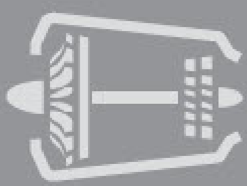
reaction DESIGN



ENERGICO

Investigating Fuel Flexibility from Gas Turbine Combustors with ENERGICO

Gas turbine combustor designers are facing a challenge to meet environmental emissions compliance with a wider variety of fuels and with fuels that have variable compositions. Fuels such as syngas (CO + H_2), landfill gas, digester gas and blast furnace gas all can have widely varying compositions that can affect ignition, flame holding, flame location and emissions. Standard fuels such as Liquefied Natural Gas (LNG) also can have widely varying compositions. Modern CFD codes are restricted to using severely reduced chemistry information and struggle to predict the effects of fuel composition changes.

ENERGICO represents the combustor with a series of idealized reactors that allows use of accurate detailed chemistry with a reasonable amount of computational time. ENERGICO automatically converts a complex combustor geometry into an Equivalent Reactor Network (ERN). Once the ERN is created, a fully detailed chemical mechanism can be used to provide an understanding of combustion performance and emissions such as NO_x, CO and Unburned Hydrocarbons (UHC). This Solution Brief shows how ENERGICO can be used to investigate the impacts of varying fuel composition to test fuel flexibility impacts on NO_x emissions.

Setting Up in ENERGICO

ENERGICO reads in the reacting flow CFD solution of a natural gas fired (simulated as methane) gas turbine combustor (Figure 1). A series of filters are applied to the variables in the CFD solution to divide the combustor into regions that have similar conditions that are important for the desired results (e.g., temperature, oxygen concentration, fuel concentration when looking at NO_x emissions). A set of these filters composes an ERN algorithm. ENERGICO can also automatically apply previously developed ERN algorithms to help save time and eliminate errors.

ENERGICO allows each reactor zone to be defined as either a Perfectly Stirred Reactor (PSR) with the temperature fixed to the average temperature in the CFD, a PSR with the energy equation turned on, or a Plug Flow Reactor (PFR). ENERGICO then creates the reactor network automatically and solves it using the detailed chemistry mechanism. This example investigates the impacts of six different fuel composition blends on NO_x emissions (Figure 2). The compositions contain different levels of CH_4, CO, H_2, and diluents such as CO_2 and N_2. An initial ENERGICO run is conducted using the methane (CH_4) and then the fuel composition is changed to match each of the various cases. We are interested in the impacts of these various fuel compositions on NO_x emissions.

