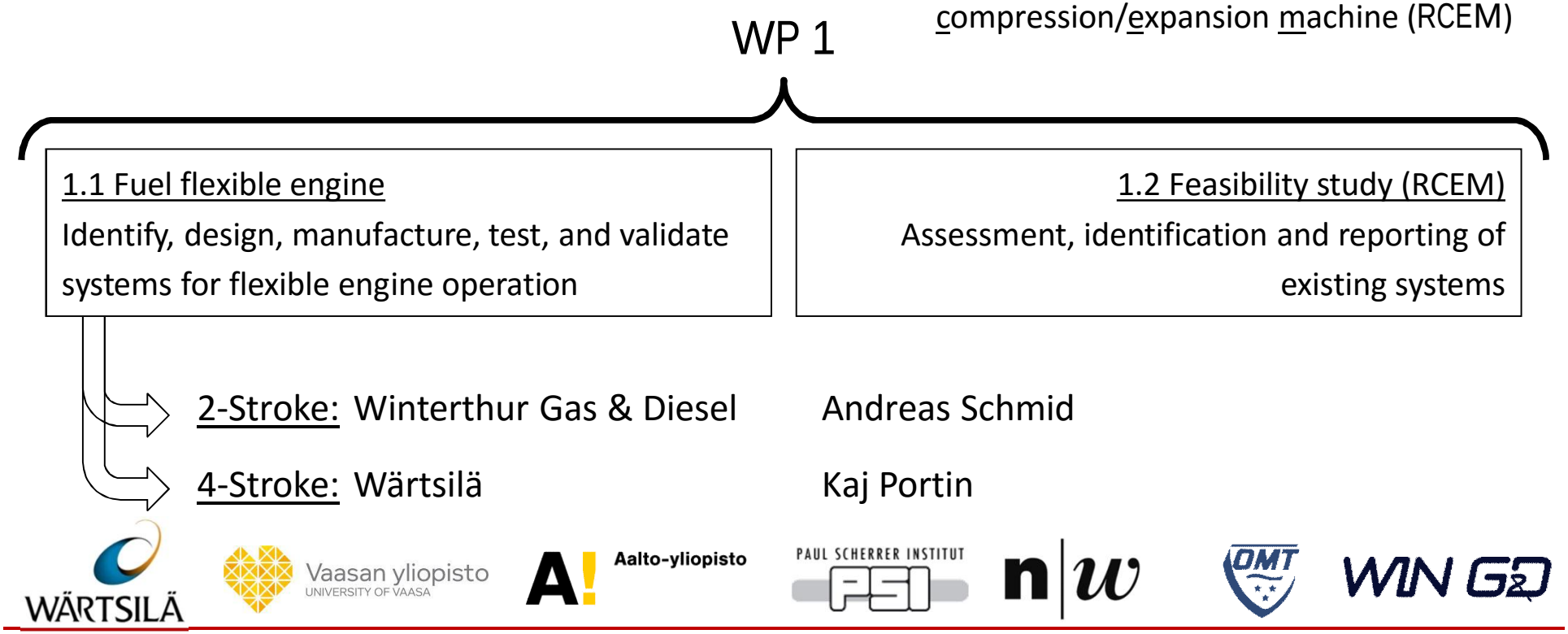
# WP1: Systems for increased fuel flexibility

## Objectives / Expected results

To develop **engines able to switch between fuels**, whilst operating in the most cost effective way and complying with the regulations in all sailing regions.

