NOx Emission Reduction from Biomass Combustion Through Air Staging and Selective Non-Catalytic Reduction
Project Optinox

Gabriel J. Roeder[1*], Johannes Haimerl[1], Yusheng Chen[2], Sebastian Weiker[2], Sebastian Fendt[1], Hartmut Spliethoff[1]

[1] Chair of Energy Systems, Technical University of Munich, 85748 Garching, Germany; [2] Professorship for Renegerative Energy Systems, Technical University of Munich, 94315 Straubing, Germany

Motivation of Project

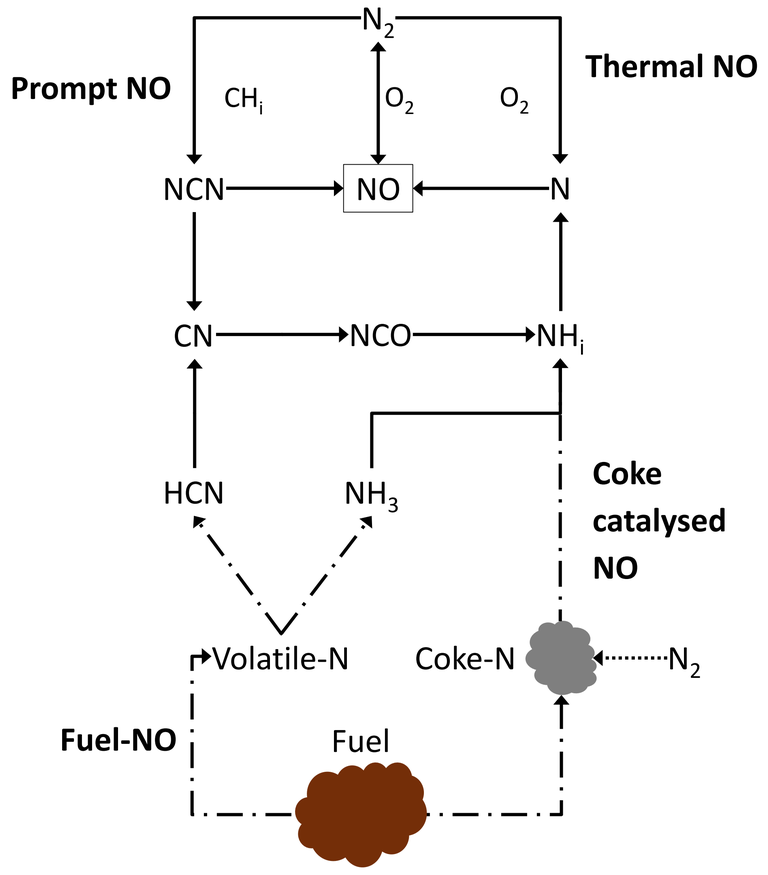
Reduction of nitrogen oxide emissions from biomass furnaces

- Nitrogen oxides (NO_x) are harmful pollutants from combustion processes.
- They damage the respiratory organs and contribute to acid rain and smog formation [1].
- In Germany, NO_x emissions have dropped significantly since 1990, mostly due to the reduction from the transport sector. However, the emissions from the energy sector have not changed much since the 2000s [2].
- Economic NO_x emission reduction methods have to be implemented in the wake of stricter emission regulations and use of different fuels with varying nitrogen content.

Project Approach

Study of NO_x in different combustion systems (entrained flow, fixed and fluidised bed)

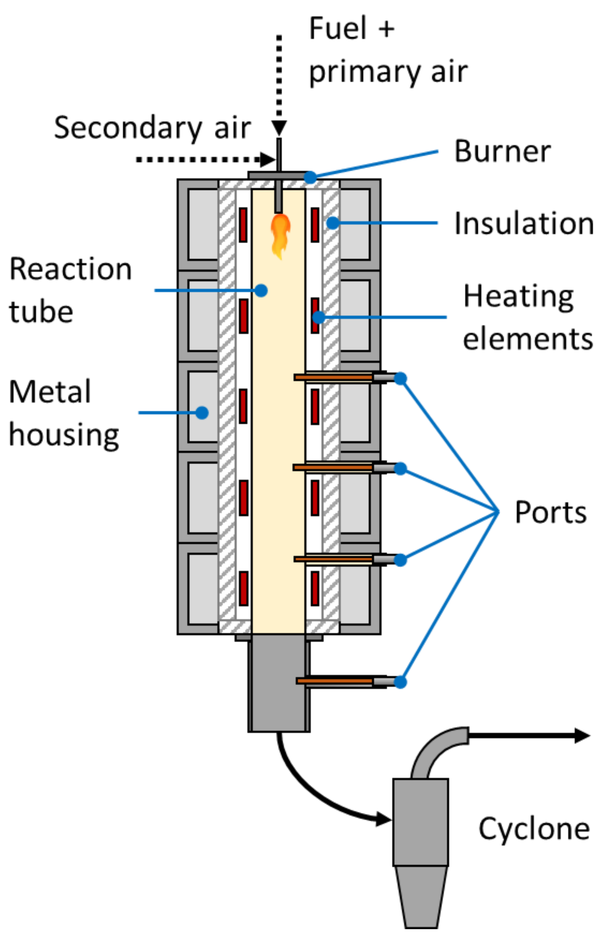
- Experimental investigation of N-species release and NO_x emissions at lab-scale
- Implementation of primary and secondary NO_x reduction methods
- CDF simulation of experiments
- On-site measurements of NO_x intermediates (HCN, NH_3) and NO_x at medium-sized biomass furnaces (1-50 MW_{th}).
- Creation of a transferable model to optimise NO_x emissions in common furnaces



