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Norwegian University of Science and Technology

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ERC Synergy grants: my experience

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ERC Synergy grant Webinar, Research Council of Norway, 26.5.2025

Outline of the talk

- Stage 3 pitch for the HYROPE project: ERC-2023-SYG
- Concept development
  - Picking the team
  - Topics and concept
  - Writing phase
- Interview Preparation
- Some advice/lessons learned

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The HYROPE project

Stage 3 interview pitch to the ERC in Brussels 14.09.2023

HYROPE proposal
Hydrogen under pressure

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A new gas turbine concept for large-scale, zero carbon power generation

Motivation:

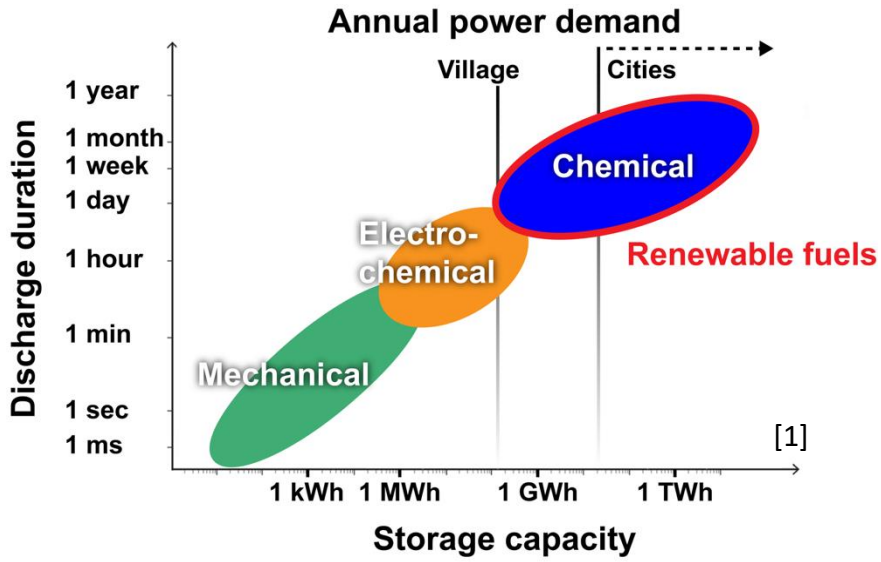
- Decarbonise our energy system as quickly as possible
- Provide safe and reliable power-on-demand

Why combustion of hydrogen and ammonia?

- No CO_2 emissions, renewable fuels
- High power density, reliability and costs

Why renewable fuels?

- Chemical storage of renewable fuels crucial for dispatchable power on demand



Why gas turbines?

- Fuel and load flexibility
- Balance renewable energy sources
- Ensure power-on-demand
- Need to go big

