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Summary of Oil and Gas Sector TSD: Significant Stationary Source of NOx Emissions

The oil and gas industry is a large contributor to air pollution. The larger components of the oil and gas sector such as refineries and processing facilities are fairly well regulated and equipped with emission reduction technologies. This paper focuses on the smaller components of the oil and gas sector, such as the support equipment at refineries or the transportation equipment that gets the oil and gas to the market place. A discussion of commercially available NOx emission reduction technology, the estimated emission reductions, and where available the estimated cost of installing such emission reduction technology is discussed in this document. All estimated costs in this document are only estimates of initial capital costs.

Reciprocating Engine- Two Stroke Lean Burn Spark Ignition Engines

Industry information indicates that most of these engines would be responsive to combustion and airflow modifications as well as post combustion NOx reduction systems such as SCR. However, some of the combustion related and post combustion NOx controls may not be commercially available for all manufacturers and models of two stroke lean burn spark ignited reciprocating engines. Industry information also indicates that the achievable NOx emission rate, in terms of g/bhp-hr would be engine specific, but the information also supports general NOx emission rate limits as low as 0.5 g/bhp-hr for engines with a name plate of 250 hp or above; and for engines below 250 hp an emission limit of around 3 g/bhp-hr. There is very limited information regarding cost of purchasing and installation of these controls.

Type of NOx Control	Engine Size Range (hp)	Estimated Range of NOx Reduction (%)	Estimated Range of NOx Emissions Rate (g/bhp-hr)	NOx Control Estimated Costs ($)
Layered Combustion	100 - 250	60 - 90	3 - 0.5	182,000 - 456,000
Layered Combustion	2000 - 2500	90	0.5	2,175,000 - 3,554,000
SCR	2000 - 2500	90	0.5	1,050,000 - 1,210,000

(Note: Estimated costs are initial capital cost estimates only.)

Reciprocating Engine- Four Stroke Lean Burn Spark Ignition Engines

Industry literature indicates that there are a number of methodologies that are commercially available to help control NOx emissions from four-stroke lean burn spark ignition reciprocating engines including the use high energy ignition systems, ignition pre-chambers and selective catalytic reduction (SCR). Many of these methodologies are related to efforts to acceptably operate engines with very lean air/fuel mixtures.

4-Stroke Lean Burn Spark Ignition Engine NOx Control Retrofit Technology	Potential NOx Reduction
High Energy Ignition System	10%
Intake Air Upgrade (turbocharger, etc)	60%-70%

Improved Mixing (high pressure fuel injection)	90%
Pre-Combustion Chamber Ignition System	90%
SCR Catalyst	50%-95%

Reciprocating Engine- Four Stroke Rich Burn Spark Ignition Engines

The information suggests that there are a few combustion related NOx emissions control applicable to these rich burn engines, such as installation of exhaust gas recirculation (EGR), improved induction and fuel delivery, modification for lean burn operation, etc. However, such modifications may not be feasible for retrofit for all subject rich burn engines due unavailability of the required components or extraordinarily high costs to make the conversions. The industry information also indicates that there are technically feasible, commercially available post-combustion (NSCR) NOx reduction systems available for use on virtually the entire range of nameplate ratings and make/model variability of the four stroke rich burn spark ignition reciprocating engines. It appears that commercially proven NSCR NOx reduction technologies are widely available from engine original equipment manufacturer (OEM) companies as well as aftermarket suppliers that can be expected to achieve NOx reductions of 90% or greater. The information therefore seems to support NOx emission rate limits of 0.2-0.5 g/bhp-hr for many four-stroke rich burn spark ignition reciprocating engines with a nameplate rating of 50 hp or above.

Type of NOx Control	**Engine Size Range (hp)**	**Estimated Range of NOx Reduction**	**Estimated Range of NOx Emissions Rate (g/bhp-hr)**	**NOx Control Estimated Costs ($)**
Retrofit NSCR	50 - 2000	99	0.2 - 0.5	16,700 - 363,000
New Unit w/NSCR	50 - 2000	N/A	0.15	N/A

(Note: Estimated costs are initial capital cost estimates only.)

Diesel Engine NOx Controls

Industry information indicates that there are several available NOx reduction technologies applicable to diesel engines. Some combustion related NOx reduction technologies offer only low levels of NOx reduction, e.g. injection timing (~ 10% reduction), emulsified fuel (10% to 20% reduction). Another combustion related diesel engine NOx reduction technology, exhaust gas recirculation (EGR), is reported to be capable of moderate levels of NOx reduction (40% to 50%), but has had limited retrofit application to date. Because of the limited NOx reduction capabilities of these technologies and apparent limited commercial availability of the technologies, at this time these combustion related technologies are not considered primary NOx reduction technologies for use in diesel engine retrofit. The industry information indicates that post-combustion controls are also applicable to diesel engines for NOx reduction. The available information describes NOx traps and NOx absorbers for diesel engine applications, but no examples of commercial application of these technologies on diesel engines could be found at the time of preparation of this document. In contrast, SCR is a post combustion NOx reduction technology applicable to diesel engines, it is commercially available from several suppliers, and has been in commercial operation on diesel engines for some time. Industry information indicates the SCR can achieve NOx reductions from diesel engines in the range of 75% to 90%.

NOx Reduction Technology	Nameplate Rating (hp)	Estimated Range of Controlled NOx (%)	Estimated Cost ($)
SCR	500-8000	75-90	371,000 - 1,523,200

(Note: Estimated costs are initial capital cost estimates only.)

Combustion Turbines

Industry information indicates that there are technically feasible, commercially available combustion and post combustion NOx controls available for combustion turbines. The most common combustion controls are water injection and the installation of low-NOx combustors. These controls are generally able to attain moderate levels of NOx reduction in retrofit application; approximately 40% for water injection and up to approximately 60% for low-NOx combustors. Industry information also indicates that retrofit SCR is a technically feasible, commercially available post-combustion NOx control for combustion turbines. SCR is applicable and available for both retrofit and new unit installations. SCR is capable of achieving combustion turbine NOx reductions of 90% or more. Based on the available information, SCR appears to be the only commercially available combustion turbine NOx reduction technology capable of attaining those high levels of NOx reduction.

NOx Control	Nameplate Rating (MW)	Estimated NOx Reduction (%)	Estimated Cost ($)
Water injection	4-23	40	398,000 – 1,481,000
Low NOx Combustors	4-23	60	260,000 – 1,094,000
SCR	5-25	90	901,000 – 2,432,000

(Note: Estimated control costs are initial capital cost estimates only.)