India's Methanol Push – New Opportunities for Coal Gasification

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Susteon Inc.

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Susteon Background

- Susteon is a private technology company based out of North Carolina's Research Triangle area.
- The company was created by number of senior researchers from the RTI Energy Division and technology commercialization expertise from industry and Venture Capital.

Technology Consulting

The company has expertise in a number of technologies including coal/biomass gasification, syngas, natural gas, hydrogen, and CO_2 capture and utilization.

IP Development

Commercialization

- Susteon works with partners and customers to develop technologies for solving industrial problems on turnkey and/or consulting basis and with flexible IP sharing arrangements.
- Susteon plans to commercialize technologies through licensing and creating spin-out companies with proprietary technology solutions.

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Susteon Team

Shantanu Agarwal

- Extensive experience in VC, private equity, Startups, managing companies
- Co-Founder and Board Director for multiple companies
- Partner in Energy Ventures In Houston
- BS, Chemical Engg, Indian Institute of Technology - Valedictorian
- MBA: Harvard Business School

Raghubir Gupta

- 28 years experience in leading technology development and research
- Senior VP Energy Division at RTI
- PhD, Chemical Engineering, Illinois Institute of Technology
- BS, Chemical Engineering, Indian Institute of Technology.

Brian Turk

- Expert in Coal conversion technologies, High-temperature and high-pressure contaminants, Sorbent development, Syngas desulfurization, Catalysis, Process Engineering, Separations
- PhD, Chemical Engineering, University of Houston
- BS, Chemical Engineering, Purdue University

Dave Denton

- 36 years of experience in gasification and syngas at Eastman Chemicals
- Worked in R&D and commercial products through the period
- 7 years in RTI managing the syngas technology development and commercialization
- BS in Chemical Engineering from Virginia Tech

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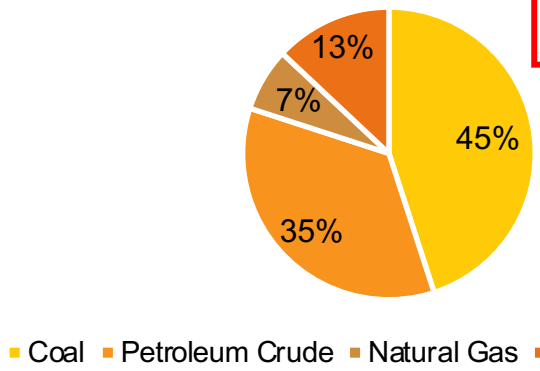
Energy Supply and Demand in India

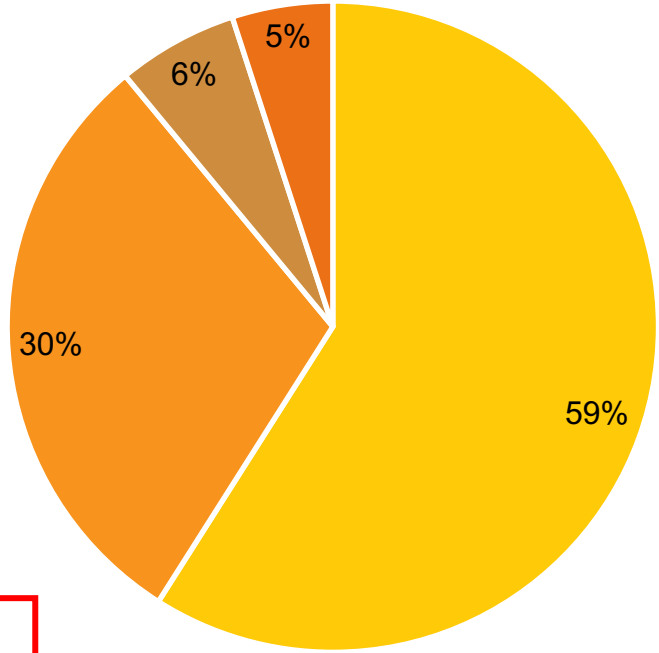
2017



8,133 TWh

2047

33,900 TWh



Current India CO_2 emissions = 1.7 ton/capita

Current World CO_2 emissions = 4.3 ton/capita

81% of the petroleum crude is imported. Serious issues with energy security and foreign exchange.

