Karlsruhe Institute of Technology

Hans-Joachim Gehrmann - Institute for Technical Chemistry

Science for Impact

We develop solutions for a safe, sustainable and future-oriented world.

KIT in Figures
2023

414
Professors

22 816
Students

10 034
Employees

49
New spin-offs and start-ups

6
Locations (200 ha area)

1 686
International scientists

3 367
Doctoral researchers

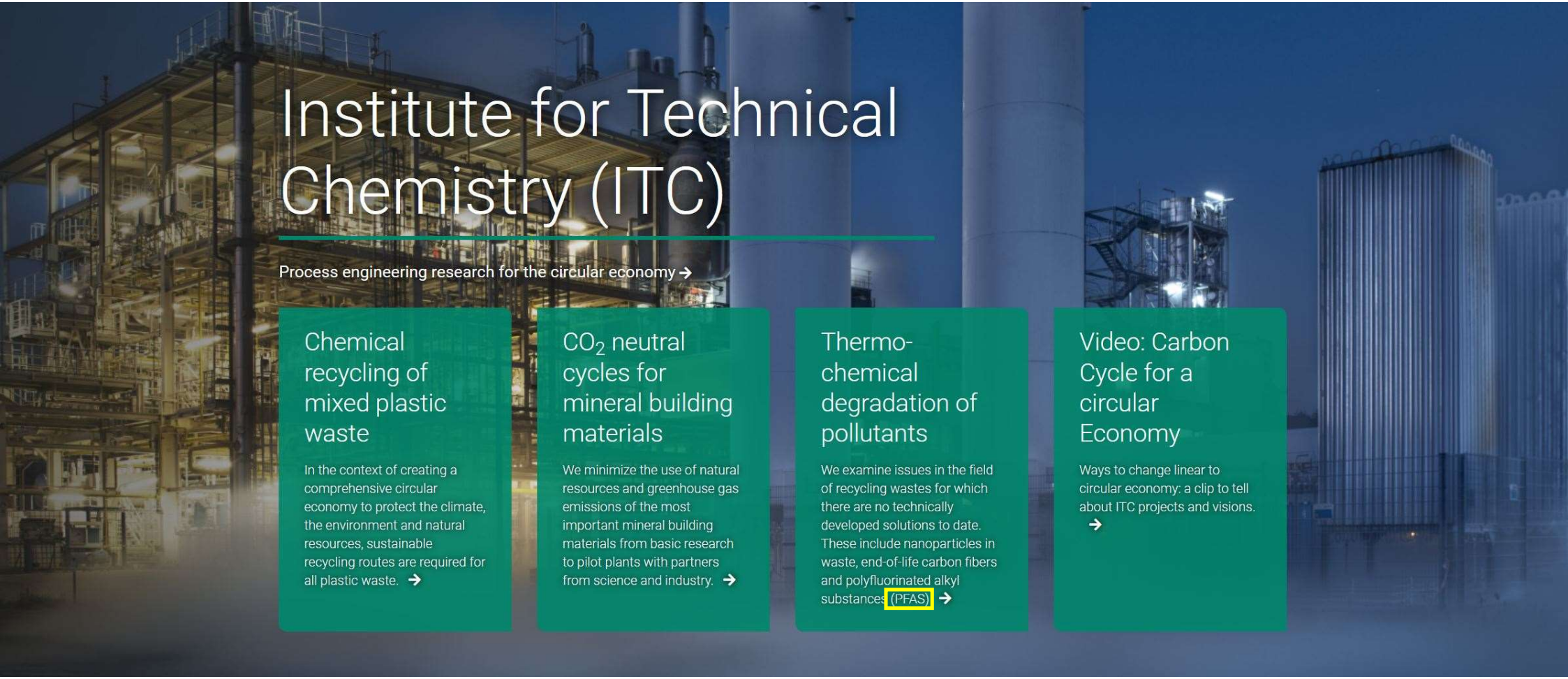
358
Trainees

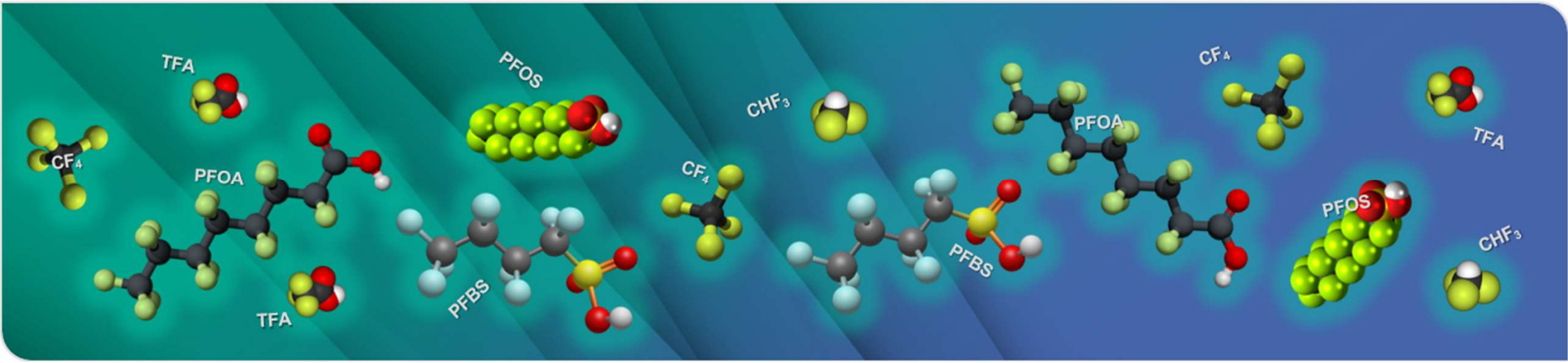
43
Patent applications

Budget
1,147.6 million euros

