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The compliance with modern EU directives on NO_x emissions together with modern urgent issues related to rising global energy demand and a safer energy supply are today one of the main concerns for combustion processes. Therefore, the choice and/or the development of environmental friendly, energy efficient and fuel flexible combustion technologies become crucial. The use of non-conventional fuels as coke oven gas (COG), a valuable by-product of coal carbonization, could fully fits the modern seek of fuel flexibility. However, deeper investigations are needed to shed light on relevant NO_x formation pathways in the combustion of these fuels that mainly contains H_2, CH_4 and CO and a small number of aromatic compounds. Moreover, if the oxidation of those aromatic species, such as C_6H_6, has been widely investigated in the literature in order to assess the competition between the depletion of such compounds and their growth to PAH and ultimately to soot, no study, until now, has tried to determine the role that benzene oxidation chemistry might play in NO_x formation. The main goal of this work will be thus to investigate NO_x formation in low-pressure laminar premixed stoichiometric $H_2/CH_4/CO/O_2/N_2$ and $H_2/CH_4/CO/O_2/N_2/C_6H_6$ flames that are representative of a real COG composition. The purpose is to highlight the main NO formation pathways in combustion of COG and to understand, through a joint experimental and modelling investigation, the effect of benzene on the main NO formation routes in such flames.