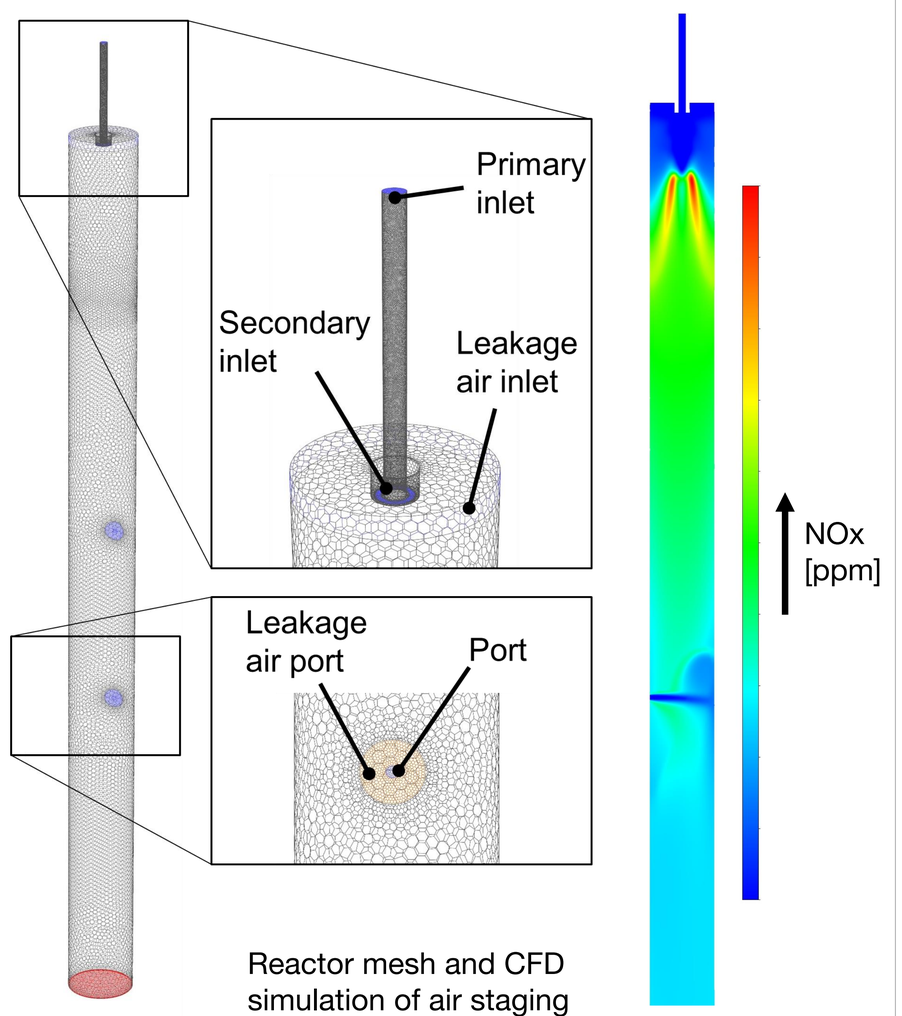
Simplified formation mechanisms of NO [3].

Entrained flow combustion

- **Reactor**
  - Externally heated (50 kW_{th}) ceramic reaction tube, 2 m length and 14,5 cm diameter
  - Fuel input of 2,5 kg/h with residence times of 1 – 3 s
  - Ports at different heights
- **Experimental Approach**
  - Variation of fuel and air mass flow
  - Investigations of air staging through side ports
  - Addition of ammonia through side ports
  - Measurements of N-species (NO_x and intermediates)
- **Simulations**
  - Modelling the release of N-species
  - Simulation of the NO_x emissions
  - Implementation of air staging and ammonia addition into the simulations
  - Up-scaling simulations to medium-sized biomass boilers



Entrained flow reactor considered in Optinox



Reactor mesh and CFD simulation of air staging

Goals and Outlook

- Experimental investigation of nitrogen species on different combustion systems
- Implementation of NO_x reduction methods (air staging, SNCR)
- CFD modelling of NO_x formation and reduction processes
- Measurement of NO intermediates and NO_x emissions from biomass furnaces
- Techno economic assessment and sustainability analysis of the emission reduction methods

[1] US Environmental Protection Agency: Integrated Science Assessment for Oxides of Nitrogen–Health Criteria.
[2] Umweltbundesamt: Stickstoffoxid-Emissionen.
[3] Adapted from Glarborg, et al. (2018): Modeling nitrogen chemistry in combustion. In Progress in Energy and Combustion Science 67, pp. 31–68

Contact

***corresponding author**

Gabriel J. Roeder, M.Sc.

+49 (0) 89 289 16288

gabriel.roeder@tum.de