Hydrogen Research Forum Finland,
Seminar Lappeenranta, 8 August 2023

VEBIC laboratories available for research into hydrogen-driven marine and peaking power

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University of Vaasa's target

- Demonstrate and optimize marine and power generation using internal combustion engines
  - ship, power, off-road engines
  - peak shaving
- Reduction of engine emissions
  - with new combustion strategies
  - by using hydrogen

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Vaasa Energy Business Innovation Centre, VEBIC

- Research platform for multidisciplinary research
  - Technology, business, societal issues
- Laboratories:
  - Engine lab
  - Fuel lab
  - Lab for Future Reliable Electricity & Energy System Integration
  - Geoenergy storage

Euroopan unioni
Leverage from the EU 2014–2020

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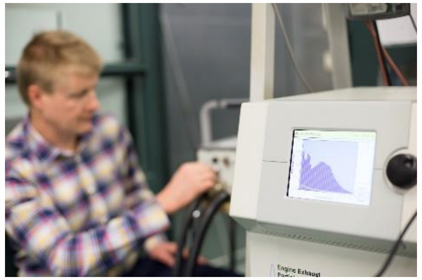
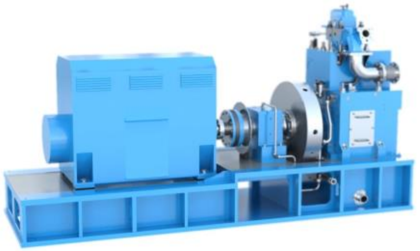
VEBIC steps

- Starting point:
  - Wärtsilä supplies experimental facilities for the research use
- University, BF, companies to finance the project
- Multidisciplinary platform for energy research

Viljo Syreniuksen rahasto

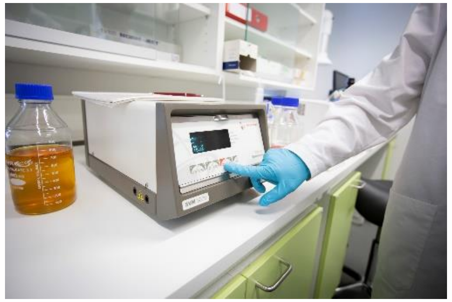
VEBIC engine and fuel laboratories





- **Unique Mid-Speed Engine Test Benches** with Wärtsilä 4L20 (Marine and Gen-set)
- Exhaust aftertreatment and fuel pretreatment test line
- ABB Electric Drive with battery-pack and grid integration
- **Test benches for high-speed engines** – 2 x Off-road AGCO (tier III + tier V)
- State of the art Combustion analysis
- Complete emissions
  - Analyzers for regulated compounds
  - FTIR for unregulated compounds
  - Detailed particulates (number, mass, distribution)
- Real time target platforms (rapid prototyping/HIL/SIL) for all engines
- **Single-cylinder mid-speed research engine** *
- **Gaseous fuel supply system for all benches + Engine Retrofit***

- Professional (Standardized) and explorative (high-end research) fuel analytics:



  - Trace elements
  - Oxidation stability
  - Fatty acid contents
  - Water content
  - Surface tension
  - Viscosity and density
  - Flash point
  - Cold Filter Plugging Point tester
  - Micro-scale
  - NIR instrument
  - Distillation analyzer
  - Ignition properties*

* Investments scheduled 2022-2024

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Fuel readiness at VEBIC lab

- Liquid
  - Fossil light and marine fuel oils (LFO, MGO, etc.)
  - Renewable fuels (renewable diesel, biodiesel, blends)
- Gaseous
  - Biomethane
  - Hydrogen (Q2/2024)
    - First H2 blending tests 2024

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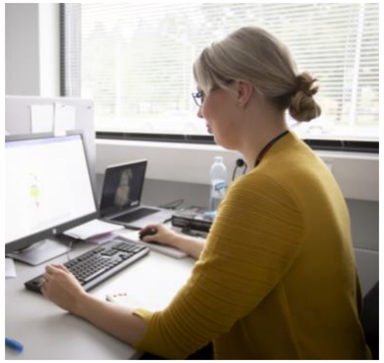