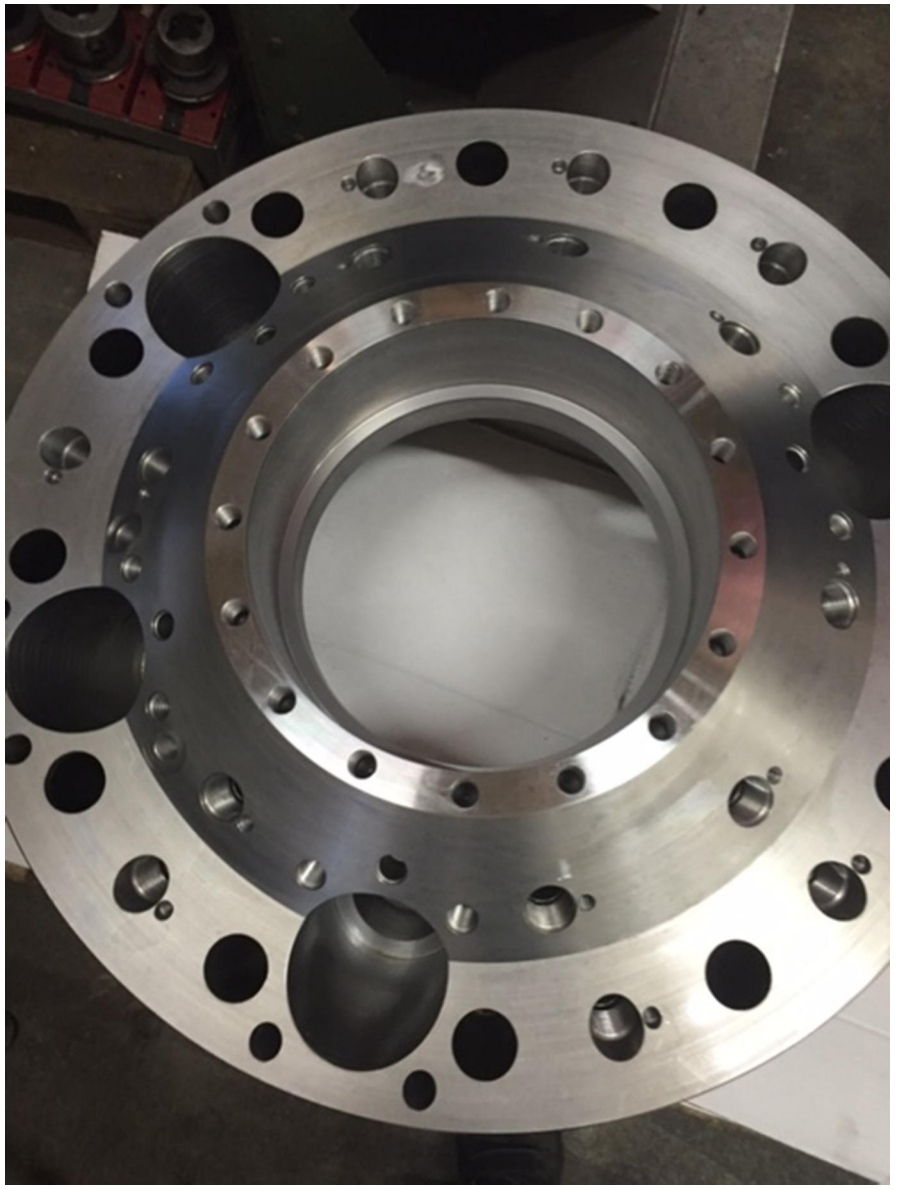
WP Leader: Andreas Schmid
DWP leader: Kaj Portin

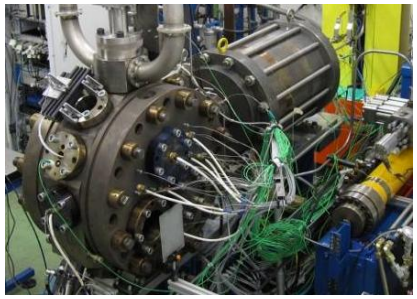
- Development of a fuel injection system for multi fuel purposes
- Demonstration of fuel flexible engine operation
- Feasibility study on rapid compression/expansion machine (RCEM)



