



Power generation from fossil fuels and biomass: An international collaboration towards low carbon energy

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Sotacarbo: Società Tecnologie Avanzate Low Carbon

Shareholders:

- ENEA (50%)
- Regional Government of Sardinia (50%)

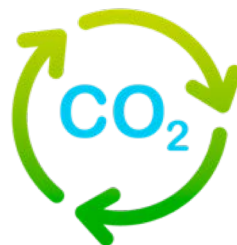
Established: 1987



coal / biomass
gasification



CO₂
capture



CO₂
utilization



CO₂
storage



energy
efficiency

Italian representative in the **IEA – Clean Coal Centre**
(first implementing agreement of the International Energy Agency)



Sponsor of the
IEA – Greenhouse Gas R&D programme

Member of **ECCSEL-ERIC** (the European Carbon Dioxide Capture
and Storage Laboratory Infrastructure)



Italian representative in the **SET Plan Implementation
Working Group** on Carbon Capture Utilization and Storage

Founding member of the no-profit **CO₂ Value Europe**
international association





gasification

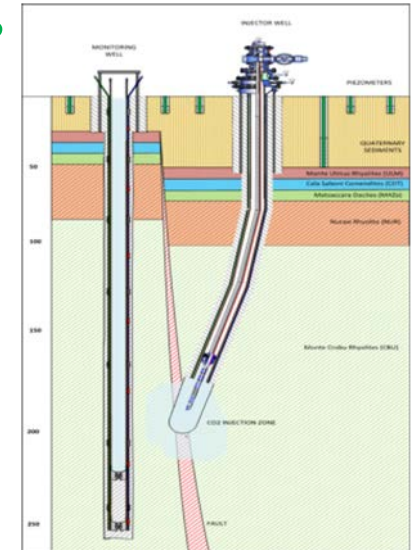
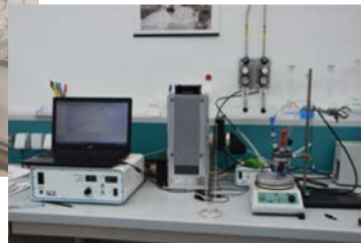


carbon capture



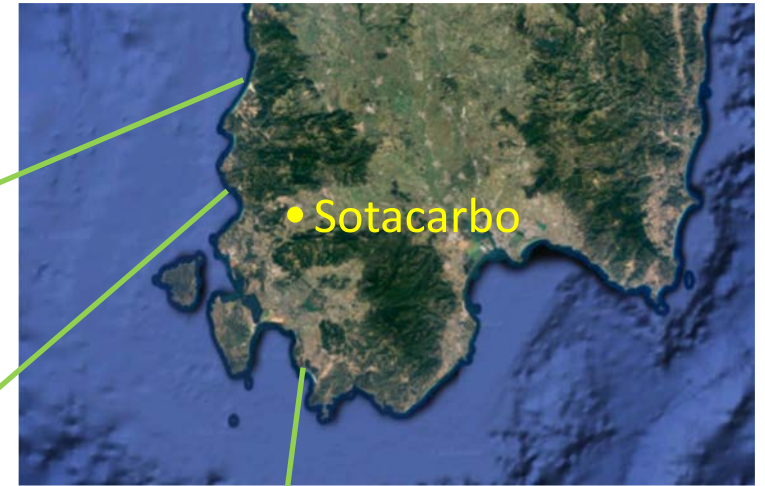
carbon reuse

geological storage



welcome!!!

Piscinas sand dunes and beach (76 km)



Porto Pino beach (27 km)



Pan di Zucchero rock, Masua (26 km)



- **fixed-bed gasification**
- fluidized-bed gasification
- carbon capture, use and storage



