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# Tutkimuksesta polttomoottorieksperttejä

Seppo Niemi  
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Mika Laurén



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# Research of internal combustion engines (ICE)

- Background and motivation
  - From the mid-1990s onwards, the ICE Laboratory developed to enable scientific research
    - To make it possible to serve the companies within the ICE field
    - To create a modern learning environment for the students





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## Targets of the ICE R&D

- Development of low emission diesel and gas engines
- Improvement of energy economy of Internal Combustion Engines
- After-treatment systems research
- Research and development of alternative fuels
- Modeling and simulation of ICEs
- Scenarios on engine and fuel development plus energy economy
- Expert services
  - Consultancy, documentation, etc.
- Education of ICE Technology





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## Main clients and partners

- AGCO Power
- Wärtsilä Finland
- Ecocat
- Valtra
- Proventia Emission Control
- Fuel producers
- Lubricating oil companies
- University of Vaasa
- University of Oulu
- Åbo Akademi University
- Tampere University of Technology
- Partner in
  - The FCEP research program of Cleen Ltd
  - The TREAM project



# Laboratory facilities

## Engine test beds

- Four Schenck-Horiba eddy-current dynamometers
  - Two ready for transients

## AVL indicating systems

## Gaseous emissions

- NDIR (CO, CO<sub>2</sub>)
- FID (HC)
- CLD (NO<sub>x</sub>)
- Paramagnetic O<sub>2</sub>
- FTIR
  - 20 compounds (e.g. CH<sub>4</sub>, NH<sub>3</sub>)
- Electrochemical cells
- Laser-based NH<sub>3</sub> indicators
- NO<sub>x</sub> sensors

## Smoke

- AVL 415 S
  - Heated, unheated
- Opacimeters

## Particle size distributions

- Dekati ELPI
- Thermodenuder
- Pegasor

## Particle mass

- Dekati FPS
- Dekati ejector diluters
- Gravimetric impactors
- AVL Micro Soot Sensors





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## Staff

- Laboratory Engineer
- Three (3) Research Engineers
- One (1) Mechanic
- Five (5) Senior Researchers
- Thesis workers
- Trainees
- Project workers

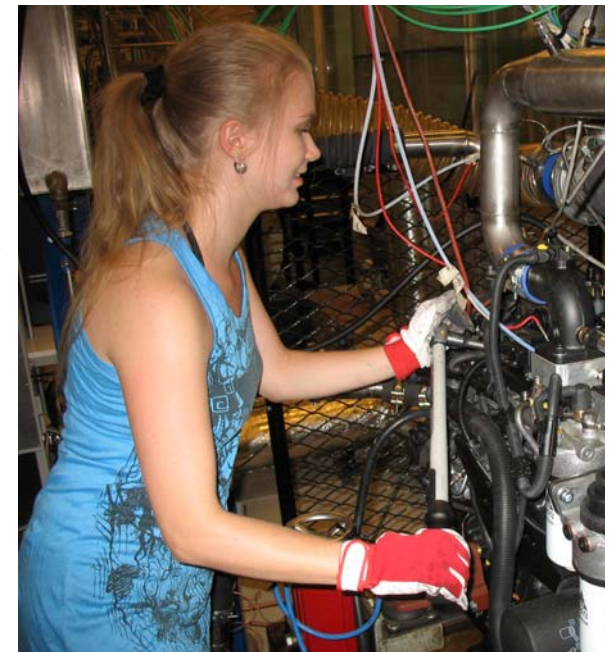




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## Modus operandi

- Each research engineer responsible for the R&D work of his or her own test bench
  - One or more students as assistants
    - Thesis workers, or
    - Trainees
  - Research engineers instruct the students and tutor them in results analyses
- Senior researchers
  - Plan and sell projects
  - Run and develop the laboratory operation
  - Supervise the theses and revise the reports
  - Publish results
- Younger students make minor project works within the ICE courses





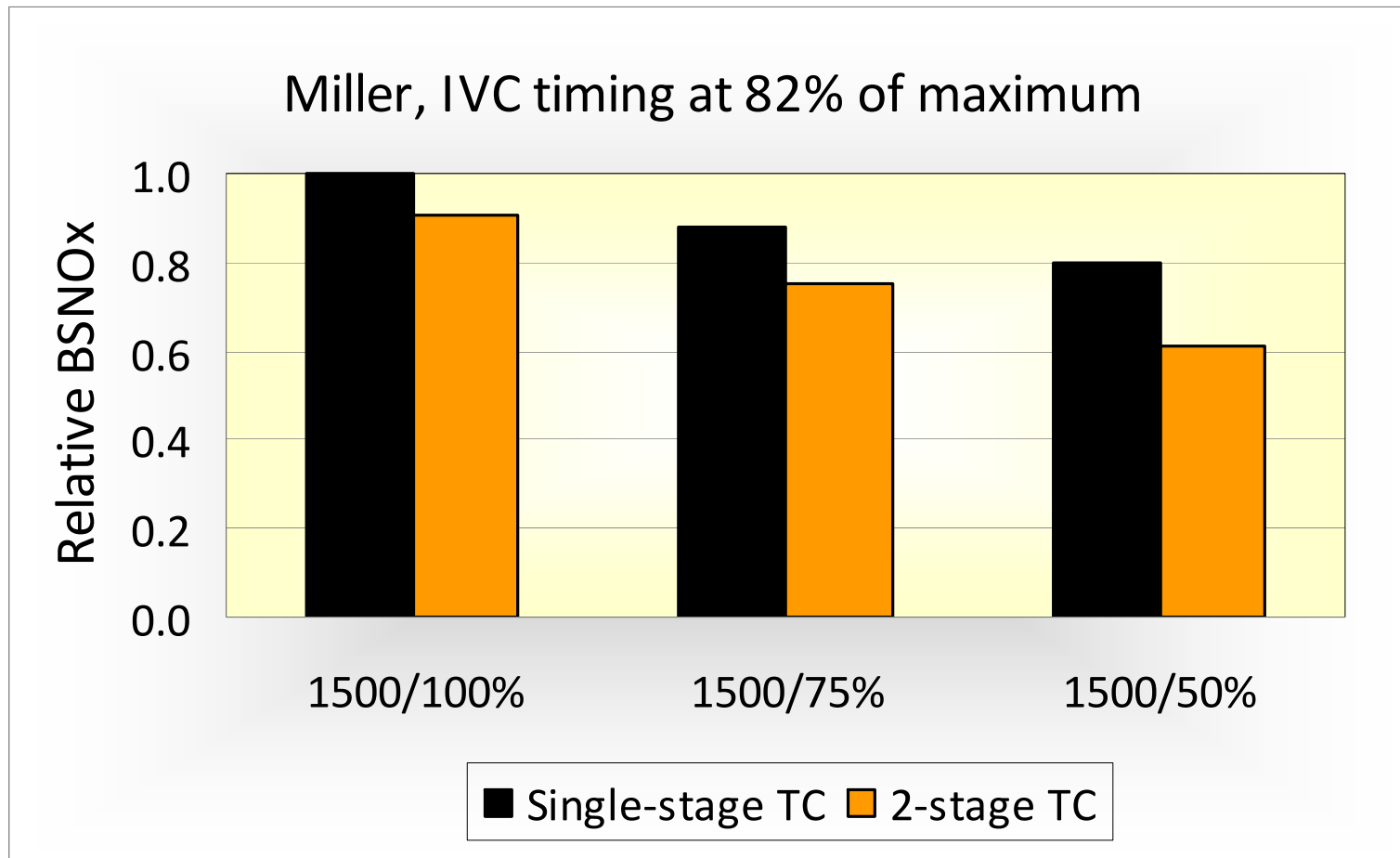
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# Some results





