Oilon – One degree better

Combustion Technology Tomorrow

Aalto University Energy Forum

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Espoo, Otaniemi

Joonas Kattelus

CTO – Oilon Technology Oy

Content

- World in a rapid energy transition phase
- Role of combustion in the future
- Requirements for combustion in the future
- Threats and possibilities
- How is Oilon solving the puzzle?
  - Heat pumps
  - Burner technology

Part 1: What is happening around us in combustion technology context?

Part 2: How Oilon is reacting into that?

World in a rapid energy transition phase

- ***Background to rapid transition***
  - Global warming
  - Understanding of economic vulnerability increased due to Covid pandemic → there can be disruptions that break global supply chains → world is vulnerable to different threats
  - Russian aggression towards Ukraine → Europe needs to replace Russian fossil fuels extremely fast

- ***Megatrends that guide the transition***
  - Electrification → heat pumps, electric process heating (electric boilers etc.), smart grids, small scale electricity production
  - Global supply chain vulnerability (Covid, political risks) and urbanization → circular economy models, rearranging of logistics and supply chains (City scale: public transport, underground network, alternative power sources. Global scale: securing alternative supply routes and spreding of primary component manufacturing to avoid political risks)
  - Abandoning of fossil fuels → increased interest to fission and fusion, solar, wind and sea turbines and sustainable fuels

Role of combustion in the future

Ref: China speeding up approvals for new coal plants: Greenpeace (phys.org)

- ***Does it stop existing?*** → no, because it can be sustainable and for some cases it's the best alternative

- ***Does it transform according to new requirements?*** → yes

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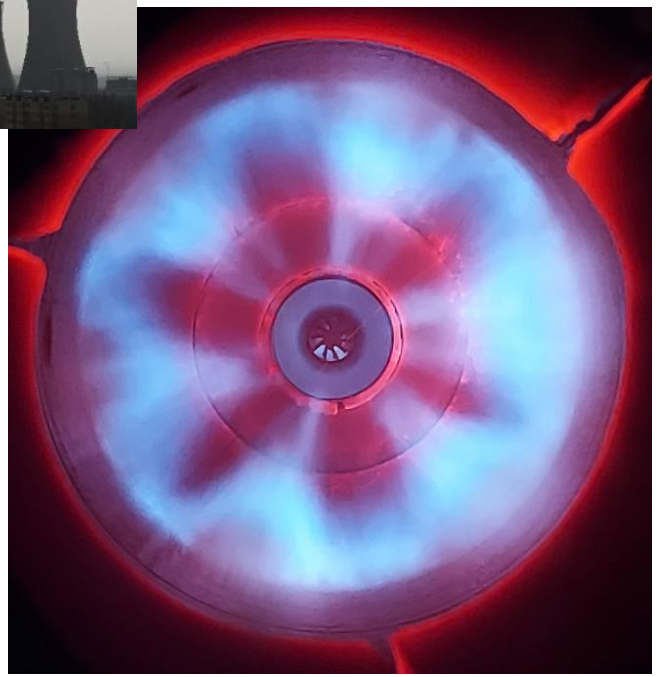

- ***Where do we need combustion in the future?***
  - Utilization of energy storages to balance supply and demand
    - P2X → X to heat
  - Heat generation
    - For high temperature processes (industry, steam)
    - For remote areas without sufficient electricity grid (scarsely populated, islands)
    - For high capacity and quick ramp up back up systems
  - Utilization of industrial side streams and circular economy (waste incineration, start up and support power for biofuel boilers, steel industry etc.)
  - Logistics
    - Aviation, Marine, Heavy transport? Trains?

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Role of combustion in the future

- ***How can we combust sustainably?***
  - Option 1: Switch to fuels that do not produce green house gases
  - Option 2: CCS (Carbon Capture an storage)
  - Mandatory: Minimize or get rid of other emissions such as NOx, unburned fuel or particles (yes it is possible to get rid of them completely)
- ***What are we combusting in the future?***
  - Many alternative fuels that will compliment each other (just a mention a few):
    - ❖ Gaseous
      - ➢ Synthetic methane
      - ➢ Hydrogen
      - ➢ Biogas
      - ➢ Ammonia
    - ❖ Liquid
      - ➢ Methanol/ethanol
      - ➢ Pyrolysis oil
      - ➢ Biodiesel
      - ➢ Other bio-oils
    - ❖ Solid
      - ➢ Raw biomasses
      - ➢ Biochar
- ***Which ones will become the major fuels and which will be left marginal?***

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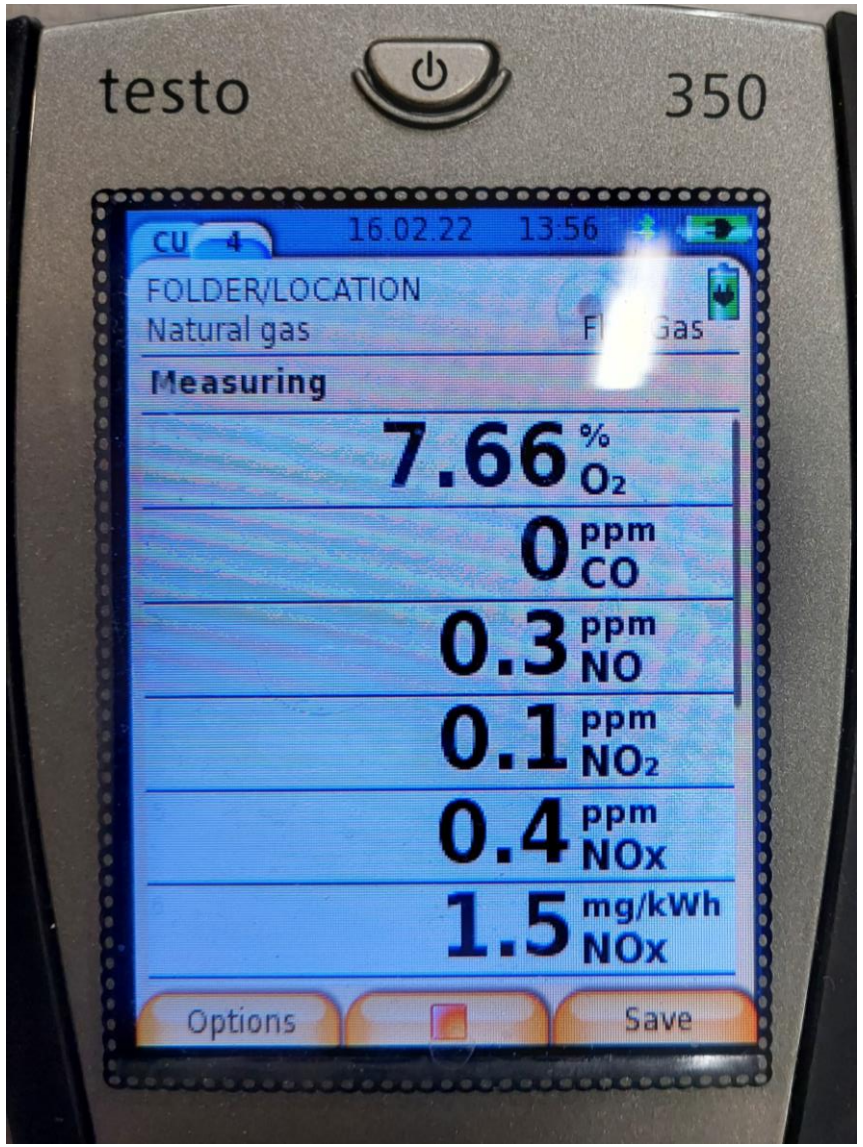

