REINHOLD ENVIRONMENTAL Ltd.

2013 Coal to Gas Conversion Round Table & Expo Presentation

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Dual Function Catalyst: Removing CO and NOx
Gas Turbine Catalyst

RESEARCH | TECHNOLOGY | CATALYSTS

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HALDOR TOPSØE

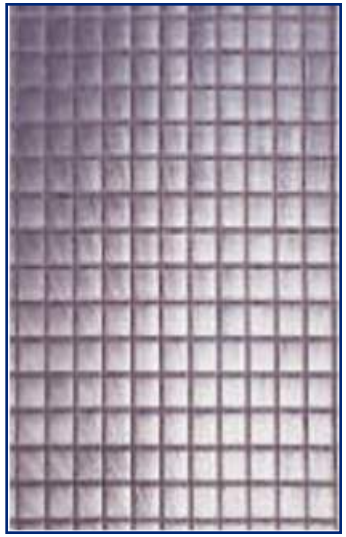
Outline

- Principles for SCR and CO oxidation catalysis
- Positioning in combined cycle plants
- CO oxidation catalyst
  - Dual function
- SCR catalyst
  - Gas turbine SCR
    - Vanadia based catalyst
  - Optimizing volume and pressure drop
- Catalyst impact on plant performance

Basic catalyst structures

Plate

- Rolled
- Coated



Honeycomb

- Extruded
- Coated

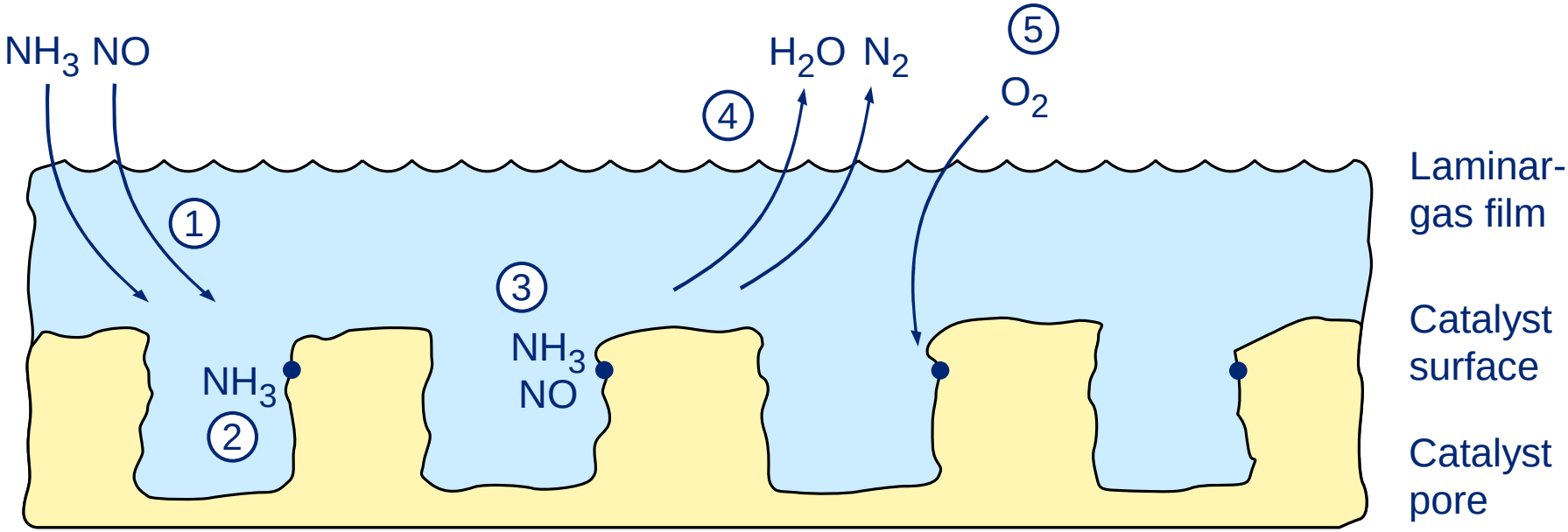
Corrugated

- Composite
- Hybrid

Composition; Titania catalyst support with Vanadium as principal active component, with other promoters, including Tungsten

Basic - SCR reactions

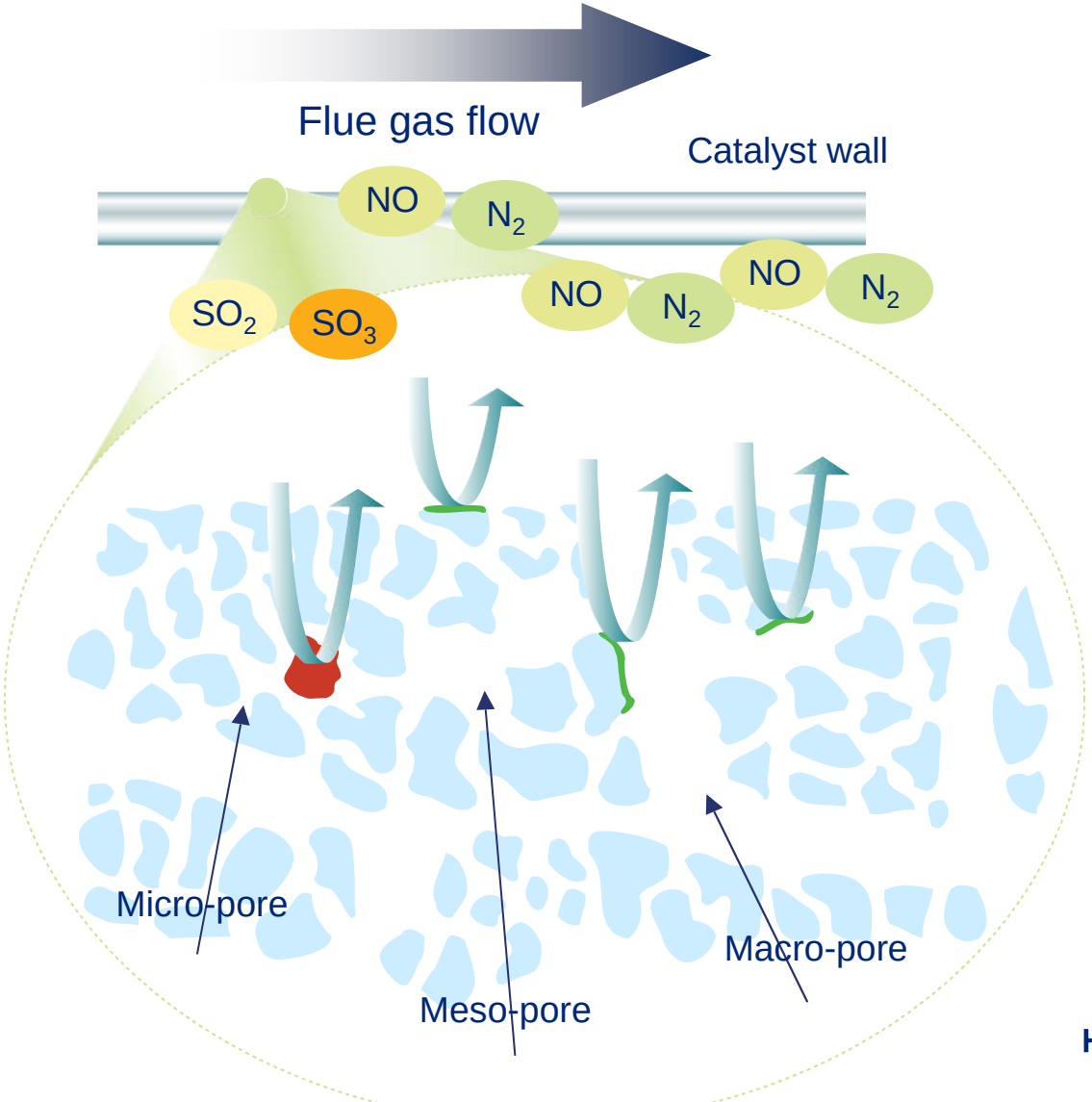
- $4\ NO + 4\ NH_3 + O_2 \rightarrow 4\ N_2 + 6\ H_2O$
- $NO + NO_2 + 2\ NH_3 \rightarrow 2\ N_2 + 3\ H_2O$
- $2\ NO_2 + 4\ NH_3 + O_2 \rightarrow 3\ N_2 + 6\ H_2O$