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Coal Availability in India

- India has coal reserves of around 315 billion tonnes.
- Around 76% of the coal reserves are low grade coal (240 billion tonnes).
- India produced about 700 million tonnes of coal in 2017-18.
- Average price of low grade coal with calorific value of ~8,100 Btu/lb.(4500 kcal/kg) is ₹1500/MT (~$20/tonne).

Coal Comparison		Indian Coal	Indonesian Coal	South African Coal	Australian Coal
Fixed Carbon	%	31-38	20-21	43-58	35-52
Volatile Matter	%	20-27	23-29	22-32	24-35
Ash	%	24-36	4-7	11-30	<15
Total Moisture	%	12-18	40-50	2.6-4.8	<16
GCV	KCal/Kg	3,600-4,800	2,850-3,730	5,000-7,400	5,800-6,400

Source: Bolyan, 2018

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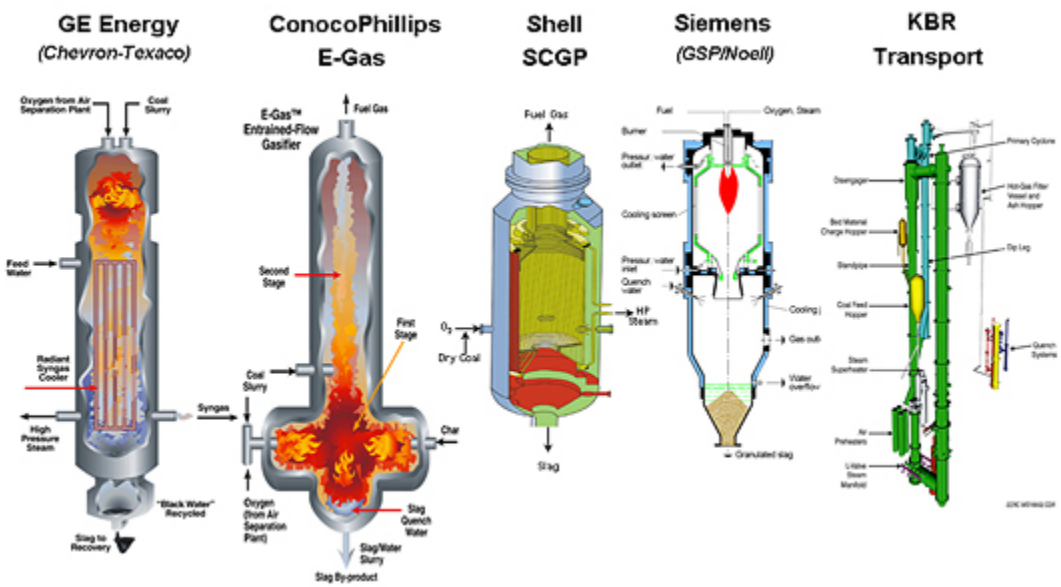
Coal Gasification for Chemicals/Fuels



- Managing slag (molten ash): biggest challenge
- Types of gasifiers with commercial references
  - Fixed Bed: Lurgi, BGL
  - Entrained-flow: Shell, GE, ECUST
  - Fluidized-bed: SES, TRIG
- Other selection criteria
  - Capital cost
  - Reliability
  - Maximum carbon conversion
  - Ash handling

Feasibility studies by GOI have shown that for a 1 MM TPA plant based on coal gasification, production costs (USD$/ton):

Methanol	Urea	FT Diesel
$312	$236	$654

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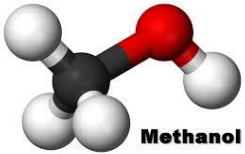
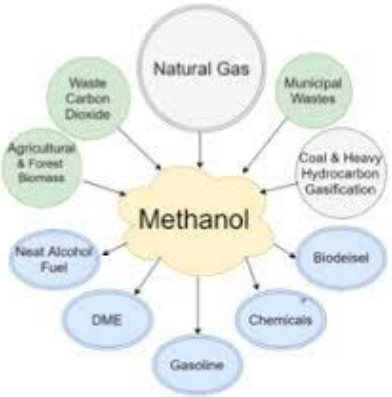
Why Methanol