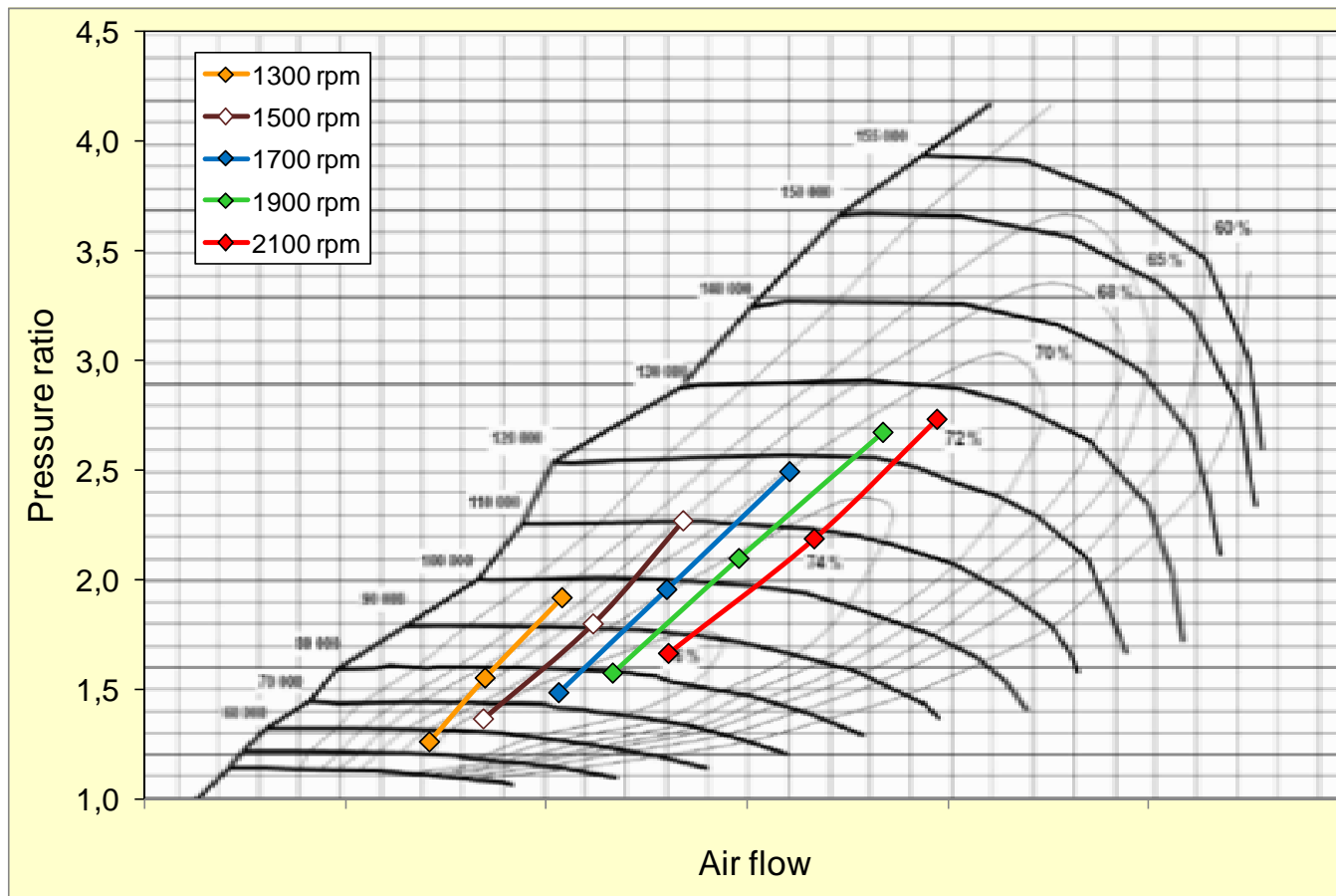
## Miller timing and two-stage turbocharging



