Energy Efficiency Gains in Indian Ammonia Plants Retrospect and Prospects

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Outline of Presentation

1. Ammonia Industry in India – A Profile
2. Energy Consumption Trends
3. Relevance of Feedstock, Technology, Vintage and Size of Plants for Energy Efficiency
4. Benchmarking Energy Efficiency
5. Energy Conservation Measures – A Retrospect
6. Recent Efforts in Energy Conservation
7. Case Studies of an Old and a Relatively New Plant
8. Prospects for Further Improvement in Energy Efficiency

Ammonia Industry in India

- First large ammonia plant in 1951 (270 MTPD) using coke oven gas as feedstock
- Second ammonia plant in 1961 (300 MTPD) using hydrogen from electrolysis
- A number of 450-900 MTPD plants in 1960's and 70's using naphtha and heavy oils as feedstock
- 7 large plants in 1980's using natural gas feedstock
- Another 7 large plants in 1990's based on natural gas and naphtha feedstock

Table 1: Profile of Indian Ammonia Plants (2004-05)

Vintage	No. of Plants
1960's	3
1970's	11
1980's	12
1990's	12
Total	**38**

Feedstock	No. of Plants
Gas	21
Naphtha	13
Fuel Oil	4
Total	**38**

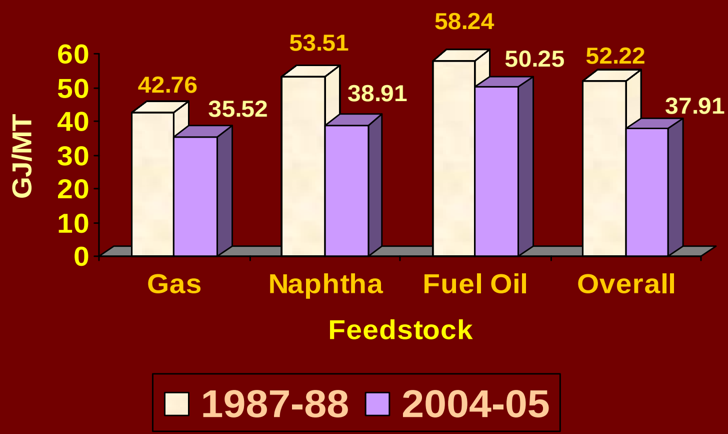
Size of Plants (MTPD)	No. of Plants
< 600	8
600 to < 900	3
900 to <1500	11
≥1500	16
Total	**38**

Accounting of Energy Consumption

- Electricity at conversion factor of
  1 KWH = 2520 kCal (10.543 MJ)
- Steam import/export at enthalpy value
- Inclusion of energy consumption in support facilities e.g. water and effluent treatment, cooling towers, etc.
- Consumption figures are the weighted average for the year.
- Accounting year: April-March

Energy Consumption Trends

Figure 1: Feedstock Wise Energy Consuption of All Ammonia Plants



Comment: Improvement by combination of new capacity and modernisation of old plants

Energy Consumption Trends

(continued..)

Table 2: Feedstockwise Energy Consumption of Old Ammonia Plants Operational in 2004-05

SL. No.	Feedstock (plants)	Average Energy (GJ/MT)		
		1987-88	2004-05	% Improvement
I	Gas (5)	41.59	37.99	8.7
II	Naphtha (8)	51.04	42.13	17.5
III	Fuel Oil (4)	56.57	50.25	11.2
	Overall (17)	**47.99**	**42.17**	**12.1**

Relevance of Feedstock, Technology, Vintage and Size of Plants for Energy Efficiency

Table 6: Feedstock wise Capacity and Energy Consumption (2004-05)

Feedstock	No. of Plants	Capacity ('000 MT)	Energy Consumption (GJ/MT)
Gas	21	8344.4 (62.2%)	35.52
Naphtha	13	3680.4 (27.5%)	38.91
Fuel Oil	4	1386.0 (10.3%)	50.25
Total	**38**	**13410.8**	**37.91**

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Table 3: Capacity and Energy Consumption based on Type of Compressors (2004-05)

Type of Compressor	No. of Plants	Capacity ('000 MT)	Average Energy (GJ/MT)
Reciprocating	6	844.1 (6.3%)	39.37
Centrifugal	32	12566.7 (93.7%)	37.87
Total	**38**	**13410.8**	**37.91**