- M15 fully operational in conventional vehicles; moving to M25 and eventually M100 with hybrid drive train design
- Estimate on plant requirements:
  - Gasoline consumed: 26 million tonnes in FY18
  - M15 requirement: 4.1 million tonnes/annum
  - Single plant size: 5,000 TPD Methanol
  - Number of plants required: 3



- Higher octane rating than gasoline
- Engine runs cooler: less NO_X and zero particulates from methanol portion helps in air quality.
- Indian railways and ships (Sagarmala) can use methanol in place of diesel.
- Replacing diesel by methanol in telecom towers (1.5 million tonnes/yr)
- Production of various chemicals (formaldehyde, acetic acid, olefins, etc.)
- Economics
  - Manufacturing cost in China: US$230 per tonne
  - India Target: ~US$300 per tonne (~$0.90/gallon)
- Currently India consumes 1.83 million tonnes/annum of methanol;
  - 90% of this methanol is imported from Iran and Saudi Arabia.
  - China consumes 45 million tonnes/annum of methanol (>70% from coal)



Source: Gasoline and Diesel Consumption Data from Petroleum Planning & Analysis Cell

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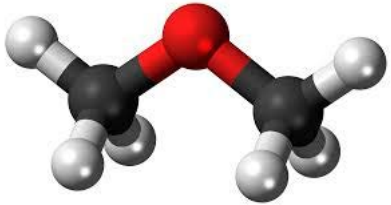
Dimethyl Ether (DME)



- Easily produced by dehydration of methanol
- Blend in diesel is limited to 20% due to poor lubricity.
- Estimate on plant requirements
  - Diesel consumed: 81 million tonnes in FY18
  - DM20 requirement: 12.9 million tonnes/annum
  - Single plant size: 5,000 TPD methanol
  - Number of plants required: 14

- DME combustion produces no particulates (no C-C bond).
- DM20 has lower temperature burn, thereby reducing NO_x production.
- Also, high oxygen content allow more complete burn of diesel.
- Volvo has 13 liter engine running pure DME.
- DME also blended in LPG with 20% blend.
- Reduce import burden of LPG (currently increased due to PMUY scheme)

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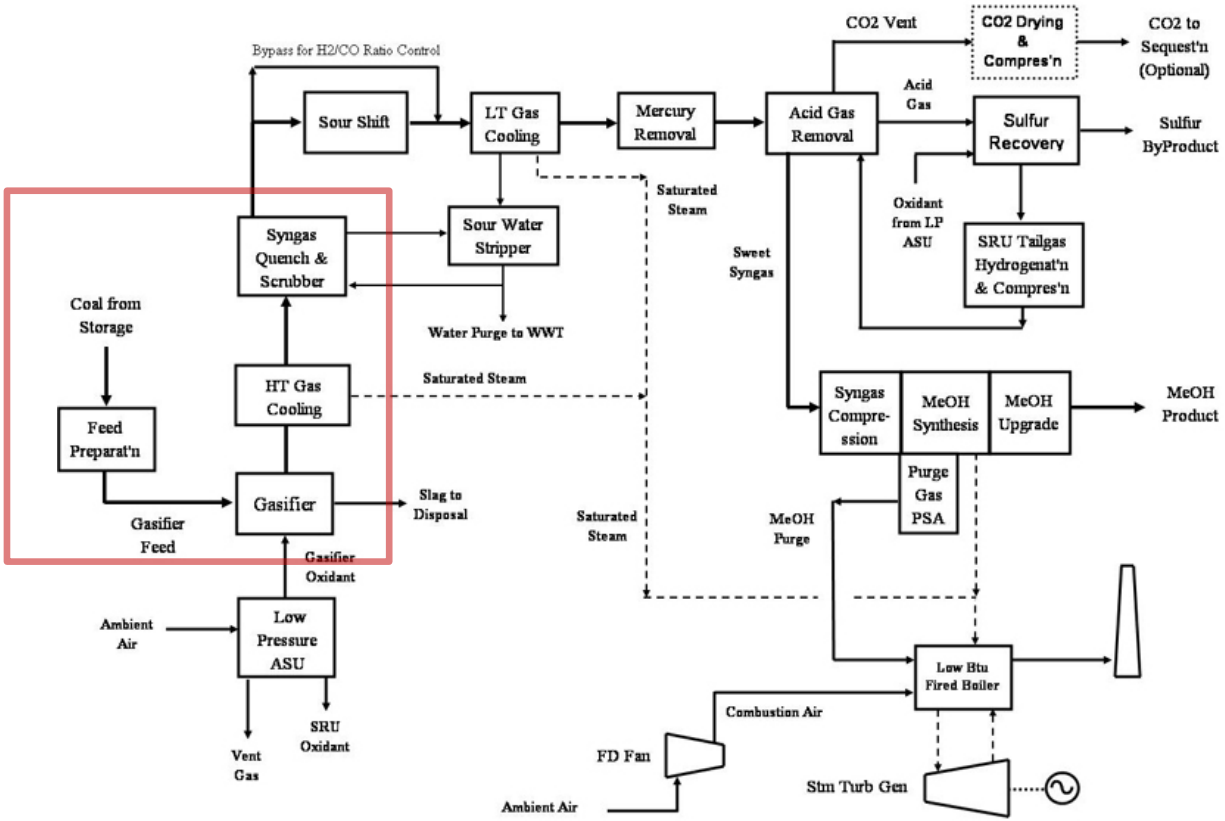
Coal-to-Methanol Process Flow Diagram