Heterogeneous catalysis

- Impact of temperature
  - Activation energy, Arrhenius law $$k_1 = A\exp\left(-\frac{E}{RT}\right)$$
- Reactions proceed faster at higher temperature
  - Also side reactions:
    - SO_2 oxidation
    - Direct oxidation of NH_3

Side reactions SO_2 oxidation



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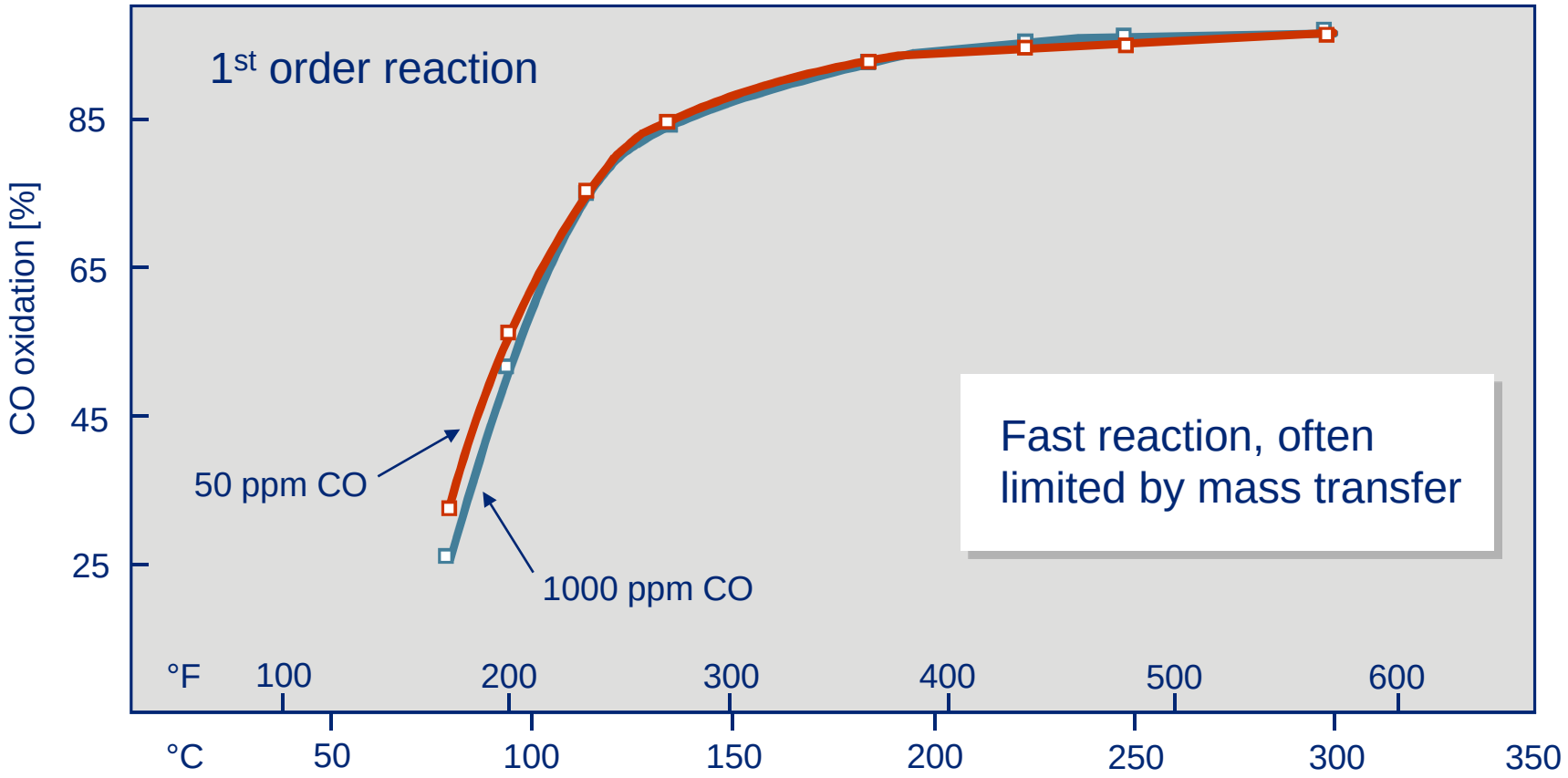
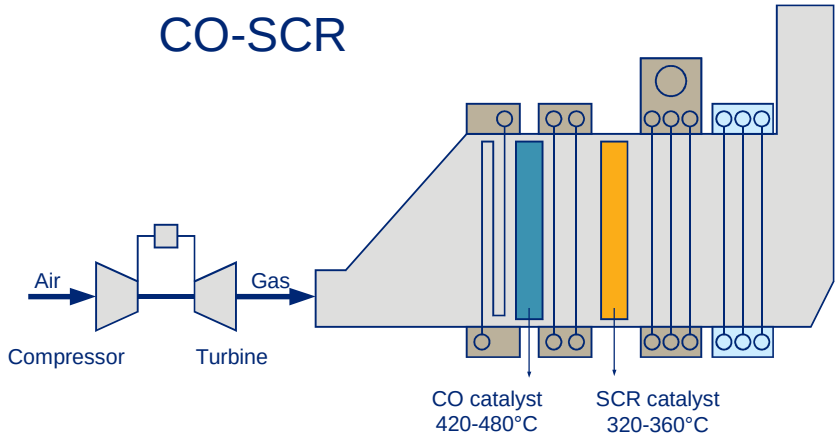
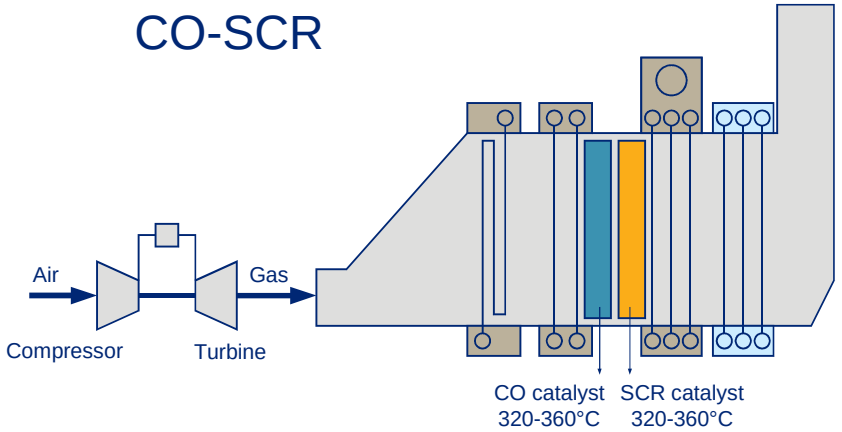
Basic - CO oxidation