Single cycle: 538 MW
Combined cycle: 760 MW

Ansaldo GT36

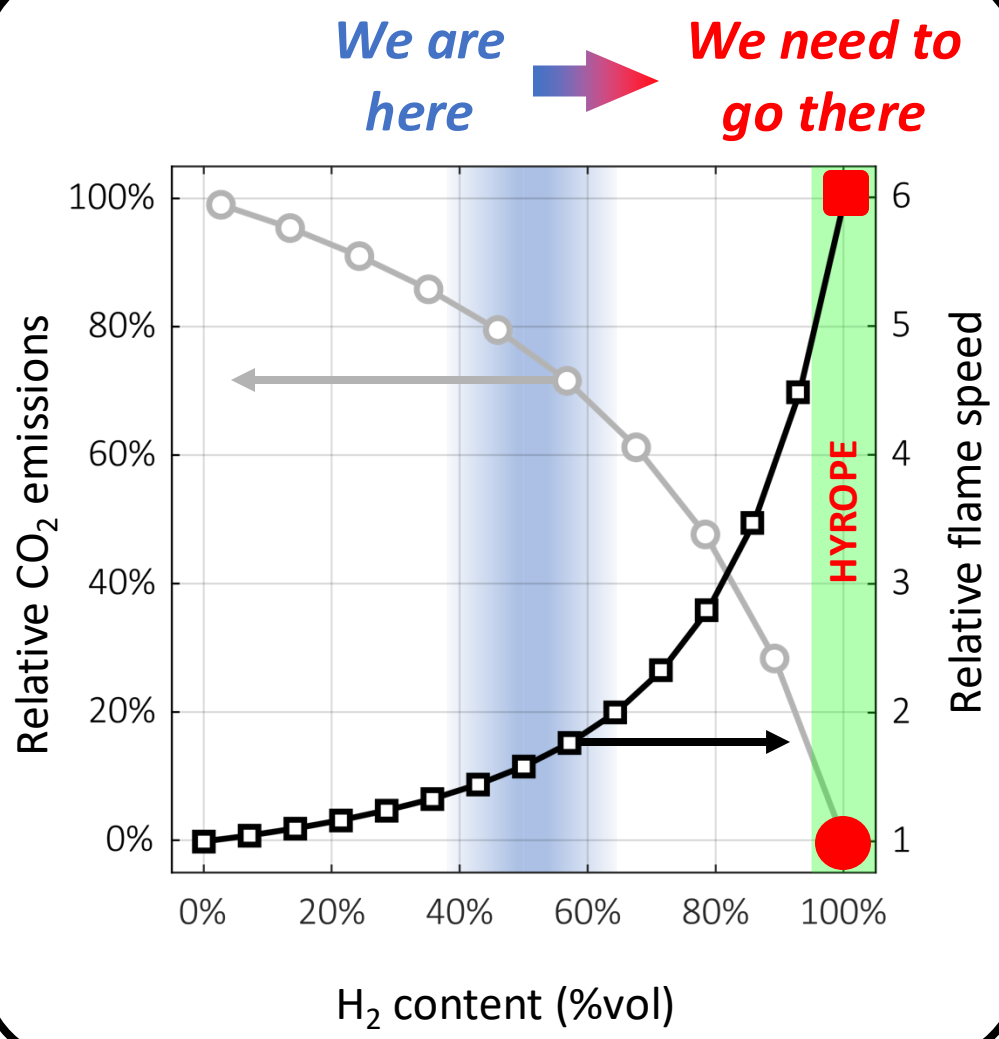
2 Gas turbines = power output of a nuclear reactor

Challenge tackled by HYROPE:

How can we transition gas turbines *from fossil fuels to hydrogen-based* fuels *in a short time*?

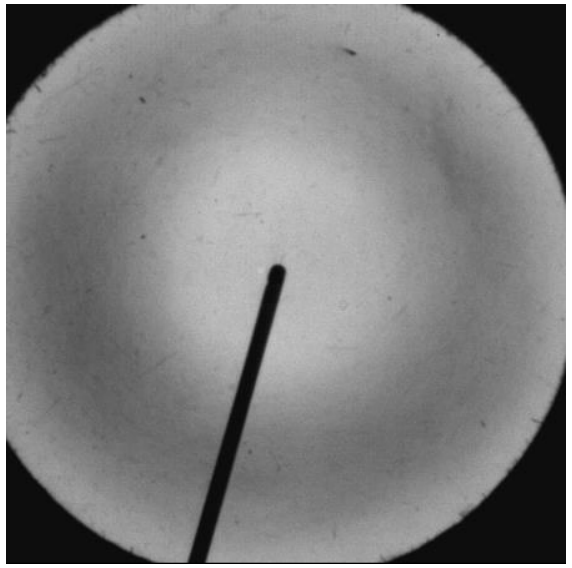
[1] Adapted from M. Sterner and I. Stadler, Elektrische Energiespeicher, Springer, 2014, p. 605