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Requirements for combustion in the future

- ***What requirements do we have for combustion in the future?***
  - Fuel transition → Capability to utilize sustainable fuels that do not produce green house gas emissions
    - Actions to take: Modular product structures to enable efficient product management and technology switch over
  - Application focus transition → part of current applications will be electrified
    - Actions to take: Re-define the business models and market+product scope
  - Fuel versatility → increased need to burn multiple fuels with variable quality and composition in same combustion system
    - Actions to take: R&D work to optimize component/part dimensioning, automation development to enable co-combustion flexibly
  - Minimal emissions with new fuels → unburned/partially burned fuel, NOx
    - Actions to take: CFD work and empirical testing, model development
  - + All the requirements that we have for combustion today
    - Combustion stability
    - Turndown ratio
    - Cost effectiveness
    - Flame dimensions
    - Reliable use (ignition, capacity adjustment, O2 tolerances)
    - Energy efficiency
    - Ease of maintenance
    - 100 % safety

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Threats and possibilities

- ***Threats***
  - Huge investment need → will there be enough political will for funding?
  - Some technologies will prevail and some are doomed to fail
  - Electricity grid load balancing

- ***Possibilities***
  - High level of energy independency achievable
  - Restrict global warming to sustainable level
  - Europe could claim world wide role of offering delivering sustainable energy technology and make lucrative business out of it

How is Oilon solving the puzzle?

- Clear vision: Creating energy technology for sustainable future
- Clear strategical focus
- Balanced product portfolio (heat pumps and burners)
- Strong R&D efforts → HTHP technology, new refrigerants, sustainable fuels, low emission technology
  - ➢ Some examples to follow: research/patents, projects, CFD

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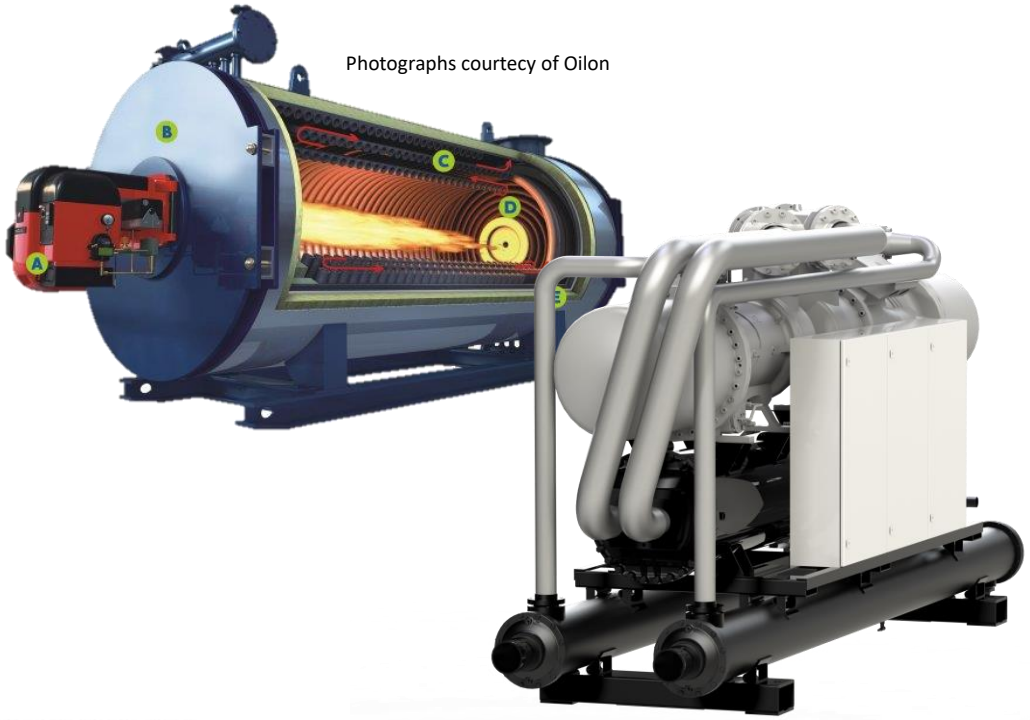


CLIMATE CHANGE IS ONE OF THE BIGGEST CRISES HUMANKIND HAS FACED...

requires action on many fronts

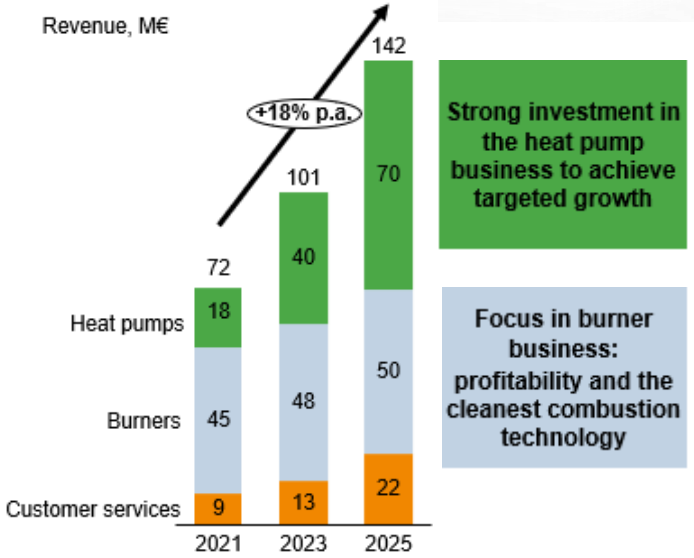
- Reduced agricultural carbon footprint
- Low-emission transportation
- Renewable energy production and storage
- Energy-efficient residential heating/cooling
- Decarbonised industrial production

...AND OILON PLAYS A SIGNIFICANT ROLE IN SOLVING THE CLEAN ENERGY PUZZLE

Oilon's purpose is to provide energy technology that drives sustainable development by reducing emissions in a direct and measurable way.

