Towards digital biomass spreader stoker boilers: a detailed, particle-based model of bed combustion coupled with CFD

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Eduardo Gimeno-Escobedo[a-b], Miguel Cámara[a], Jaime Milla[a], Carlos Montañés[a], Antonio Gómez[a], Norberto Fueyo[b]
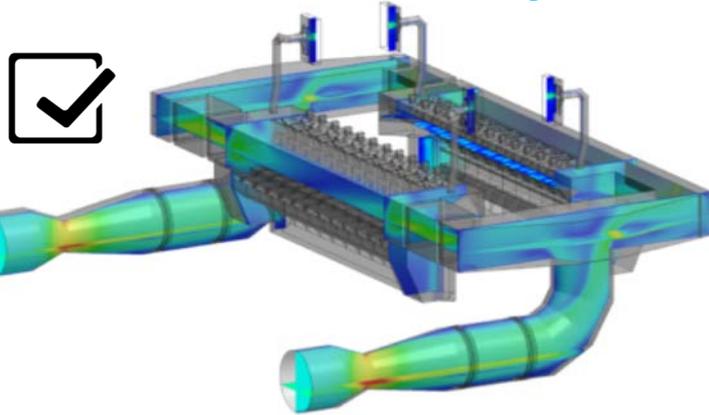
[a]Nabladot S.L., WTCZ Torre Oeste, Planta 11, Avda. María Zambrano 31, 50018, Zaragoza, Spain

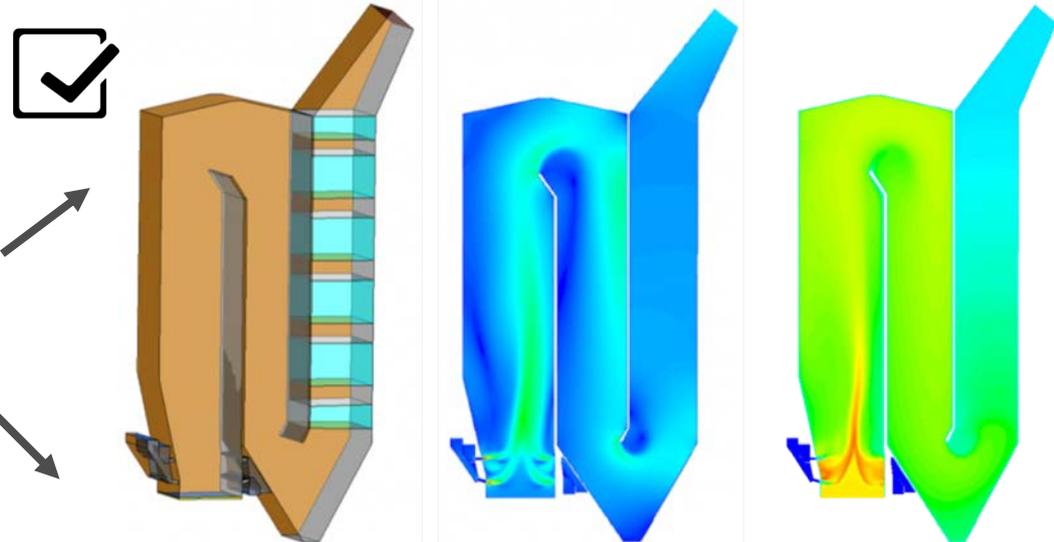[b]Fluid Dynamics Group, University of Zaragoza, María de Luna 3, 50018, Zaragoza, Spain