Ongoing projects

- Clean Propulsion Technologies, CPT (BF) 2021-2023
  - Novel combustion and advanced after-treatment, model-based design methodology, multi-fuel engine
  - Hybrid technology
- CHEK (EU Horizon 2020) 2021-2024
  - Hydrogen fuel system and H_2-driven engine for marine applications
- Silent Engine (BF) 2022-2025
  - New silent and vibration-free solutions for Finnish powertrain industry
- CASEMATE (BF) 2022-2025
  - Model Based Design methodology, Predictive Combustion models connected in system level framework
- DAZE (BF) 2023-2026 Data Analytics for Zero Emission Marine
  - Condition-based monitoring solutions for next generation combustion engines
- Company projects
  - Analyses of fuels and lube oils, life-cycle analyses
- Fundamental fuel research

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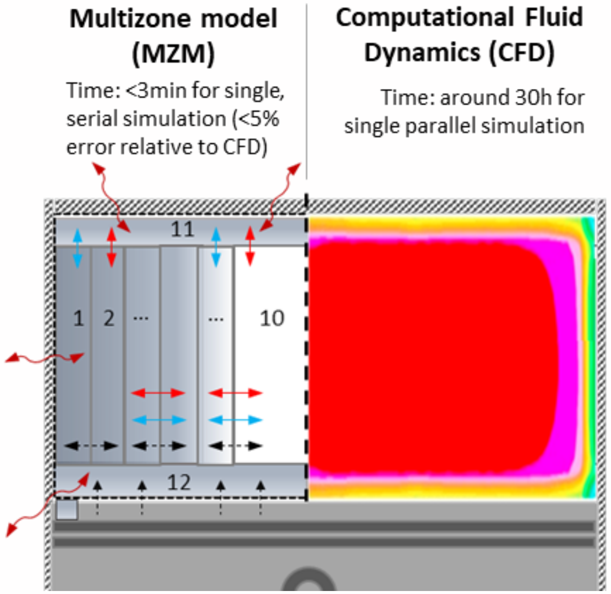
”Effects of H2 admixture on RCCI combustion dual-fuel marine engines: A model-based study” by Aneesh Vasudev / poster

- Simulations performed using a predictive combustion model - the UVATZ University of Vaasa Advanced Thermo-kinetic Multi-zone model
- Selected results:
  - Blending H_2 aids combustion performance of NG-diesel RCCI powertrains
  - Under part- and low-load operation: reduced UHC emission (methane slip) and specific fuel consumption
  - High load operation: H_2 blending not recommended



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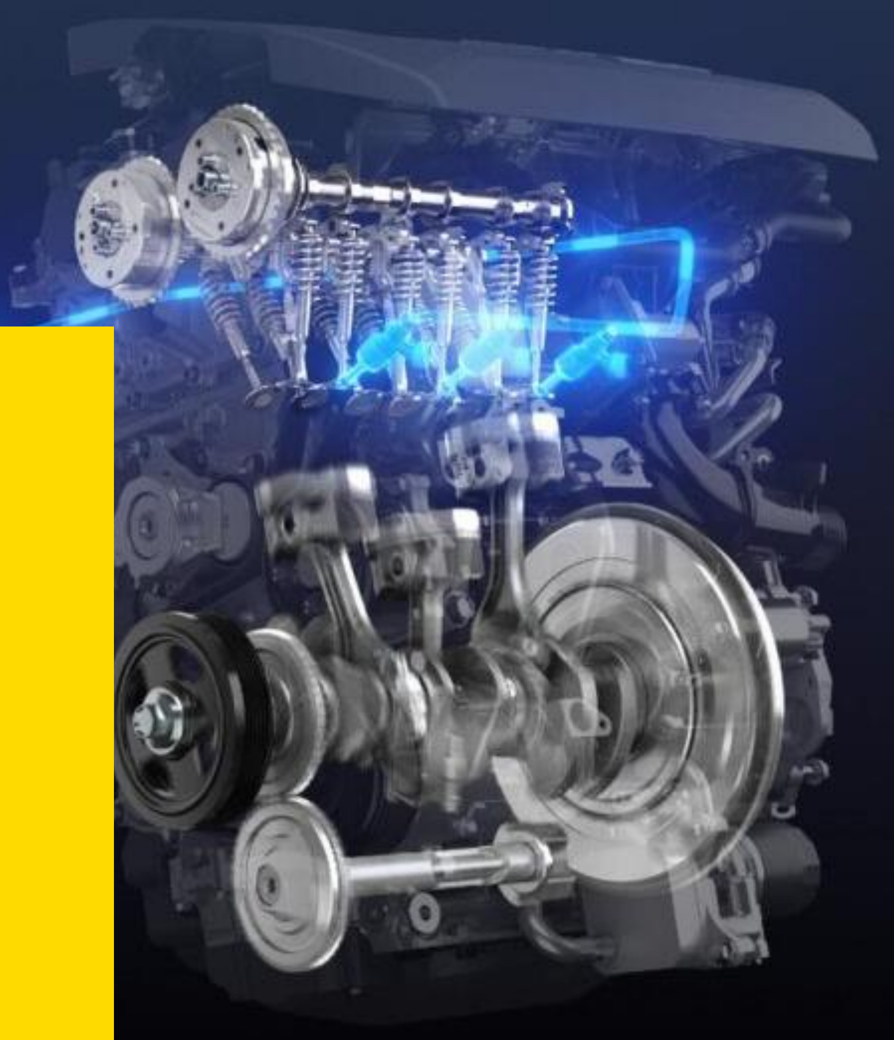