Oilon provides efficient, high-quality heat pump solutions that are suitable for the most demanding industrial applications.

Oilon has decades of experience in burner development. Oilon is a forerunner in low-emission technologies.



Strong investment in the heat pump business to achieve targeted growth

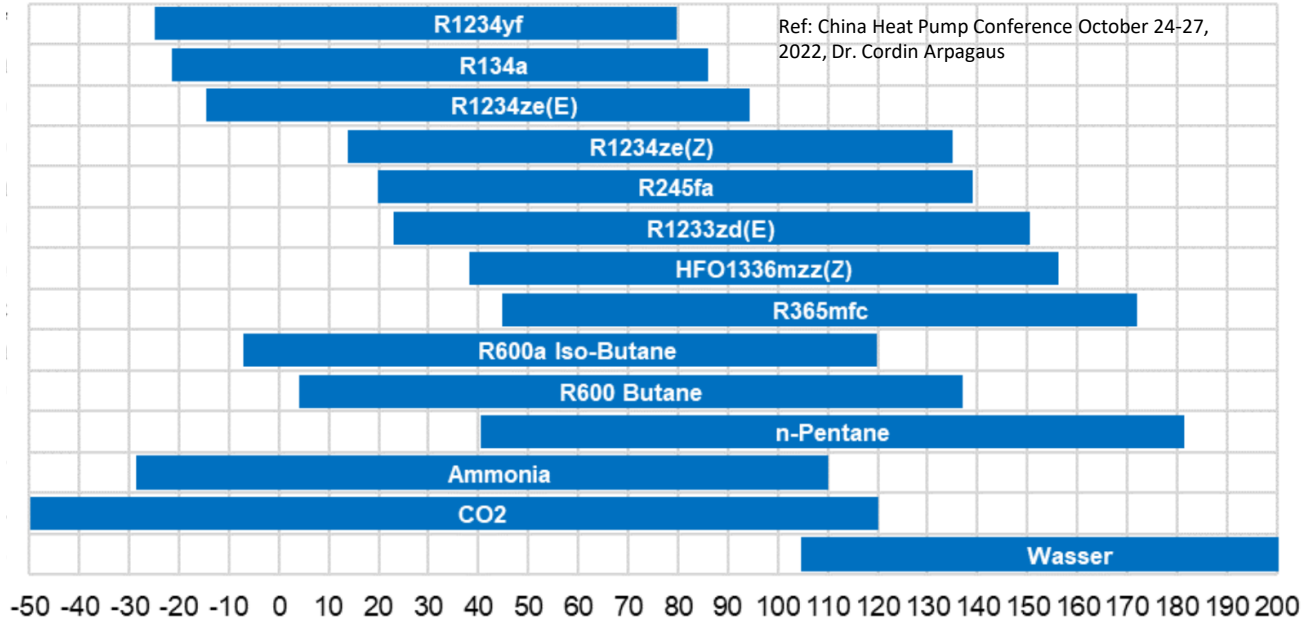
Focus in burner business: profitability and the cleanest combustion technology

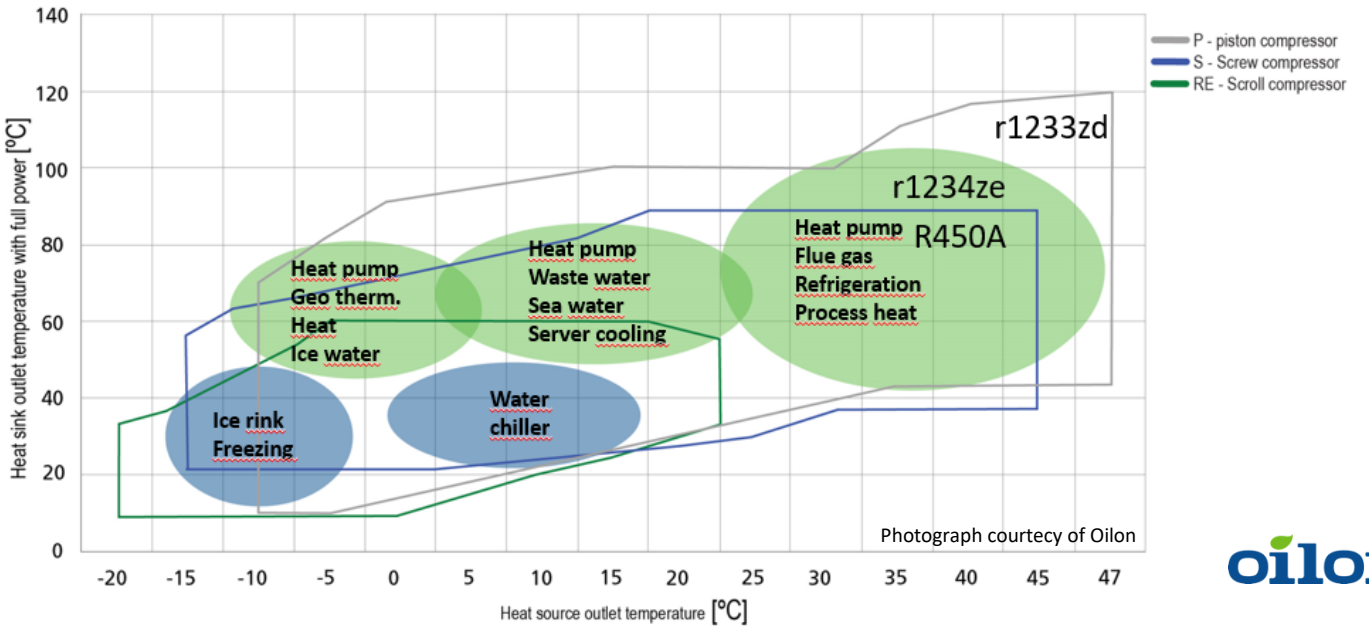
How is Oilon solving the puzzle?