# Matching compressors for two-stage turbocharging

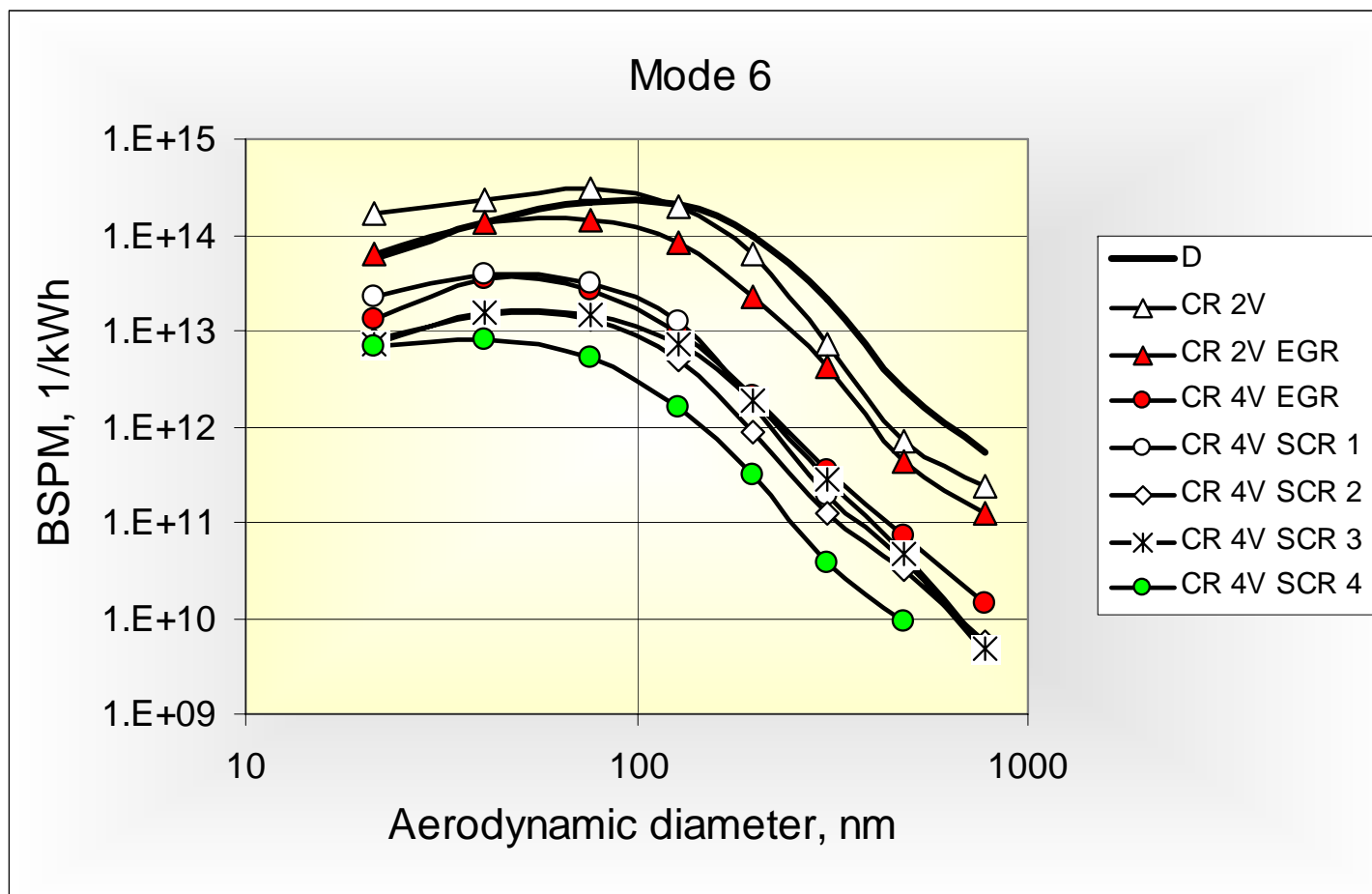


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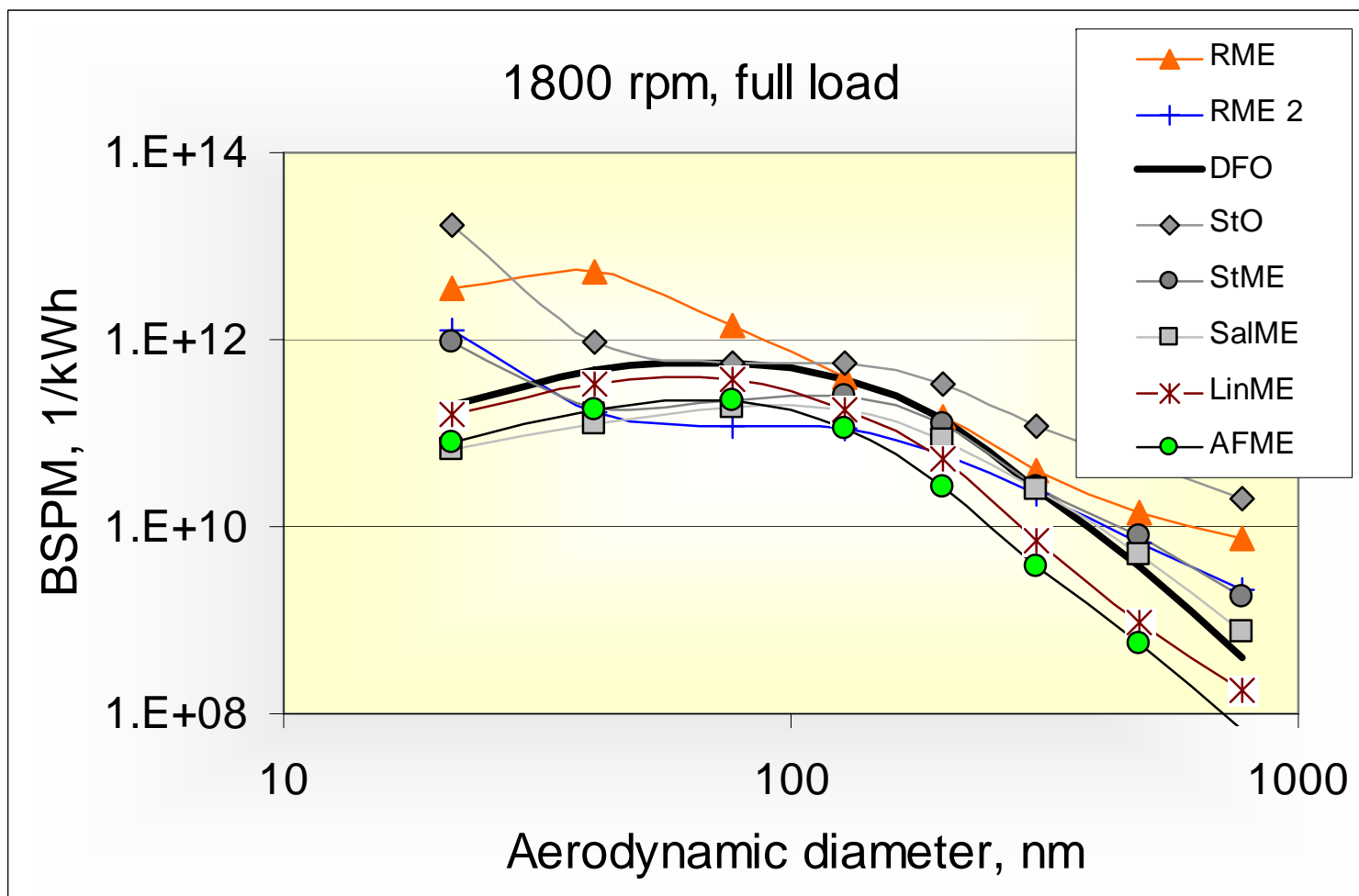