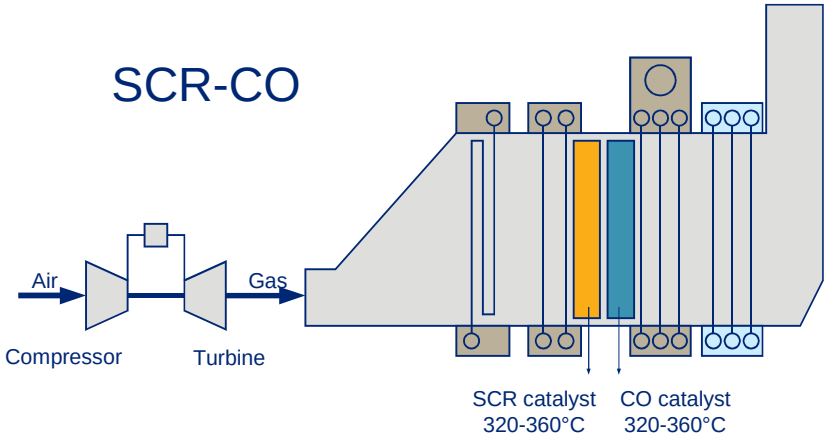
- $CO + ½\ O_2 \rightarrow CO_2$

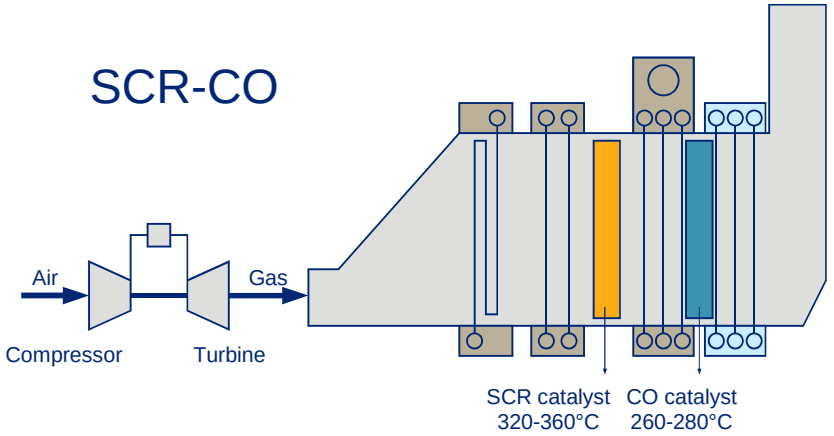


Combined cycle - HRSG layouts









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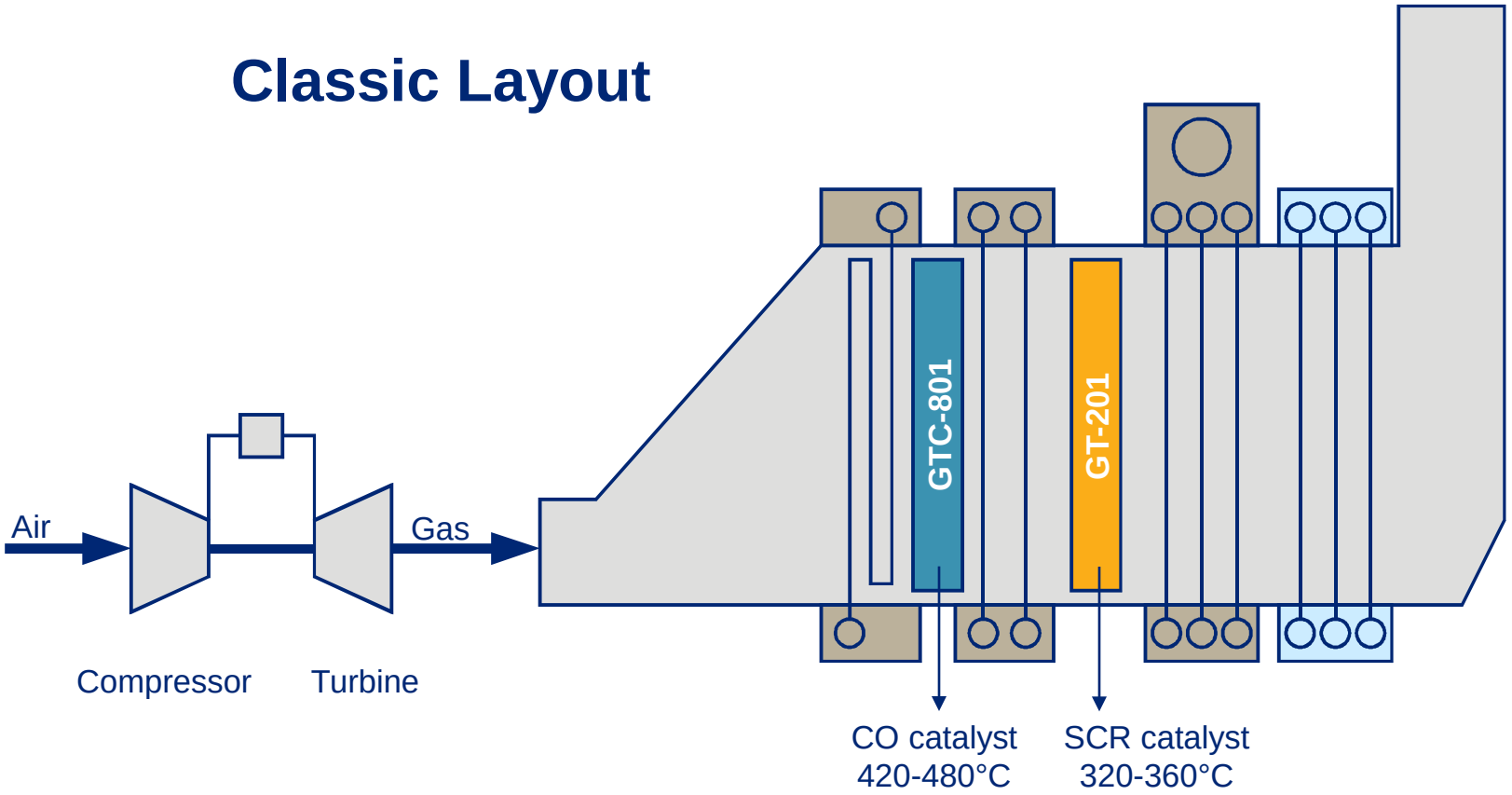
DNX® GTC catalysts

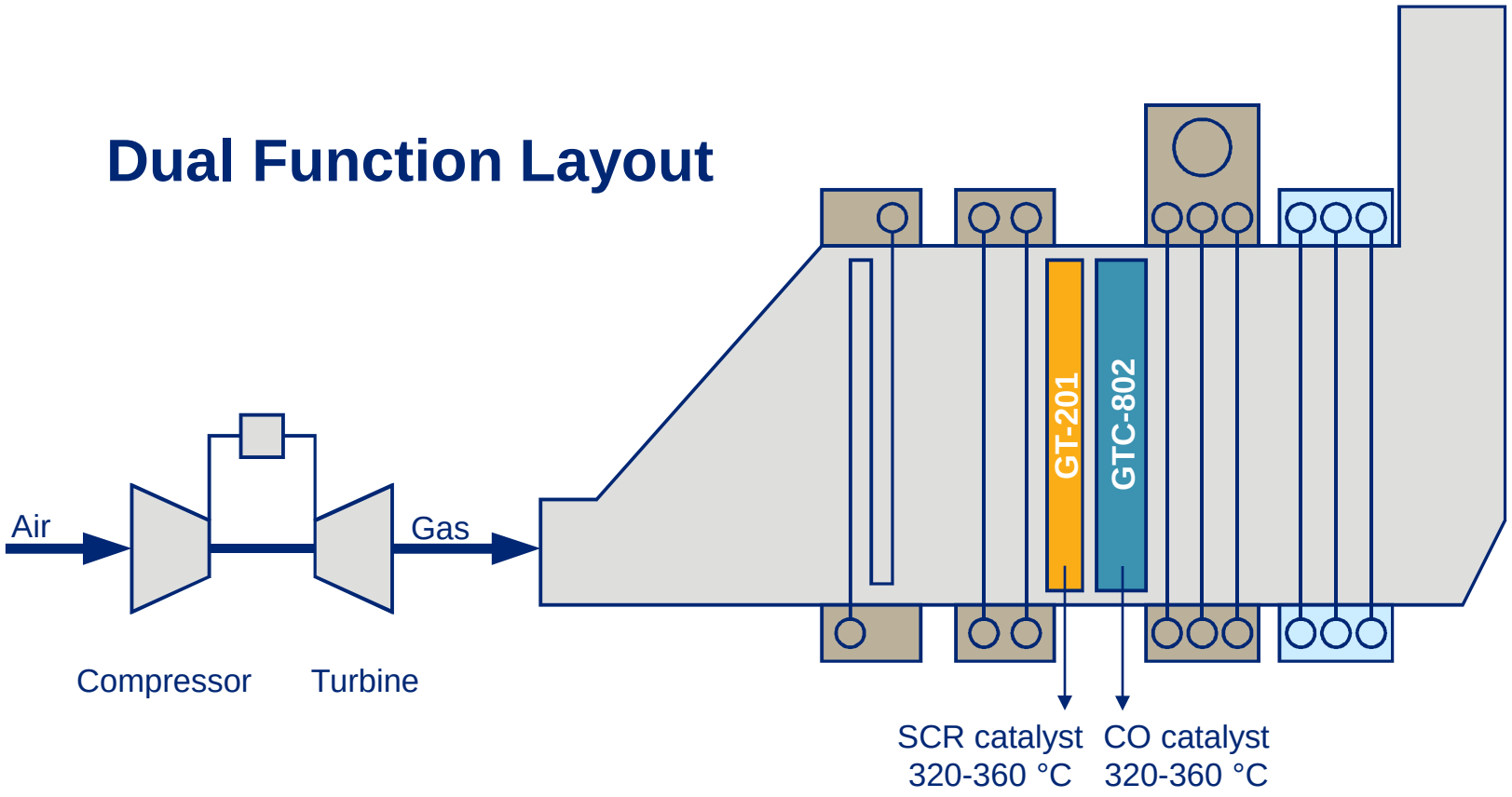
- Developed from CO & VOC oxidation catalyst in challenging environments
  - Iron sinter plants
  - Gas engines (landfill gas)
  - Diesel engines
  - Chemical plants
- Pd based
  - High temperature – DNX GTC-801
  - Medium temperature – DNX GTC-802