28%	state funds
30%	federal funds
42%	third-party funds

Research Activities at the Institute for Technical Chemistry





Fate of Fluoropolymers in WtE

CEWEP Waste-to-Energy Congress in Gdansk, 4th to 6th of June 2025

Hans-Joachim Gehrmann, Krasimir Aleksandrov, Vanessa Nuredin, Anna Holfelder, Manuela Wexler, Manuela Hauser, Steffen Zuchowski, Philipp Bergdolt, Andrei Bologa, Dieter Stapf

Institute for Technical Chemistry

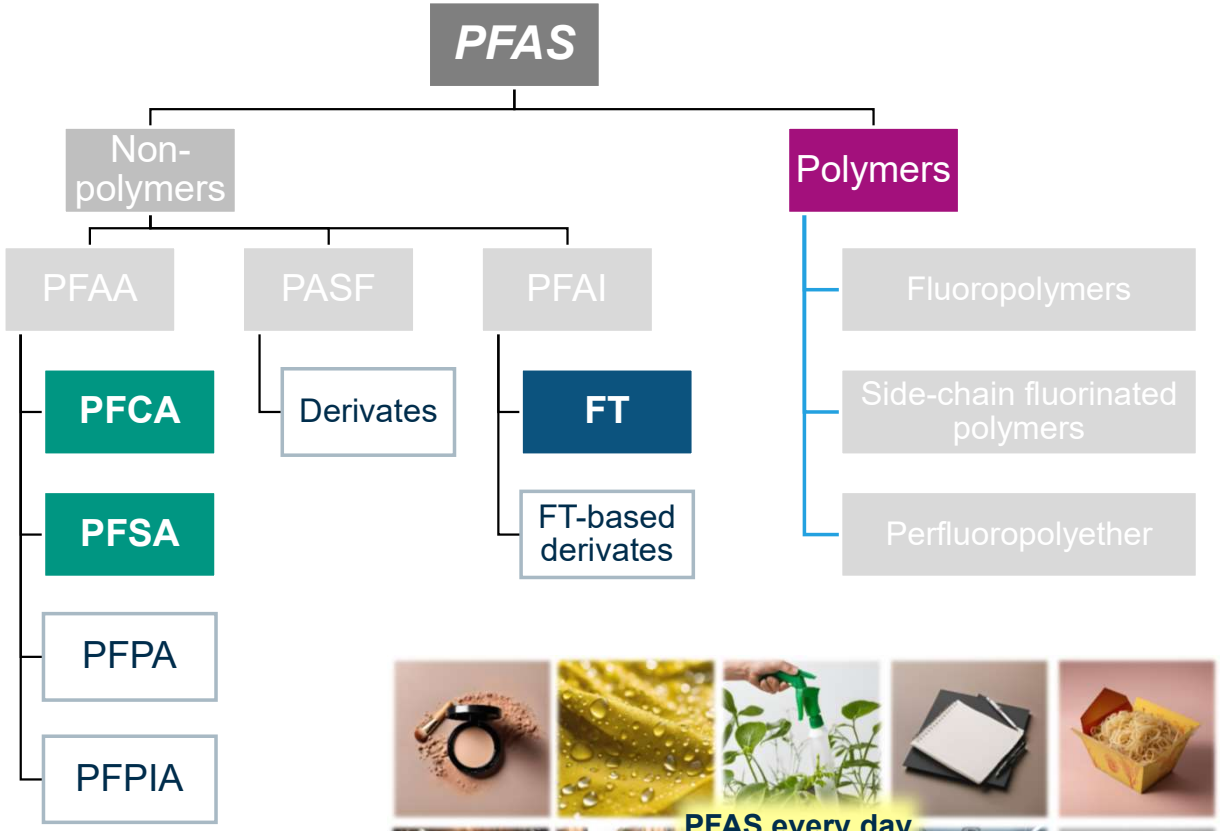
Per- and poly-Fluorinated Alkyl Substances (PFAS) key facts