# Particle number emissions, engine generations



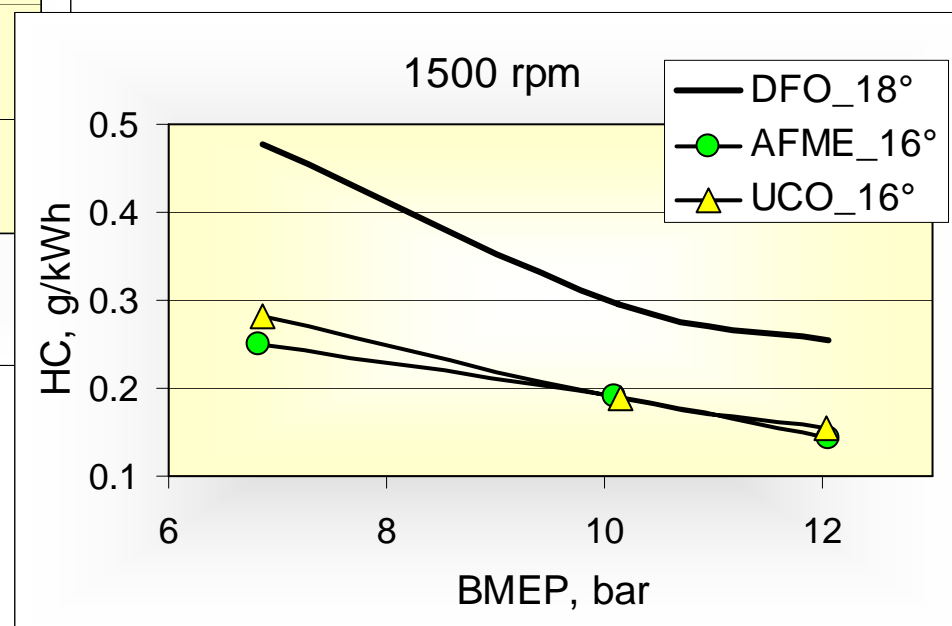
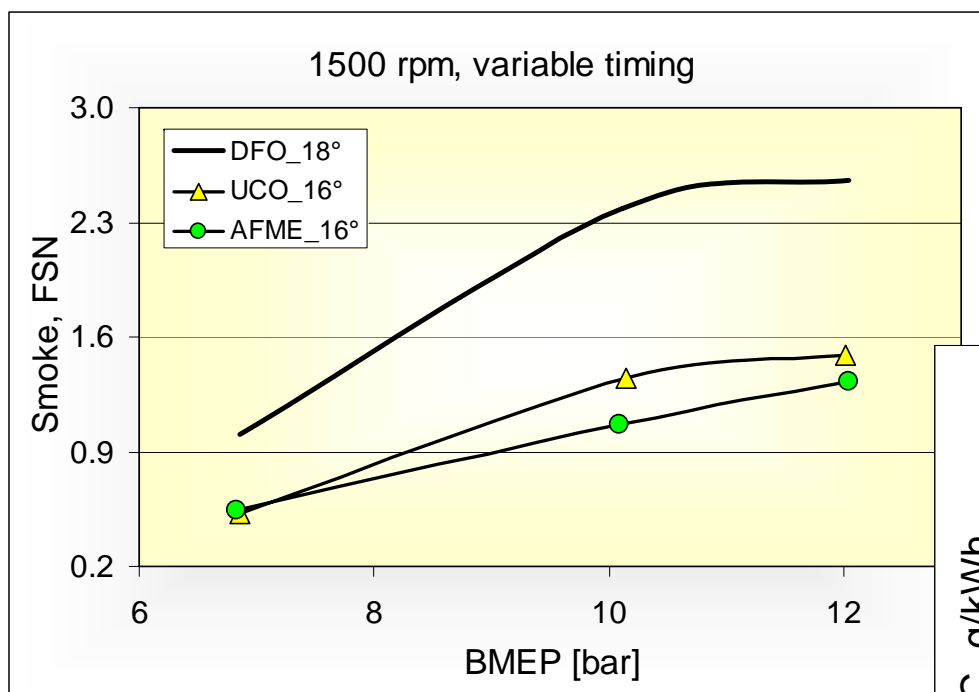