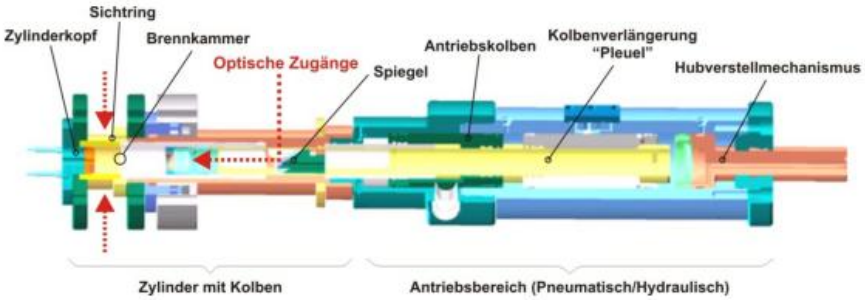
## SCC - modification

- New cover machined
- Injector adapters designed and ready to be machined
- Next steps:
  - Installation on site, adaption of interfaces
  - High pressure piping, wiring
  - Commissioning
  - First reference measurements of existing systems





“Missing link”

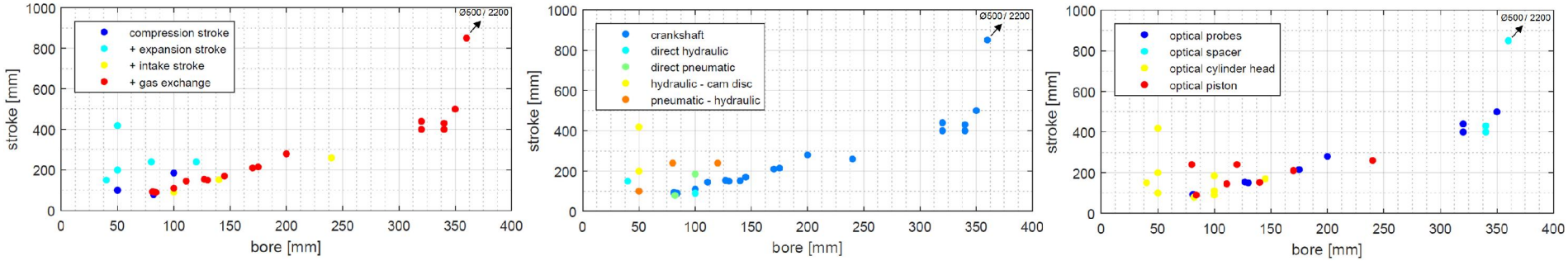


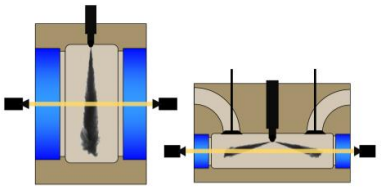
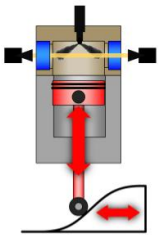
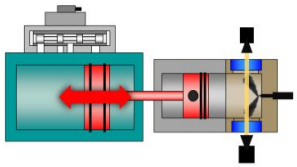
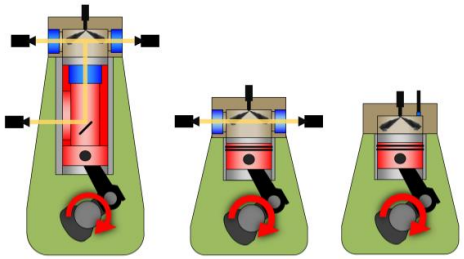

