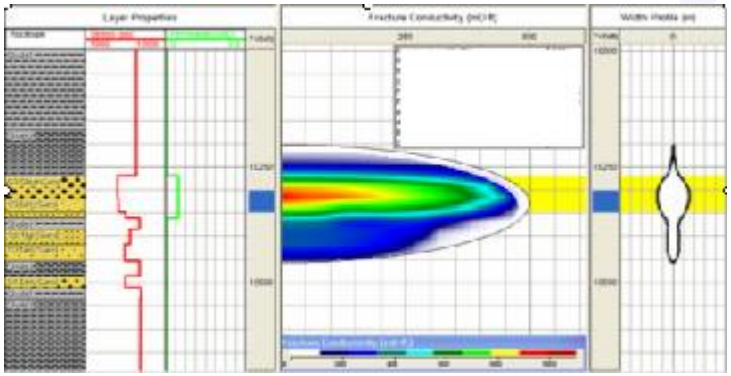
	First Generation	Second Generation	Third Generation	Current
	Pre-1990	1992-1993	1994-1995	2000+
Pay Selection	Bottom 40%	Bottom 20-50%	50%	50% to 100%
Frac Stages	1	1	3	Up to 10
Frac Fluid	X-Link Gel	N_2	N_2/Gel	Borate Gel
IP (MMcf/d)	1.4	1 to 4	3 to 5	5 to 15
EUR (Bcf)	1.5	2.0	3.0	5 to 10+

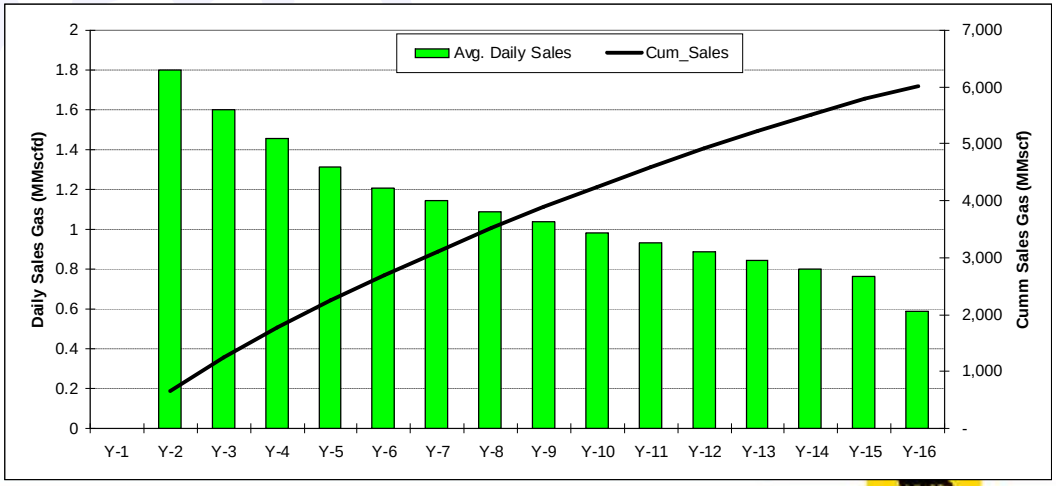
Evaluation of well completion practices, Jonah Field, Great Green River Basin (GGRB) is the dominant natural gas-producing basin in the Rocky Mountains (Colorado).

Tight Gas Sands Development– How to Dramatically Improve Recovery Efficiency,
by Vello A. Kuuskraa, Advanced Resources International, Inc. and James Ammer, NETL
Winter 2004 • GasTIPS

Tight Gas Reservoir (Pilot Well) Production

i. Pilot well have been selected to determine the expected production profile from tight gas reservoir in Pakistan using 3D numerical simulator.
   i. Well will be tied into existing facility
   ii. Well can't produce without hydraulic fracturing
   iii. Expected Fracture parameters
      i. Half length, xf=164 ft , Height ~ 118 ft
      ii. Fracture conductivity, 2417 mD.ft , Fracture width, w= 0.15 in
   iv. Initial gas rate after the hydraulic fracturing is around 2 mmscf/d
   v. Well decline from 2 to 1 MMscf/d in the initial 8 years.
   vi. Estimated Well cumulative sales gas is ~ 6 bcf.