PFAS

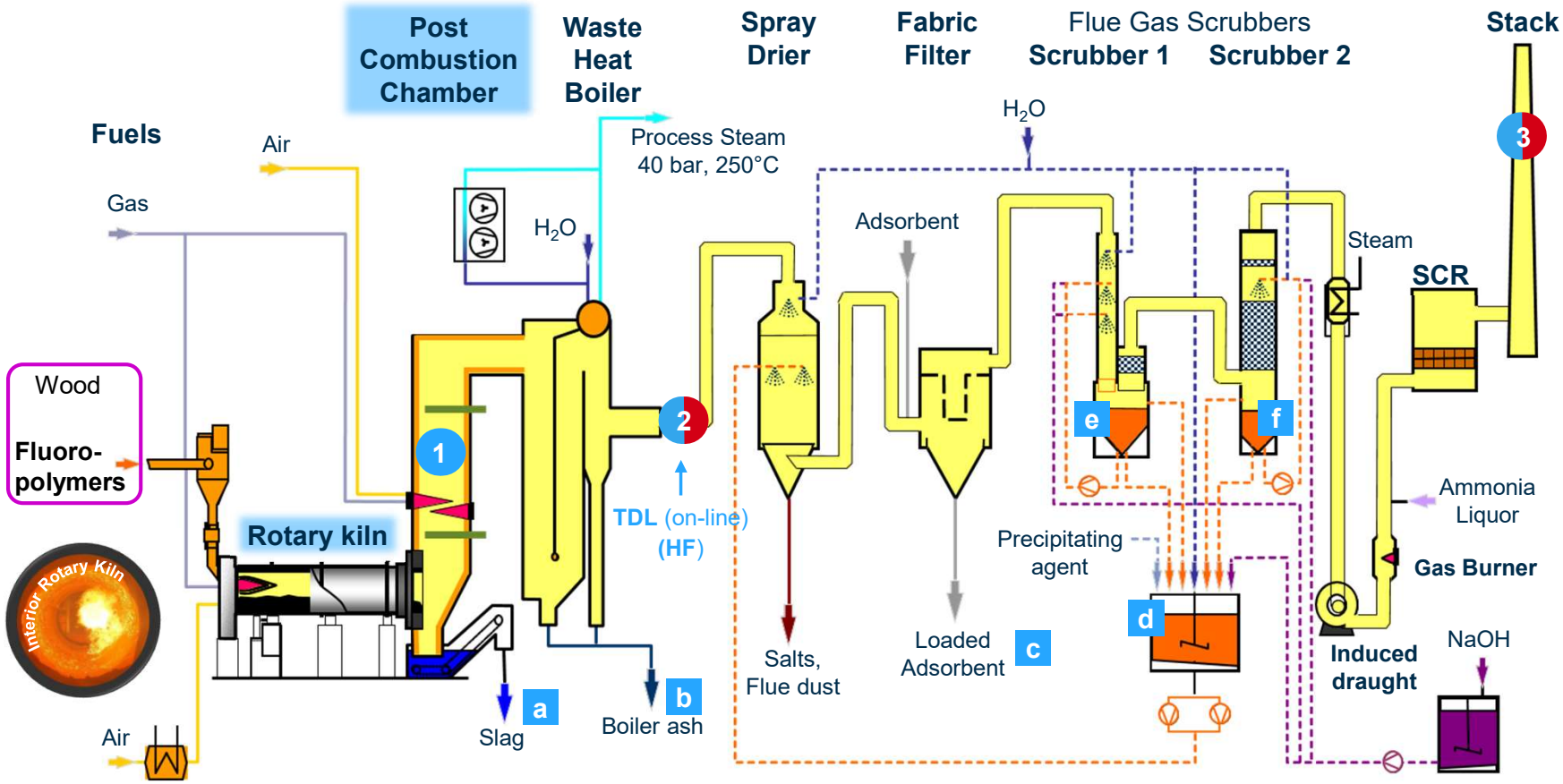
- 1938 - PTFE discovery
- > 14.000 substances
- outstanding chemical and thermal stability
- oil & fat repellent