## PM number, biofuels





## Biofuels

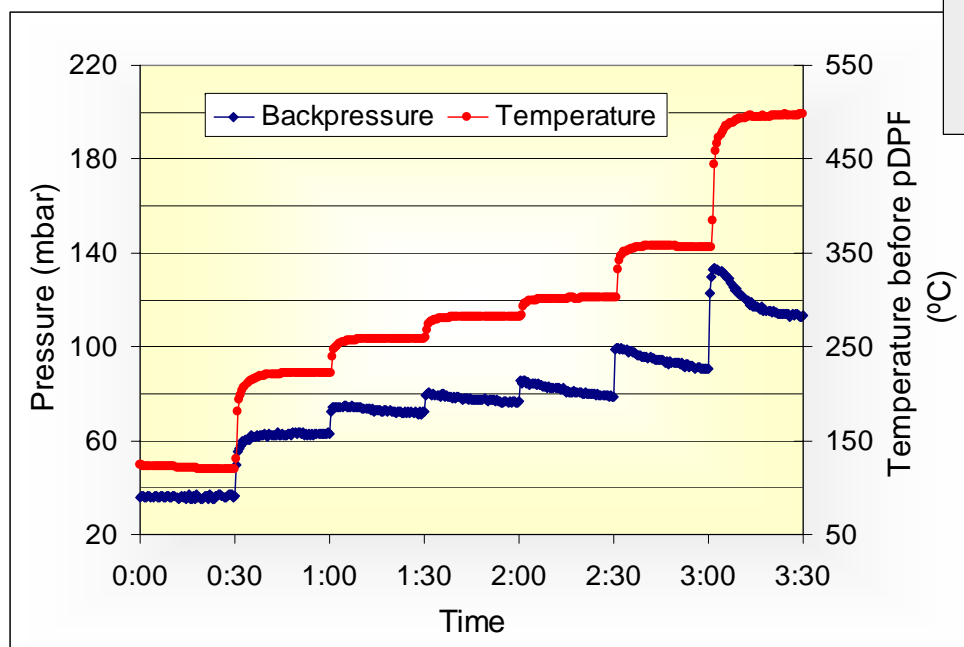
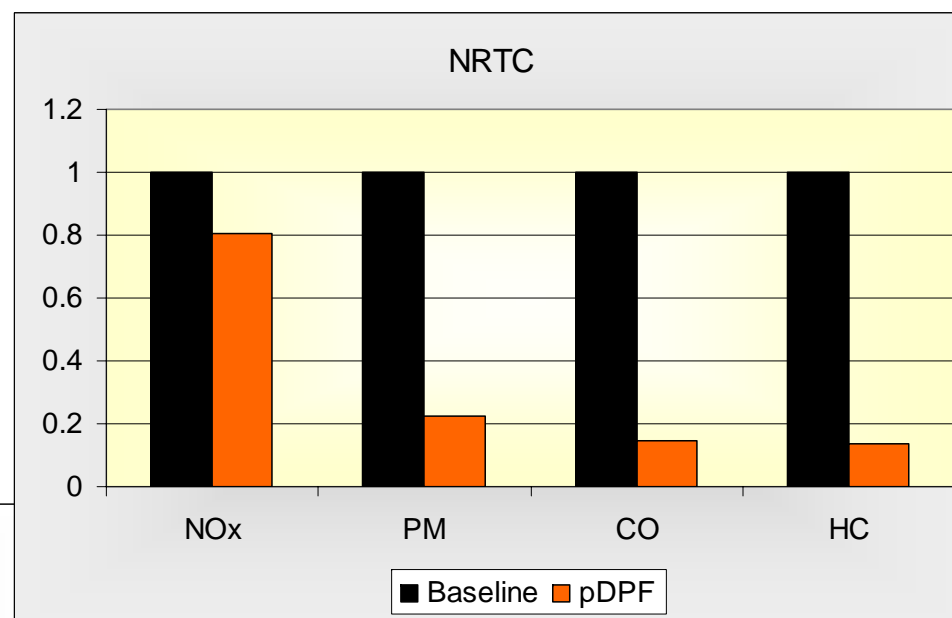


- DFO, Diesel Fuel Oil
- AFME, Animal derived Fatty acid Methyl Ester
- UCO, Spent Cooking Oil



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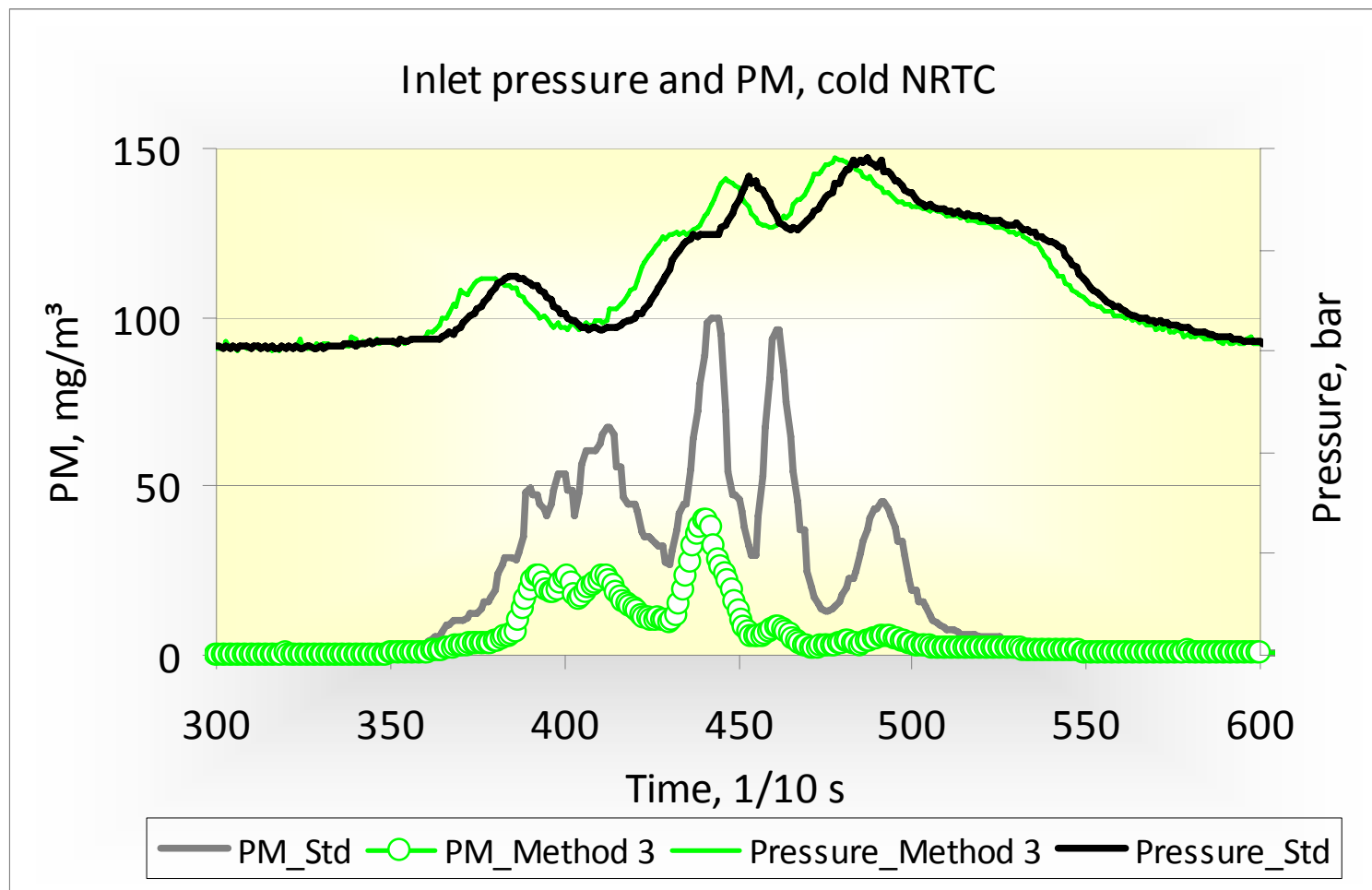
# Particle filters







