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# $NO_x$ Emissions Solutions For Gas Turbines

## GT Modernizations

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# $NO_x$ Emissions

- Formed During Combustion
- Contribute to Tropospheric Ozone Formation
- Regulated

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# Mature Frame gas Turbines

- Not Designed with $NO_x$ Abatement in Mind
- Generally High - $NO_x$ Emissions
- Engine “Fixes” limited by frame

# Selecting Optimal $NO_x$ Control

Depends On:

- Frame / Age
- Configuration (Simple / Combined)
- Availability of Space
- Availability of Water
- Performance Requirements

# Approaches to $NO_x$ Control on Mature Gas Turbines

1) Gas Turbine Modifications

2) Post Combustion Controls

3) Synergistic Application of (1) + (2)

# NOx Abatement Methods (Primary-Engine)

- Water/Steam Injection
- Lean Premix Combustor (Dry Low NOx)
- Fuel Conversion
- Wet Compression

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# Water/Steam Injection

- One of the most widely used methods of controlling $NO_x$ emissio
- Injection-water (or steam) reserved for diffusion based combusto
- Water (or steam) injection can be used to increase power
- Need source of high purity water (or steam)

# Lean Premix Combustor (Dry Low NOx)

- Modern gas turbine use Dry Low $NO_x$ combustors to control $NO_x$
- Principle - dilute mixture of fuel with air before combustion starts
- Peak flame temperature reduced, $NO_x$ formation limited
- Retrofit DLN may not be available for older gas turbines

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# Fuel Conversion

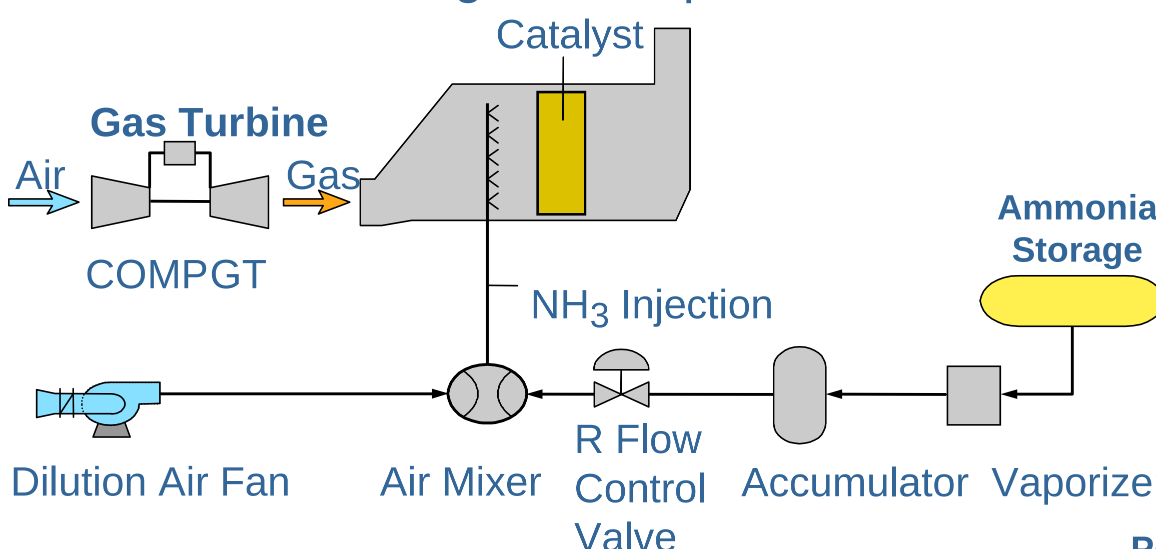
- Converting from oil to natural gas reduces NOx by up to 40%

# Wet Compression

- Water is injected into the compressor increasing mass flow
- Power increases can be in the 15% range
- NOx reduction can be as much as 35%

# Selective Catalytic Reduction (SCR)

- Reduces NOx - converts NOx into Nitrogen and Water
- Exhaust enters reactor where ammonia is added Then flows through Siemens made catalyst where reaction with NOx takes place
- NOx removal efficiency is readily achievable to 90%, and some current designs have pushed this to 95+%.