Tight Gas Sand Conceptual Development 1/2

Conceptual development for a Tight Gas Reservoir:

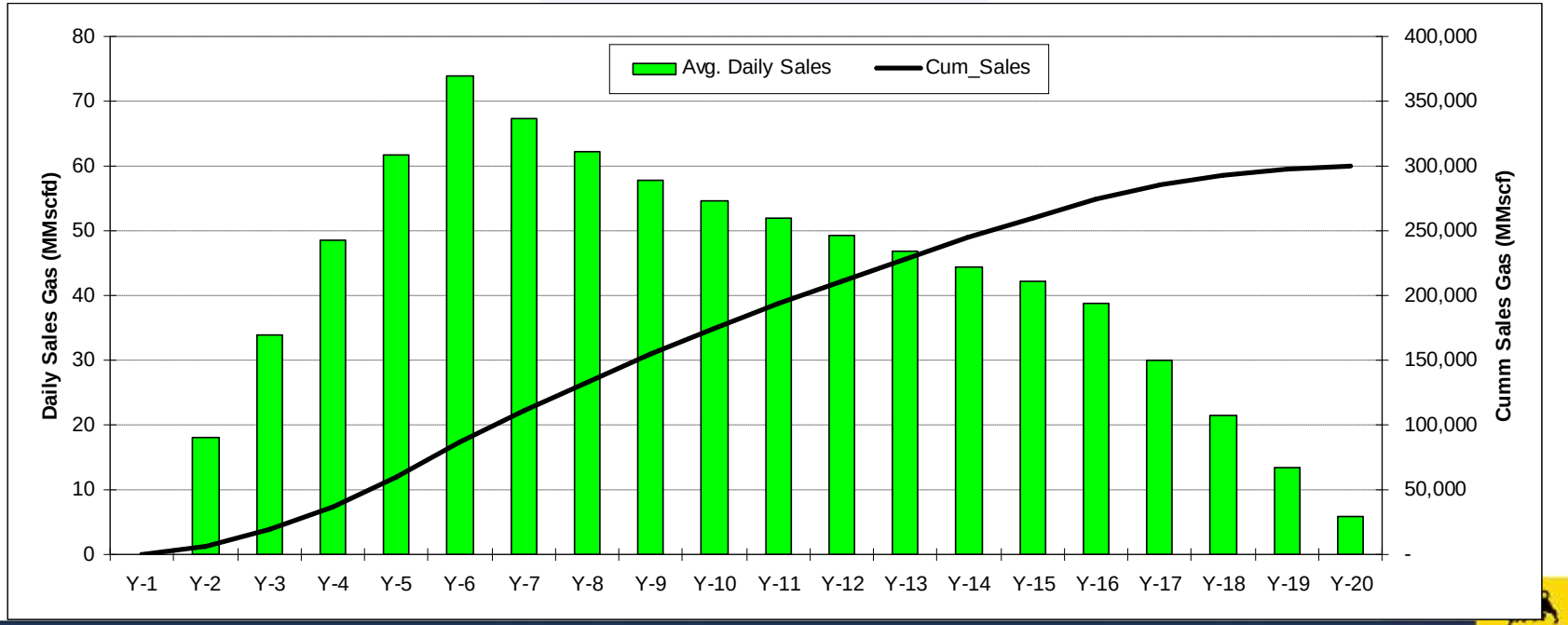
i. Pilot well production profile is the base of total field (Initial rate is 2 MMscf/d and cum production is ~ 6 BCF / Well)

ii. No of wells Estimated to produce around 300 bcf (50 Wells with hydraulic fracture)

iii. 10 Wells will be drilled every year.

iv. 1st gas after 1 year from approved FDP

v. Duration of the field production is 20 years.



