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Numerical analysis of characteristics of biogas and syngas combustion

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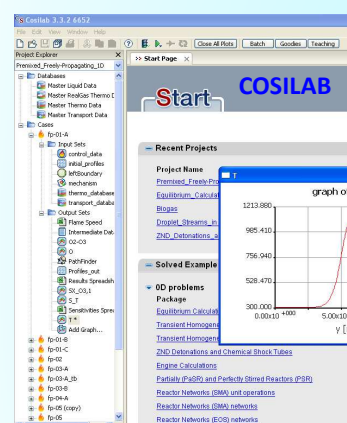
RenewValue Project

- ▶ European project: **ERANETMED2-72-169**
RQ2: Energy and Environment
Collaborative Innovation Project - Mobility
- ▶ **Subject:** Local sustainable renewable energy supply for vulnerable communities in arid and semi-arid Mediterranean zones (MENA)
- ▶ **Partners:** ICARE CNRS (France), Universität Rostock, DBFZ (Germany), Ibn Tofail University (Morocco), INSAT and ENIT (Tunisia), Politecnico di Torino (Italy)
- ▶ **Duration :** 3 years (2018-2021)

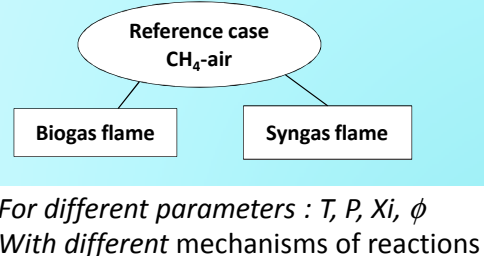
ICARE tasks and objective of the study

- ▶ **Development of modular adapted energy concept**
⇒ Gasifier - multi-fuel burner - boiler
- ▶ **Characterization of syngas and biogas flames**
Experimentally: stability, pollutant emissions, temperature
Numerically: Calculations of laminar burning velocity, flame temperature, pollutants (NOx, CO)...
- ▶ **This poster:** some results of calculations

Combustion characteristics _ calculations



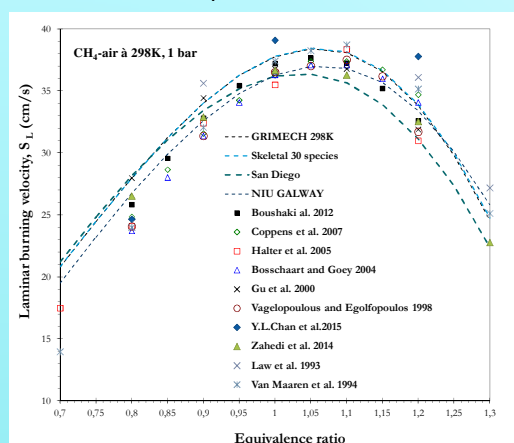
- ✓ Laminar flame velocities (S_L)
- ✓ Flame temperatures (T_f)
- ✓ Chemical species distributions
- ✓ Pollutant emissions (NO, CO...)
- ✓ Pathways of chemical reactions



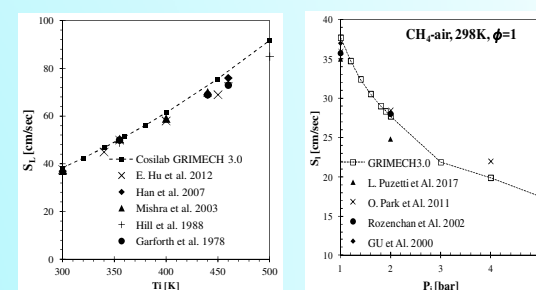
COSILAB: Combustion Simulation Laboratory
Numerical simulation tool for laminar combustion problems 0D, 1D and recently 2D. Here, calculations of flame 1D (RUN 1DL)

Case of CH₄-air flame

Laminar burning velocity with equivalence ratio: CH₄-air, at 298 K, 1 bar



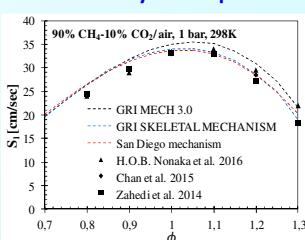
Laminar burning velocity with initial temperature and pressure : CH₄-air, 1 bar, $\Phi=1$