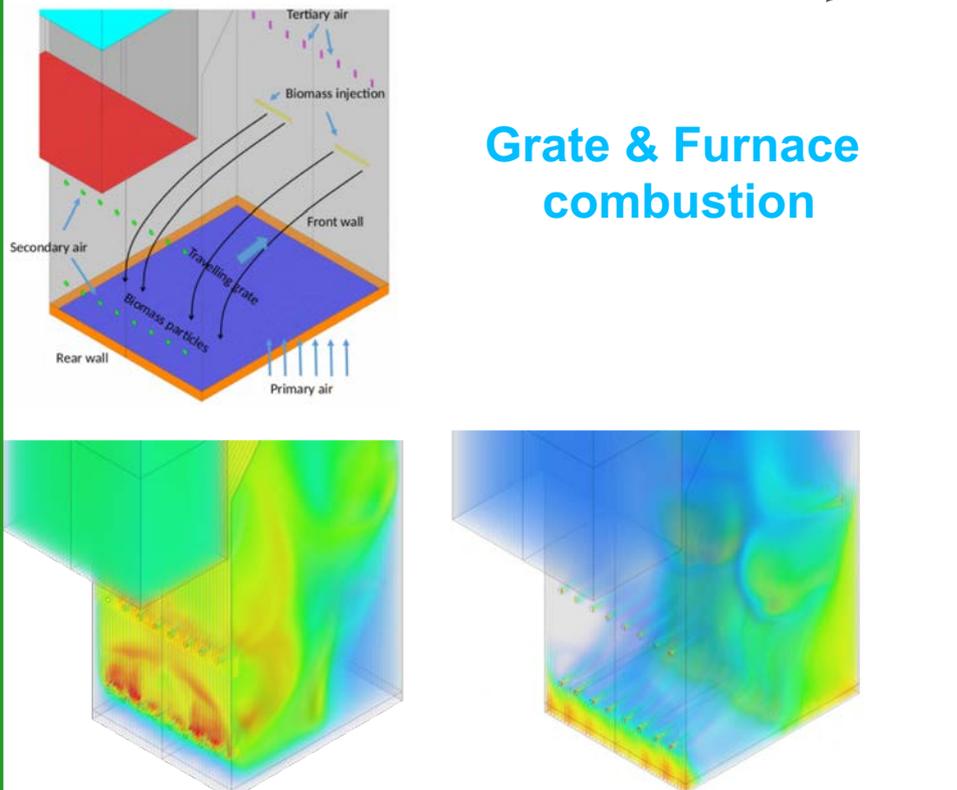NABLADOT::()

A modeling toolkit for biomass boilers
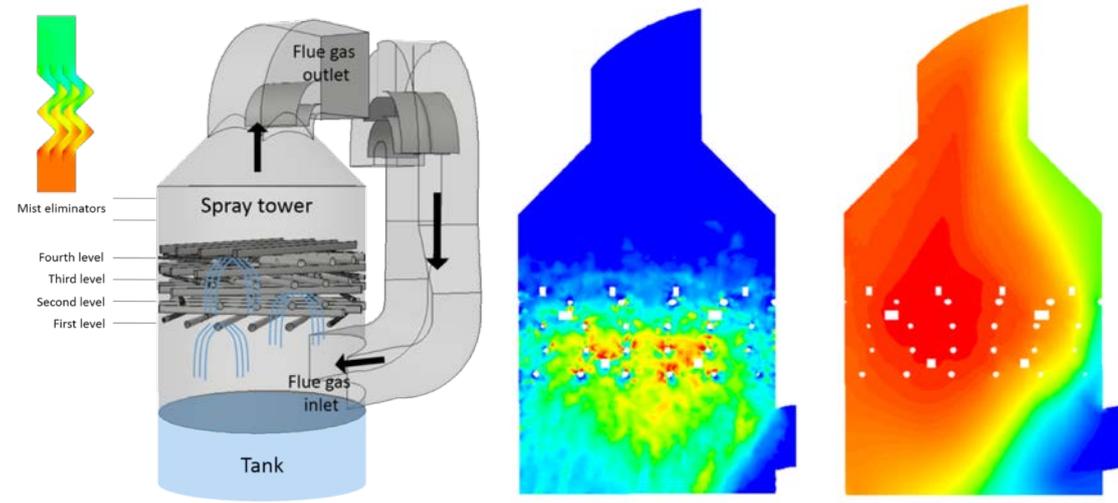
Air distribution system

Post-combustion - Heat recovery zone

**Grate & Furnace combustion**

Flue gas treatment: DeSox, DeNOx

# But... modeling biomass combustion is complex!

- ▶ Highly complex because...
  - ▶ 3 M's:
    - ▶ Multiphysical: chemistry, particle movement, heat transfer, radiation, particle accumulation... at the same time!
    - ▶ Multiphase: solid particles + gaseous phase
    - ▶ Multiscale: biomass particles (mm) to boiler dimensions (m)
  - ▶ Heterogeneous particles: different materials, sizes, shapes, water/volatile/char content...