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Table 4: Vintage-wise Capacity and Energy Consumption (2004-05)

Year	No. of plants	Capacity ('000 MT)	Energy Consumption (GJ/MT)
1960's	3	475.1 (3.5%)	40.00
1970's	11	2950.3 (22.0%)	45.35
1980's	12	4919.2 (36.7%)	38.62
1990's	12	5066.2 (37.8%)	33.51
Total	**38**	**13410.8**	**37.91**

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Table 5: Plant size wise Capacity and Energy Consumption (2004-05)

Size	No. of plants	Capacity ('000 MT)	Energy Consumption (GJ/MT)
< 900	11	1858.7 (13.9%)	45.73
$\geq$ 900	27	11552.1 (86.1%)	37.32
Total	**38**	**13410.8**	**37.91**

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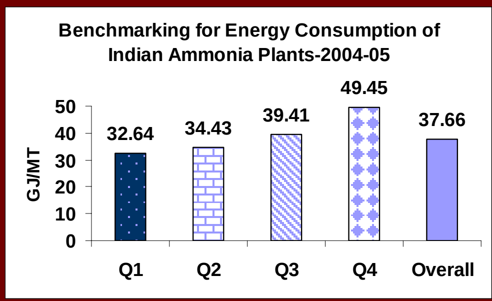
Internal Benchmarking



Quartiles

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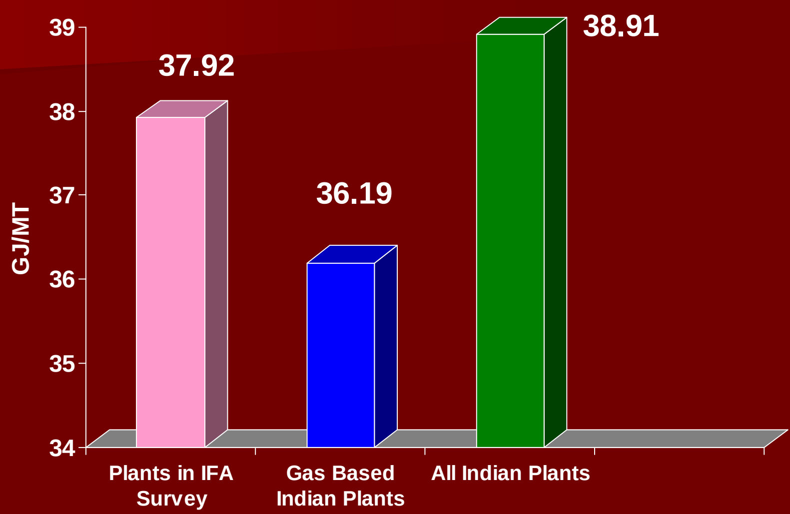
External Benchmarking



For the year 2002-03

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External Benchmarking (continued..)

Table 7: Feedstock-wise Energy Data of Indian and Chinese Ammonia Plants (1999-2000)

Feedstock	Indian Plants		Chinese Plants	
	No. of Plants	Average Energy (GJ/MT)	No. of Plants	Average Energy (GJ/MT)
Gas	15	35.06	8	36.69
Naphtha	3	38.83	5	38.70

Source: *Wang Wenshan, "The Status Quo of China's Synthetic Ammonia and Urea Production Based on Natural Gas and Oil" – IFA Production and Industrial Trade Committee Meeting, 17-19 October, 2000.*
FAI Data for Indian Plants

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Energy Conservation Measures

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Gas Making

- Thermal efficiency of primary reformers
  - Improvement in recovery of heat from furnace exhaust gases
  - Better insulation
  - Excess air control
- Efficiency in reforming
  - Lower steam carbon ratio
  - Superior tube metallurgy
- GT drive for air compressors

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Gas Purification

- Extra catalyst for CO slip from shift reactor
- More efficient CO_2 removal process

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Synthesis Section

- Change of gas flow in synthesis converters from axial to radial or radial-axial
- Hydrogen recovery from purge gas
- Cooling of syn-gas at the inlet of the compressor
- Molecular sieve drying of synthesis gas

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Recent Efforts in Energy Conservation

- Installation of Pre-reformer
  - Flexibility in feedstock
  - Lower steam-carbon ratio
  - Reforming at lower temperature

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Recent Efforts in Energy Conservation

(continued..)