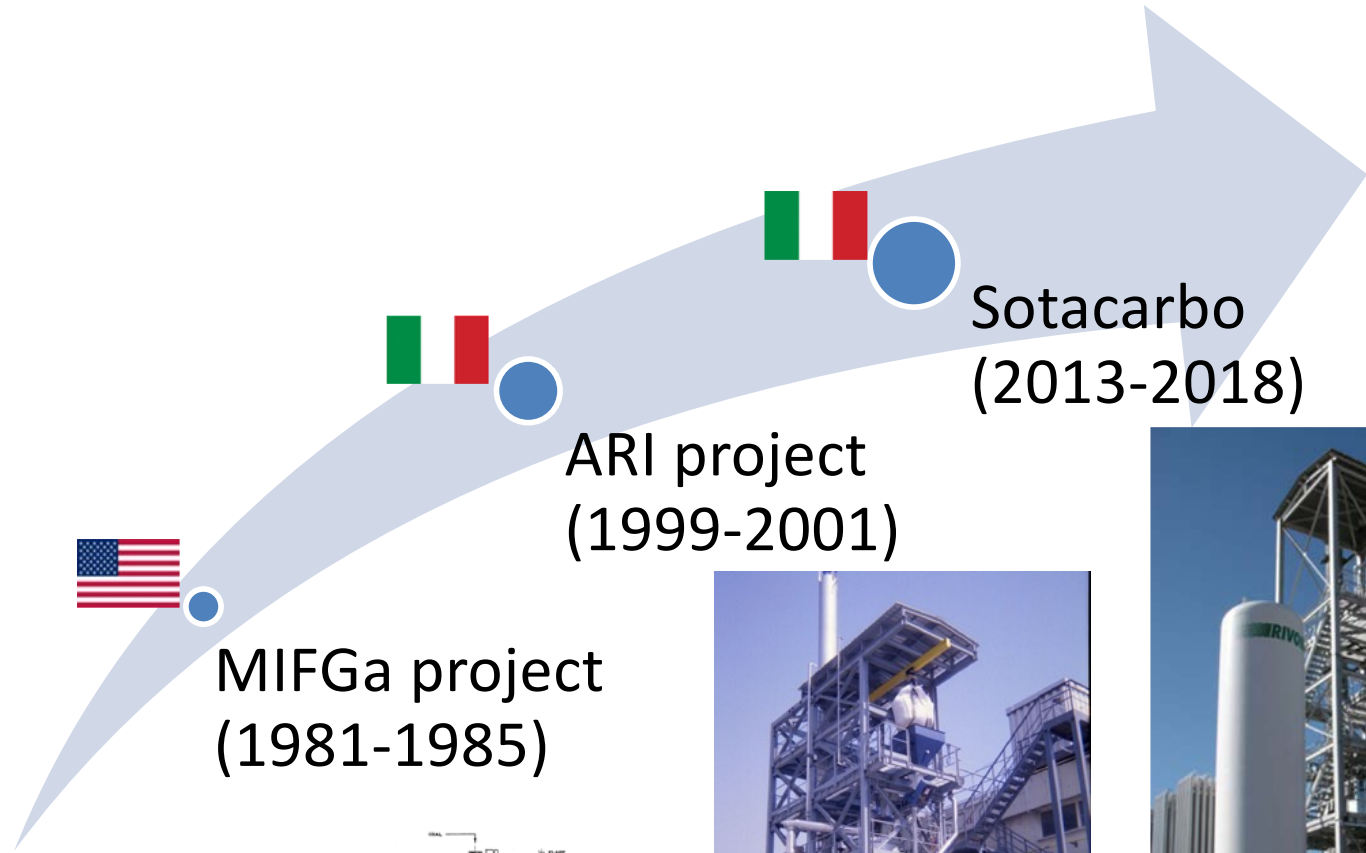
*fixed-bed up-draft
demonstration-scale
gasification unit*

operating since 2013

- technology: HMI
- original design: ARI
- thermal power: $< 5 \text{ MW}_{\text{th}}$
- internal diameter: 1.3 m
- fuel: coal and/or biomass

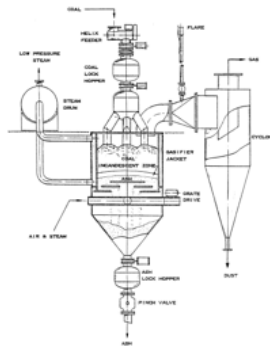
For more details:
Calì et al. Fuel 2017;207:671

technology development



... to be continued

historical
Wellman-Galusha
technology



Alaska Syngas project



modular units

- high efficiency
- low emissions
- low cost



demo-scale CHP unit



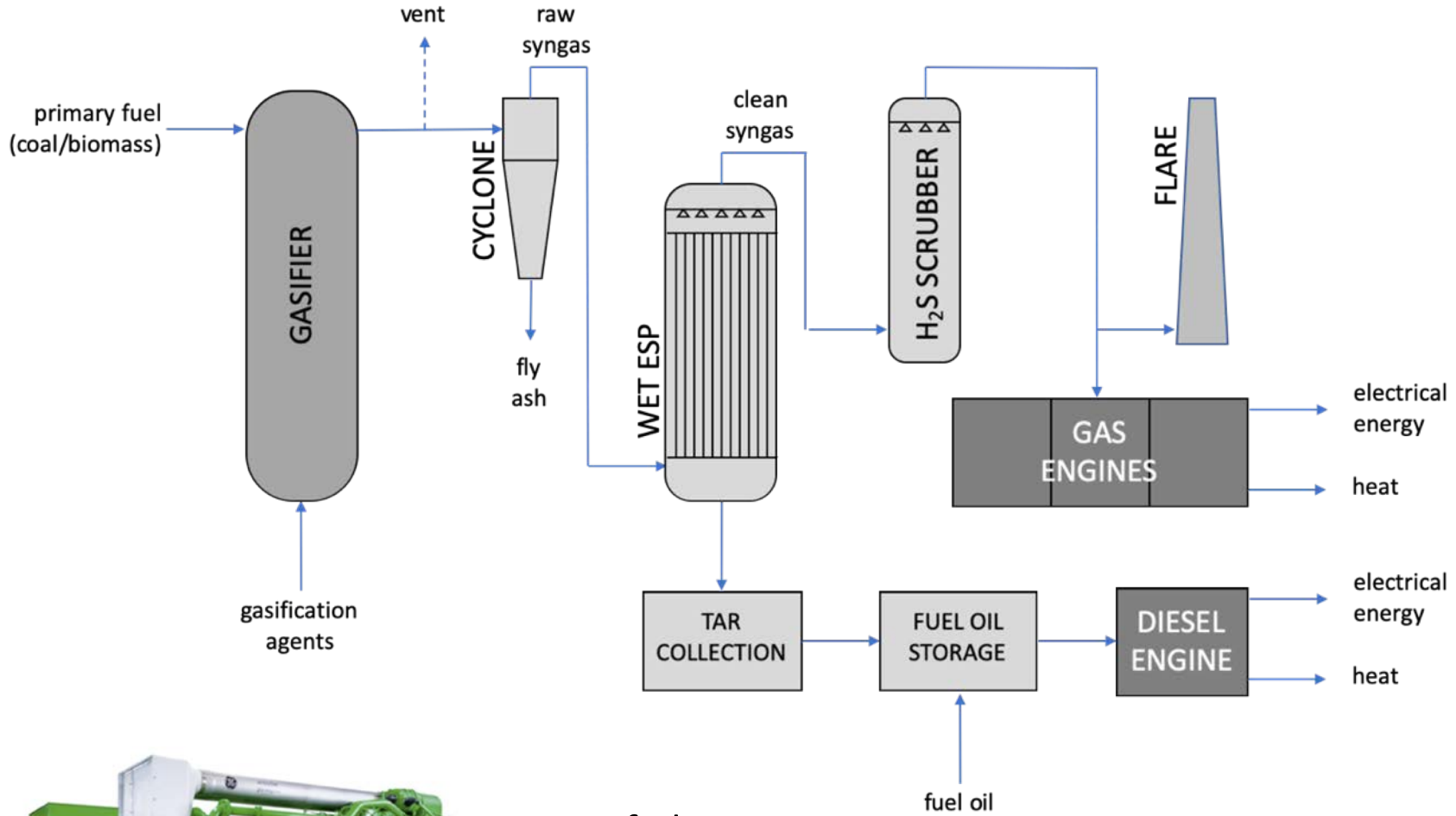
UAF campus (Atkinson Power Plant)