CO-oxidation catalyst positioning

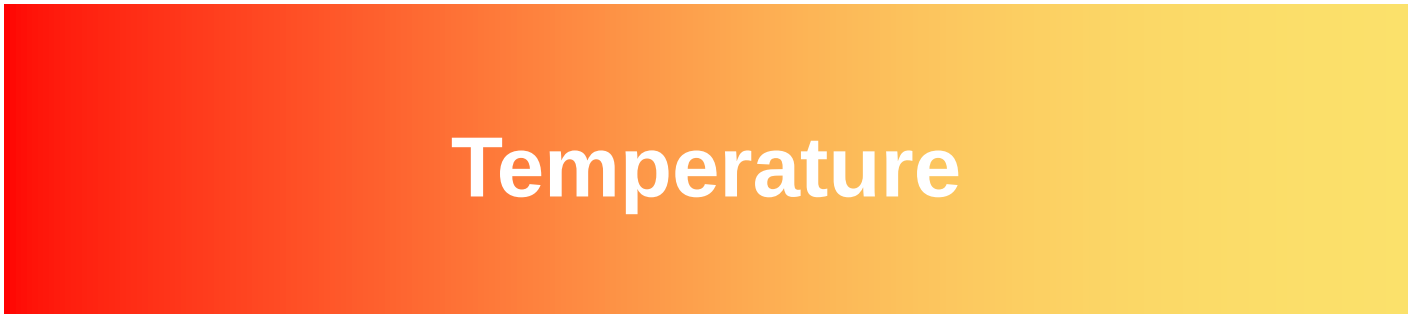


Dual Function position - DNX® GTC-802

- Simultaneous NO_X conversion and CO oxidation



Optimal CO Catalyst Positioning



Higher catalyst activity (also for side reactions)

Smaller catalyst volumes

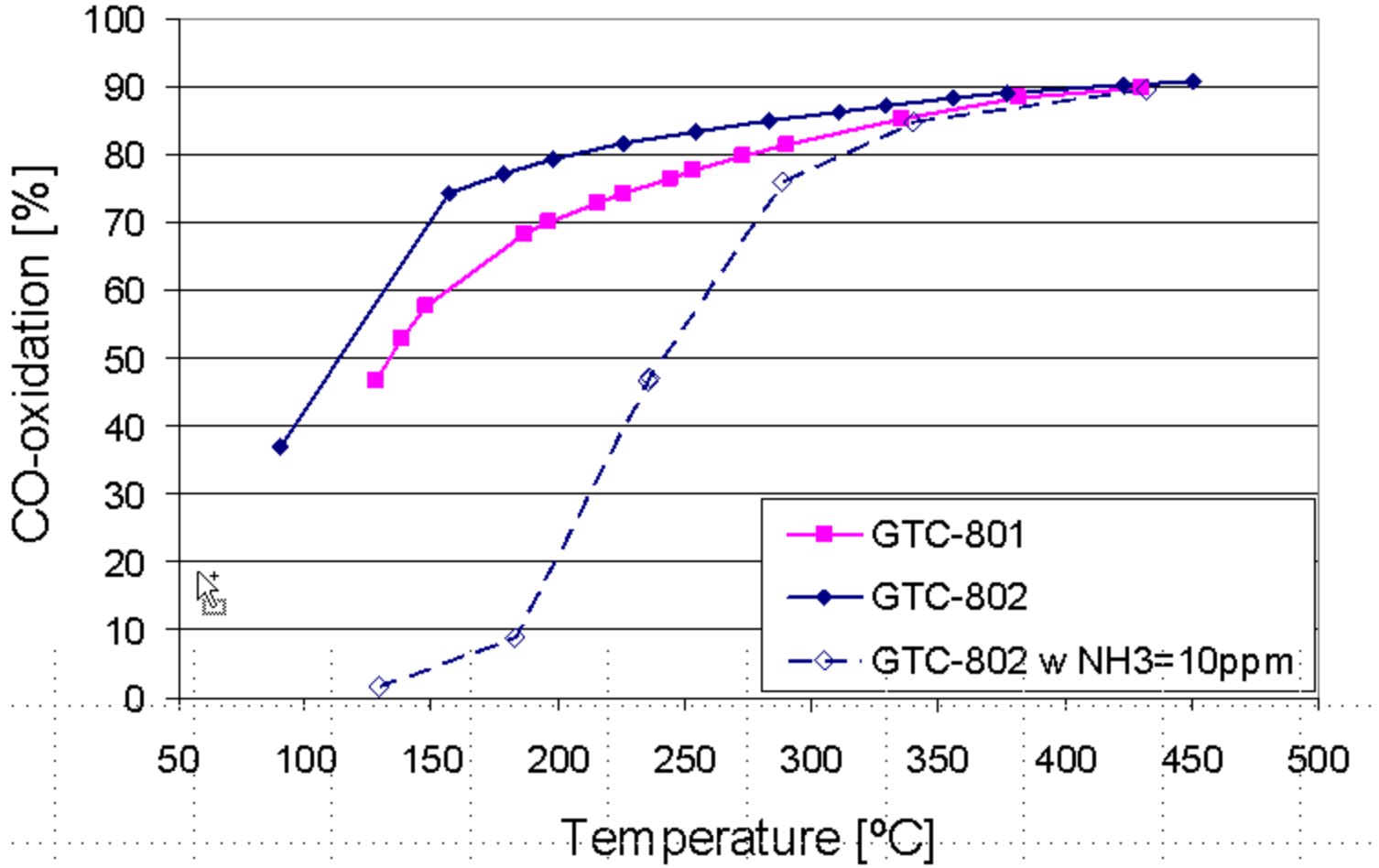
Higher specific pressure drop

Lower catalyst activity (also for side reactions)