Industrial heat pump development

- New applications → increase envelope area (supply temperature)
  - ➢ Actions to take: New refrigerants and compressor technology
- Better efficiency → increase COP (heat/el.)
  - ➢ Actions to take: improve refrigeration cycle (for example by additional components like subcooler, economizer etc.)

Refrigerants and achievable temperatures





How is Oilon solving the puzzle?

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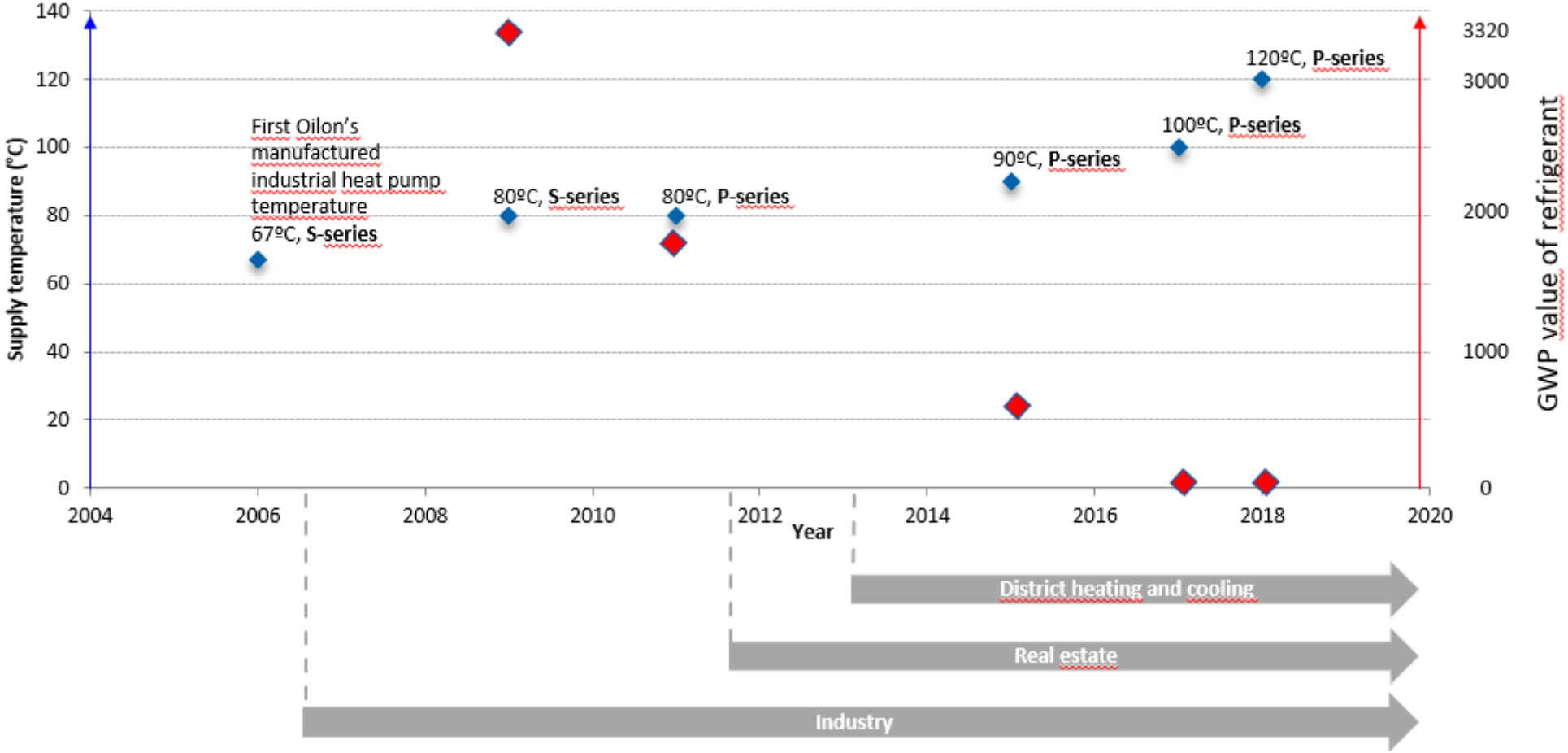
Oilon industrial heat pump development 2006-2019