Courtesy of C. Ward (UAF)

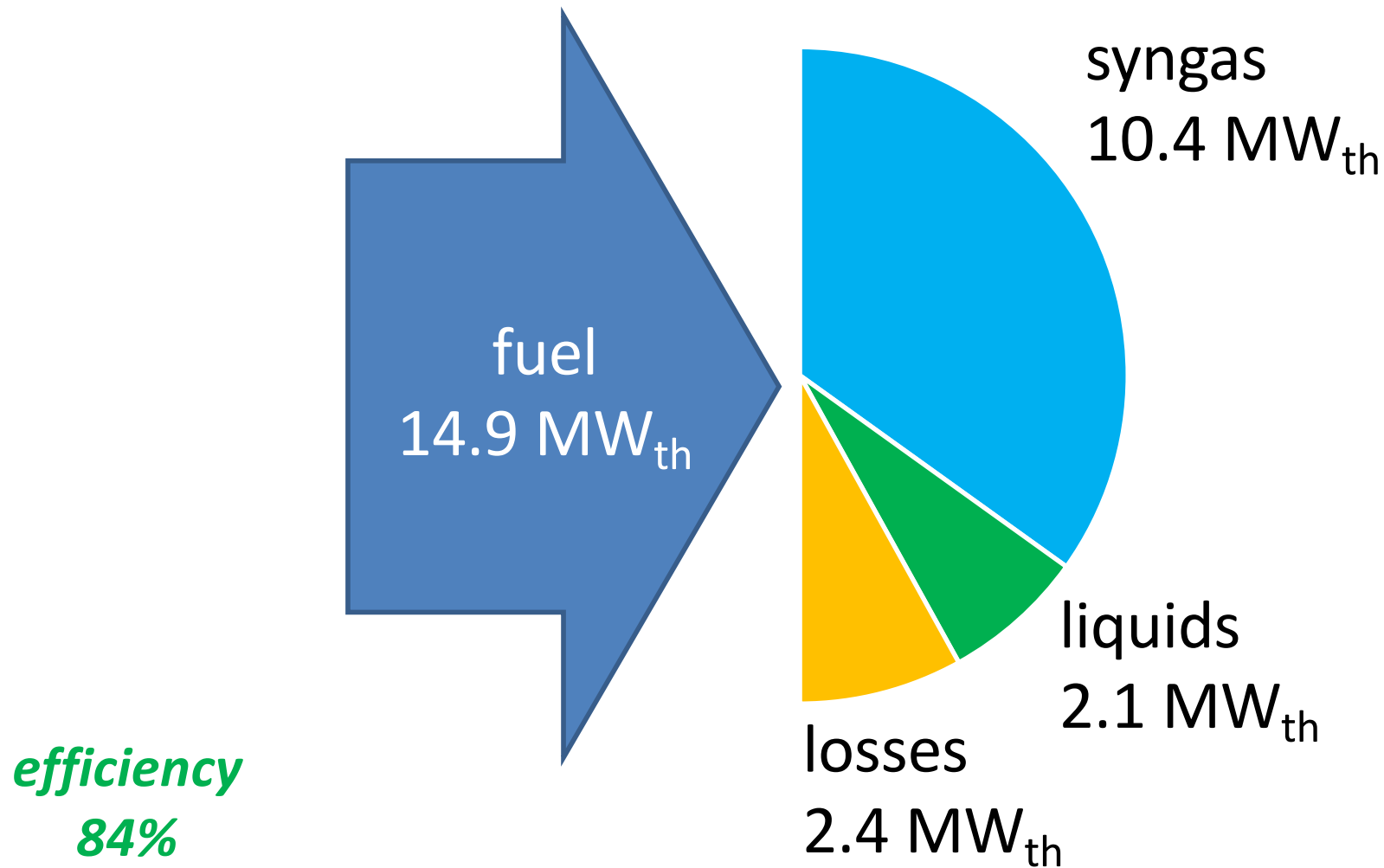


Alaska Syngas project

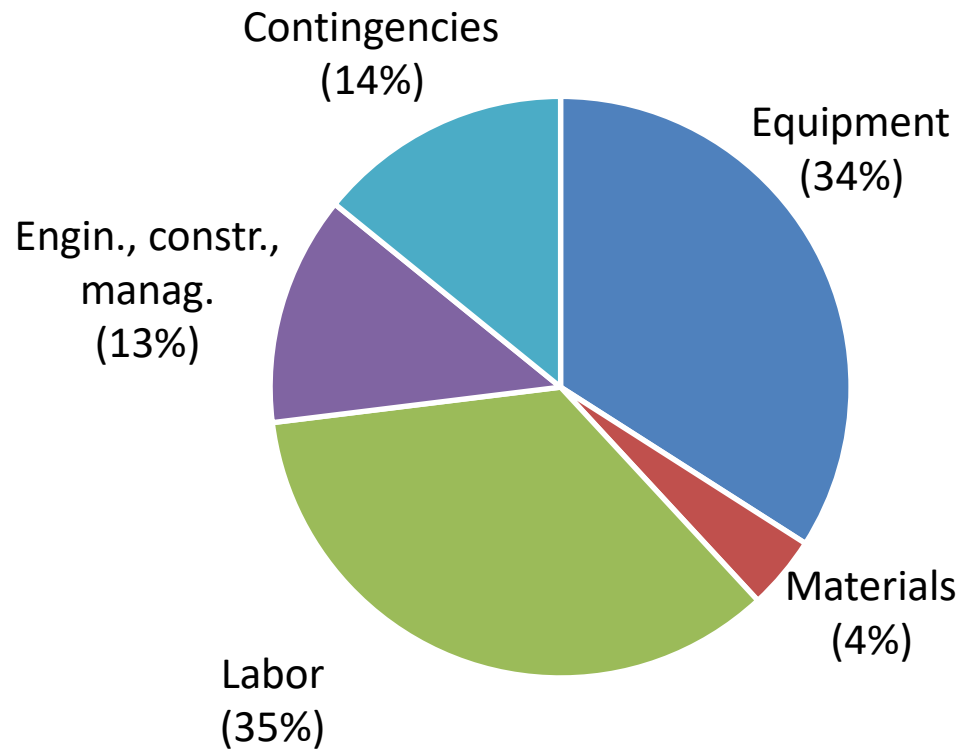


syngas fed
Innio Jenbacher JMS620
spark ignition engine (1965 kW_e)