- Installation of S-50 Converter
- Liquid ammonia wash of synthesis gas
- Two stage regenerator in CO_2 removal system

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Case Studies

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Case 1: Energy Conservation in Unit 1
(910 MTPD plant of 1974 vintage)

- Better metallurgy reformer tubes
- Additional heat recovery from furnace off gases
  - Temperature of Off-gases brought down from 290 to 200°C
- Change from MEA solution to activated MDEA for CO_2 removal - 30% reduction in energy consumption
- Synthesis converter retrofit increased conversion from 13.6% to 15.5%

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Case 1: Energy Conservation in Unit 1
(910 MTPD plant of 1974 vintage)

- Installation of hydrogen recovery unit – energy saving of 0.96 GJ/MT
- Installation of a pre-reformer
- Improvements in compressors' efficiency
- Increase in capacity from 910 MTPD to 1100 MTPD
- A large number of other measures to improve reliability and efficiency

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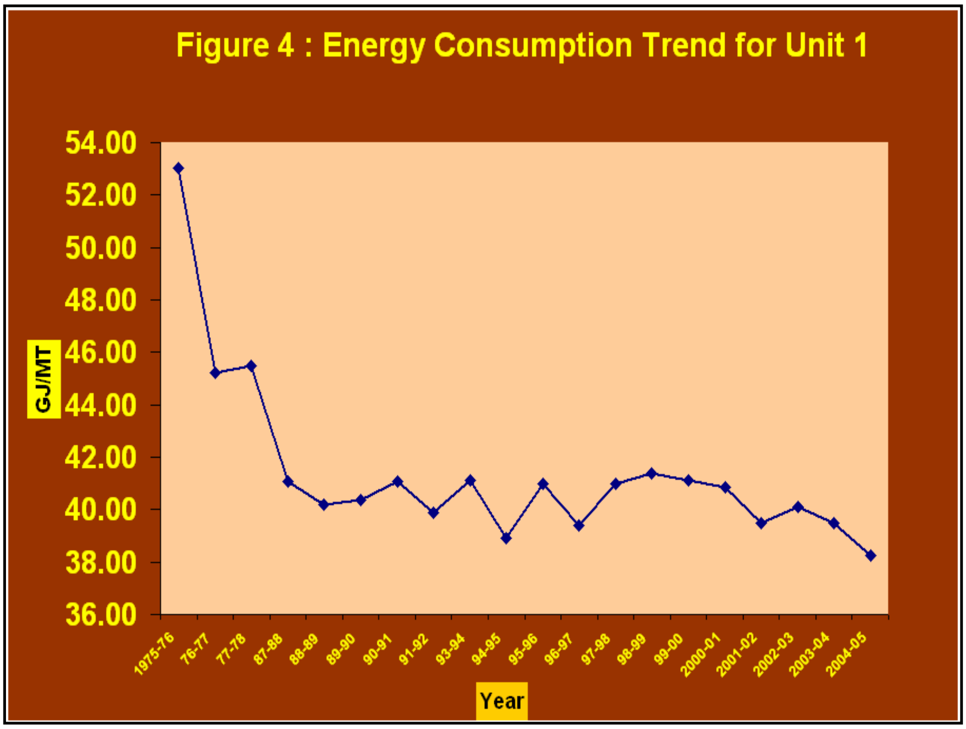

Figure 4 : Energy Consumption Trend for Unit 1

Energy Conservation in Unit 2
(1520 MTPD of 1994 Vintage)

- **High energy efficiency from design stage**
- **Numerous measures for heat integration and process integration**
  - Preheating of fuel natural gas in reformer stack
  - Excess syn-gas tapping from the upstream of make-up gas cooler
  - Utilisation of oxygen enriched air in secondary reformer
  - Numerous other measures