Tight Gas Sand Conceptual Development 2/2

i. **Wells will be tied into an existing facility.**
ii. 50 wells with hydraulic fracture stimulation are required to produce ~ 300 Bcf in 20 years.
iii. Well Drilling, completion and fracturing estimated cost is 13 M$/Well
iv. Tie-in cost is 3 M$/Well and abandonment cost is 1 M$/Well
v. Cost will be escalated 5% every year.
vi. OPEX is estimated at 3.5$/BOE

i. Total CAPEX ~ 884 M$
ii. Total OPEX ~ 183 M$
iii. Potential CAPEX Saving:
    i. Multi-lateral drilling
    ii. Clustered drilling

	No of Wells	Production WH Sales		ANNUAL Sales	Capex (KUS$)		OPEX
Year		MMscf/d	MMscf/d	MMscf	Drilling	Facilities	KUS$
Y-1	10			-	130,000	30,000	-
Y-2	10	20	18	6,574	136,500	31,500	4,007
Y-3	10	38	34	12,424	143,325	33,075	7,573
Y-4	10	54	49	17,748	150,491	34,729	10,818
Y-5	10	69	62	22,540	158,016	36,465	13,739
Y-6		82	74	26,948			16,426
Y-7		75	67	24,562			14,972
Y-8		69	62	22,690			13,831
Y-9		64	58	21,146			12,889
Y-10		61	55	19,945			12,157
Y-11		58	52	18,947			11,549
Y-12		55	49	18,000			10,972
Y-13		52	47	17,100			10,423
Y-14		49	44	16,245			9,902
Y-15		47	42	15,433			9,407
Y-16		43	39	14,158			8,630
Y-17		33	30	10,918			6,655
Y-18		24	21	7,839			4,778
Y-19		15	13	4,915			2,996
Y-20		7	6	2,136			1,302
Y-21		0	0	-			-
Total	50			300,267	718,332	165,769	183,026

TGR Conceptual Development Project, Economic Evaluation Using 2008 Draft Policy and Pricing (Zone-3)

Total CAPEX (MUS $)	884
Total OPEX (MUS $)	183
No. of Wells	50
Total Cost per well	17.7
Project NPV (MUS$)	- 410
PV Government Take (MUS$)	62
Project IRR	- 6.33 %
Reserves (BCF)	300
Total Cost ($/boe) @ 12.5 % Discount Rate	$ 14.21
CAPEX $/boe @ 12.5 % Discount Rate	$ 12.71
OPEX $/boe @ 12.5 % Discount Rate	$ 1.5

The Project is not economic

To make it Economic other policy/pricing scenario is required

TGR Conceptual Development Project, Economic Evaluation
Assumed Economic Model

- Type of Contract: Petroleum Concessions Agreement
- Location: On-shore fields.
- Sliding Scale taxation system based on Annual R-Factors
- No production bonuses
- Zonal Index used : 75%
- Pricing Mechanism: Improved gas pricing with higher Reference Crude Price slabs
- Discount Rate: 13%
- Price Floor set at 42 $ / boe
- Evaluation Year : 2009 (Year 1)

Assumption for TGR Gas Pricing

Zonal Index = 75 %

Applicable Marker Price (Pm)			Increment
Price Floor: For RCP < = 56; Marker Price = 56 $/bbl			
56	RCP < =	60	100%
60	< RCP < =	75	50%
75	< RCP < =	100	25%
100	< RCP < =	150	15%