Source, NETL

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Coal Gasification in India

- Fertilizer Corporation of India (FCIL) had setup fertilizer plants at Ramagundam, Sindri and Talcher during 1970-80 using coal gasification technology.
  - Failed to achieve commercial success
- GOI awarded coal blocks in Orissa to JSPL-Lurgi and Tata-SASOL JV in 2009 for setting up 80,000 bbl per day CTL plant each.
  - Both projects were scrapped due to various reasons including cancellation of the allocated coal blocks.
- Jindal Steel has setup a coal gasification project at Angul, Orissa for its DRI based steel plant in 2013.
- Reliance has setup a major petcoke gasification with 10 E-Gas gasifiers.
- CIL, GAIL, RCF & FCIL formed a JV to setup a new coal gasification based 1.27 MMTPA urea plant at Talcher. Bids are being evaluated.

NITI Ayog Leading this Initiative

- NITI Aayog has setup three expert groups focused on production, utilization, and R&D for methanol and DME.
- Indian parliament has approved a ₹5000 crore (~US$700 million) methanol fund to develop methanol as a fuel blend/fuel.
- NITI Ayog is planning to secure a small coal block dedicated to methanol.
- NITI is planning to set up a mega complex for integrated production of methanol, ammonia, and power.
- NITI has also developed guidelines for using methanol as a transportation fuel.

Methanol Supply Options

- Coal-to-methanol
  - 5 companies forming a venture to get the first plant in India
  - With the availability of good quality coal in Mozambique, set up a plant there to produce methanol and bring it to India
- Use cheap natural gas in Qatar and Iran to produce methanol there and import to India
- Use biomass/solid waste as feedstock
- Use flared gas/stranded gas

Technology Needs

- Commercial gasification technology for high-ash Indian coals
- Partnerships for indigenous technology development
  - Bharat Heavy Electrical Ltd (BHEL) has developed a fluidized-bed gasification system at pilot-scale
  - A bench-scale/small pilot gasifier is being developed at IIT Madras
- Small modular low-cost oxygen systems (5-20 TPD) for gasification of biomass and partial oxidation of flared gas for methanol production
- Small modular low-cost syngas cleanup and conditioning systems
- Small modular methanol synthesis plants for biomass and flared gas

Summary

- Indian Government is aggressively pushing methanol as a fuel (learning from the Chinese experience):
  - Reduce crude imports
  - Improve air quality
  - Improve public health (LPG/DME cooking gas)
  - Create jobs
- Coal gasification for high-ash, high moisture Indian coals is the key technology needed to realize this vision.
  - Cost effective, robust, and highly reliable technology is needed.
- CO_2 emissions (Well-to-Wheel)
  - Petroleum route: 95-100 g CO_2e/MJ of fuel
  - Coal-to-methanol: 190 g CO_2e/MJ of fuel
  - With CO_2 Storage/Utilization: 80 gCO_2e/MJ fuel

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Thank you

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