- ▶ Two typical, extreme approaches:
  - ▶ Many simplifications & hypothesis: eg. 0D models for the grate; too simplistic?
 - ▶ DEM: tracks particles + interactions; accurate, but expensive!

Gas phase (3.3e-10 m) — Biomass (0.00165 - 0.015 m) — Grate boiler (21 m)
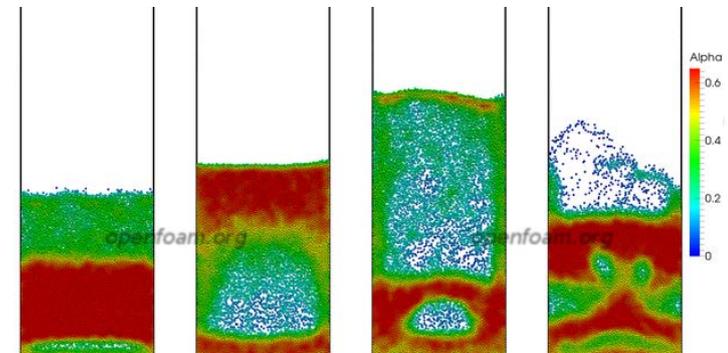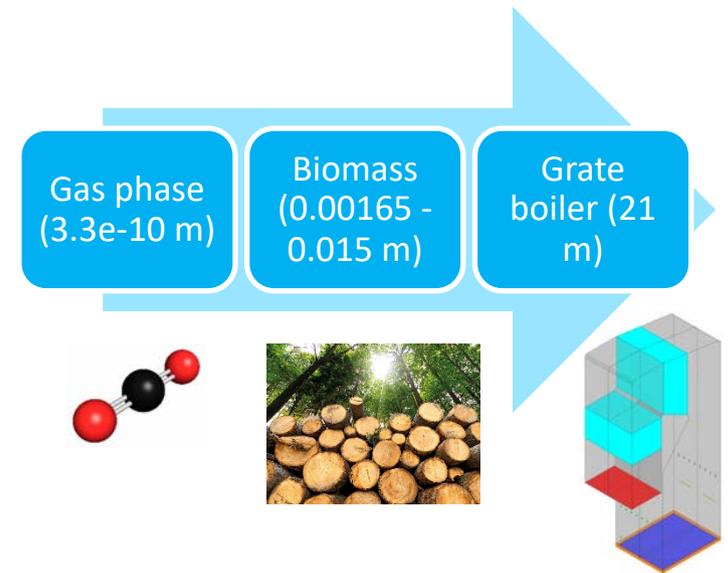
Lagrangian approach + Euler discretization

▶ Particles clustered into groups, according to size & material

  ▶ Reduced number of particles!

▶ Discretized bed: particles only in discrete positions

▶ In bed, movement only due to grate (straight line) + bed height differences (diagonal)