Hydrogen fuels are radically different at high pressure

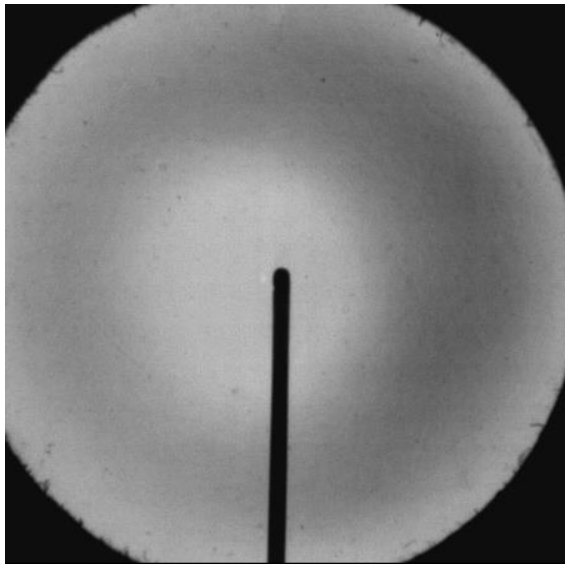


What is the problem?

- H_2 and NH_3: radically different combustion physics than fossil fuels
- H_2-air flames burn **much faster**
- They are **severely wrinkled** by thermo-diffusive instabilities
- Impacts flame stability, flashback and emissions