# Upgrading with SCR Technology

- Combined Cycle Units
  - Generally Better Candidates
  - Challenge to Find Space
  - Challenge to Find Temperature Window
- Simple Cycle
  - Exhaust Should be Under 450º C - 500º C
  - Reactor Must be Constructed

**No** **single primary method can attain low single-digit ppm NOx.**

**Selective Catalytic Reduction can attain them.**

**-BUT-**

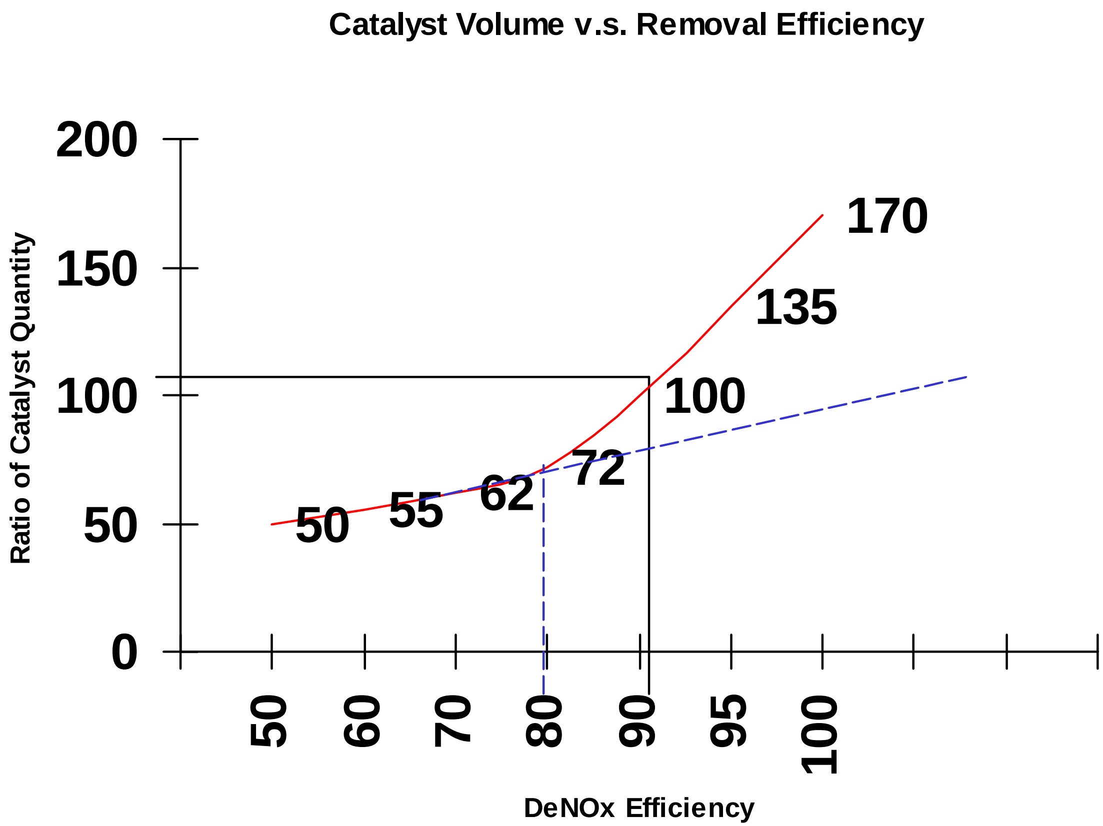
Reduction efficiencies above 80% pose a variety of issues:

- Increased Quantity of Catalyst Required = **INCREASED COST**
- Increased Backpressure = POWER LOSSES = **LOST REVENUE**
- Increased Quantity of Reducing Agent Required = **INCREASED COST**
- Increased Ammonia Slip = **ENVIRONMENTAL COMPLIANCE ISSUE**

- Only proven technology to achieve low single - digit ppm $NO_x$

# Conversion Rate and Catalyst Quantity

- Designs beyond 80% Conversion become more complex
- Need More Catalyst



# Cases 1

100 MW Combined Cycle
Gas Turbine
$NO_x$ in: 38 ppm
$NO_x$ Target: 4 ppm
Back Pressure Issues
Solution: Combustion Modification to 25 ppm
Lower Temperature SCR with Increased Surface Area

# Case 2

Gas Turbine approximately 20MW Simple Cycle
$NO_x$ Inlet: 140 ppm
$NO_x$ Target: 9 ppm
Solution:

- No Engine Upgrades Available
- High Efficiency SCR

# Conclusion

- Optimal approach for $NO_x$ abatement on mature Gas Turbines
- Synergistic approach of engine modifications and turnkey SCR where possible
- Compensate for the inevitable power output and efficiency losses due to SCR pressure drop
- Opportunity to increase power output and/or efficiency together with $NO_x$ control
- Opportunity to keep or increase steam production

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