## Constant volume chamber

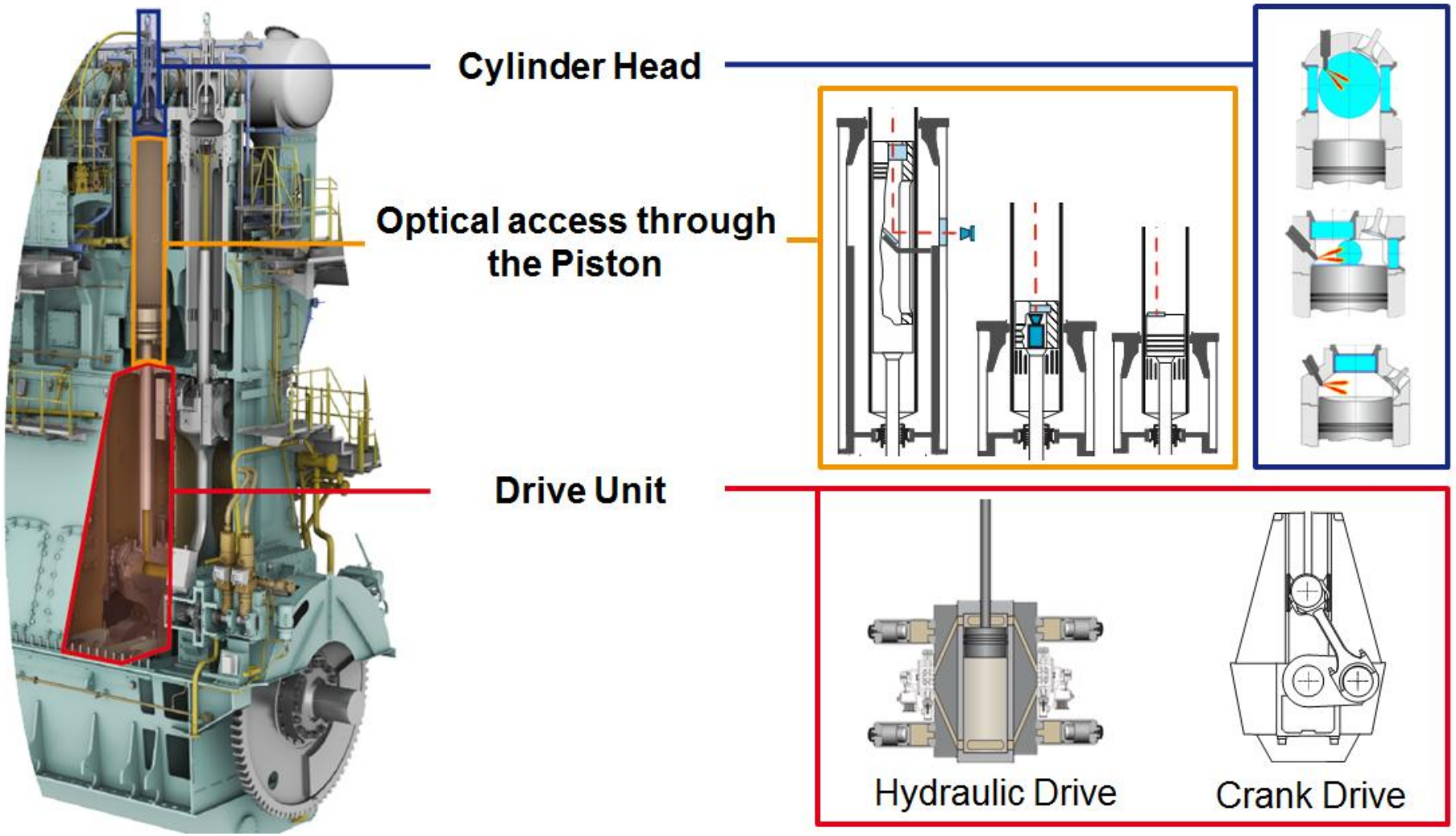
- Real engine dimensions
- No piston => no mechanical compression
- Very good optical accessibility
- No vibration
- No oil mist
- Negligible fuel consumption