Air management system for PFI and DI type Hydrogen Combustion Engines

UVA: Maciej Mikulski, Aneesh Vasudev, Jeyoung Kim

UTM: Srithar Rajoo, Meng Soon Chiong

Research collaboration (UVA-UTM)

UTM UNIVERSITI TEKNOLOGI MALAYSIA

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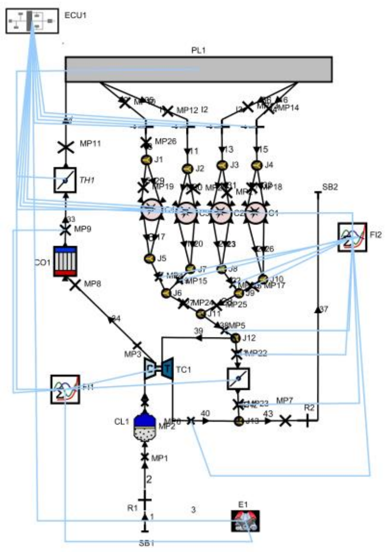
"Air management system for PFI and DI type Hydrogen Combustion Engines" by Jeyoung Kim / poster

Background:

- Abundant research on H2ICE with Port-Fuel Injection (PFI) and Direct Injection (DI): mostly with focus on combustion, emission, and operation characteristics
  - Air Management System (AMS) is neglected in most of the works
- In general, H2ICE is operated at ultra lean conditions. - How do we supply the required fresh charge when we converted conventional gasoline engine to PFI/DI-H2ICE without penalizing engine performance? AMS (boosting system & cooling system) play an important role!!



Main objectives:

- Developing AMS of PFI and DI type H2ICE to achieve same performance (66kW/L) as baseline gasoline engine
- Compare AMS between PFI and DI H2ICE operation

  1) PFI H2ICE (more boosting demand)
  2) DI H2ICE (less boosting demand)

  } How does H2 delivery strategy affect air management system?

Methods: Model-based investigation (AVL-BOOST) with baseline engine model (1.6L PFI Turbocharged SI Engine)

* Current level: > 60kW/L (TC-SI)
TC: Turbocharged, PFI: Port Fuel Injection, SI: Spark Ignition

CHEK

Decarbonising Shipping

deCarbonising sHipping by Enabling Key technology symbiosis on real vessel concept designs