Larger catalyst volumes

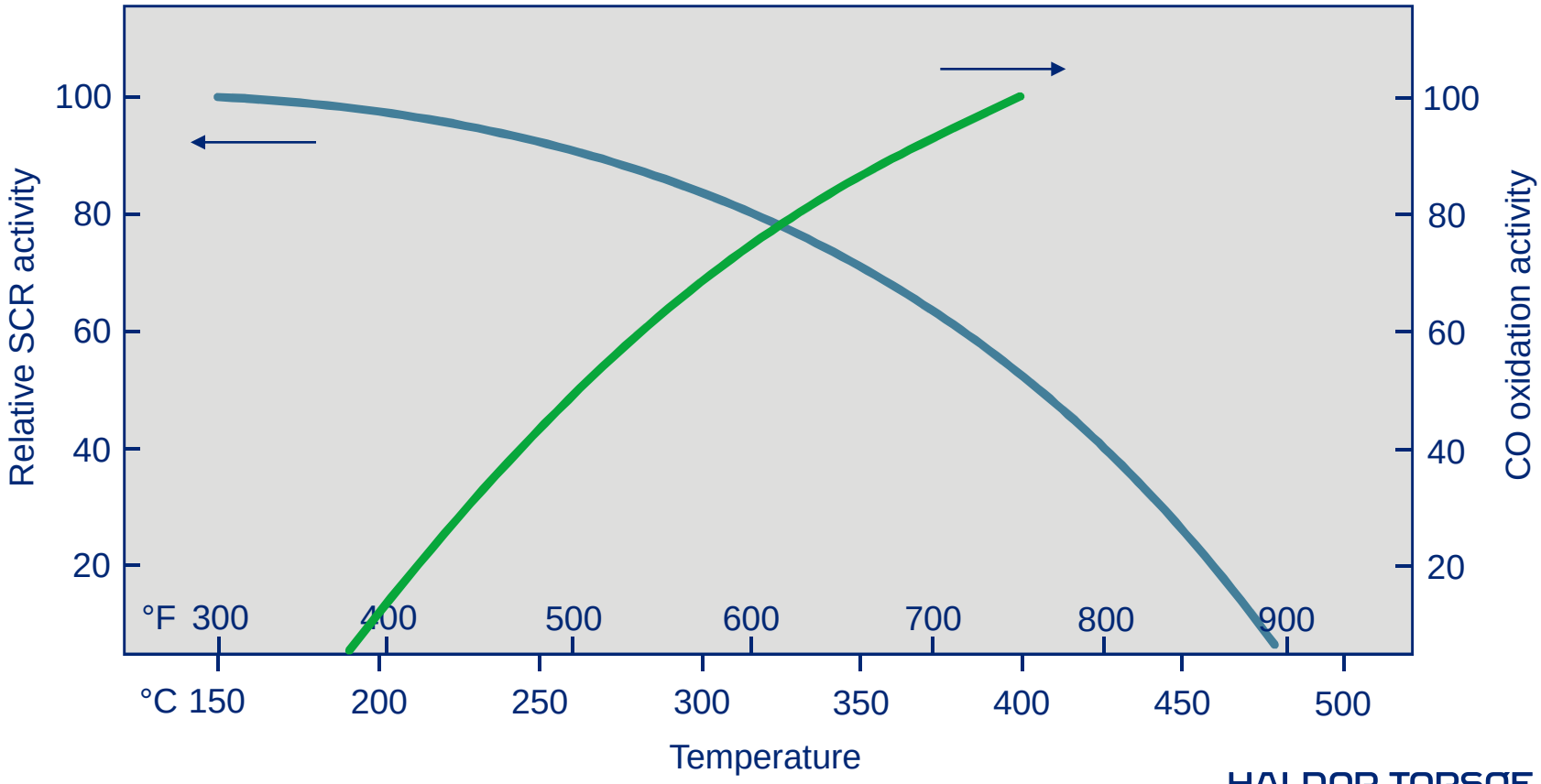
Lower specific pressure drop

CO oxidation over GTC catalysts



Dual Function - DNX® GTC-802

- Dual action CO oxidation catalysts cleans up
  - Allows operation with higher NO_x and NH_3 slip from the SCR



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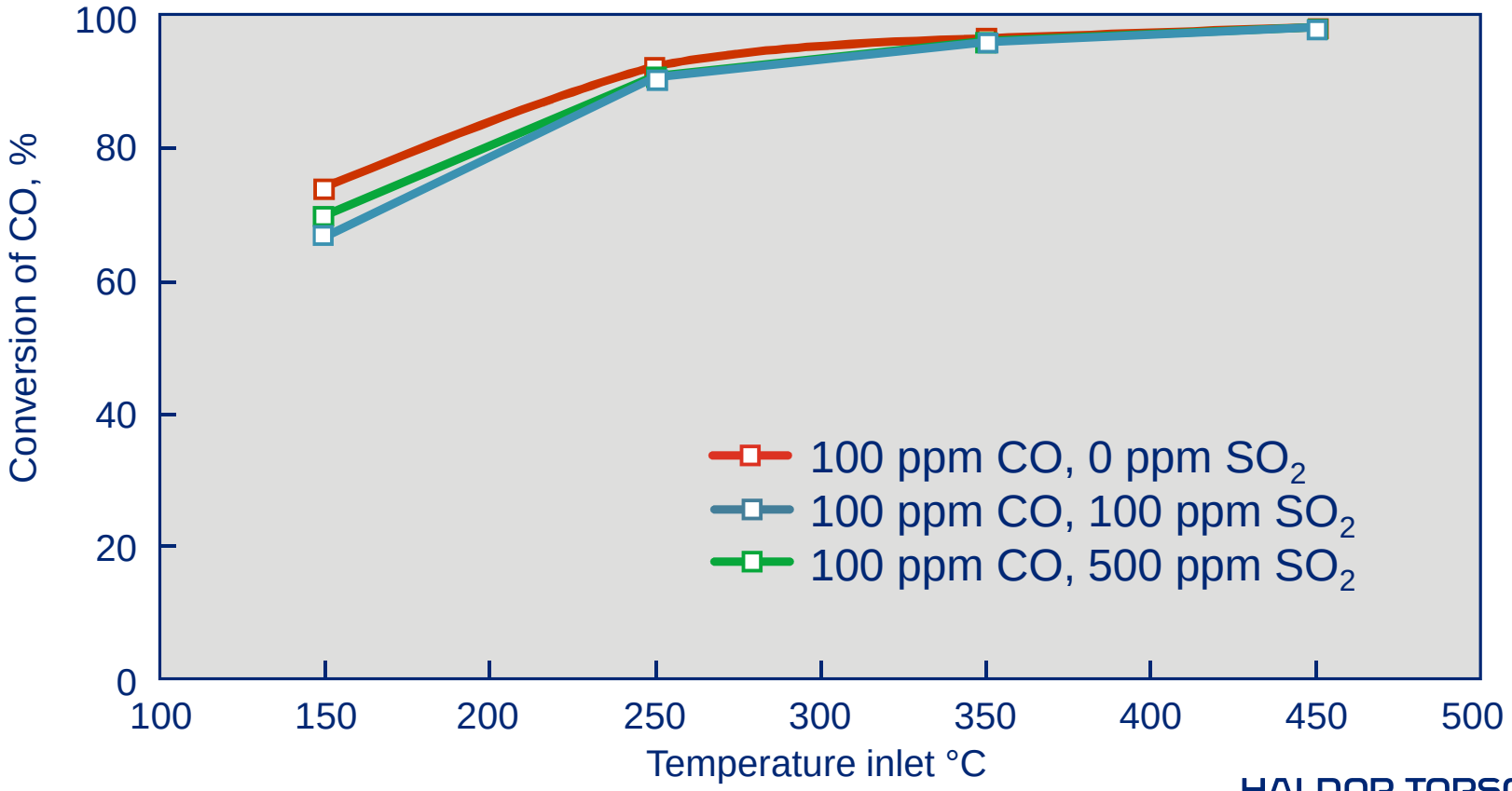
DNX® GTC Series