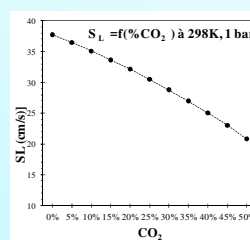
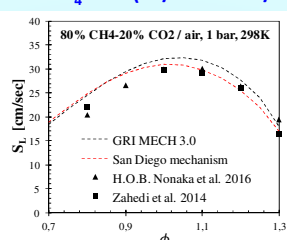
- ✓ Results are validated, with 4 mechanisms of chemical reactions
- ✓ $S_L \nearrow$ with T_i : ⇒ Heating of gas intake induces a better combustion
- ✓ $S_L \searrow$ with P_i

Biogas flame calculations

Flame velocity with equivalence ratio: CH₄-CO₂ (90/10 and 80/20%)

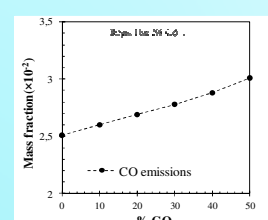
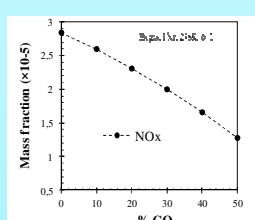
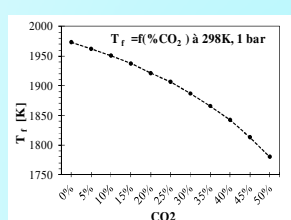


Flame velocity with CO₂



- ✓ Results validated by experiments from the literature
- ✓ Laminar burning velocity (S_L) decreases with CO₂ addition

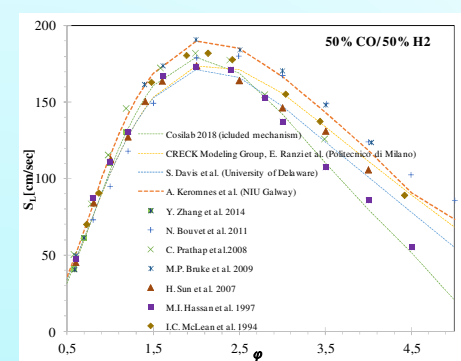
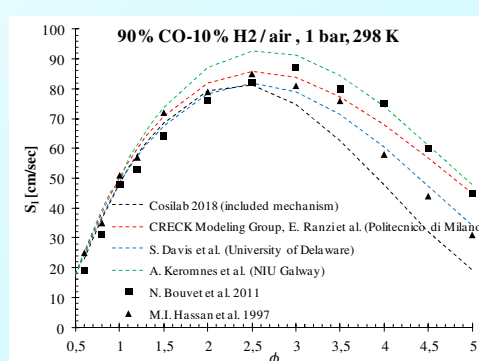
Temperature, NOx and CO emissions of CH₄-CO₂-air flames with CO₂



- ✓ Flame temperature decreases with CO₂ addition
- ✓ NOx \searrow with CO₂
- ✓ CO \nearrow with CO₂
⇒ It is necessary to find a good balance to meet the standards

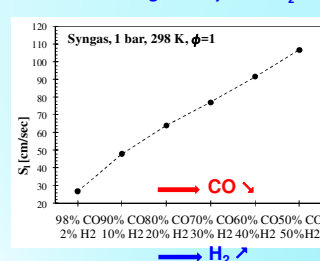
Syngas flame calculations

Laminar burning velocity of CO-H₂-air flames: 90/10% and 50/50 % CO-H₂

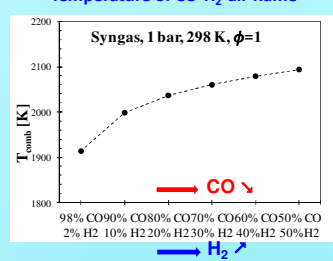


- ✓ Results are compared and validated with experimental results
- ✓ With +H₂: S_L max at $\Phi=2.5$ (CH₄-air: at $\Phi=1.05$)
- ✓ + H₂ ⇒ $S_L \nearrow$; S_{Lmax} : 190 at 50% of H₂, 90 at 50% H₂ against 38 cm.s⁻¹ CH₄-air
- ✓ + H₂: higher reactivity, higher flammability limits, higher velocity, higher T

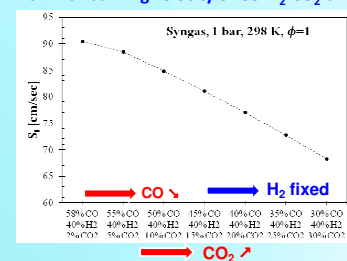
Laminar burning velocity of CO-H₂-air



Temperature of CO-H₂-air flame



Laminar burning velocity of CO-H₂-CO₂-air



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