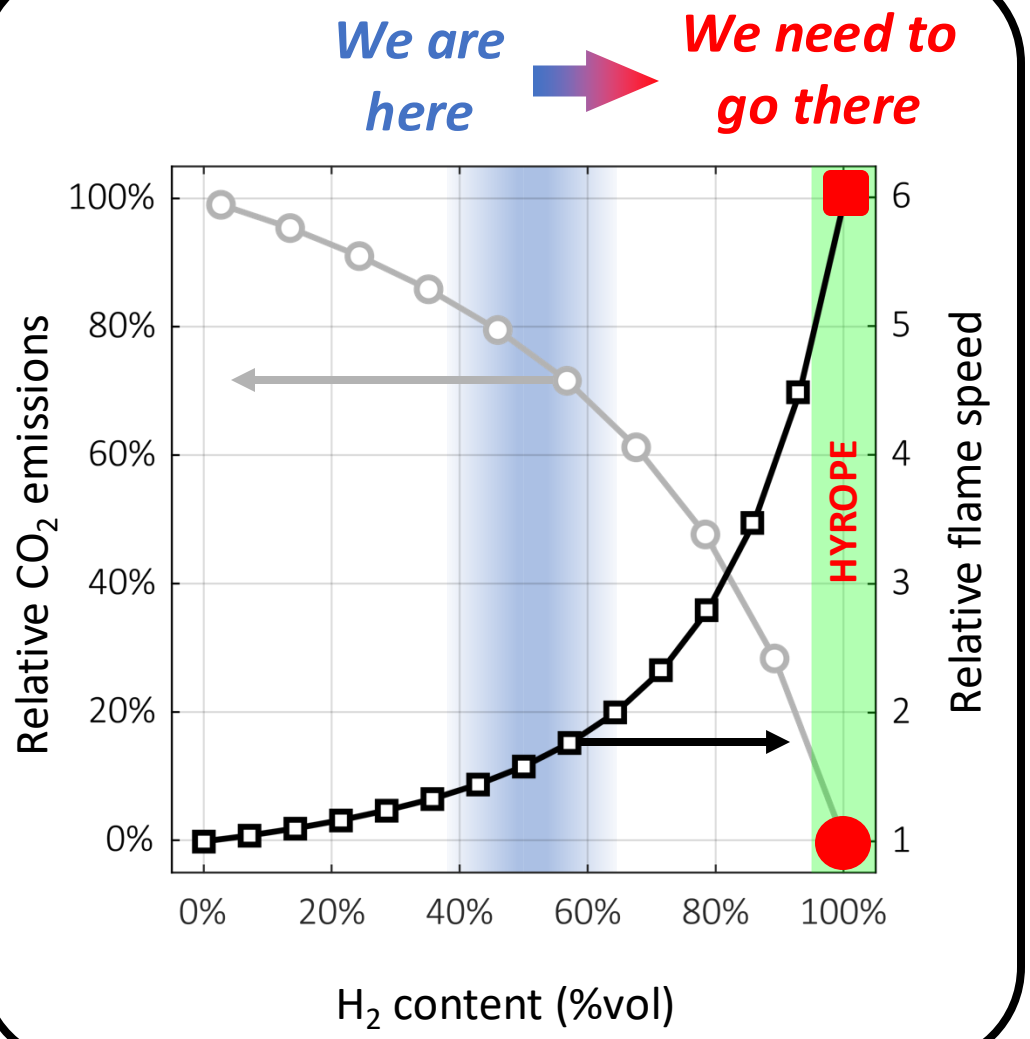
CH_4 – air



H_2 – air

Movies courtesy of H. Pitsch:
J. Beeckmann, et al, PROCI, 36(1), 1531–1538, 2017.

Main scientific challenges



Main scientific challenges:

Hydrogen (H_2)

- Extremely reactive
- High molecular diffusivity, thermodiffusive instabilities

→ highest burning rate, strong ***unexplained pressure dependence***

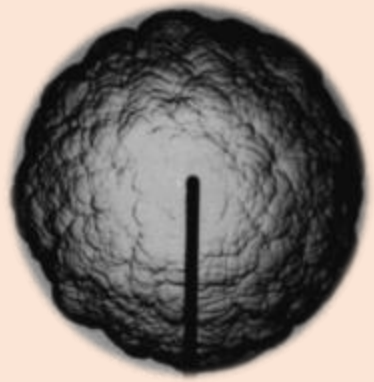
Ammonia (NH_3)

- Poor reactivity and fuel-bound N_2

→ prone to NOx and N_2O emissions, ***unexplained pressure dependence***

Knowledge gaps

- Understanding of **coupling** between reaction rate, diffusion, and turbulence
- No **models** to predict the complex coupling



Unravelling the combustion physics of hydrogen and ammonia

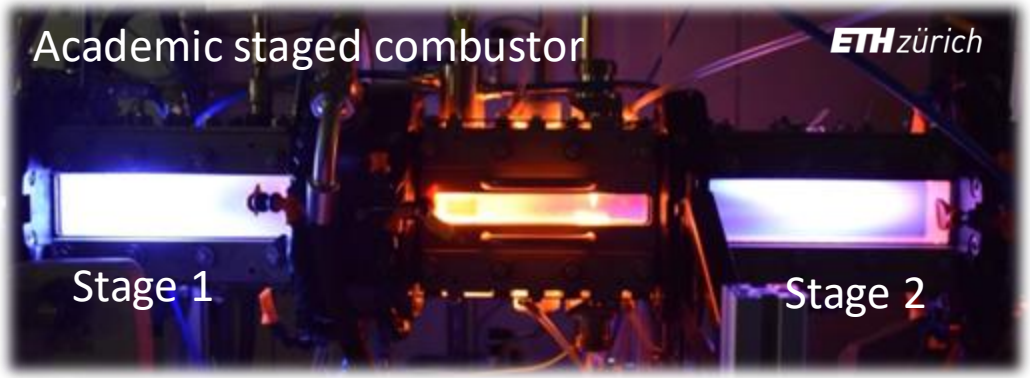
HYROPE

Main ideas

1. Unravel **effect of pressure** on H_2 and NH_3 flames
2. Adopt a staged combustion paradigm to take **advantage of two combustion modes**

Why staged combustion?