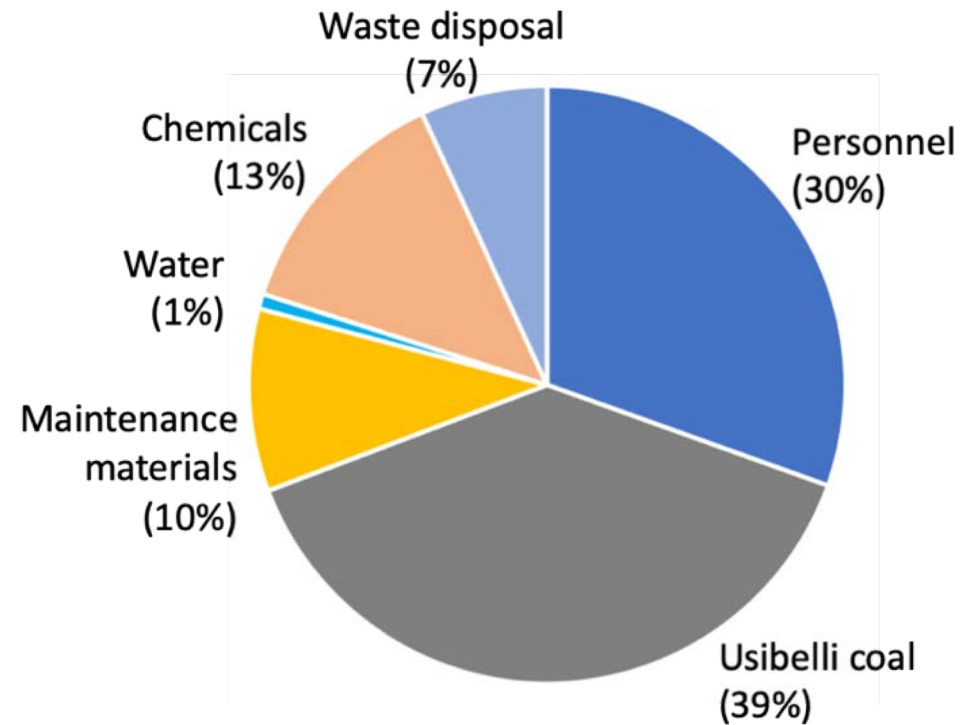
expected gasification performance



cost analysis



total plant cost
45.7 M\$



total operating cost
3.9 M\$/year

extreme operating conditions...