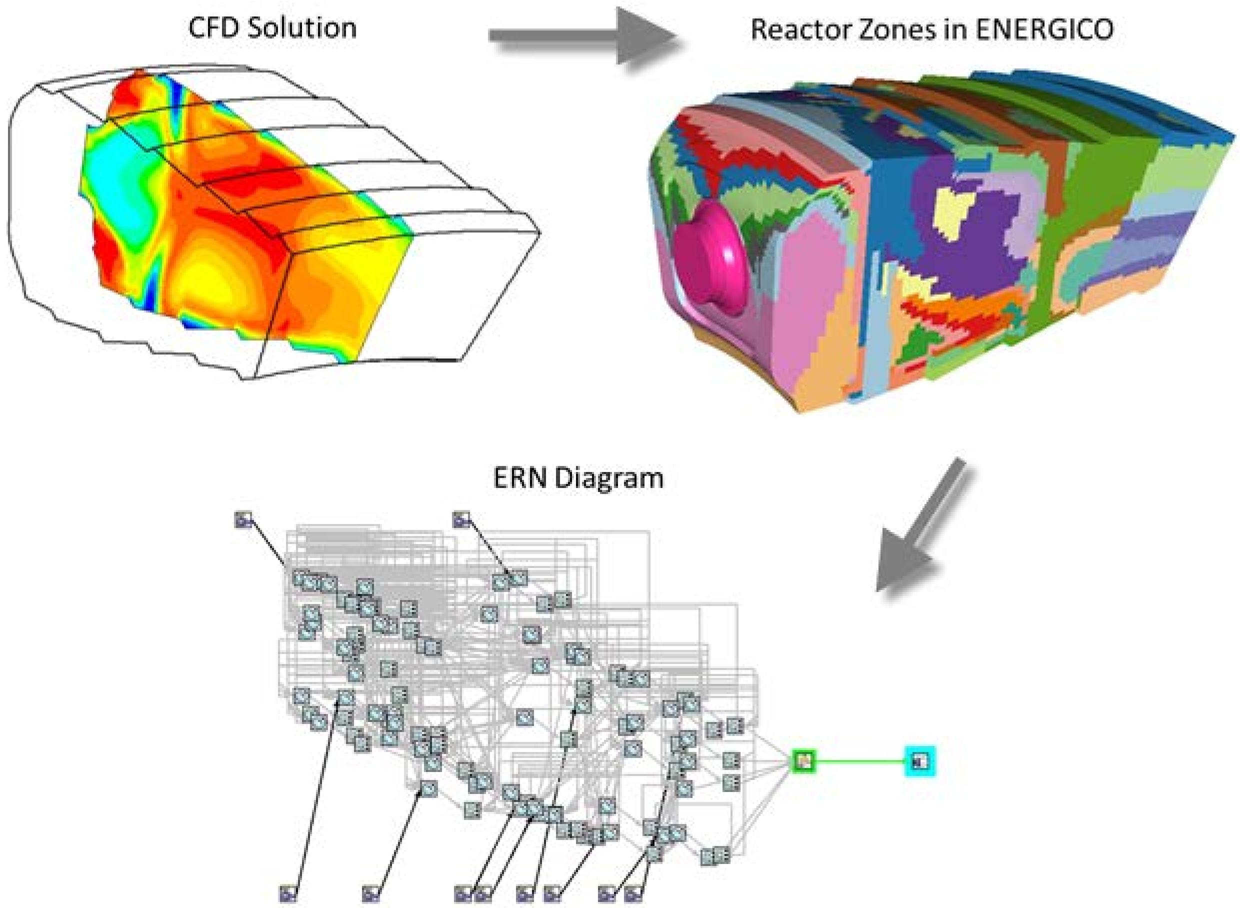


Figure 1. ENERGICO workflow starting from a CFD solution, dividing the combustor into Zones that become reactors in the ERN.

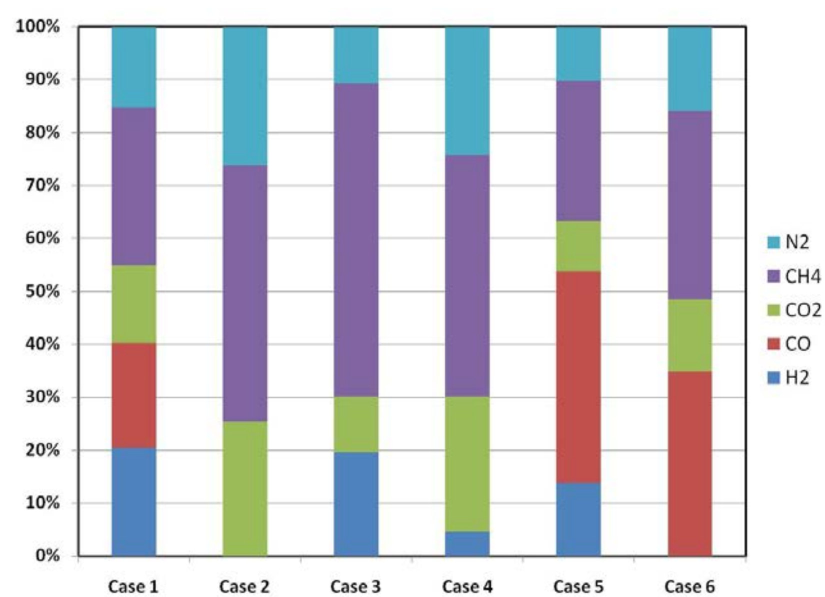


Figure 2. Fuel composition cases used in the fuel flexibility study.

Results

Results for CO, NO, NO_2 and UHC emissions at the exit are presented in a table. They also can be plotted on top of the combustor geometry. The NO_x emissions for the various fuel cases are presented in Figure 3, where the experimental data are defined by a black bar. The NO_x emissions results in this case are normalized by the NO_x emissions for the baseline CH_4 fired case. It is interesting to note that the ENERGICO ERN accurately predicted the trends of NO_x emissions impacts with composition changes.

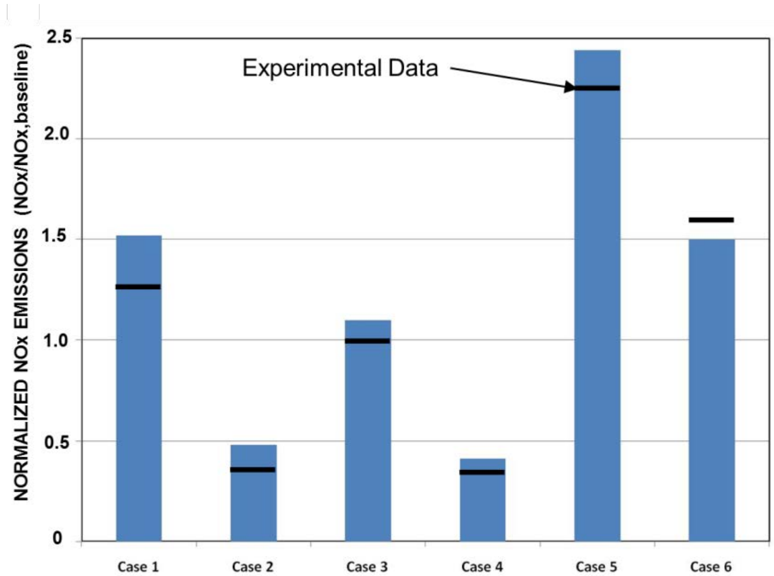


Figure 3. ENERGICO NO_x emissions results capture impacts of variable fuel composition.