https://www.projectchek.eu/

8 August 2023

Funded by the European Union

Objectives

- Develop and demonstrate at full scale two first-of-a-kind vessel concept designs (Kamsarmax bulk carrier and Meraviglia class cruise)
- Based on real operational profiles
- Equipped with an interdisciplinary combination of innovative technologies working in symbiosis
- Reduce greenhouse gas emissions by 99%, achieve at least 50% energy savings and reduce black carbon emissions by over 95%.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 955286.
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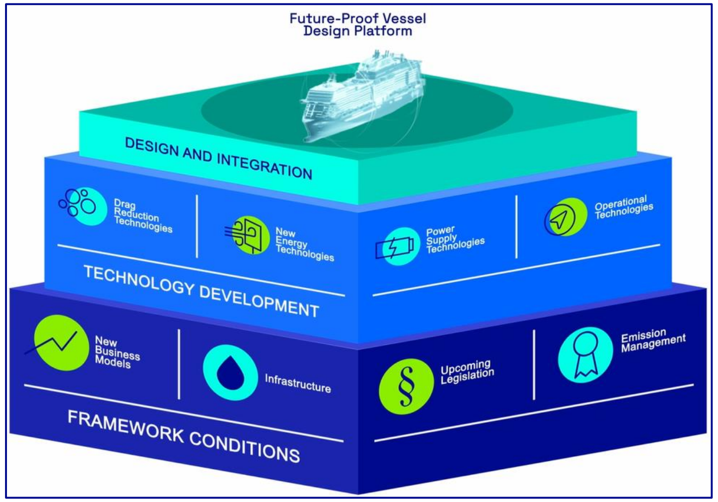
Consortium

Ship engineering and designing company

Tech providers

Marine classification society



Research, education, capability building

End-users

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University of Vaasa – Current activities with hydrogen

1. **Conceptual development of hydrogen fuel system for the EU CHEK vessel**

2. **Participating in development work of a hydrogen fuelled ship engine**

3. **Building a hydrogen fuel system to the VEBIC Engine laboratory**

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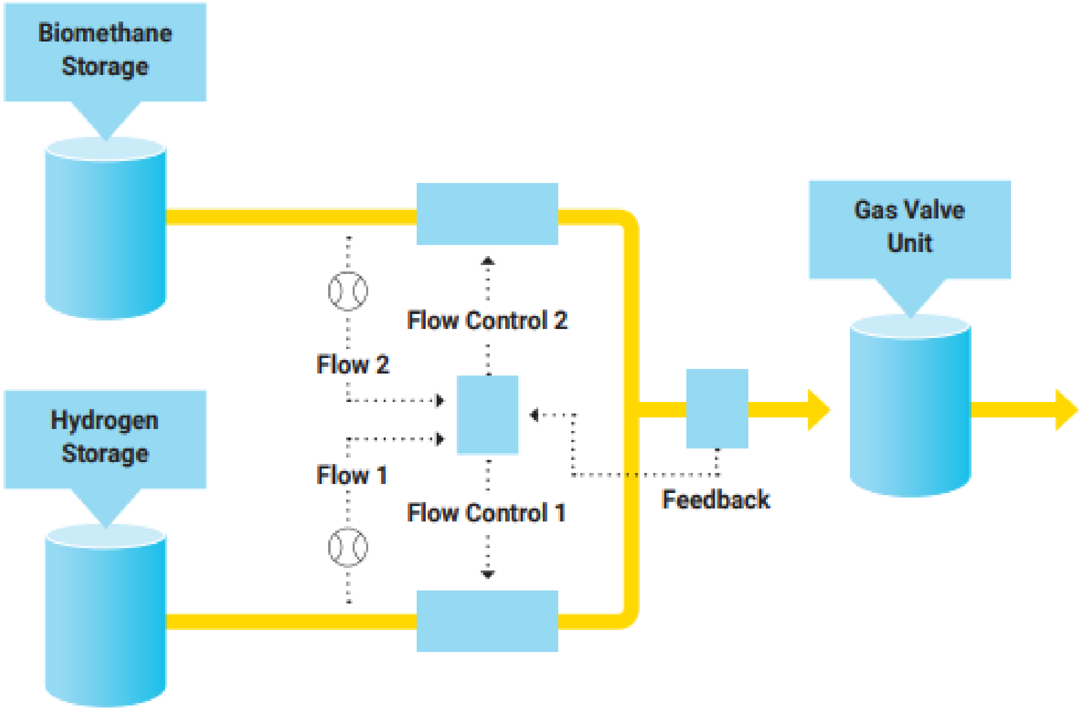
Hydrogen fuel system at the VEBIC laboratory

- **Hydrogen gas fuel system planned for following specifications**
  - Compressed hydrogen, pure
  - Opportunity to blend hydrogen in methane with at most H_2 25 vol.-%, later higher percentage
- **Permit applied for at Tukes Finnish Safety and Chemicals Agency**
- **Procurement of parts ongoing**
  - Valves
  - Instruments



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Efficient Powertrain Solutions

MACIEJ MIKULSKI
CAROLIN NUORTILA

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