Courtesy of C. Ward (UAF)

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Cost share by:



Working team

- Brent J. Sheets (UAF, PM)
- Harvey Goldstain (Worley Group)
- Randy Hobbs (Hobbs Industries)
- Frances Isgrigg (UAF)
- Diane R. Madden (NETL)
- Rolf E. Maurer (HMI)
- Alberto Pettinau (Sotacarbo)
- Andrea Porcu (Sotacarbo)
- Russel Steiger (UAF)
- David Thimsen (HMI)
- Charles Ward (UAF)

- ✓ fixed-bed gasification
 - **fluidized-bed gasification**
 - carbon capture, use and storage

Italy-USA joint project



cooperative research and development
agreement (CRADA)
signed in June 2018



Joint research
activities on

- gasification
- CO₂ capture (membranes)
- CO₂ utilization
- CO₂ geological storage



*bench-scale
bubbling fluidized-bed
gasification unit*

operating since 2017

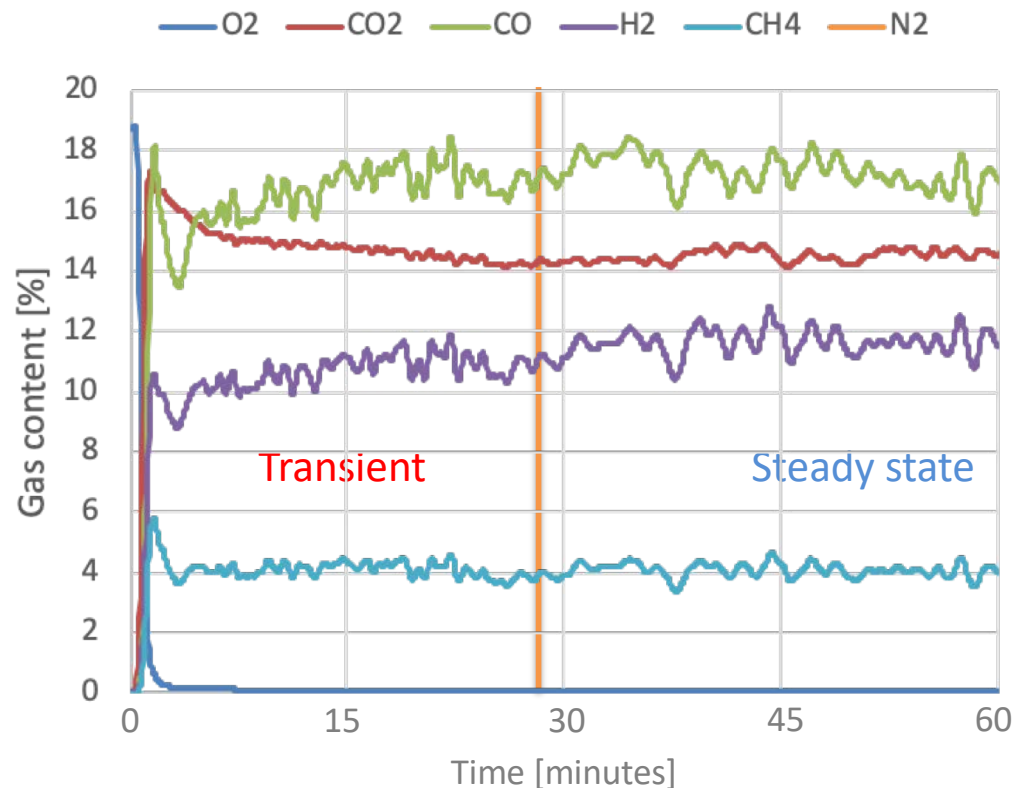
- design: PID Eng & Tech
- fuel: biomass / coal
- feedstock: < 100 g/h
- thermal power: < 500 kW_{th}
- internal diameter: 26 mm
- total height: 800 mm



biomass size: 0.5 - 2.5 mm



Sample Name	Moisture %	Volatile %	Ash %	Fixed Carbon %	Volatile Dry %	Ash Dry %	Total C %	H %	N %	S %	O %
Cypress	10.06	67.39	2.37	20.18	74.92	2.63	49.80	6.25	0.44	n.a.	43.51