## Test engine (e.g. RTX-6)

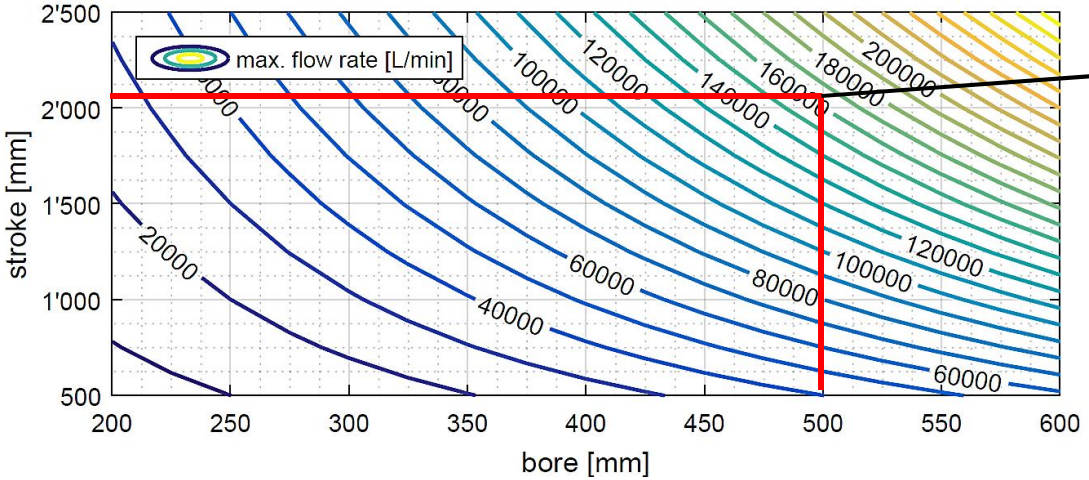
- Limited optical accessibility
- High fuel consumption
- Vibration, noise, emissions
- Non ideal conditions for quantitative optical measurements



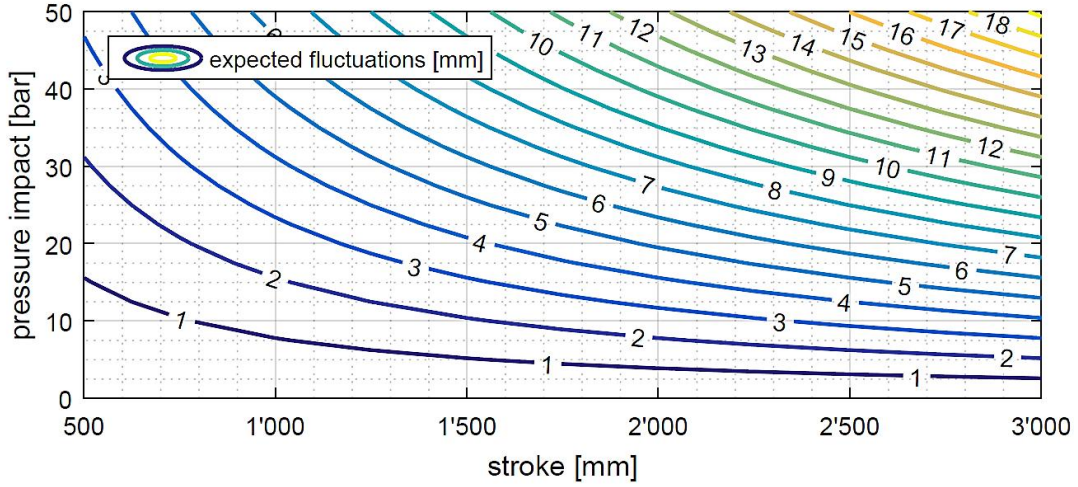

| | | | | | |
|---|---|---|---|---|---|
| **included systems** | combustion → | + charge movement → | + compression stroke → | + expansion stroke → | + intake stroke → | + gas exchange → |
| **categories** | **Constant Volume Combustion Chamber** | | **Rapid Compression and Expansion Machine** | | **Single Cylinder Engine** | |
| **operating mode** | single combustion → | | single combustion<br>single stroke | | single combustion<br>continuous motored | continuous combustion<br>continuous motored |
| **example** |  | |  |  |  | |
| **optical accessibility** | excellent | | good | | poor | |
| **engine–like piston motion** | - | | ballistic | | crankshaft drive | |
| **bore** | up to Ø500 mm | | up to Ø100 mm | | from Ø 200 mm to Ø 600 mm<br>depending on the optical accessibility | |