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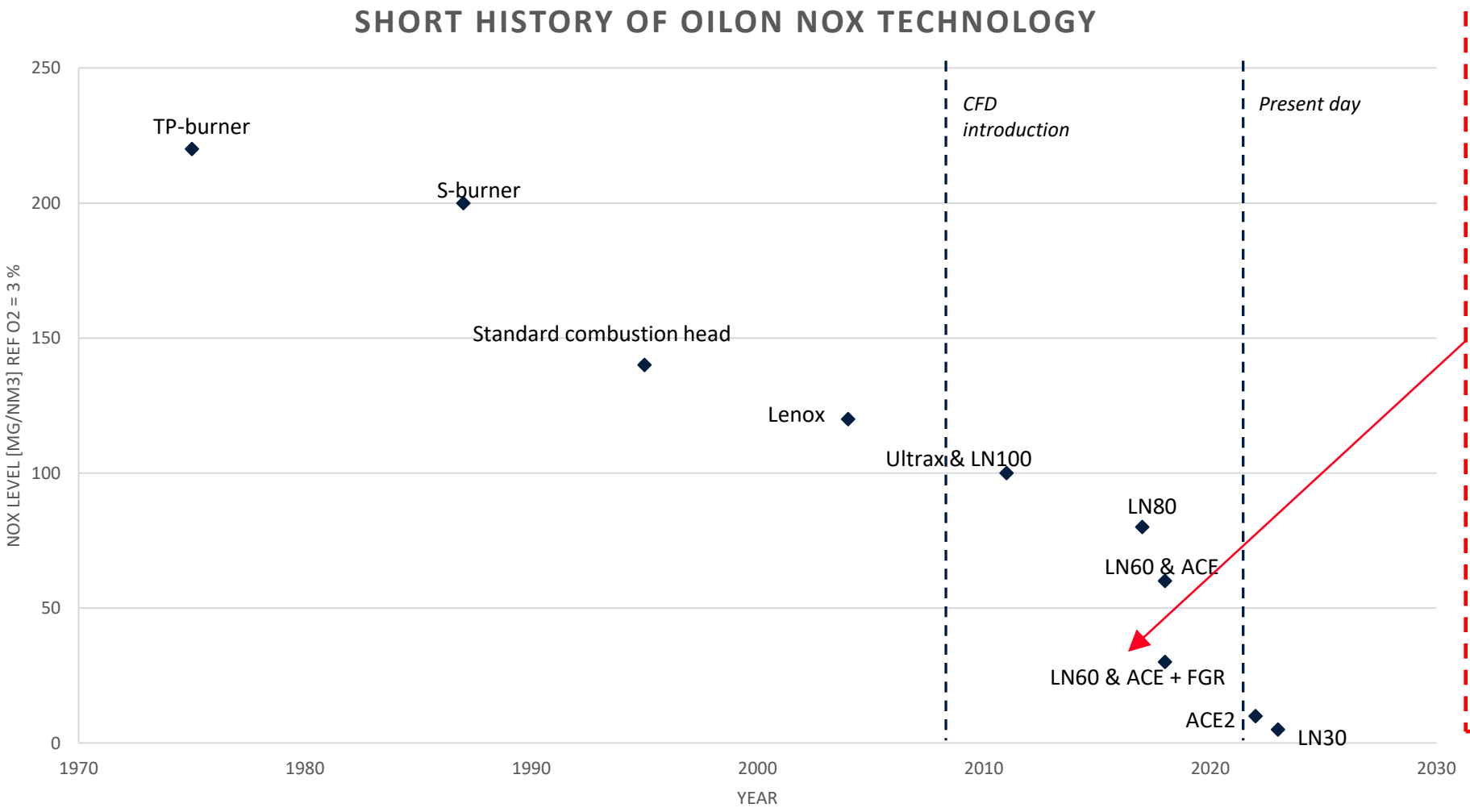

SUOMALAINEN INSINÖÖRITYÖPALKINTO

TEKNIIKAN AKATEEMISET

tfif TEKNISKA FÖRENINGEN I FINLAND

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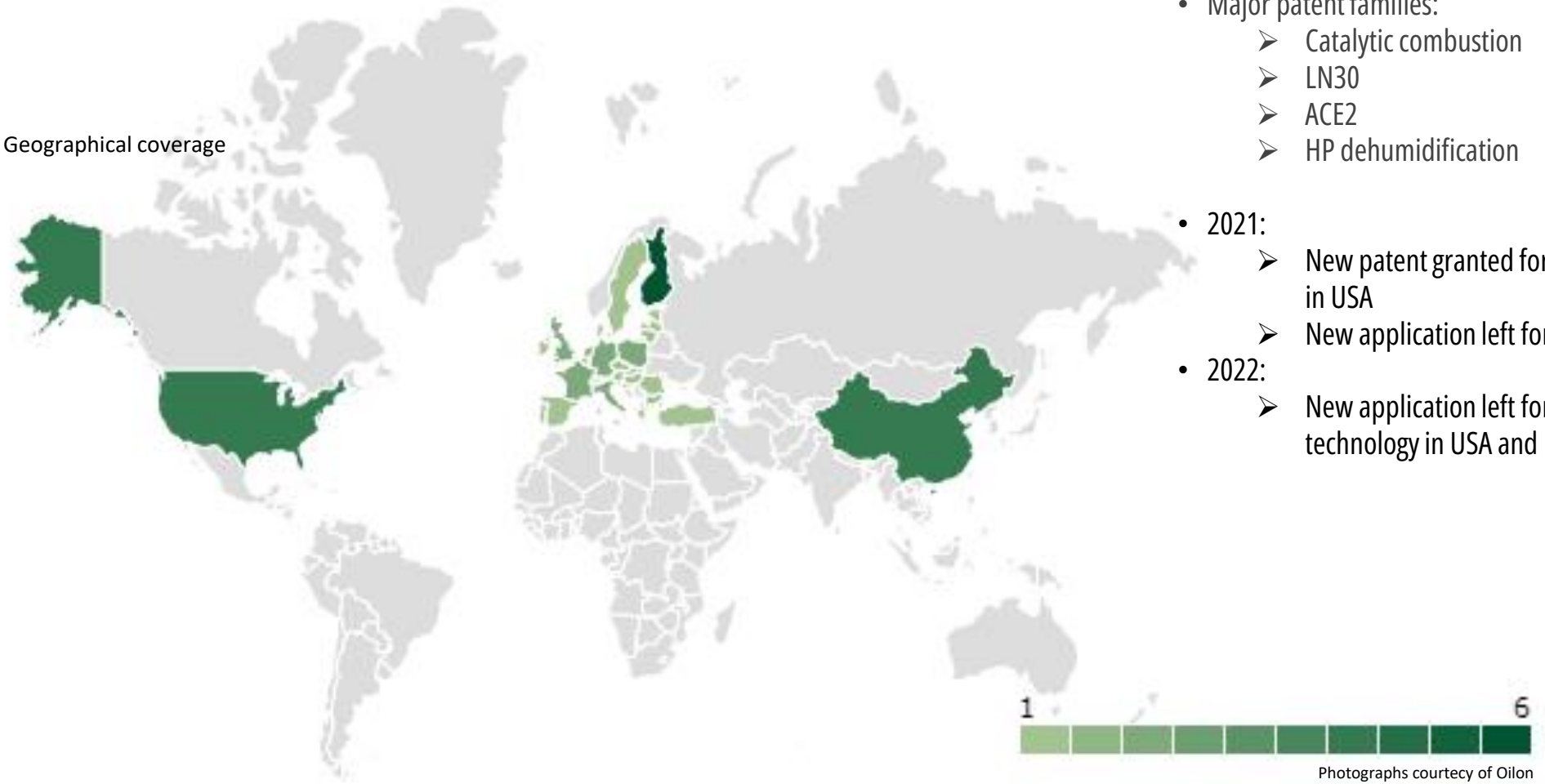
How is Oilon solving the puzzle?