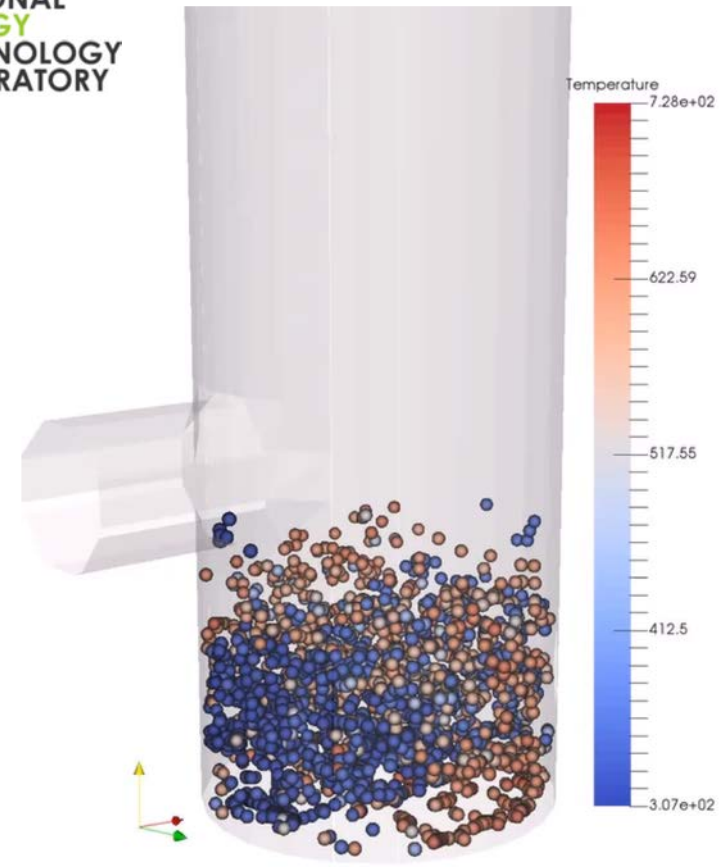
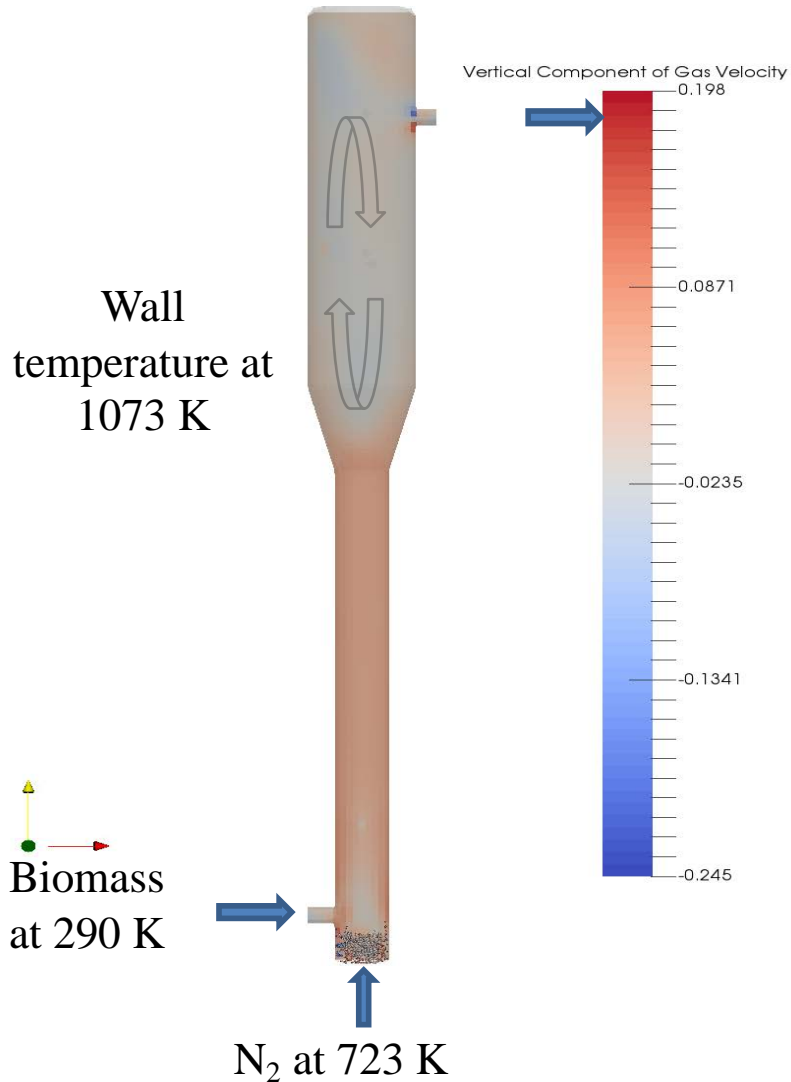
- biomass flow rate: 100 g/h
- air flow rate: 1.8 NI/min @ 350°C
- olivine loaded: 35 ml → 56.4 g
- reactor temperature: 850 °C
- condenser temperature: 7 °C
- condensed water+TAR : 15.40 g
- elutriates into the filter: 0.85 g

