

## Nitrogen Enrichment of Intake air for Gas Engines

**Background:** DOE's Advanced Reciprocating Engine Systems (ARES) program targets remain >50% efficiency and, of prime concern, NO<sub>x</sub> emissions < 0.1g/bhP-hr. by 2010. One strategy to achieve such low emissions in a rich-burn ( $\phi = 1.0$ ) engine is to use a combination of EGR and a three-way catalyst. While such a strategy benefits from low-temperature combustion and thereby leads to lower NO<sub>x</sub> formation, it also compromises engine maintenance: particulate matter and acidic compounds in the exhaust lead to hardware corrosion and lube oil contamination. Following a parallel path, Argonne has developed a strategy that benefits from low-temperature combustion while avoiding all the shortcomings of EGR. Under Argonne's strategy, engine intake air is selectively enriched with nitrogen (up to 2%) to reduce NO<sub>x</sub> by close to 70%. Polymer membranes that facilitate selective air-separation can be used for such purposes.

Initially, a zero-dimensional computer modeling was performed to evaluate the effectiveness of nitrogen enrichment in natural gas fired engines. Such a modeling showed the present strategy to be very effective for rich-burn engines. Subsequently, testing was performed in a 4 kW Kohler engine (*cf.* fig. 1). Through optimization of nitrogen content in intake air and ignition timing, NO<sub>x</sub> reductions up to 70% could be achieved (*cf.* fig. 2). The concurrent efficiency penalty was marginal, amounting to less than 1%.



Figure 1 The engine used for nitrogen enrichment of intake air

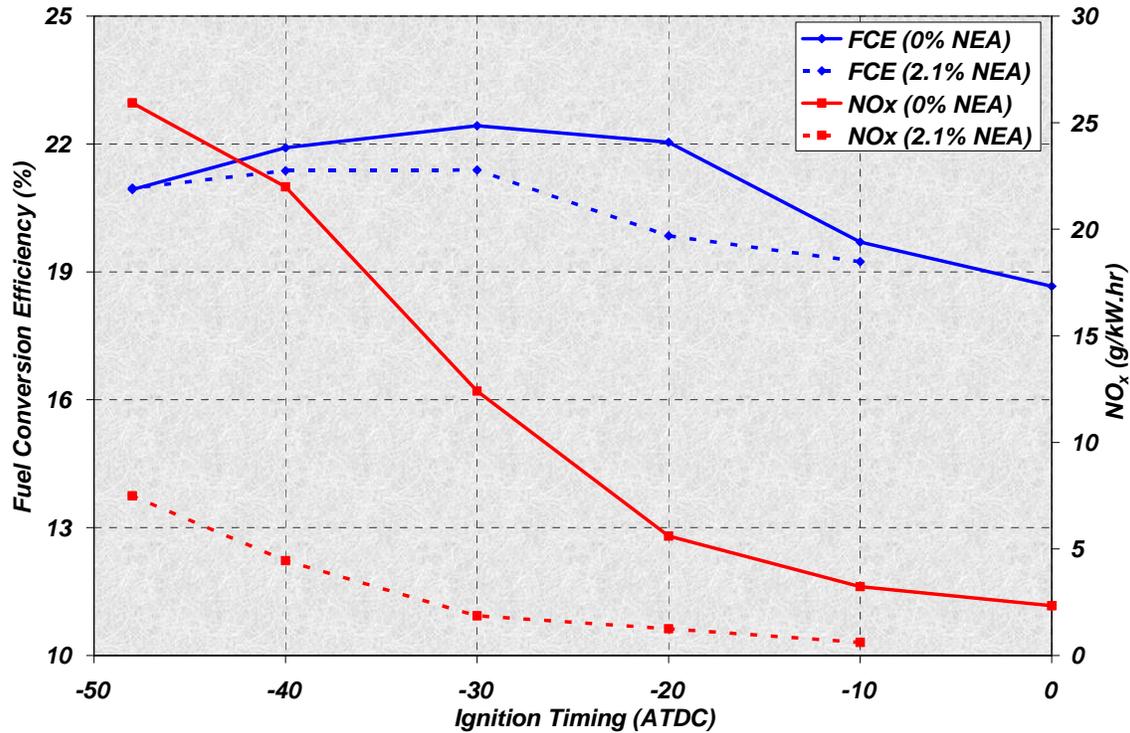


Figure 2 Fuel Conversion Efficiency and NO<sub>x</sub> with respect to Ignition Timing

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**Relevant Publication:** “Nitrogen Enriched Combustion of a Natural gas Engine to Reduce NO<sub>x</sub> Emissions,” ASME ICEF2004-843, Long Beach, CA, Oct. 2004.

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