Strong R&D investments

Geographical coverage



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- IPR = Intellectual Property Rights, meaning patents and utility models
- Major patent families:
  - Catalytic combustion
  - LN30
  - ACE2
  - HP dehumidification
- 2021:
  - New patent granted for LN30 technology in USA
  - New application left for ACE2 in Finland
- 2022:
  - New application left for 2.5 ppm LN30 technology in USA and FI

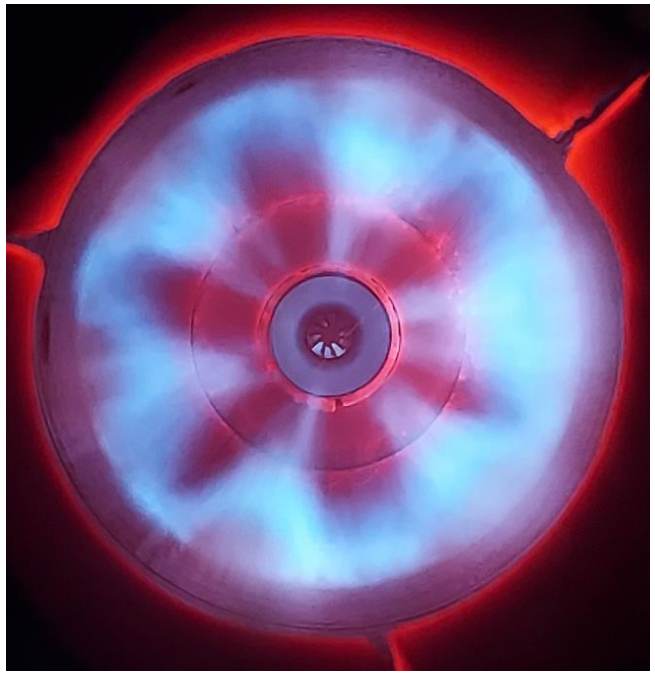
How is Oilon solving the puzzle?

LN30 technology

- Project target: Reach world record NOx performance of 2.5 ppm (ref 3% O2) without FGR

- Based on new idea of air/fuel premixing + utilizing internal flue gas circulation without traditional mesh technology

- Project status:
  - All 5 UL models designed (North American market)
  - New model GP-600 M-II LN30 tested and performance ensured
  - UL-approval testing ongoing
  - Currently arranging pilot testing in USA
  - EU models need to be designed and tested (GP-250 and 350)
  - Patent pending



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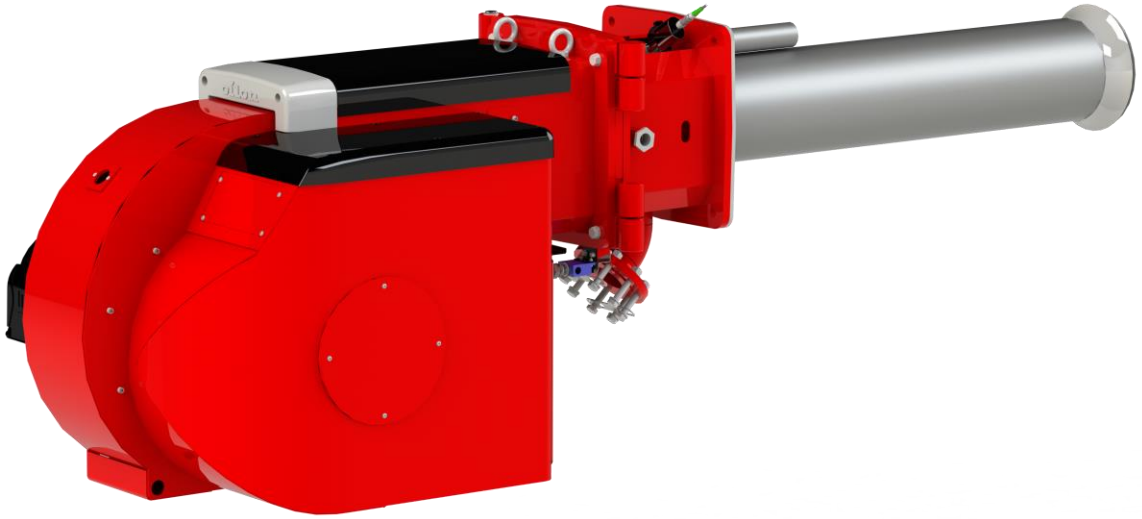

How is Oilon solving the puzzle?

ACE2 technology

- Project target:
  1. To reach 30 mg/nm3 NOx performance without FGR and elevated O2 throughout the ACE capacity range
  2. To reach 9ppm with elevated O2

- Technological idea is to effectively recirculate flue gases inside the furnace instead of external pipe system

- Project status:
  - ➢ Extensive CFD and empirical research has been made over 2 years.
  - ➢ Newest prototype is promising. Targets already fulfilled in certain points at laboratory conditions
  - ➢ Patent will be applied with world wide coverage

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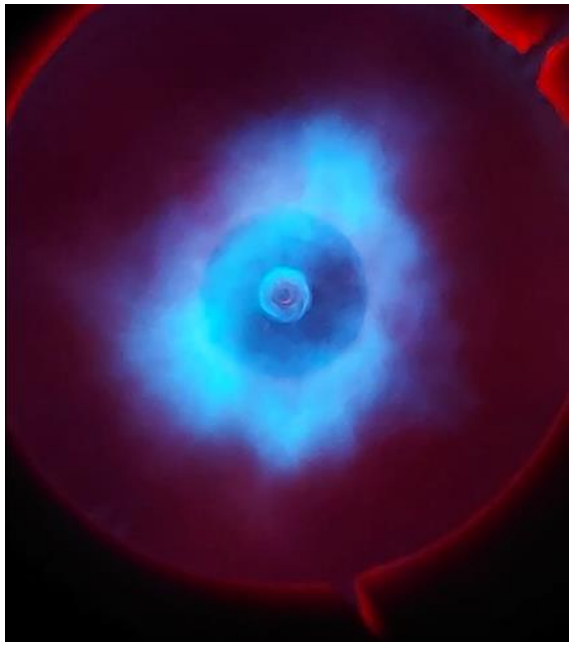


How is Oilon solving the puzzle?