Examples

- **Carboxylic acids** → **- COOH**
  - PFOA, TFA
- **Sulfonic acid** → **- SO_3**
  - PFOS, TFSA
- **Fluorotelomer**
  - FTOH, FTCA, FTSA
- **Polymers** → **$[C_lF_m]_n$**
  - PTFE, PFA



Pilot Waste Incinerator BRENDA
(BRENnkammer mit DAmpfkessel)



Key figures

Total thermal power
2,5 MW

Rotary kiln
- Thermal output = 1,5 MW
- Temperature flue gas 800 – 1200°C
- Turnover solid fuels 250 kg/h

Post-combustion chamber
- Thermal output = 1 MW
- Temperature flue gas max. 1250°C

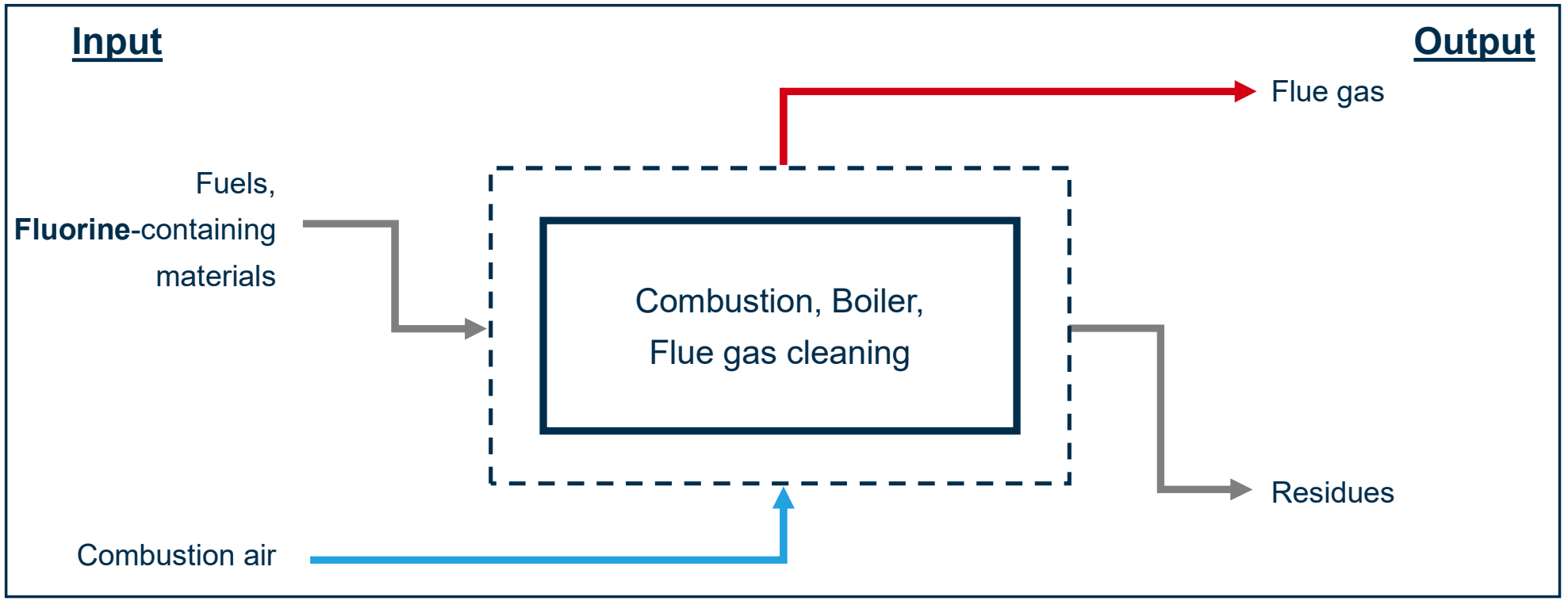
Boiler
- Saturated steam 40 bar, 250°C

Flue gas cleaning
- IED

1 2 3 PFAS sampling flue gas / GFL / Gore

a b c d e f PFAS sampling residues & liquids

Balancing Space / R2PIC

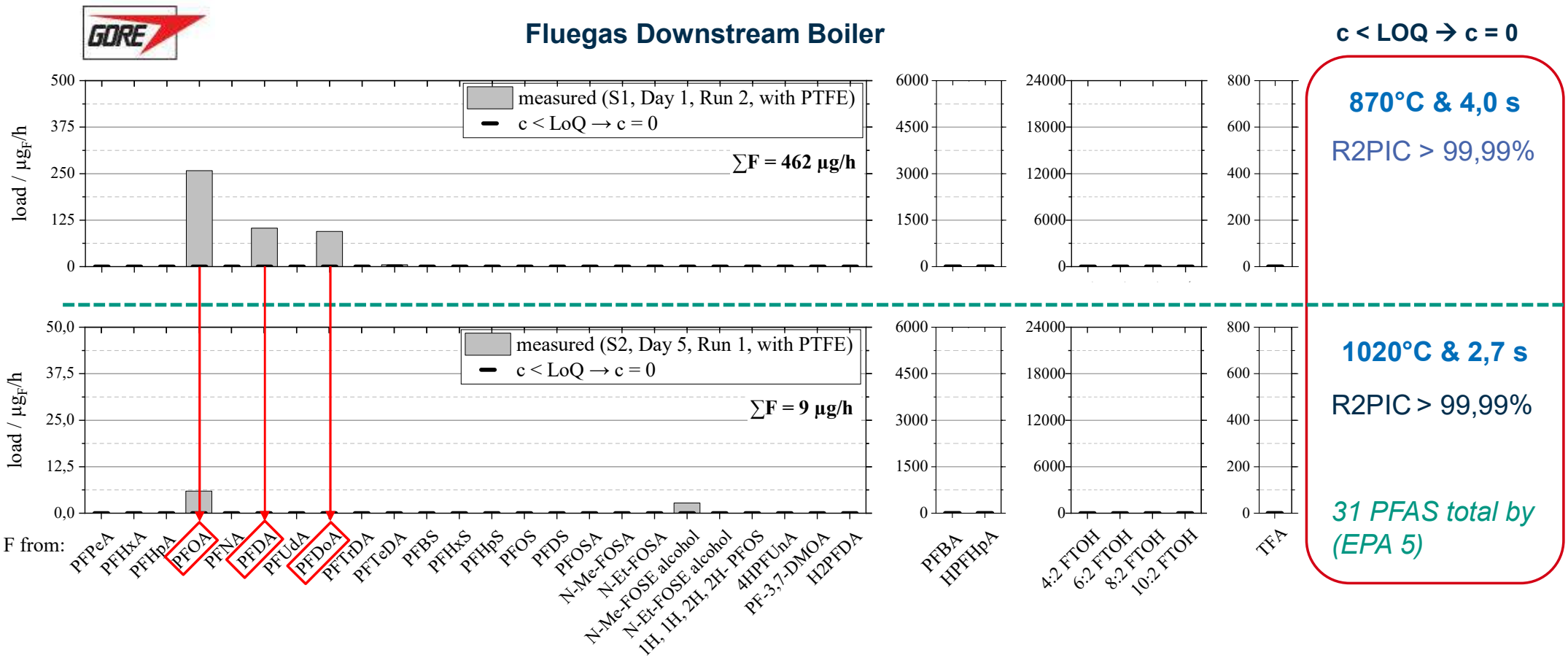


In: F from fluoropolymers ($F_{PFAS,in}$)