  ▶ Interactions/colisions negligible
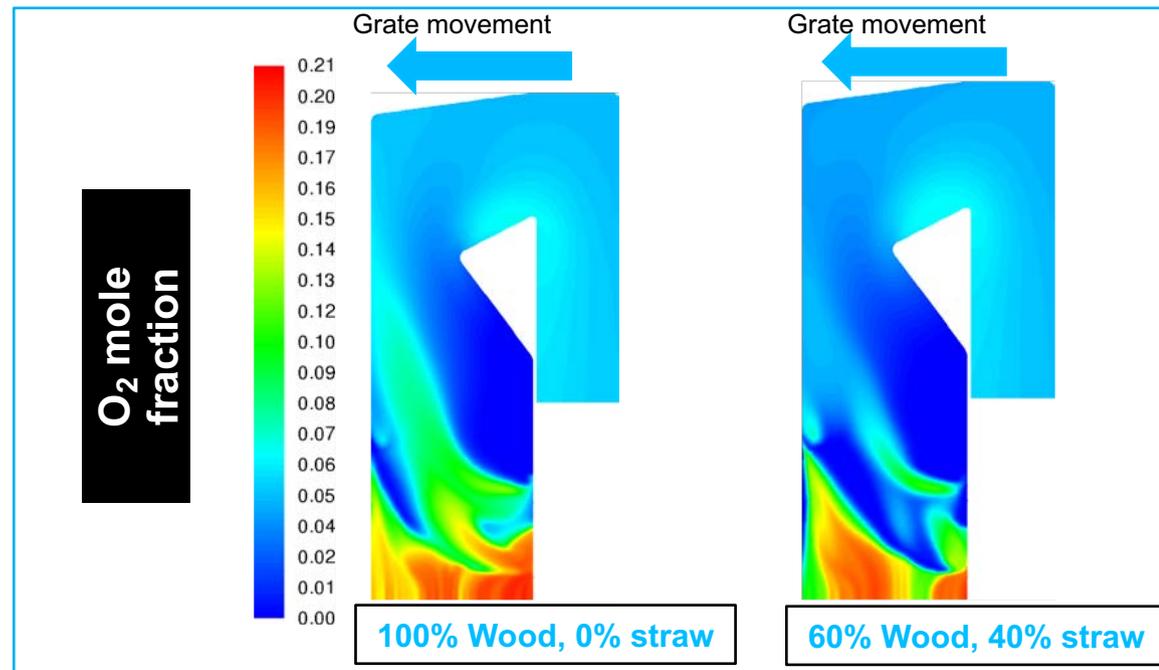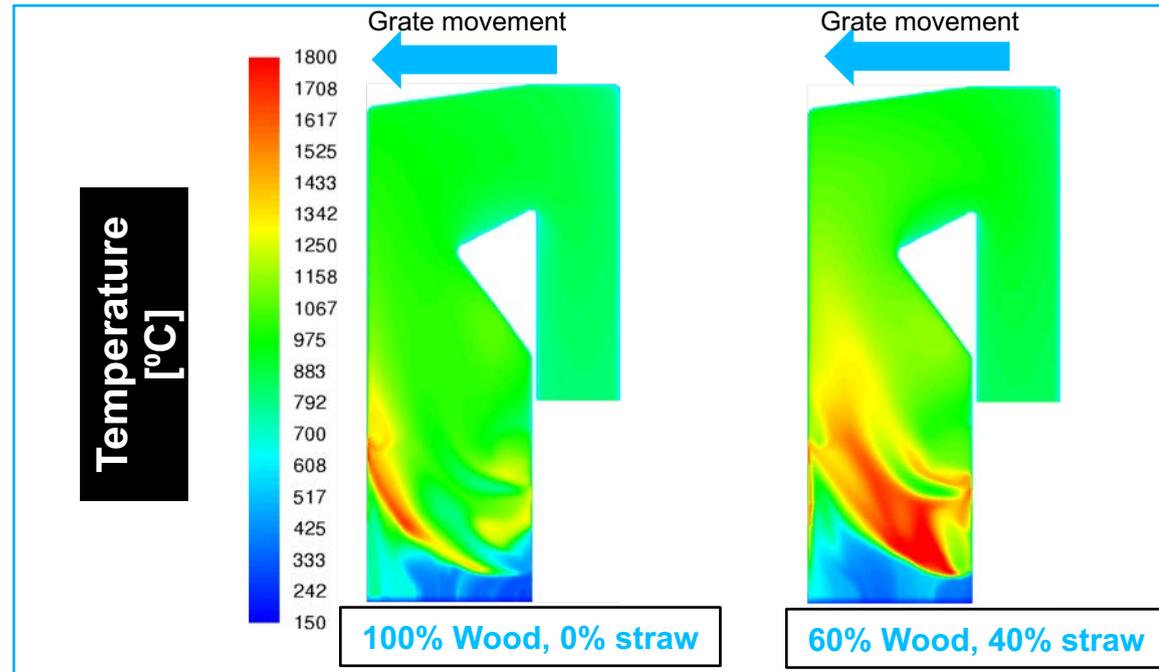 ▶ Movement through exchange between neighbouring cells
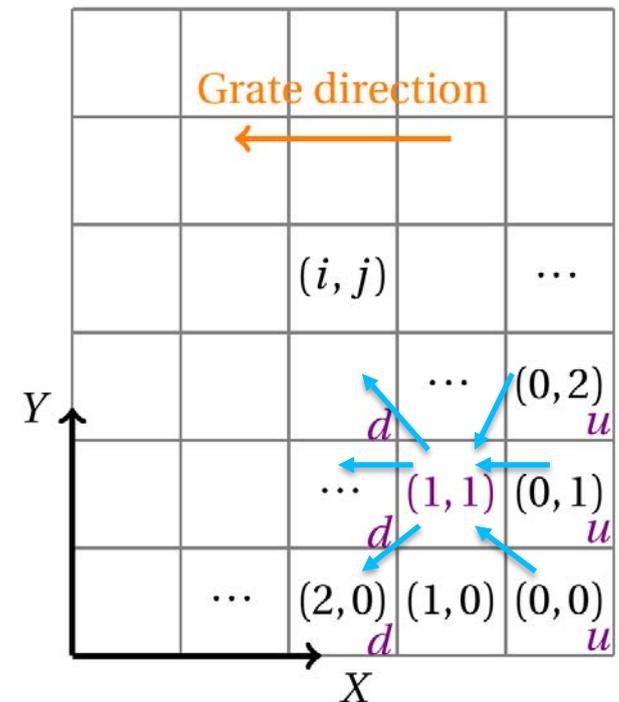
Bed results: high detail, low computational cost