Cylinder Head
Optical access through the Piston
Drive Unit
Hydraulic Drive
Crank Drive

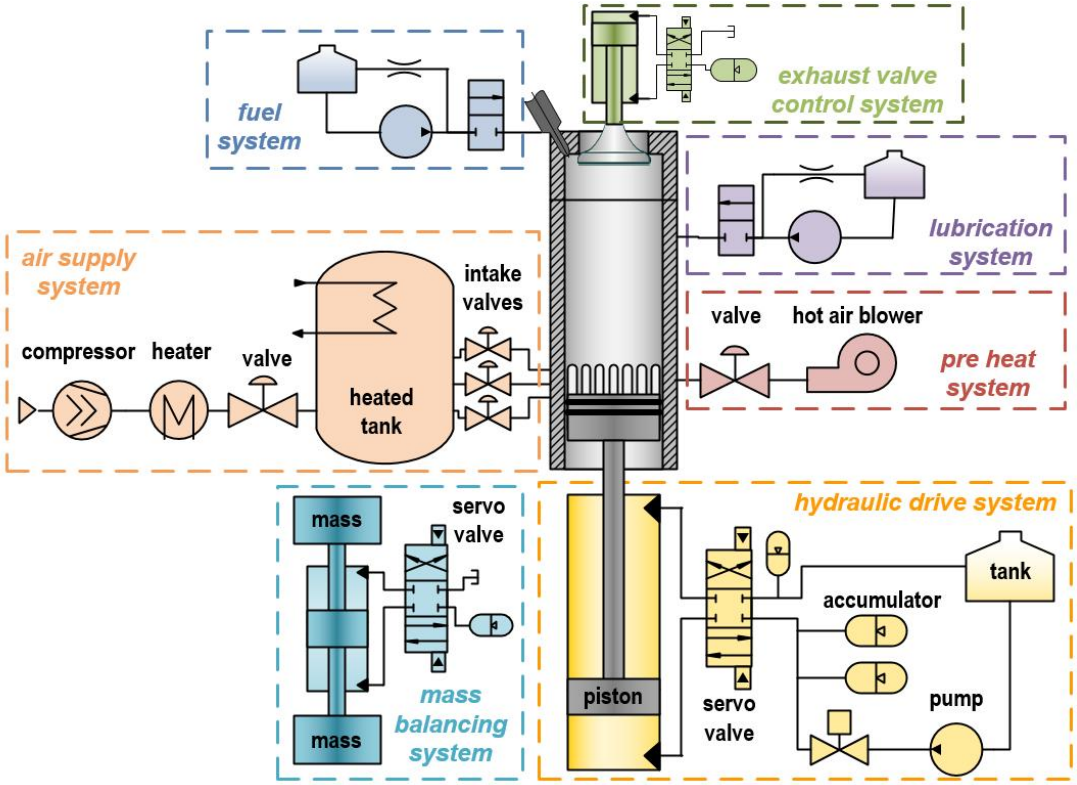
# Hydraulic driven system




RT-Flex 50 DF
Almost 3 m³/s of oil



# Hydraulic driven system




Next step is the evaluation of the concepts and proposal to management for decision

# WP1: Sub project 1.1 ***Fuel flexible engine (4-stroke)***

DWP Leader: Kaj Portin

## How

Measurement technology for intermediate combustion products formed inside the combustion chamber will be developed and tested.

The impact of switching between different fuels on possible after-treatment devices and engine components will be part of the investigations.

Partners: Aalto-yliopisto, Vaasan yliopisto UNIVERSITY OF VAASA, WÄRTSILÄ

## Expected Results

A fully fuel flexible optical injection and ignition test platform for low-speed Diesel engines will also be produced. A fully optical medium-speed multi-fuel engine will be developed and tested for the first time.