Out: F from PFAS ($F_{PFAS,out}$)

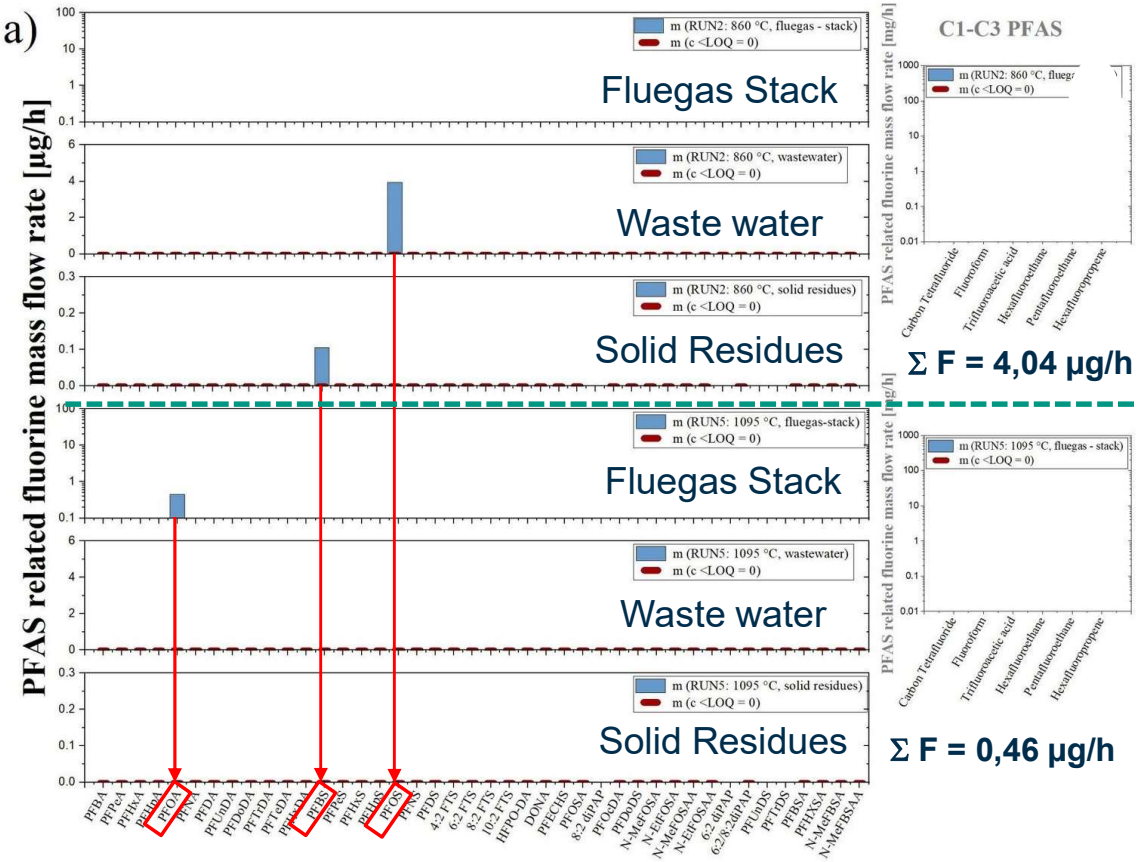
Reduction Rate for Products of Incomplete Combustion: **R2PIC** $= \left(1 - \frac{\sum F_{PFAS,out}}{\sum F_{PFAS,in}}\right) \cdot \mathbf{100}$ [%]

