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Numerical analysis of characteristics of biogas and syngas combustion

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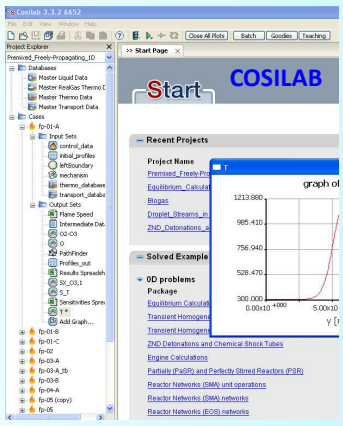
RenewValue Project

- 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

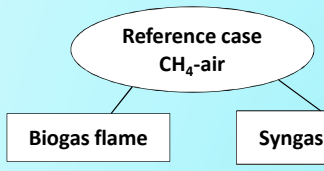
- **Development of modular adapted energy concept**
  ⇨ Gasifier - multi-fuel burner - boiler
- **Characterization of syngas and biogas flames**
  Experimentally: stability, pollutant emissions, temperature
  Numerically: Calculations of laminar burning velocity, flame temperature, pollutants (NOx, CO)…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

Combustion characteristics _ calculations



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

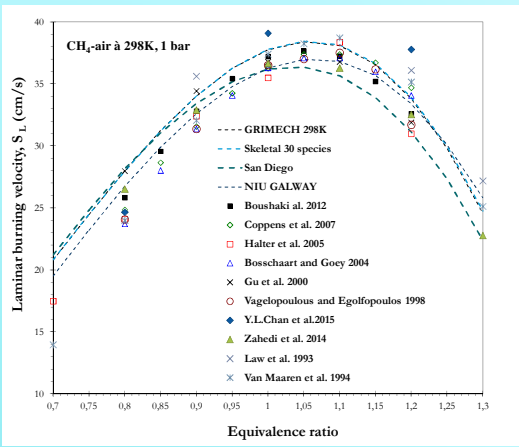
- ✓ *Laminar flame velocities (S_L)*
- ✓ *Flame temperatures (T_f)*
- ✓ *Chemical species distributions*
- ✓ *Pollutant emissions (NO, CO…)*
- ✓ *Pathways of chemical reactions*



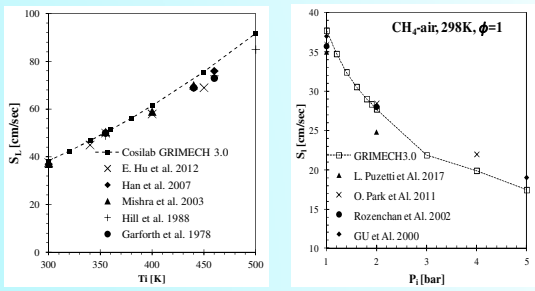
⇨ *For different parameters : T, P, Xi, ϕ*
⇨ *With different* mechanisms of reactions

Case of CH_4-air flame

Laminar burning velocity with equivalence ratio: CH_4-air, at 298 K, 1 bar



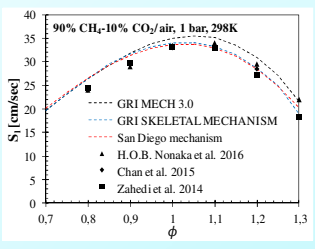
Laminar burning velocity with initial temperature and pressure : CH_4-air, 1 bar, Φ=1

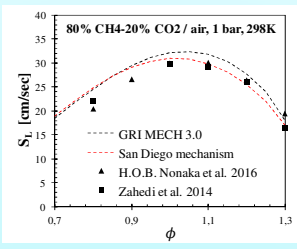


✓Results are validated, with 4 mechanisms of chemical reactions
✓ S_L ↗ with T_i : ⇨ Heating of gas intake induces a better combustion
✓ S_L ↘ with P_i

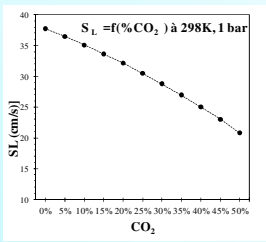
Biogas flame calculations

Flame velocity with equivalence ratio: CH_4-CO2 (90/10 and 80/20%)