## Activities Plan Year 1 (Status and progress May 2016)

- Flex fuel pre-study (Identify requirements for flexible injection system)

  →Investigation finalized on injection system requirements for fuels C3 to C20

- Numerical modeling studies for liquid bio-fuels, methanol, or DME

  →On-going master thesis on 1-D simulation of the effect of the methane and methanol on pre-combustion in-cylinder conditions.

- Spray chamber studies for various new fuels and for different DF pilot setups

  →Planning and development of research environment is started.

- Ignition studies for non-auto-igniting fuels

  →Background material is being collected

  →Fuels are selected: Naphtha, Kerosine, Glyserol+Mazut, MGO from Wood Pyrolysis process

  →Fuel properties will be analyzed in the end of July 2016

- Development of new in-cylinder measurement and diagnostics sensors

  →Online gas quality sensor installed and testing started in November.

  →Master´s Thesis work to be finalized in May 2016.

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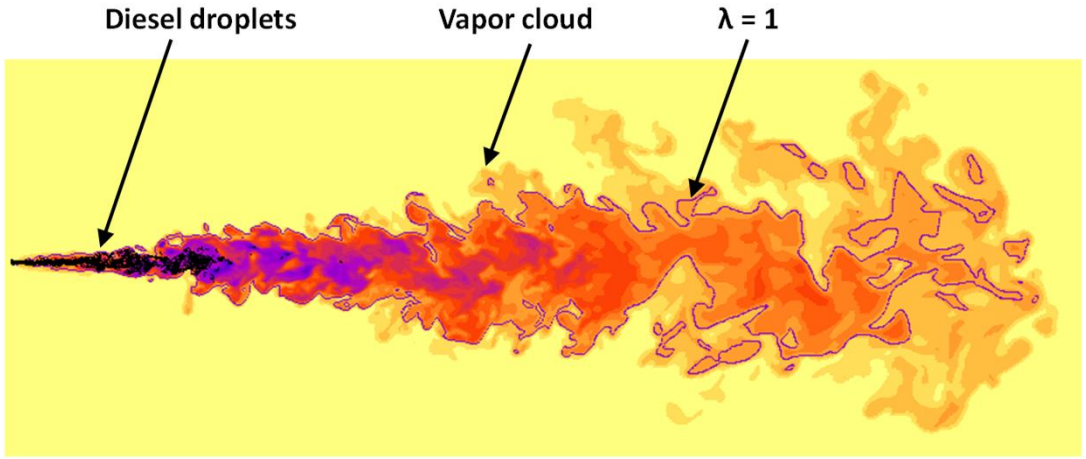
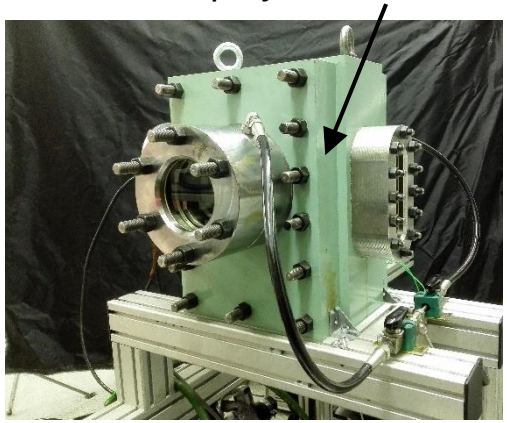
# Activities Plan Year 1 (Status and progress May 2016)

- Numerical modeling studies for liquid bio-fuels
- Validation completed for Engine Combustion Network (ECN) target condition 'Spray A' for diesel fuel. Figure below shows an evaporating diesel spray with Lambda (λ) = 1 contour using an accurate turbulence modeling approach (LES). The work continues with different liquid bio-fuels.