Results / PFAS - Loads and R2PIC



Results / PFAS - Loads and R2PIC

Fluegas Stack + Waste water + Solid Residues



Σ F = 4,04 µg/h

Σ F = 0,46 µg/h

c < LOQ → c = 0

860 °C & 2 s

R2PIC: > 99,99 %

1095 °C & 2 s

R2PIC: > 99,99 %

40 PFAS total (by modified OTM 45)

Literature – PFAS Release by Combustion

Facility	Temperature [°C]	Residence time [s]	PFAS - analytics	R2PIC / Concentrations / Removal Efficiency	Reference
BRENDA / GORE	870 1020	4,0 2,7	LC/MS/MS	31 $PFAS_{total}$: > 99,99 ± $8x10^{-5}$ %* 31 $PFAS_{total}$: > 99,99 ± $2,83x10^{-4}$ %*	Aleksandrov et. al
BRENDA / GFL	860 1095	2,0	UPLC-MS / MS GC / MS	40 $PFAS_{total}$: > 99,99 %* 40 $PFAS_{total}$: > 99,99 %*	Gehrmann et al.
Waste-to-energy / Sweden	850 - 1125	-	LC/MS	$Conc._{8\ PFAS,\ total}$ = 4,6 $ng/m^3_{tr.}$ (Flue gas)	Björklund et al.
Clean Harbors / Aragonite Utah	1122 - 1149	-	LC/MS/MS	49 $PFAS_{total}$: > 99,9999	Clean Harbors
Cement Australia Gladstone Kiln	>1450	12-15	GC (acc. USEPA SW-846 0010 modified method)	27 $PFAS_{total}$: > 99,33499**	Cement Australia

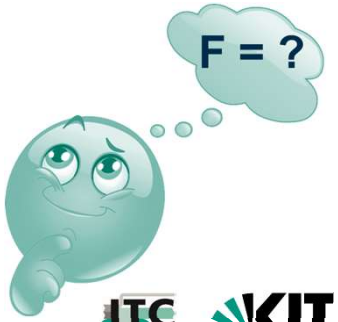
LC/MS/MS = Liquid Chromatography/ Mass Spectrometry/ Mass Spectrometry

FTIR = Fourier-Transform Infrared Spectroscopy

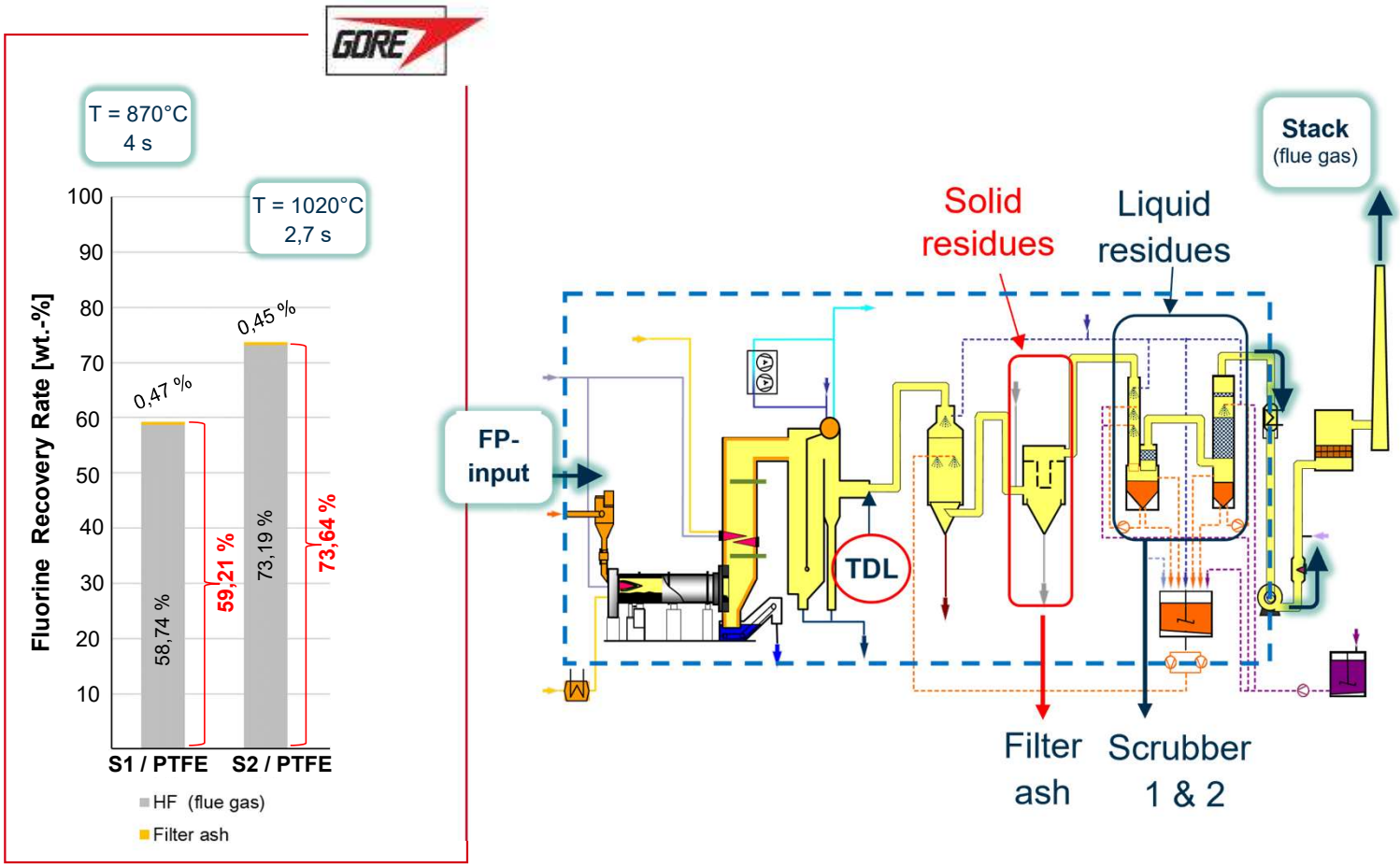
GC/MS = *Gas Chromatography / Mass Spectroscopy*