Pg = Pm * 0.75 / Cf

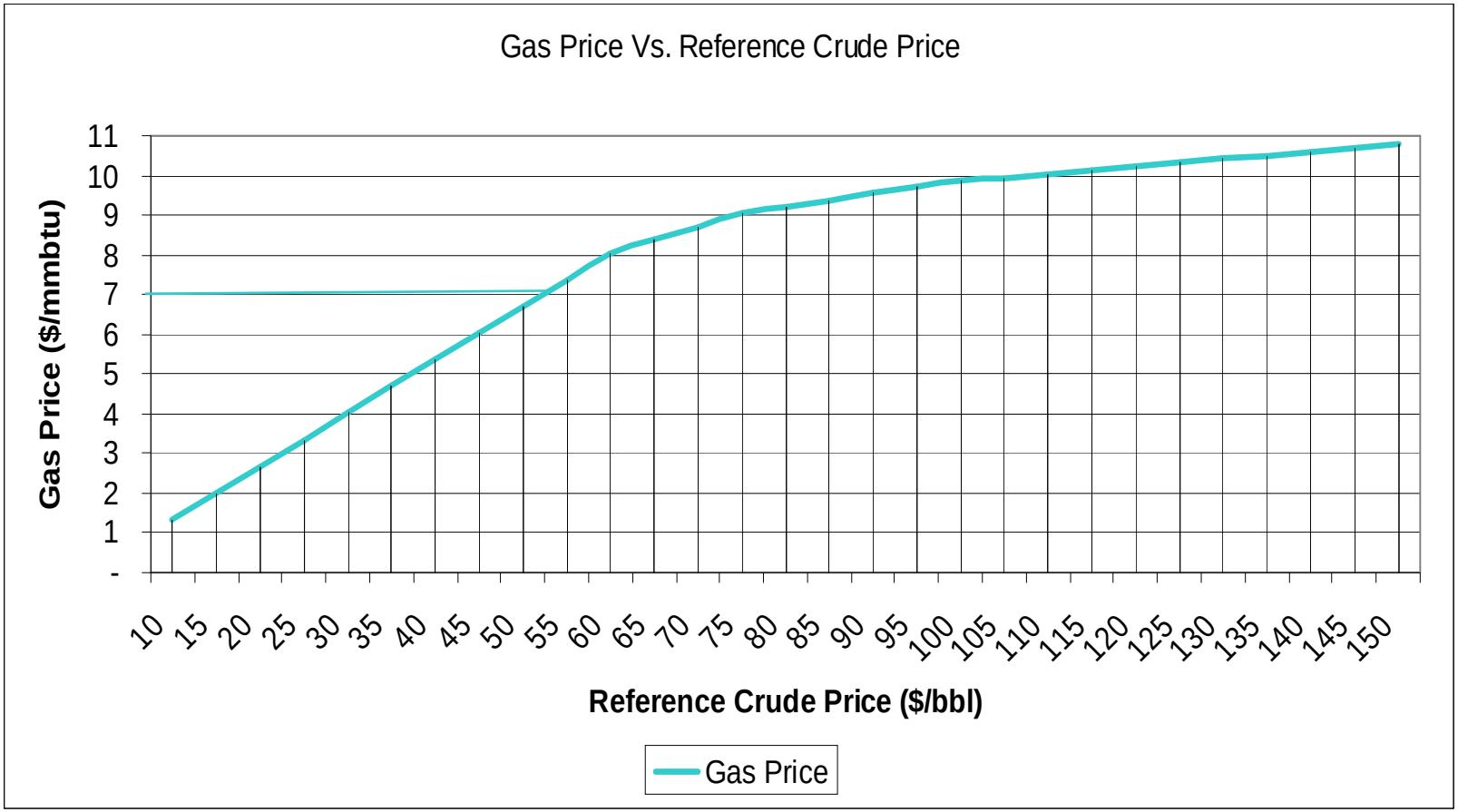
Where Pg is the Gas Price in USD per MMBTU
Pm is the Applicable Marker Price in USD per barrel determined as follows:

- Price Floor set at RCP 56 $/bbl which gives a gas price of $42 / boe
- When RCP is between USD 56/barrel and USD 60/barrel, Pm equals RCP;
- When RCP is higher than USD 60/barrel and not over USD 75/barrel, Pm equals 60 plus 50% of the incremental RCP above USD 60/barrel;
- When RCP is higher than USD 75/barrel and not over USD 100/barrel, Pm equals 67.5 plus 25 % of the incremental RCP above USD 75 /barrel;
- When RCP is higher than USD 100 /barrel and not over USD 150 /barrel, Pm equals 73.25 plus 15 % of the incremental RCP above USD 100 /barrel;.