equivalence ratio = 0.26
average syngas LHV = 4.2 MJ/kg
carbon conversion = 0.74

multiphase flow modeling

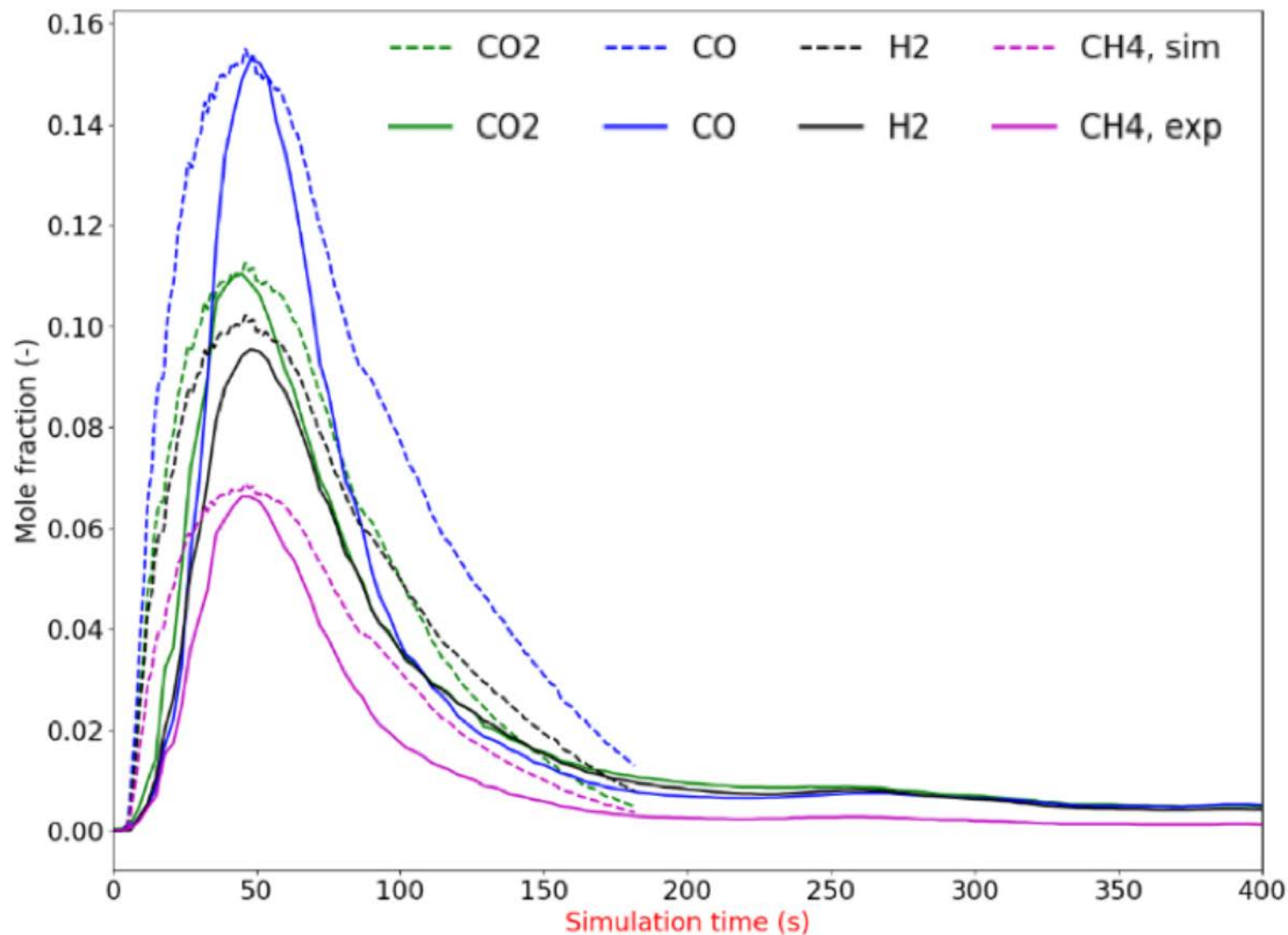
MFiX Multiphase Flow with Interphase eXchanges

powered by



Courtesy of M. Shahnam (NETL)

simulation vs. experimental



future steps

model
validation for
bench-scale
gasification unit



simulation of
pilot-scale
gasification unit

design of a
new pilot-scale
gasification unit



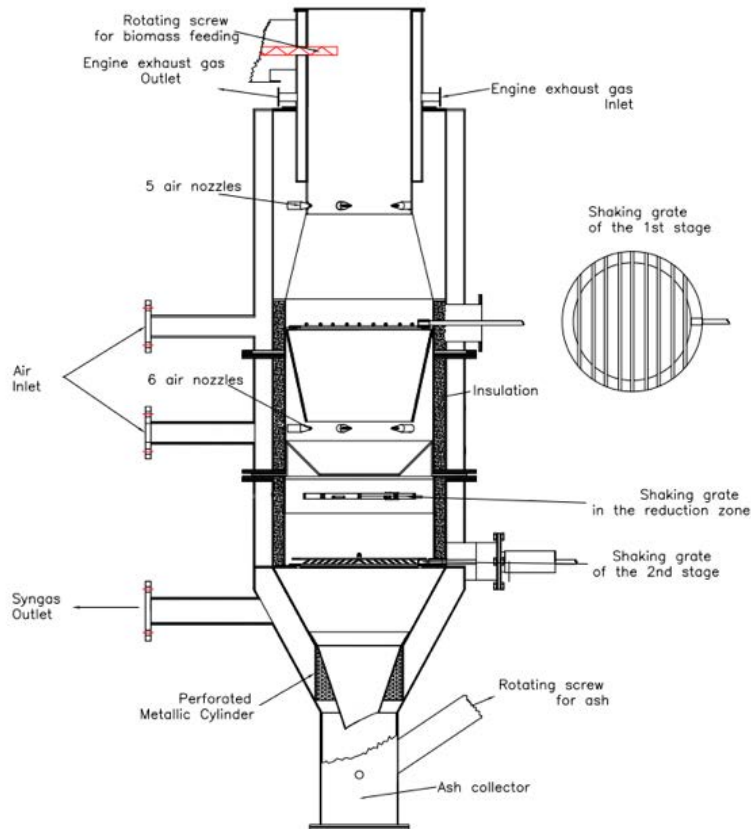
FABER
*fluidized-bed pilot-scale
gasification unit*

operating since 2018

- design: Vanvitelli Univ.
- thermal power: $< 500 \text{ kW}_{\text{th}}$
- internal diameter: 0.49 m
- total height: 5.73 m
- bed temp.: 700-950 °C
- fuel: wood chips (100 kg/h)

For more details:

Porcu et al. Energies 2019;12:494



*Design of a new
fixed-bed down-draft gasifier*

expected operation in 2021

- thermal power: 30 kW_{th}
- fuel: wood pellet and brewery spent grain



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CRADA References:

- Gianni Serra (Sotacarbo)
- Charles Taylor (NETL)
- Anthony Armaly (NETL)

Working team

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- Andrea Porcu (Sotacarbo)
- William Rogers (NETL)
- Bhima Sastri (U.S. DoE)
- Mehrdad Shahn timer (NETL)
- Yupeng Xu (NETL)
- Jia Yu (NETL)