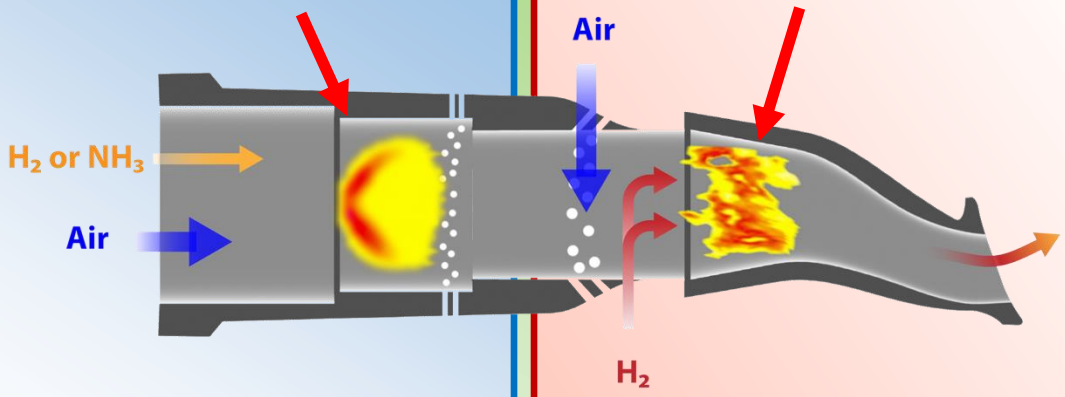
- Control **high reactivity of H_2** and **low reactivity of NH_3**
- **Ensure ultra-low NO emissions**



Staged combustion paradigm

1st stage (WP1)
Propagation stabilised

2nd stage (WP2)
Autoignition stabilised



Knowledge gaps:
Effect of pressure on flame front instabilities and burning rate

Knowledge gaps:
Effect of pressure on kernel formation in partially mixed environments

Coupled System (WP3)

Knowledge gaps:

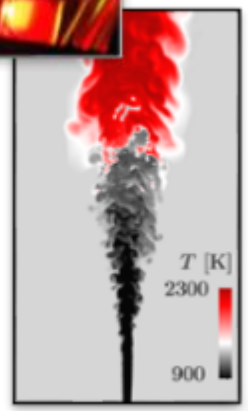
- Effect of pressure on combustion dynamics, instabilities and NO_x emissions

What we will do

Canonical flames

Laser diagnostics

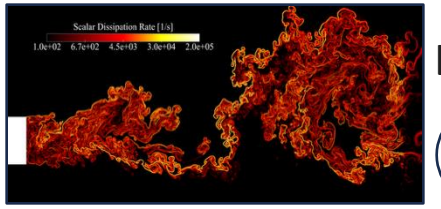
Direct Numerical Simulations



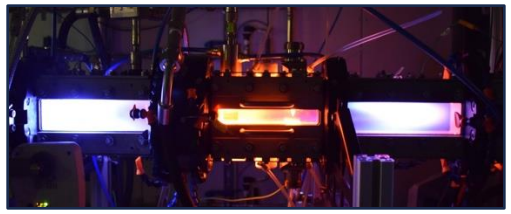
New combustion physics

Fundamental effects

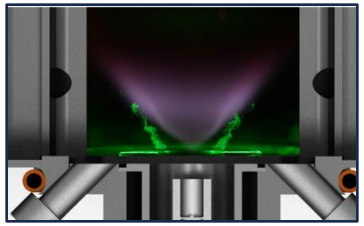
Two-Stage combustion



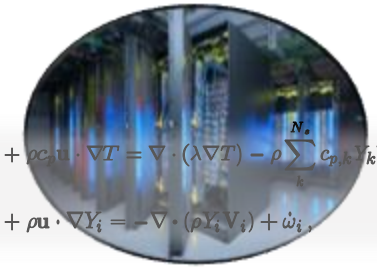
Large Eddy Simulations



Two-stage combustion



Single-stage combustion



$$\rho c_p \frac{\partial T}{\partial t} + \rho c_p \mathbf{u} \cdot \nabla T = \nabla \cdot (\lambda \nabla T) - \rho \sum_k^{N_s} c_{p,k} Y_k \mathbf{V}_k \cdot \nabla T + \dot{\omega}_T,$$

$$\rho \frac{\partial Y_i}{\partial t} + \rho \mathbf{u} \cdot \nabla Y_i = -\nabla \cdot (\rho Y_i \mathbf{V}_i) + \dot{\omega}_i,$$

New combustion models

Pressure scaling

High power, high turbulence, high pressure

Why we need to work together as a team now

Why is ERC Synergy essential?