- Common features
  - SO_2 tolerance



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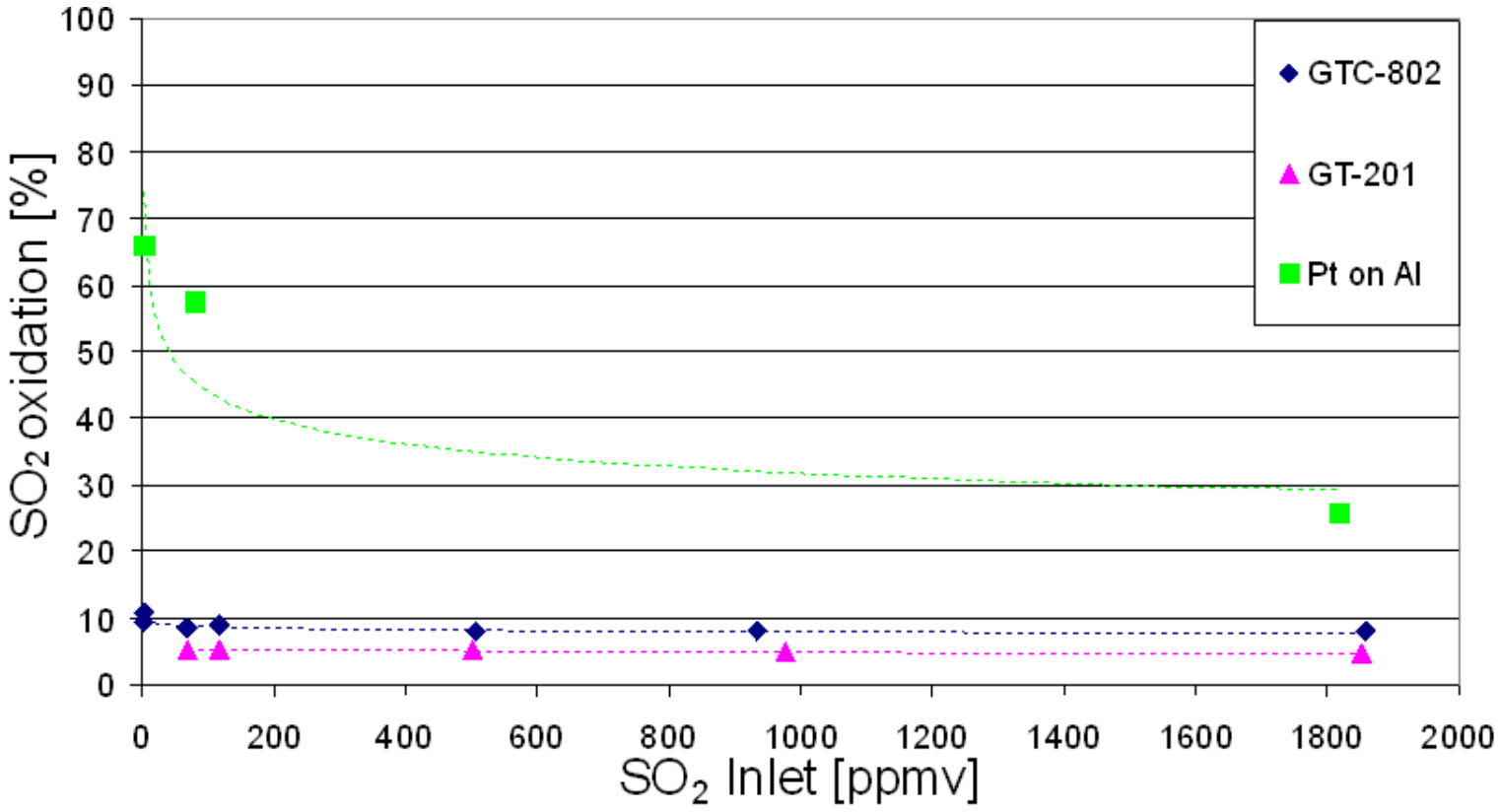
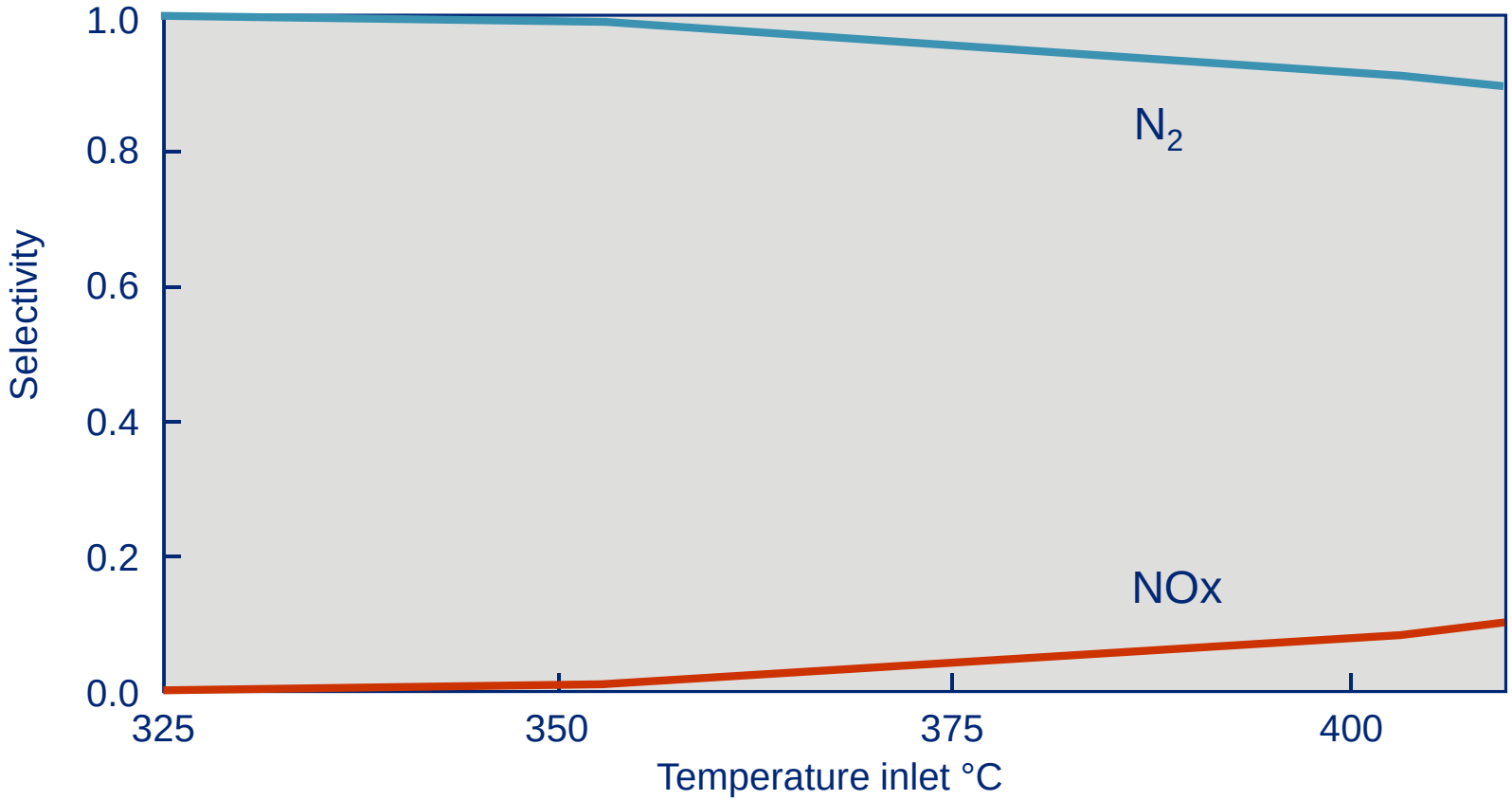
Catalyst impact on HRSG efficiency