- ✓ fixed-bed gasification
- ✓ fluidized-bed gasification
- **carbon capture, use and storage**



*bench-scale unit for
membrane characterization*

operating since 2018



current collaboration with
the University of Bologna



joint activities within CRADA
under definition



For more details:

Olivieri et al. Journal of Membrane Science 2018;555:258



*bench-scale unit for
catalyst characterization
for CO₂ hydrogenation to fuels*

operating since 2016



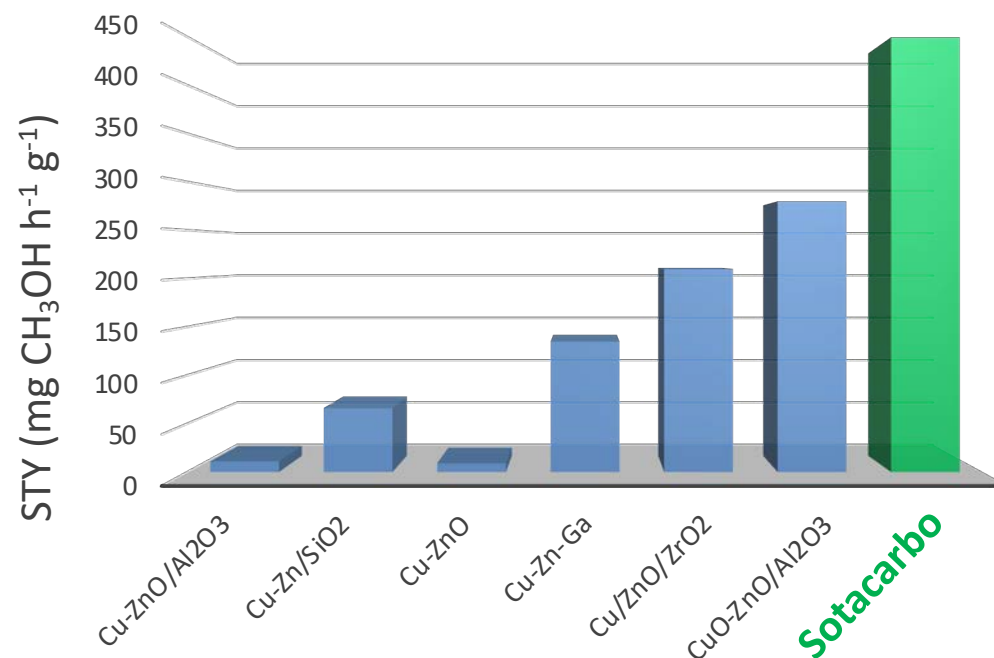
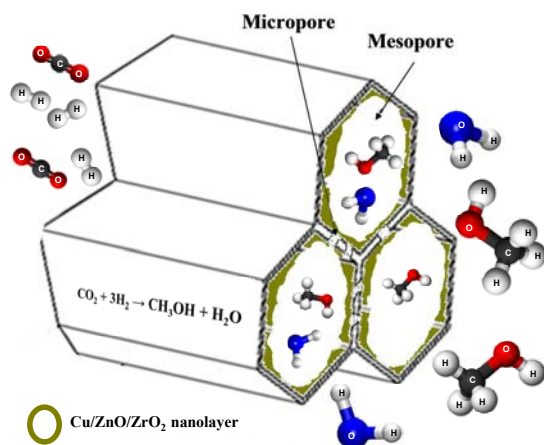
current collaboration with



joint activities within CRADA
under definition

... but ...



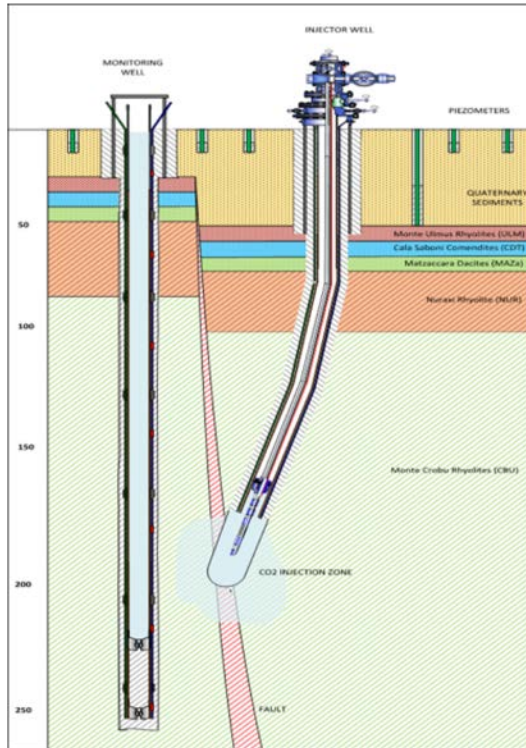


PCT application number
PCT/EP2019/053068
(February 2019)

- **high conversion** efficiency
- **no activation** required
- tolerance to **oxygen**

For more details:

Mureddu et al. Applied Catalysis B 2019;258:117941



Sotacarbo Fault Lab

expected operation in 2020



current collaboration with
several international partners
(including European ENOS project)



K-COSEM
Research Center



preliminary activities within CRADA

rock sample characterization

(further activities are planned for 2021)



8th annual international
Sotacarbo Summer School
on low carbon technologies
8-12 June 2020



In partnership with:



www.sotacarbosummerschool.it