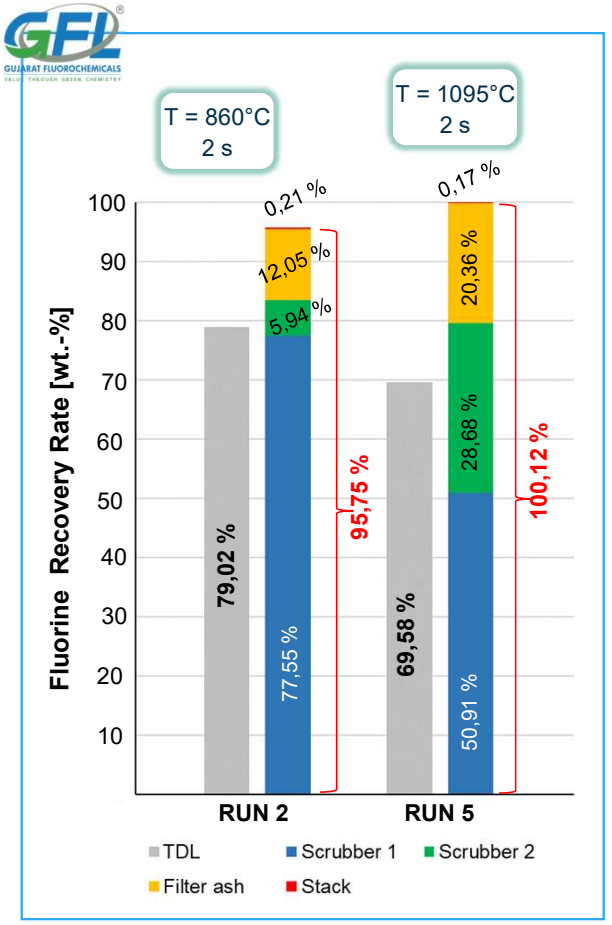
GC = Gas Chromatography

Note:
* calculated with c < LOQ
→ c = 0
**calculated with c < LOQ
→ c = 50% LOQ



Results / Fluorine - Balance





PFAS Campaign at GKS Schweinfurt (Germany)

Current Status

Hans-Joachim Gehrmann[1], Daniel Wohter[2], Ragnar Warnecke[3], Anna Holfelder[1], Dieter Stapf[1], Peter Quicker[2]

1 ITC Institut für Technische Chemie | KIT Karlsruher Institut für Technologie
2 TEER | RWTH AACHEN UNIVERSITY
3 GKS

Many thanks to the supporters and sponsors and Stakeholders / Companies

Investigating PFAS Removal in MSWI in Schweinfurt

preliminary data

PFAS - free Future? ToDo's – Open Questions

- **Balance the use and restriction of PFAS responsable!**
- **Develop National & International Standards!**
  - ✓ sampling
  - ✓ analytics – on- & off-line
  - ✓ emission limits
- **Expand the scientific data base!**

Source: https://www.zvei.org/en/press-media/publications/pfas-containing-technologies-for-the-eu-path-to-a-climate-neutral-society-based-on-the-european-green-deal