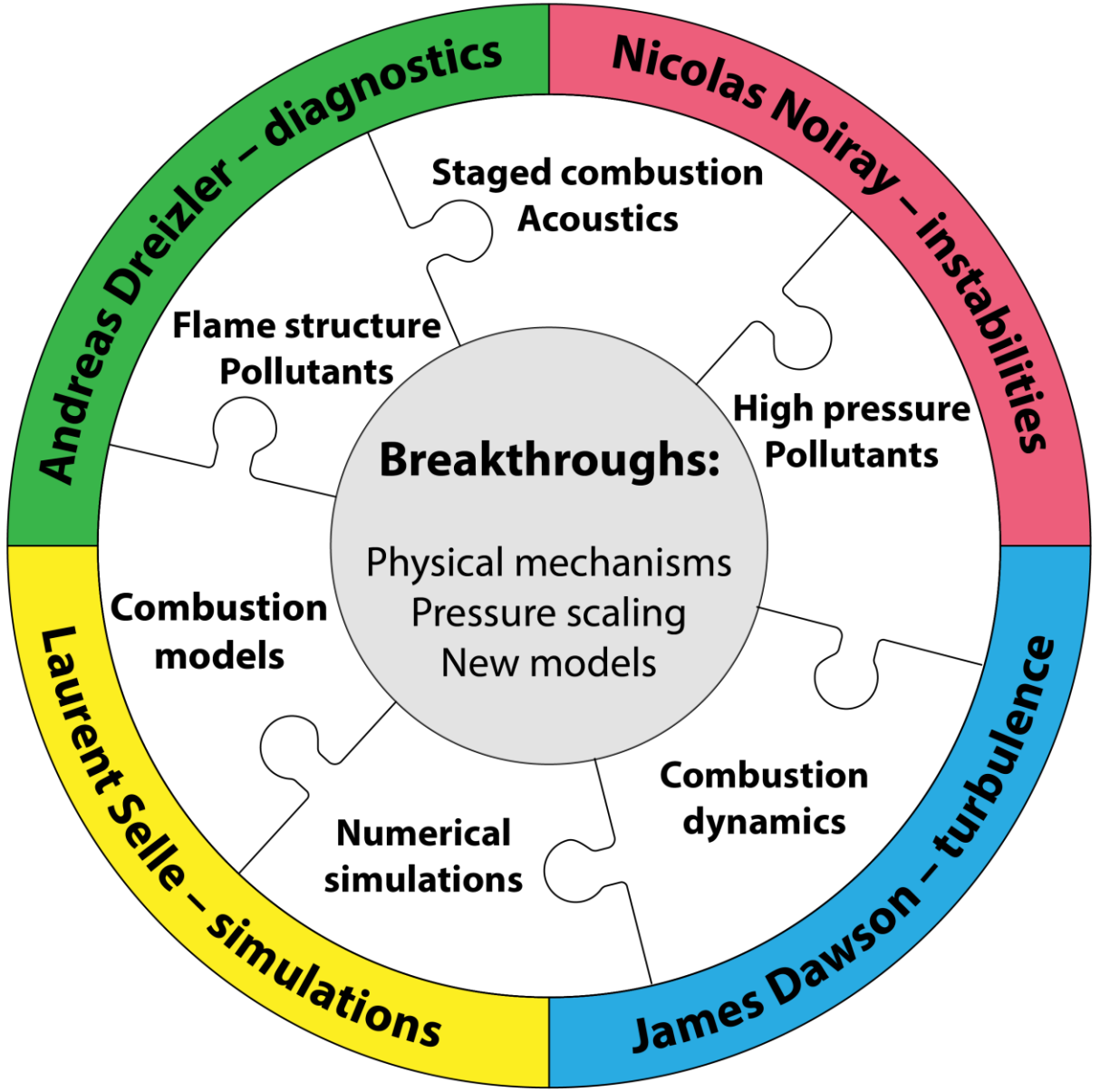
- Complex task beyond the scope of any single PI - *cannot be done unless we work together*

Why us?