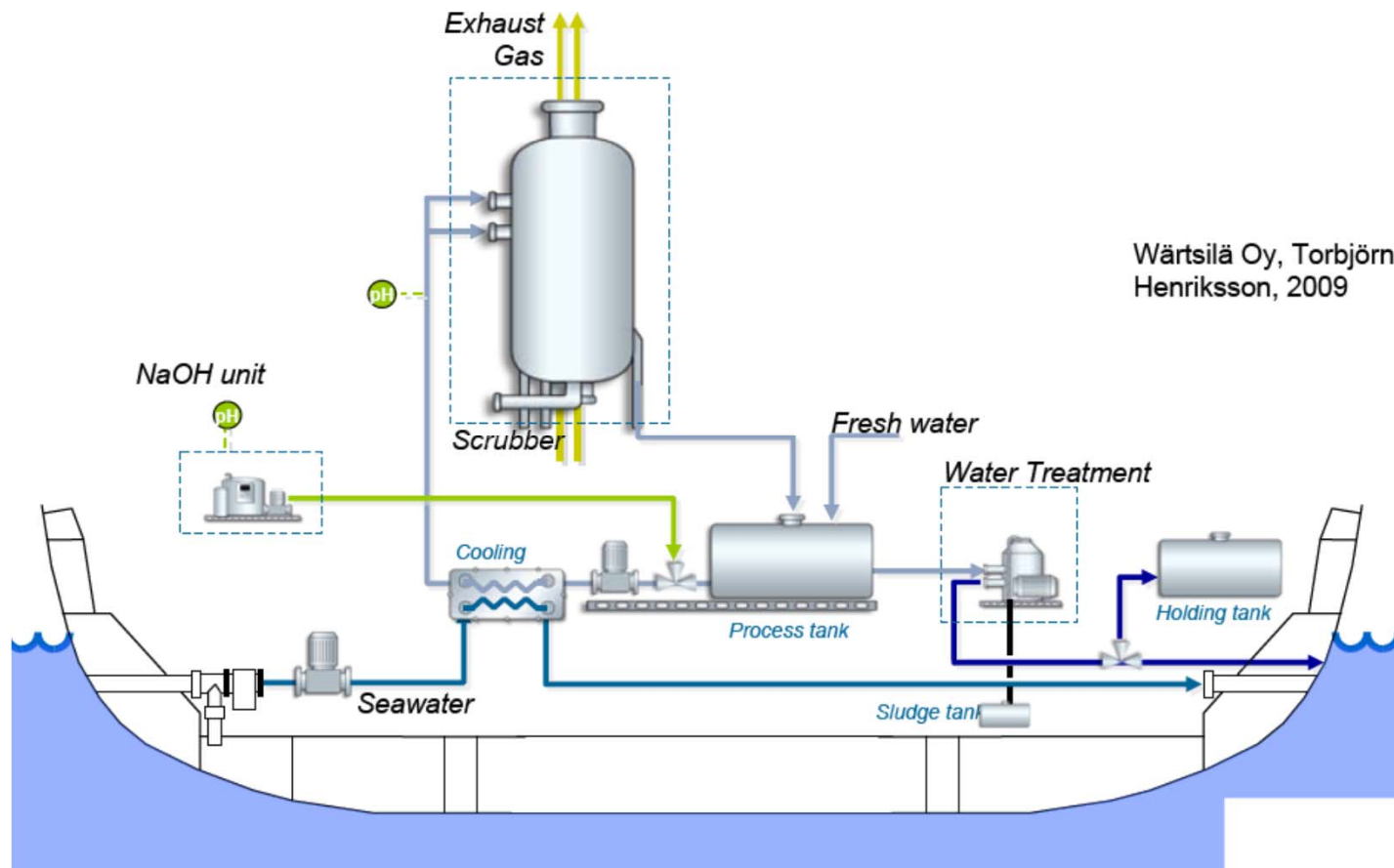
# Charge pressure and PM mass in transients