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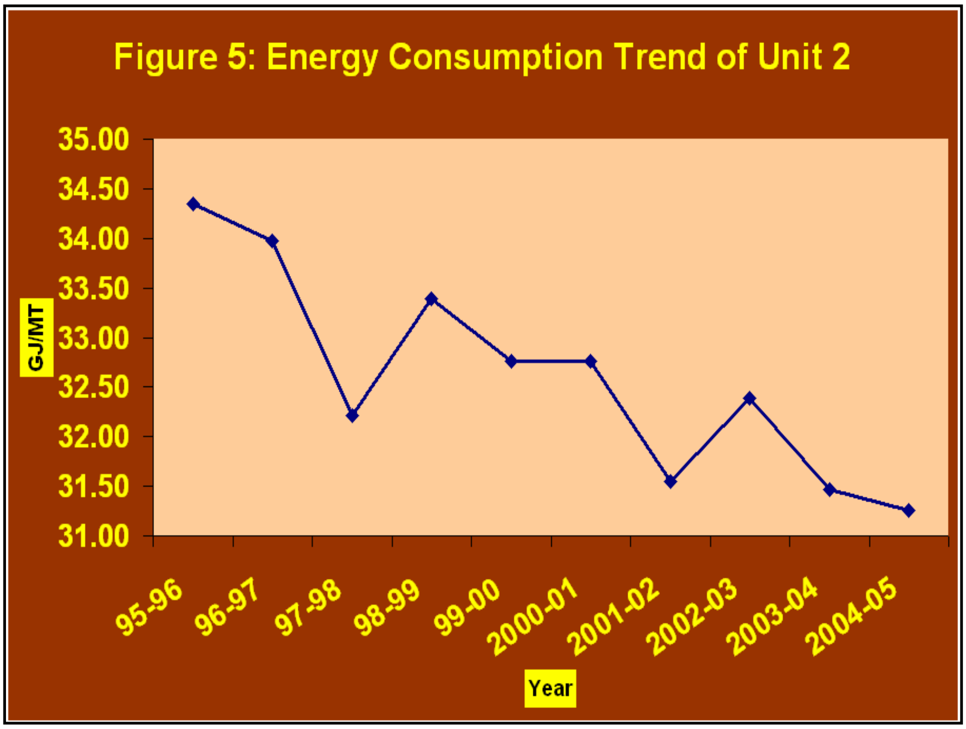

Prospects for Further Improvement in Energy Efficiency

1. Feedstock change
2. Debottlenecking of capacity
3. Revamp and retrofits
4. Optimisation of operating parameters

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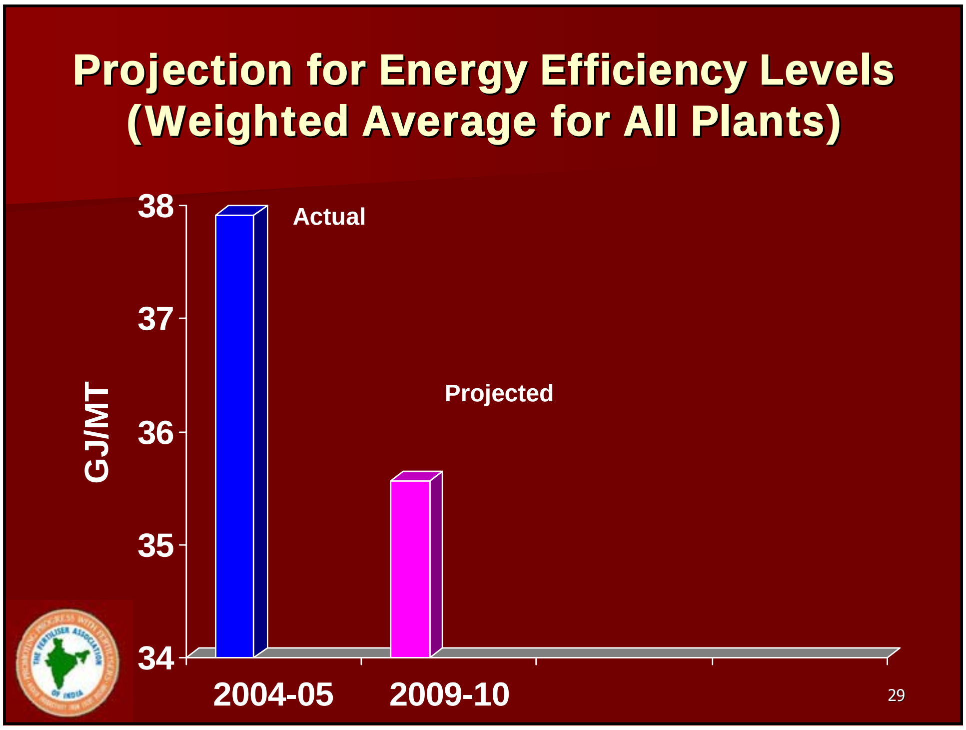
Projection for Energy Efficiency Levels
(Weighted Average for All Plants)
38
37
36
35
34
GJ/MT
Actual
Projected
2004-05
2009-10
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