Cf = Conversion Factor from $/boe to $/mmbtu set at 5.6

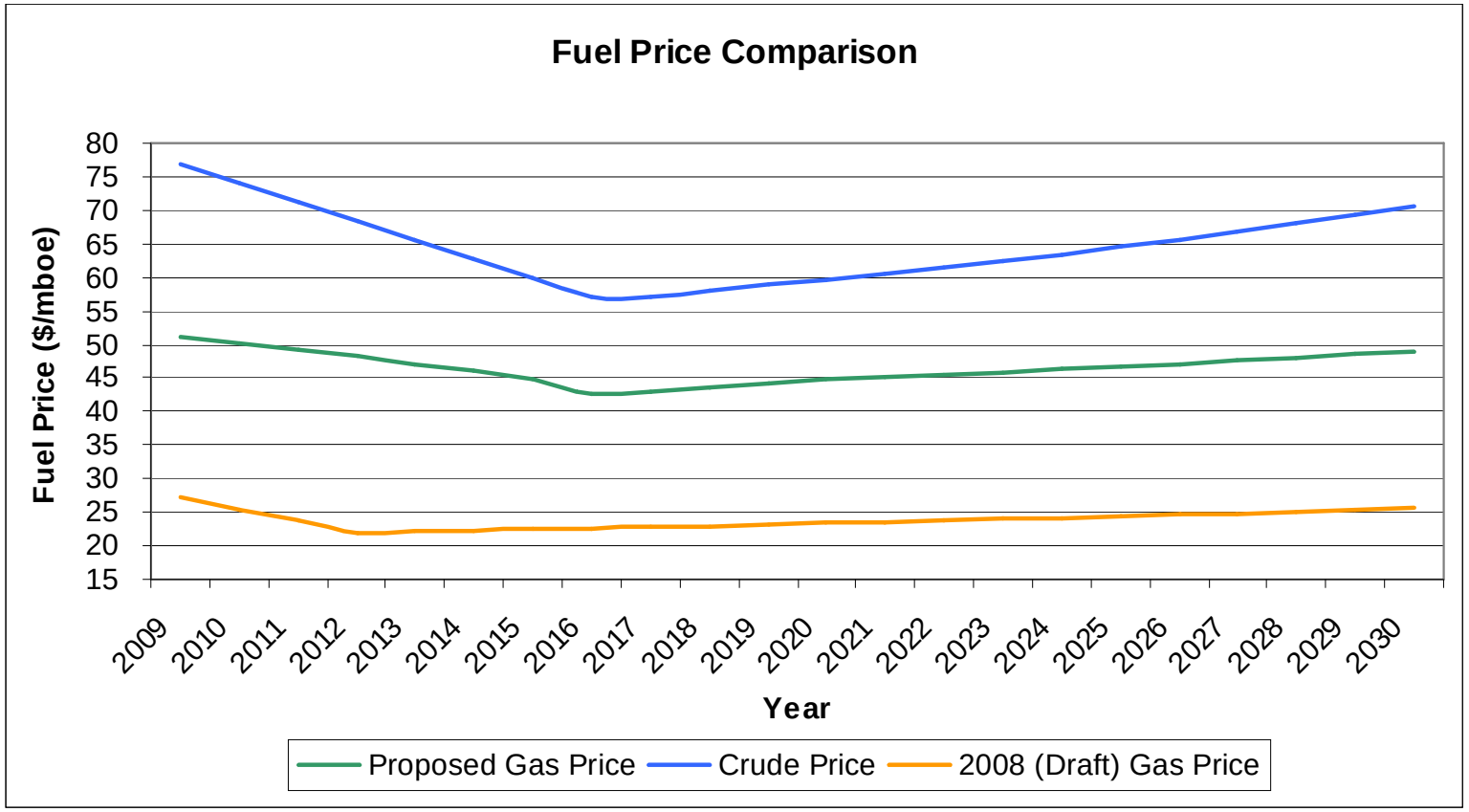
Reference Crude Price Vs. Gas Price

Calculation of Gas Prices using the proposed pricing mechanism



Model Price Comparison with Gas and Reference Crude Price

- **Current Gas Price as per Draft 2008 policy**
- Evaluated commercial Gas Price for this model
- Reference crude price: Low Sulphur Light Crude Oil Price Forecast 2006 – 2030 provided by EIA