Sustainable fuels

→ Oilon already has significant amount of references for varying H2 compositions

→ Low NOx H2 research is going to be continued by aqcuiring Hydrogen to Oilon's laboratory facilities and developing suitable CFD-models (co-operation with Aalto and hydrogen providers)

→ Oilon has respectable amount of references for other fuels of the future aswell. See our offering to H2 below:

Burner:

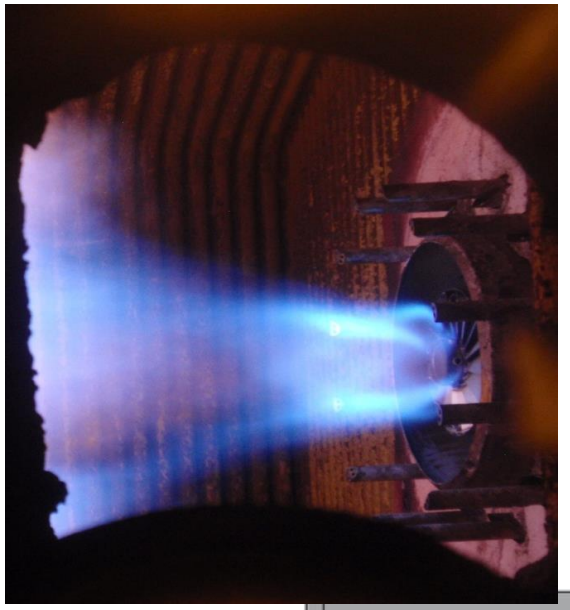
- 0-20 vol-% of H2 → All Oilon burners
- 20-70 vol-% of H2 → All Oilon burners with special nozzle structure
- 70-100 vol-% of H2 → ACE burner series (LN80)

Gas train:

- 0-20 vol-% of H2 → Standard gas train configurations
- 20-70 vol-% of H2 → Standard gas train configurations
- 70-100 vol-% of H2 → Special gas train with possibility for nitrogen purging and flame arrester

Automation:

- 0-20 vol-% of H2 → All Oilon supported automations
- 20-70 vol-% of H2 → All Oilon supported automations
- 70-100 vol-% of H2 → Lamtec CMS/Siemens PLC, special flame detector



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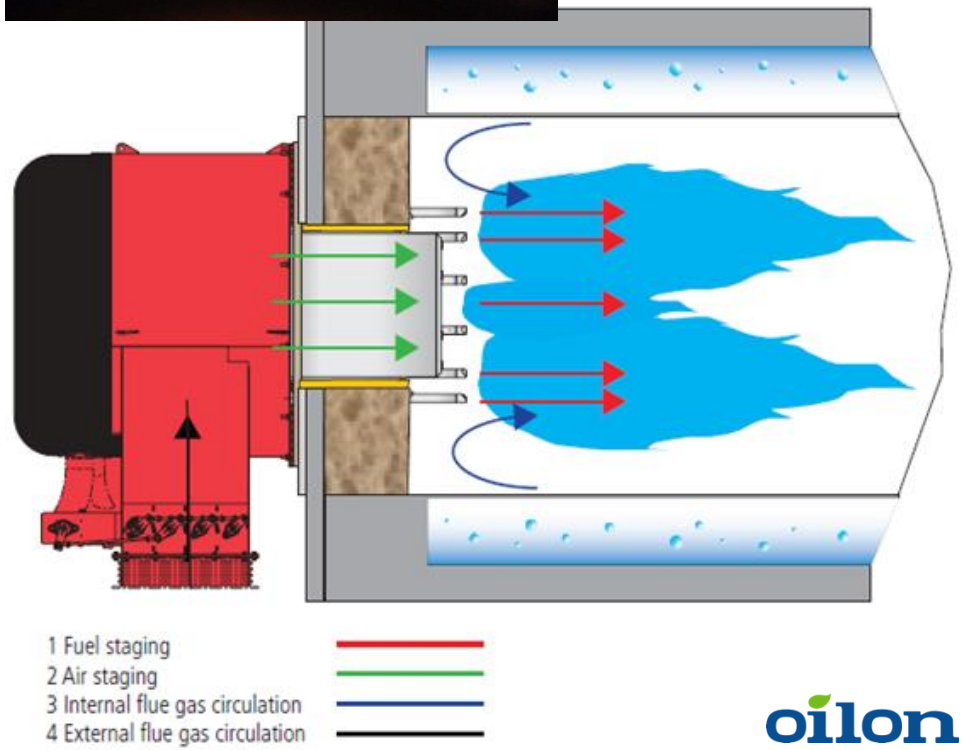
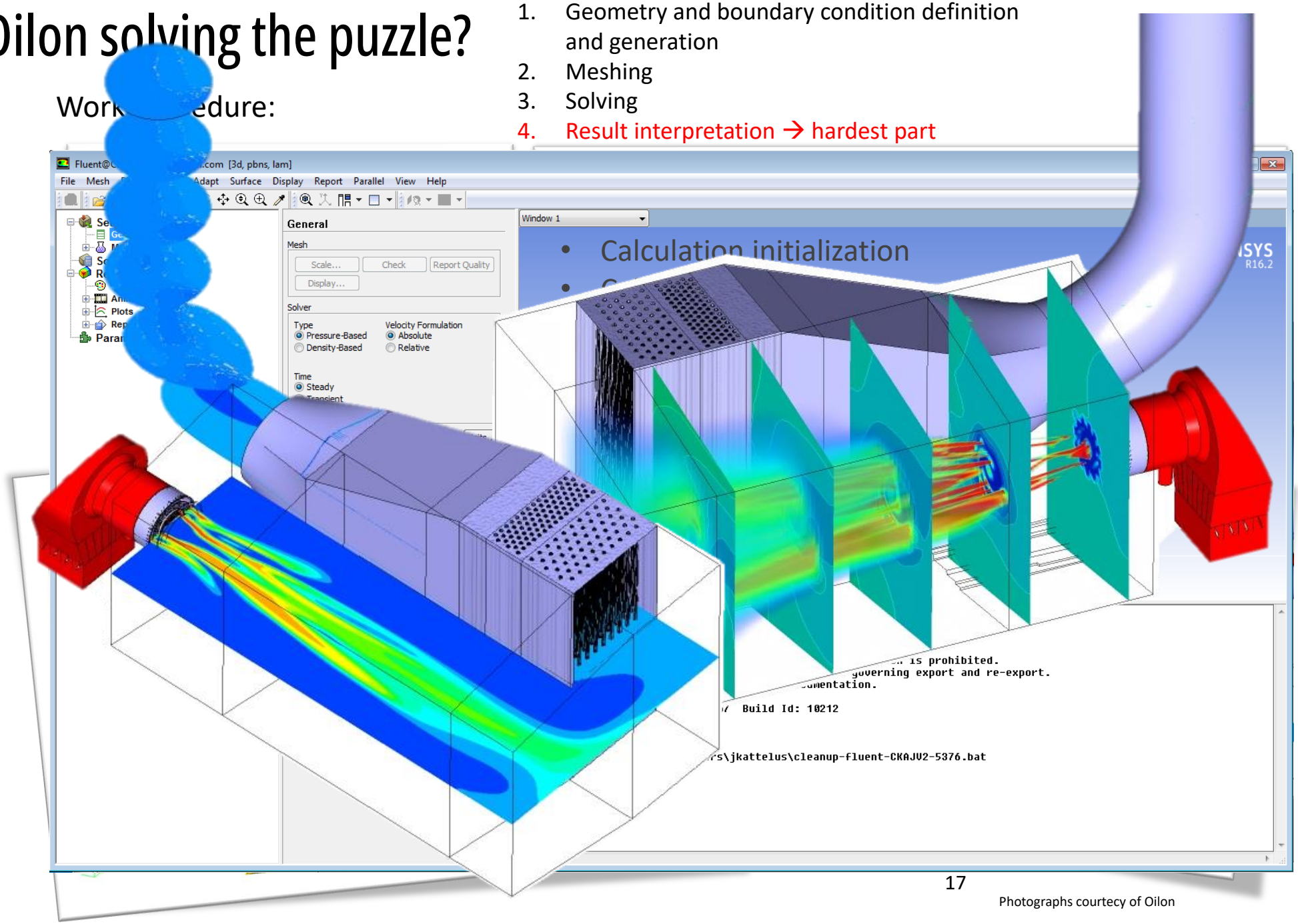