- SO_2 oxidation benchmark

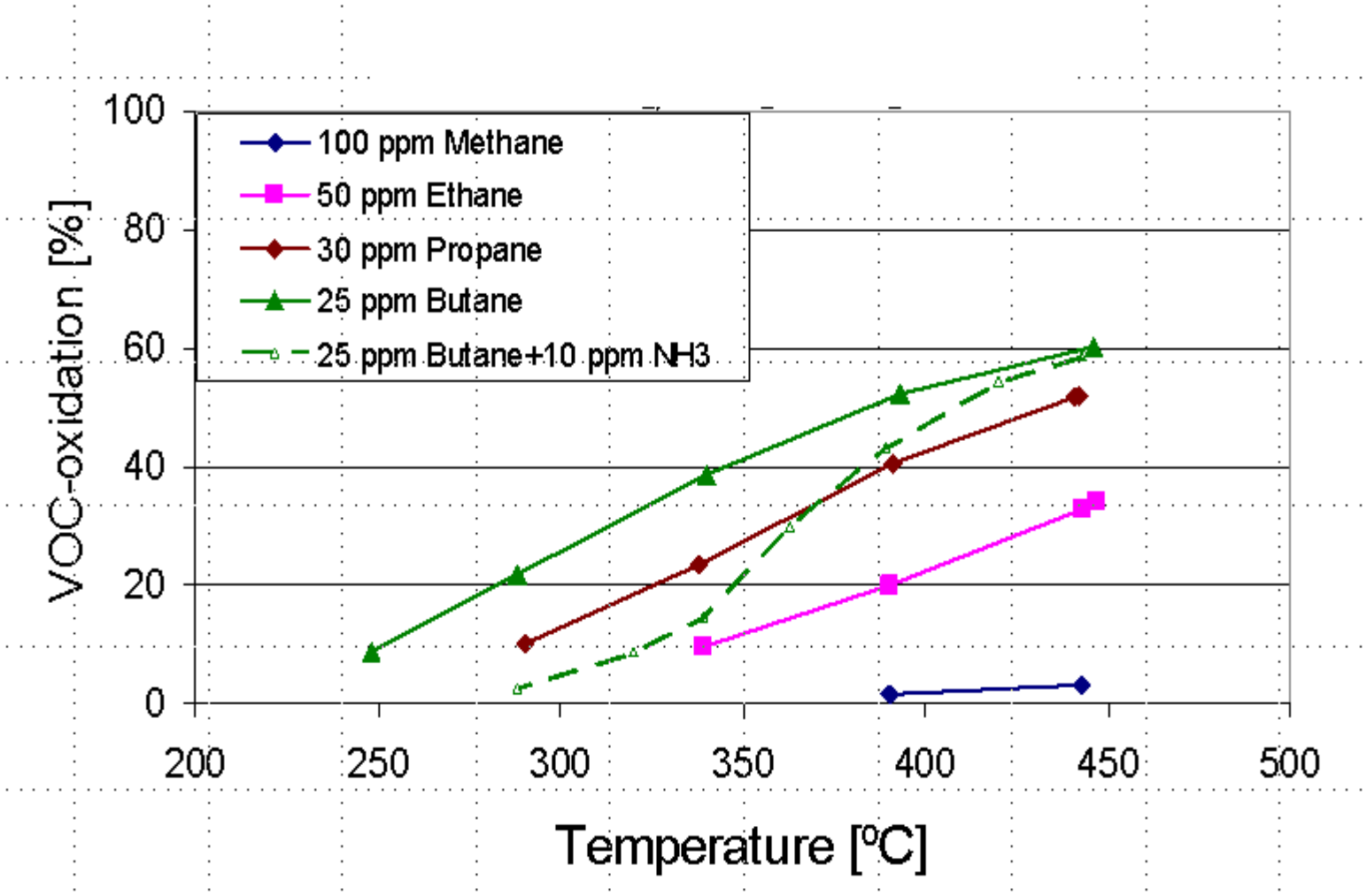


Dual Function - DNX® GTC-802

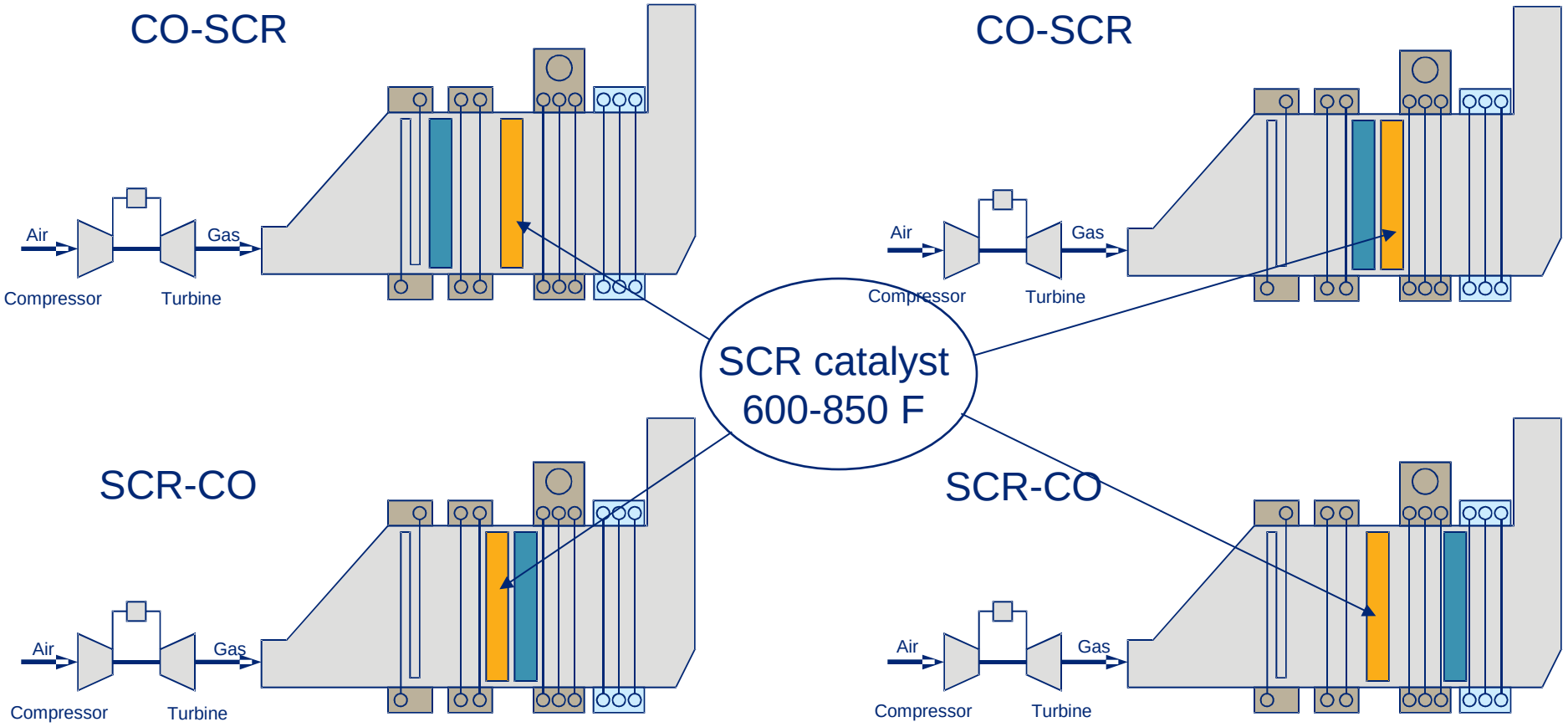
- NH_3 oxidation selectivity



C1-C4 oxidation

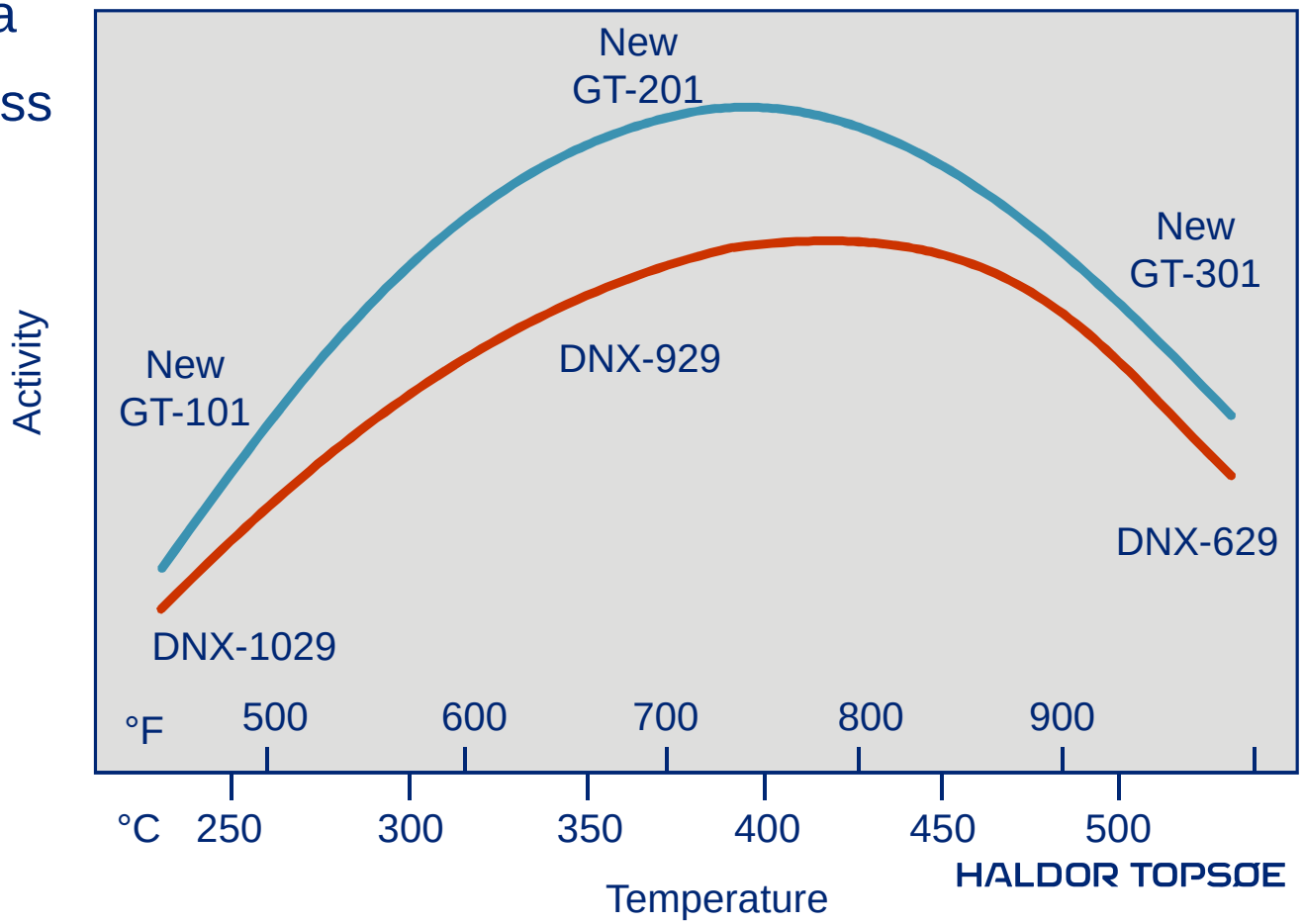


SCR Catalyst Position



SCR Catalyst Performance

- Mass transfer enhancement
  - Wall porosity
  - Surface area
  - Wall thickness



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Impact on plant performance
300 MW gas turbine benchmark