- Unique combination of facilities and infrastructure for high pressure
- Maintain European scientific leadership
- Track record of working together

How will we work as a team?

- Integrated research tasks (methods, rigs)
- Full team workshops (~2 per year)
- Researcher mobility
- Close coordination



HYROPE: A transformational and novel combustion science project

Empirical led approach:
"trial and error" is slow and expensive

New science driven approach

First industrial GTs
4-15MW
17% efficiency

[Deutsches Museum]

Ultra-low NOx
>500 MW
>60% efficiency

[Siemens]

1940s 1950s 1960s 1970s 1980s 1990s 2000s 2035

Taken 50+ years of empirically led research to understand combustion physics of fossil fuels

→ *BUT we need to get to zero carbon within ~10 years!*

What is new and transformational?

- A science driven approach for staged combustion
- Combustion physics of H_2 and NH_3 at high pressure
- Landmark experimental database, new models

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Concept and development

- Picking the team
- Topic and concept
- Proposal writing/development

Picking the team

Timeline: July 2023 – deadline for November

I wanted to work with my international collaborators - many of whom had ERC grants so top international track records!

It’s all about the idea and the science – I knew our area could get funded

Met with potential PIs at a conference and had meetings/lunches to discuss (I had several possible configurations in mind)

Decided the general topics and themes at the conference

We were worried about being engineers… not many SYG grants for engineers

Topics and concept

- I was thinking about topics for a couple of years
- We had been working on H2 combustion before the H2 “boom” so had a track record
- In real applications, combustion happens at high pressures – everything gets more efficient - but we knew H2 behaves totally differently to hydrocarbons, so there were massive knowledge gaps
- We chose difficult problems we would normally try to avoid due to cost and difficulty – followed the scientific need
- We used a model problem to highlight all the knowledge gaps and connect the different skills/teams needed to solve them

Proposal writing

- Weekly meetings with the PIs and their key researchers (sometimes meetings were structured, sometimes just a brainstorm)
- One main author to make the proposal coherent (don't just cut and paste) *– I assigned written tasks which I integrated into a document and we revised*
- Started in B1 first - We felt the challenge was to get to stage 2 – were confident we could convince experts but worried about the lack of "sexiness" of our topic to a general panel.
- In B1 we worked to balance high level concepts with detailed science
- Make bold but believable statements… pointing out why the knowledge gaps you want to fill have been difficult etc.

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Interview preparation

- Panel presentation development
- Rehearsal

Interview preparation

Presentation

- Follow the instructions!
- Spoke with other SYG winners – main advice was that the panel would unlikely have specialists (true!).
- Interview was foremost about how "*the synergy of the team*"
- Balance presentation between scientific need, what we would do and why our team could do it
- *Met in person for a full week* to work on the presentation – who would present what parts, generate a list of questions, and who would answer them

Rehearsal

- *We had many mock interviews*: groups of international colleagues, ERC contact points in Switzerland, France/CNRS, NTNU - we rehearsed a lot.

Random lessons learned/suggestions

- Self-check
  - Is your track record and idea truly fundamental and excellent? Can you benchmark it against international research? Have you sufficient proposal writing experience/success?
- Spend time on graphics to break up the text of the proposal
  - it takes a long time if you do them yourself
- It has to be a team effort - it helps if you have already established collaborations
- Again, it's all about *the idea* and *the people*
- If you get to stage 3 prepare as much as you can – meet in person for a good period of time.
  - *Sitting together in a room for 3-4 days is essential (not the same as meeting online)*


Questions?