Tax and Royalty Assumptions

R- Factor = Cumulative Earnings / Cumulative Costs

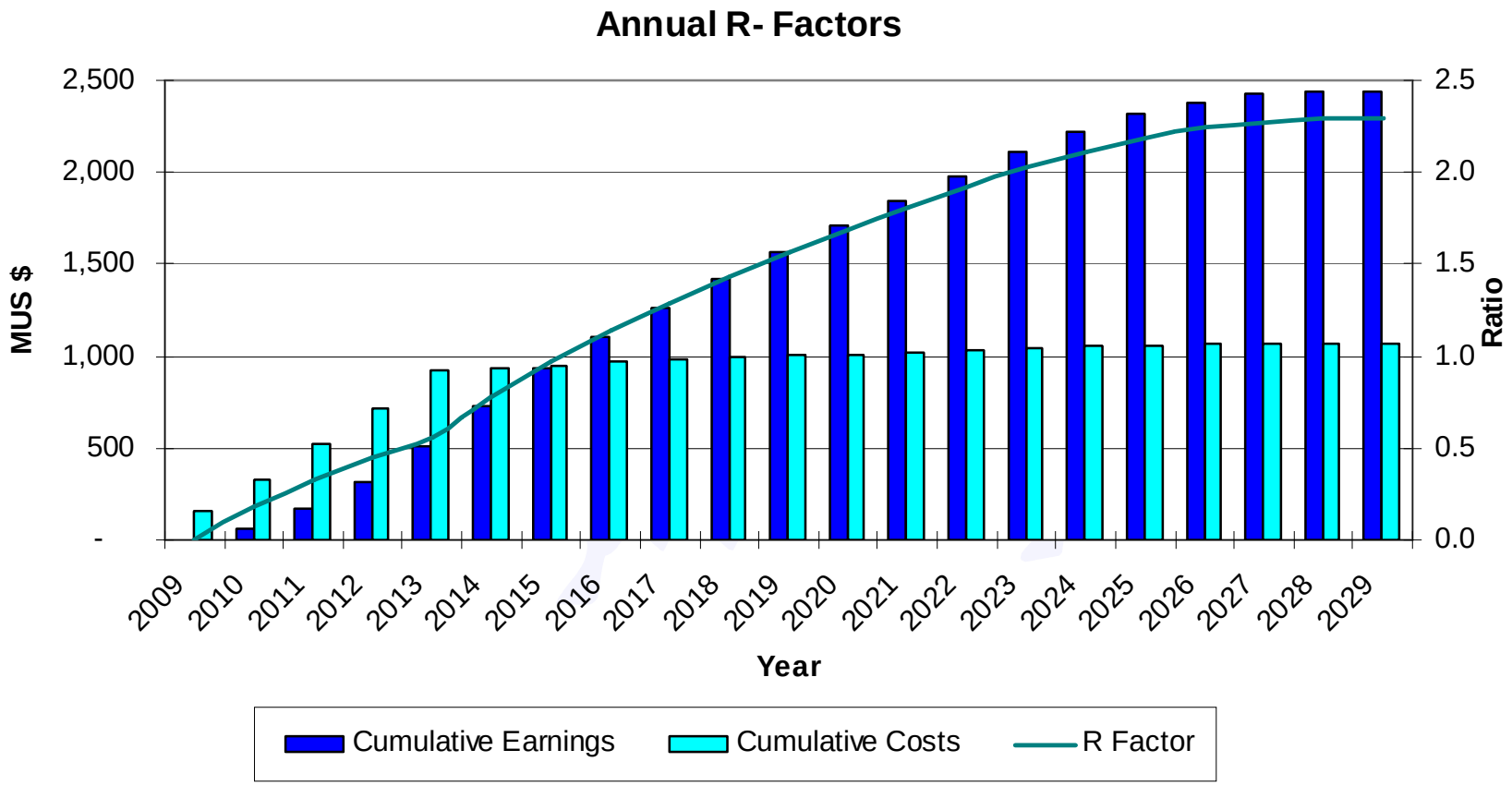
- Tax Rate applied according to the slabs provided below:

R factor			Tax Rate
-	< R < =	1.50	0%
1.50	< R < =	2.00	15%
2.00	< R < =	2.50	30%
	R >	2.50	40%

- Royalty Rate applied:

Royalty Rate = 12.5 % of Gross Revenues from the commencement of production

Annual R-Factor



TGR Conceptial Development Project, Scenario Summary

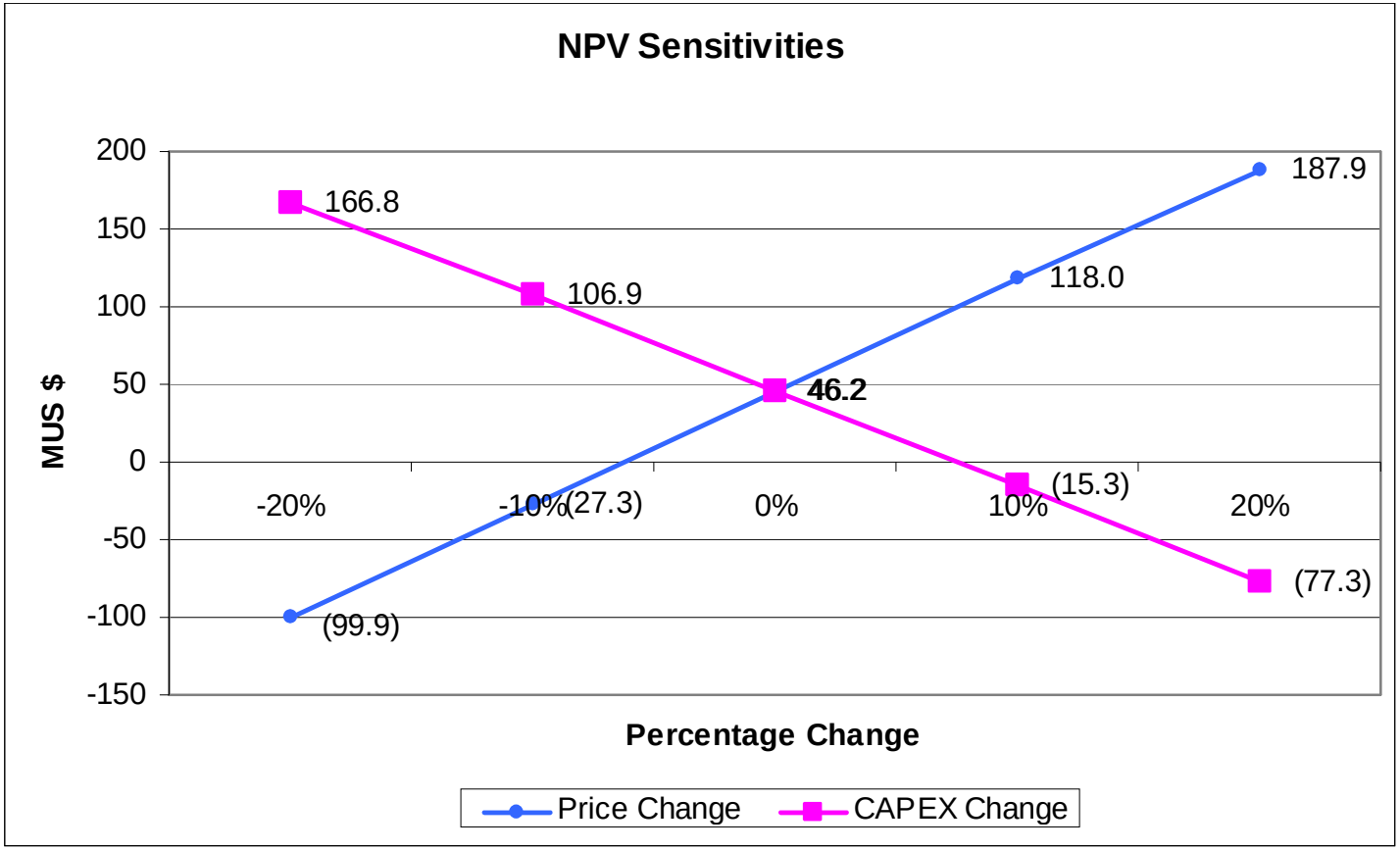
Using proposed economic model

Total CAPEX (MUS $)	884
Total OPEX (MUS $)	183
No. of Wells	50
Total Cost per well	17.7
Project NPV (MUS$)	46
*NPV Government Take (MUS$)	141
Project IRR	15 %
Reserves (BCF)	300
Total Cost ($/boe) @ 13 % Discount Rate	$ 13.45
CAPEX $/boe @ 13 % Discount Rate	$ 12.18
OPEX $/boe @ 13 % Discount Rate	$ 1.26

* Additional benefit to Government is the reduction in furnace oil consumption not incorporated.

TGR Development Project, NPV Sensitivities

NPV sensitivities by changing Price and CAPEX



Conclusion

- More than 33 TCF (~ 5,700 MMboe) Gas Initial In Place distributed in different areas of Pakistan, while large area still unknown.

- Tight Gas Reservoirs producing in other part of the world.

- Tight Gas Reservoir in Pakistan could commercially produce provided the availability of:
  - Required technology at competitive price
  - Suitable fiscal terms including but not limited to:
    i. Improved pricing mechanism
    ii. R-Factor based taxation
    iii. Minimum price floor
    iv. Elimination of production bonuses

Questions/Remarks
Open Discussion