# Scrubber development



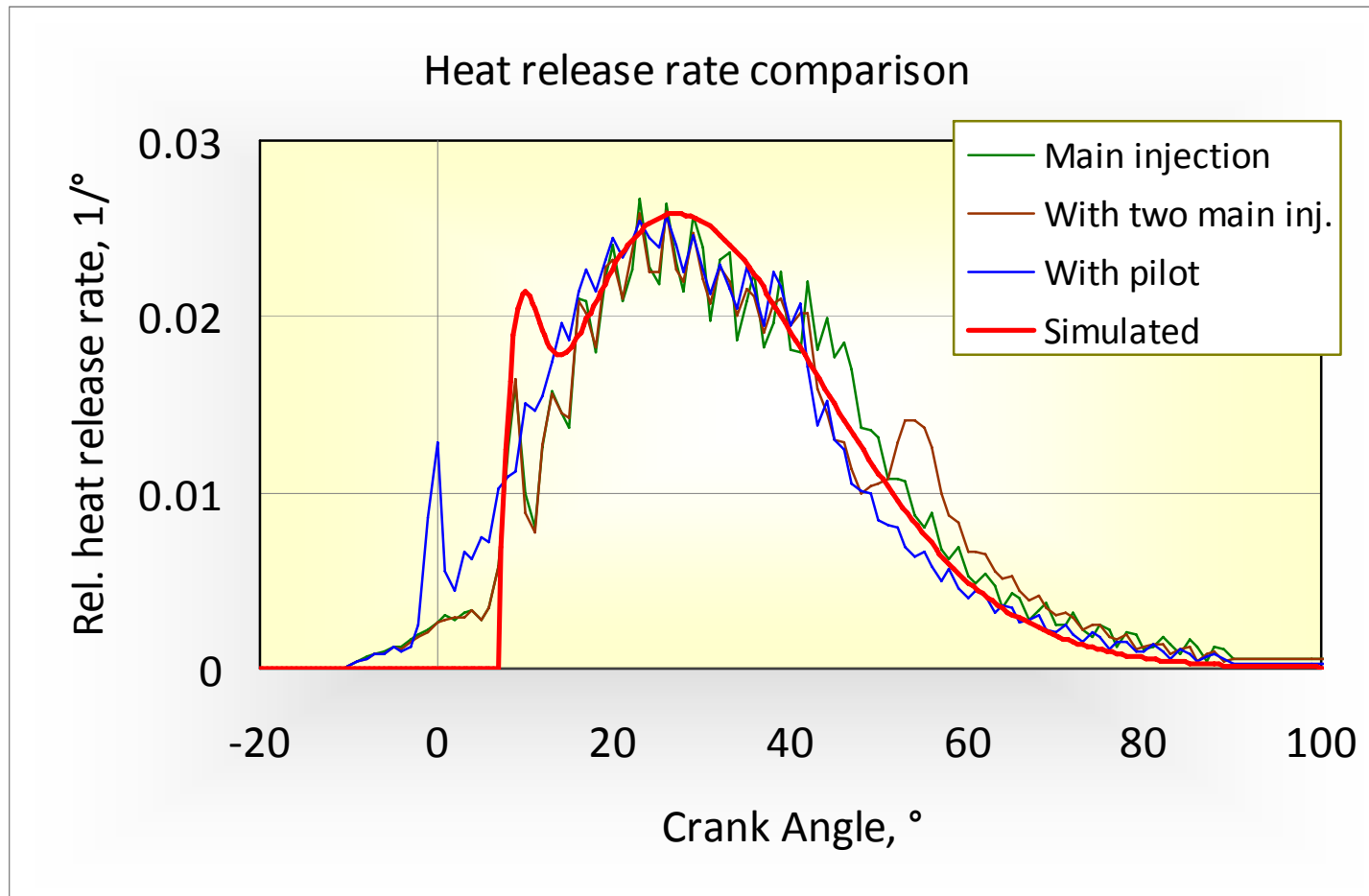
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# Engine modeling and simulation



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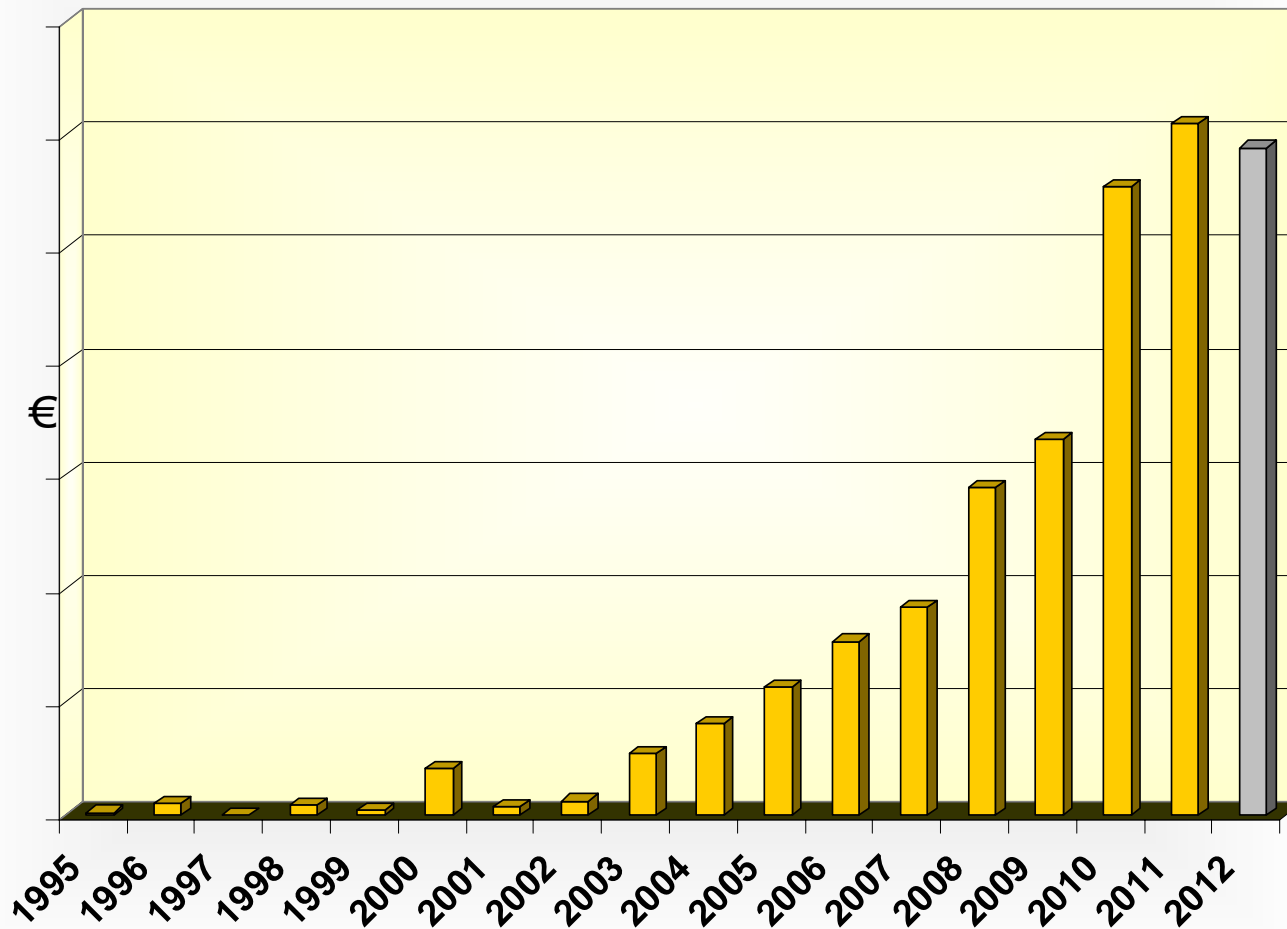