How is Oilon solving the puzzle?

CFD

Work[illegible]edure:

1. Geometry and boundary condition definition and generation
2. Meshing
3. Solving
4. Result interpretation → hardest part



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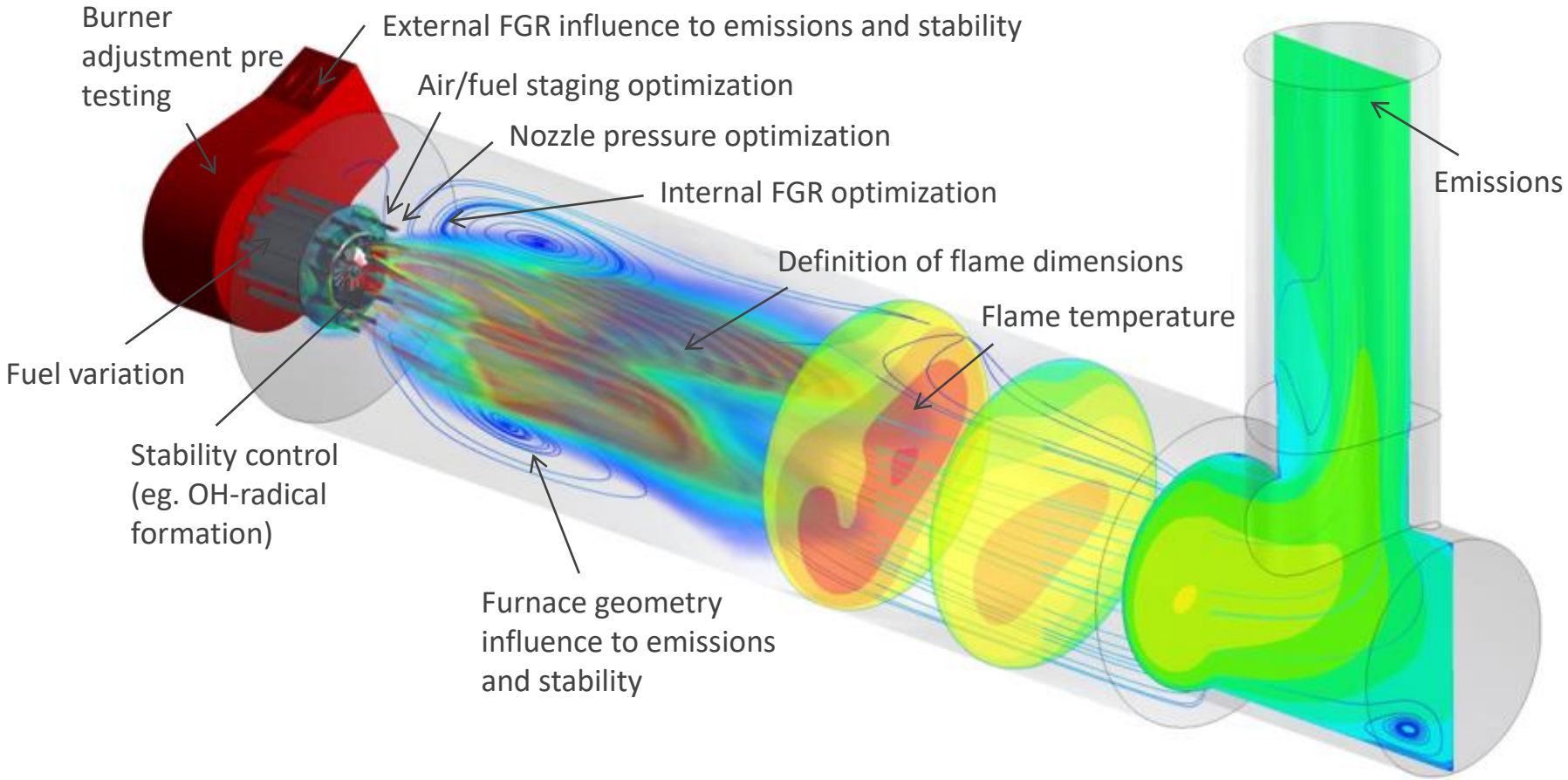
How is Oilon solving the puzzle?

CFD modelling – Example: ACE1 development

performance optimization:



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Q&A

Common discussion