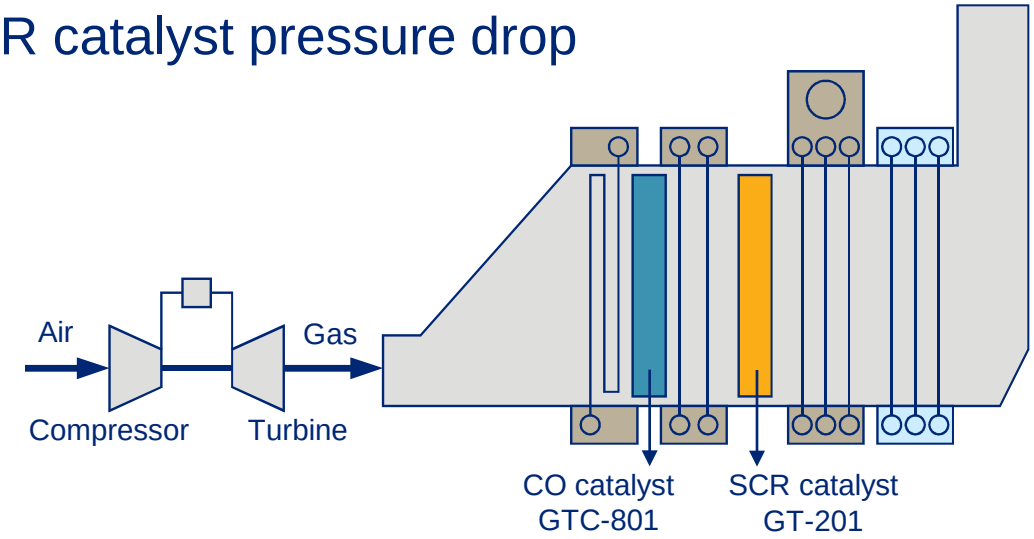
- 720 kg/s (5,710,000 lb/hr)
- 25 ppm NOx (full load)
- 60 ppm CO (full load)

- Classic layout (GTC-801 + GT-201)
  - CO-slip < 5 ppm (for load ≥ 50%)
  - NO_x-slip < 5 ppm and NH_3-slip < 3 ppm

- Dual function layout (GT-201 + GTC-802)
  - CO-slip < 5 ppm (for load ≥ 50%)
  - After GT-201
    - NH_3-slip ~10 ppm
  - After GTC-802
    - NO_x-slip < 5 ppm and NH_3-slip < 3 ppm

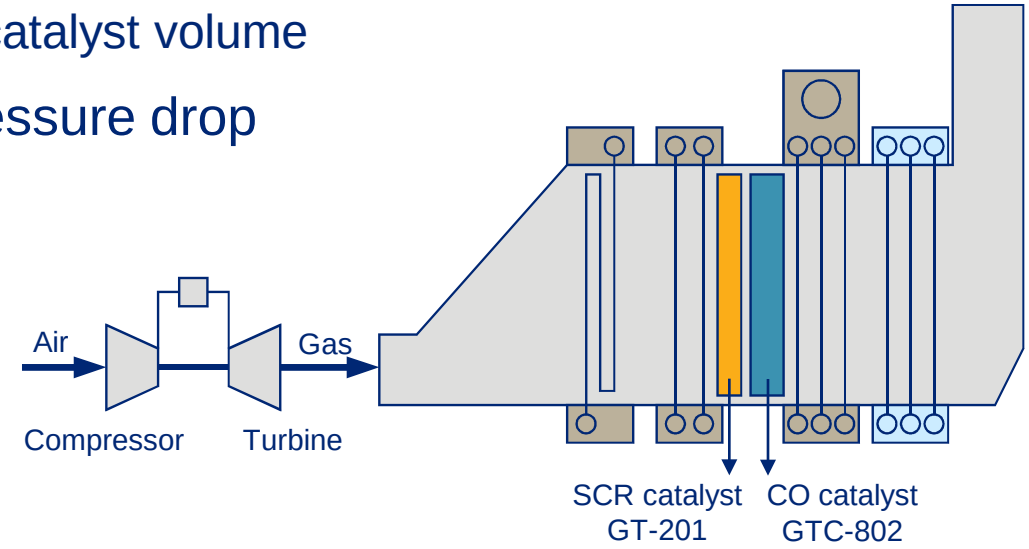
Benchmark, 300 MW plant
Volumes and pressure drop, classic layout

- Classic layout - optimized catalyst
  - 20 % reduction of SCR volume
  - 20+ % reduction of SCR catalyst pressure drop

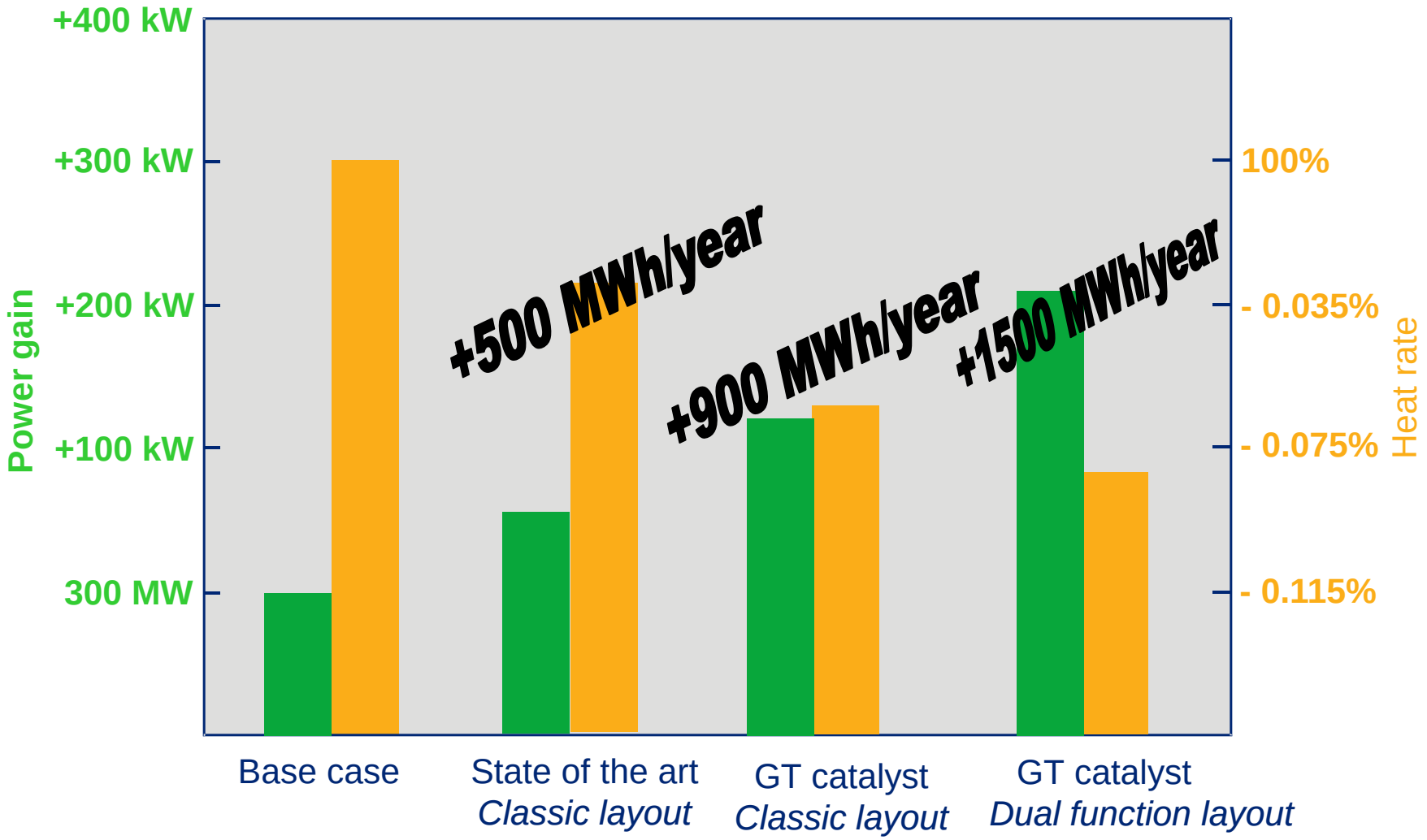


Benchmark, 300 MW plant
Volumes and pressure drop, dual function

- Dual function layout
  - 45 % reduction of SCR catalyst
    - 15 % increase of CO catalyst volume
  - 28+ % reduced total pressure drop



Benchmark, 300 MW
DNX® GT catalysts series



Catalyst impact on HRSG maintanence

- Simultaneously reducing SO_2 oxidation and ammonia slip
  - Maintenance
    - **Lowering Ammonium Bisulphate precipitation**
  - Efficiency
    - **Reducing fouling in HRSG cold-end**
    - **Lower sulfuric acid dew point ~20 F**
    - **Increasing heat recovery**
  - Construction material

Questions?

Thank you

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