▶ Provides results at each location in the bed: temperature, landing particle mass, released volatiles, accumulated ash...

Temperature [K]

Landing particle mass [kg/s]

Released volatiles [kg/s]

Accumulated ash [kg]
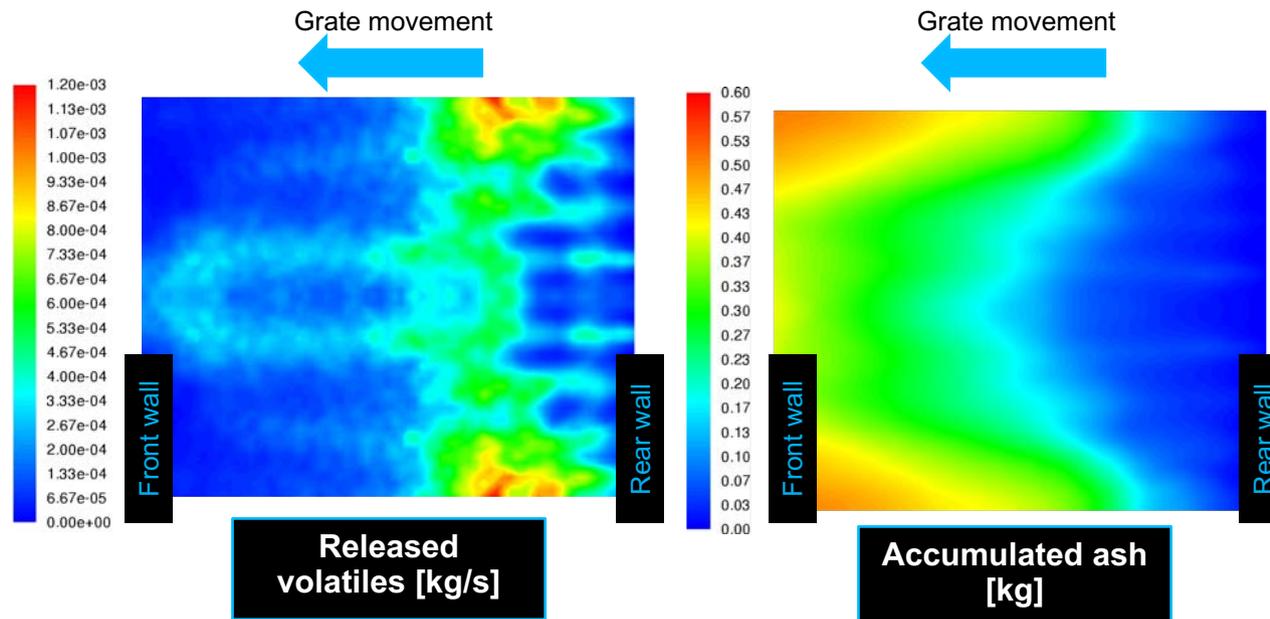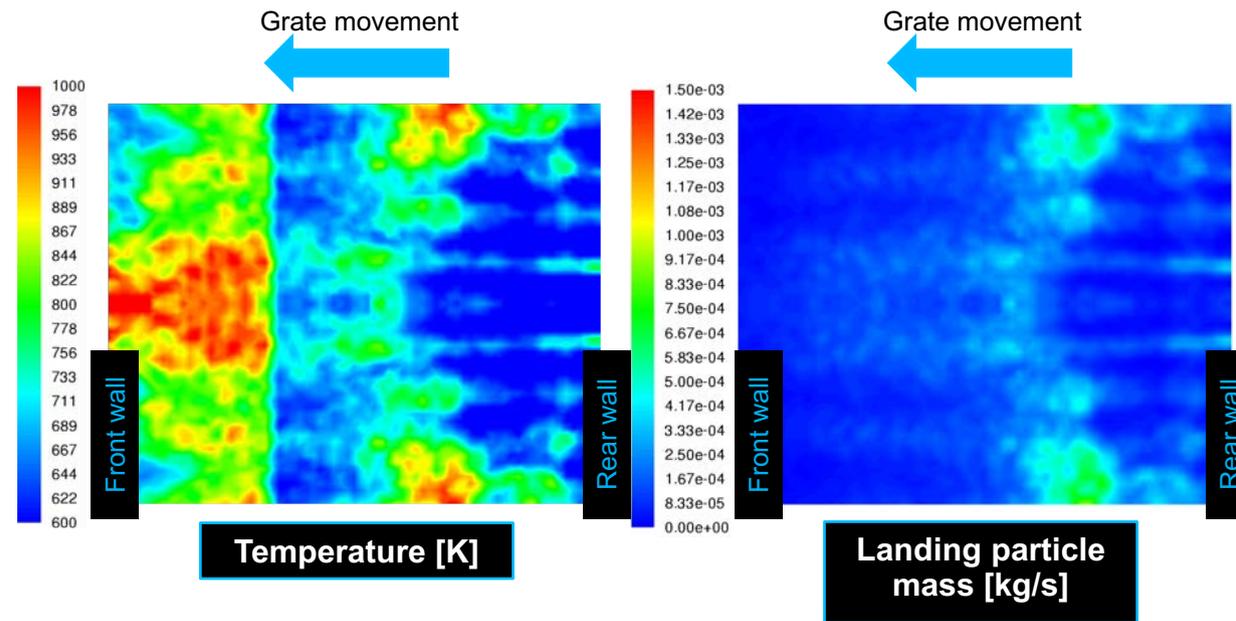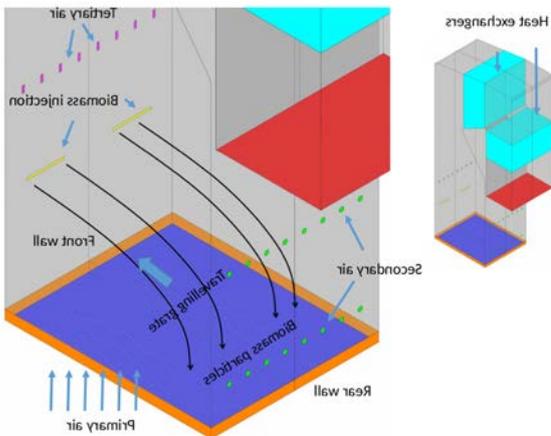
Freeboard results: high detail, low computational cost

▶ Enables parameter studies in practical times

▶ Valid for heterogeneous mixtures:

  ▶ Effect of straw content in feed

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  ▶ www.nabladot.com

▶ Or send us an email:

  ▶ egimeno@nabladot.com

  ▶ agomez@nabladot.com

  ▶ cmontanes@nabladot.com

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High detail, low computational cost

▶ Provides results at each location in the bed: temperature, landing particles, heat released, particle content...