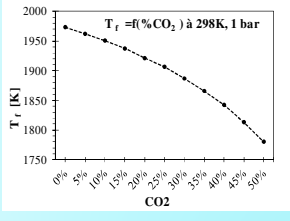


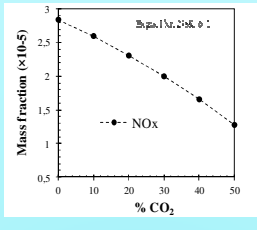
Flame velocity with CO_2

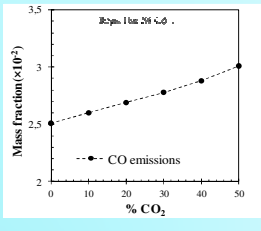


✓ Results validated by experiments from the literature
✓ Laminar burning velocity (S_L) decreases with CO_2 addition

Temperature, NOx and CO emissions of CH_4-CO_2-air flames with CO_2



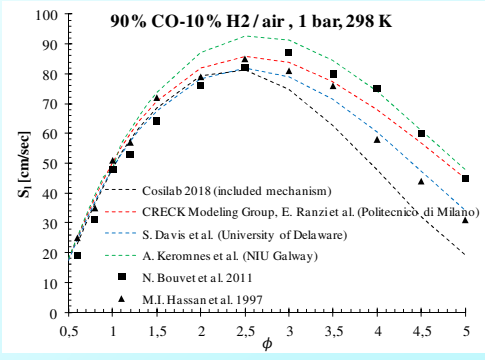


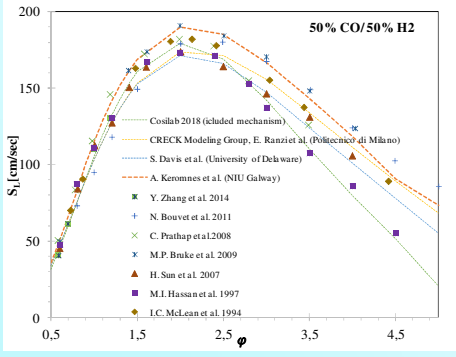


✓ Flame temperature decreases with CO_2 addition
✓ NOx ↘ with CO_2
✓ CO ↗ with CO_2
⇨*It is necessary to find a good balance to meet the standards*

Syngas flame calculations

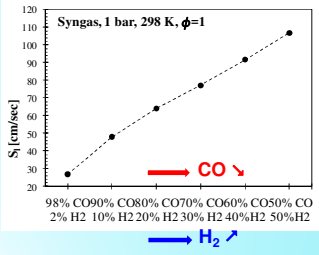
Laminar burning velocity of CO-H_2-air flames: 90/10% and 50/50 % CO-H_2



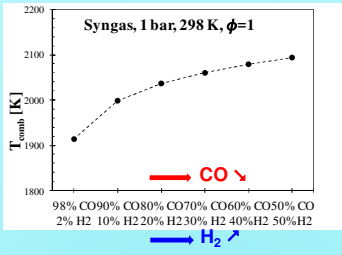


✓ Results are compared and validated with experimental results
✓ With +H_2: S_L max at Φ =2.5 (CH_4-air: at Φ = 1.05)
✓+ H_2 ⇨ S_L ↗ ; S_{Lmax}: 190 at 50% of H_2, 90 at 50%H_2 against 38 cm.s^{-1} CH_4-air
✓ + H_2 : higher reactivity, higher flammability limits, higher velocity, higher T

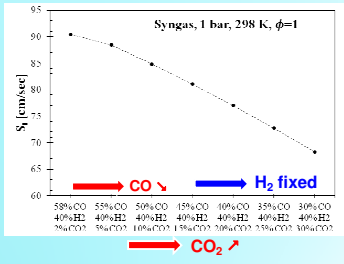
Laminar burning velocity of CO-H_2-air



Temperature of CO-H_2-air flame



Laminar burning velocity of CO-H_2-CO_2-air



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