100 bar spray chamber



- Spray chamber studies for various new fuels and for different DF pilot setups

  →Testing phase of the finished research environment.

Aalto-yliopisto

# Activities Plan Year 1 (Status and progress May 2016)

## • Online gas quality measurement

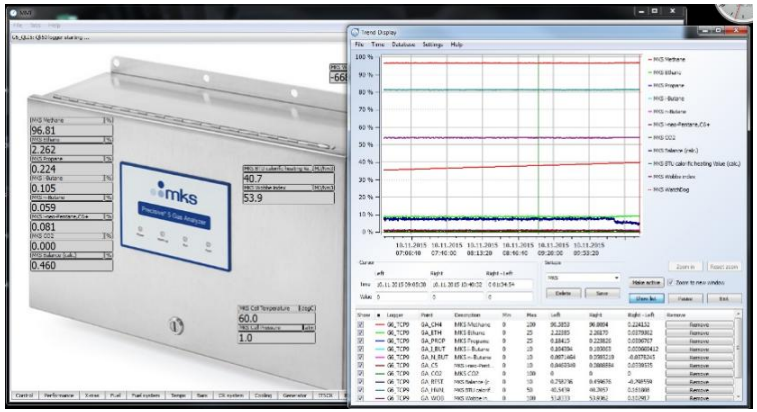
• Continuous logging of data to the laboratory measurement system November- February and on biogas February - April

•Calculations for LHV and Methane Number added in the system

•Possibility for portable measurement added

•Additional pressure sensor added for monitoring purpose

• First software development started for engine control. The chosen function is ”engine maximum output based on gas quality measurement”



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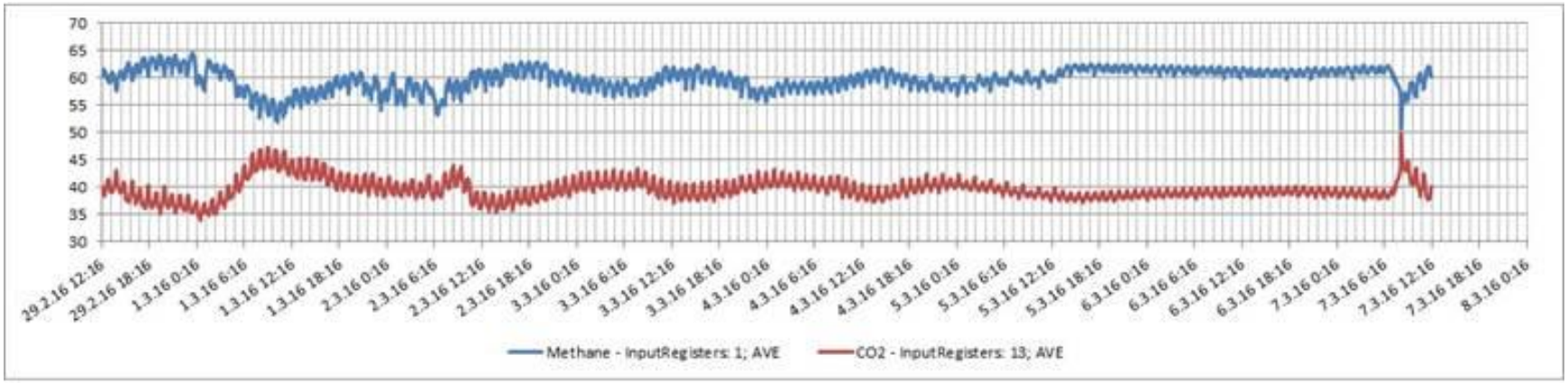
# Activities Plan Year 1 (Status and progress May 2016)

- The landfill biogas quality fluctuations

  → were analyzed during the gas production process when using collected organic waste. Using an optical gas analyzer, the biogas quality was characterized as the variation of methane, carbon dioxide and contamination components compositions measured online. Below, recorded methane and CO2 fluctuations are shown against a time period.

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