# Revenues



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IC Engine research, external funding



# Theses, reports and publications



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- Theses
  - Barely 50 Bachelor of Engineering
  - One Master of Engineering
  - One Master of Science
  - One Licentiate of Technology thesis
- Publications
  - Approximately 30 international
  - A few domestic articles and presentations
- Several reports based on younger students' project works





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# Conclusive notes



# Experiences



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- Between the industry and university, good personal relationships necessary for successful R&D co-operation
- A certain time required to create confidence
  - High-quality results required
  - International publications as proofs
- Employment opportunities of graduated students very favorable
  - Systematic working within the real projects, becoming more challenging phase by phase



# Future



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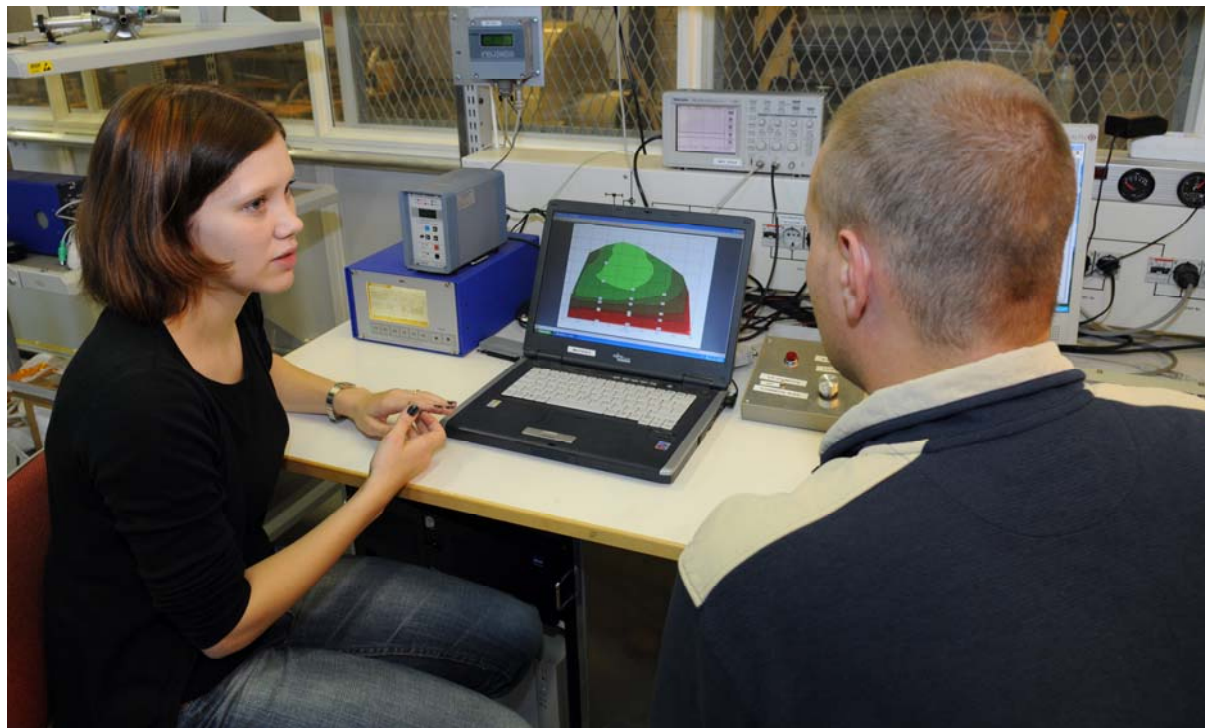
- Increased attention to students'
  - Basic knowledge of natural sciences
    - Physics
    - Chemistry
    - Thermodynamics, etc.
  - Scientific information retrieval
    - Theory and articles should also be read!
      - Massive reading forms the basis for the competence
  - Technical writing ability
- In total, the future looks bright
  - Companies continuously willing to co-operate
  - Increased number of students to energy technology
  - New laboratory premises under construction



# Thank you



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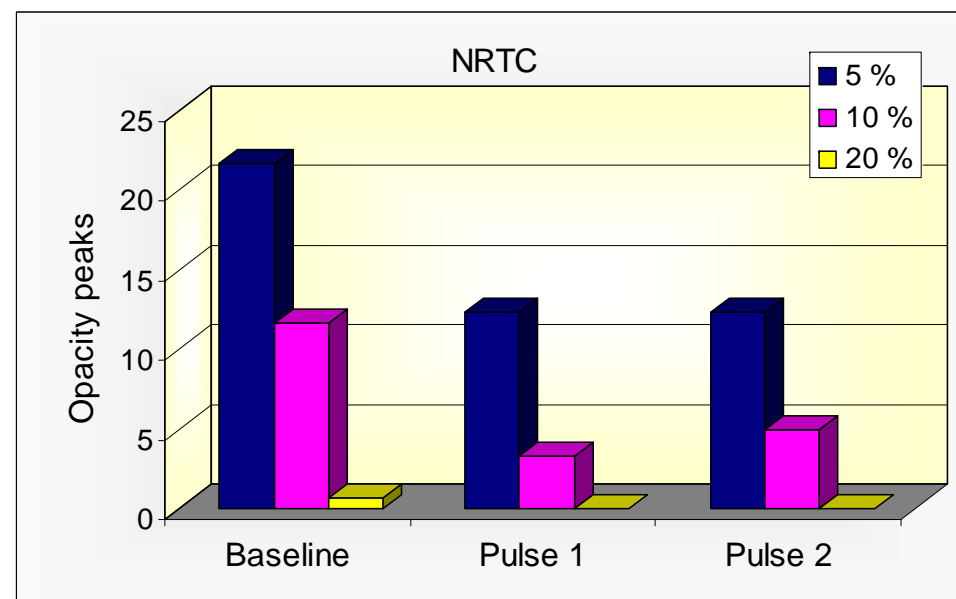
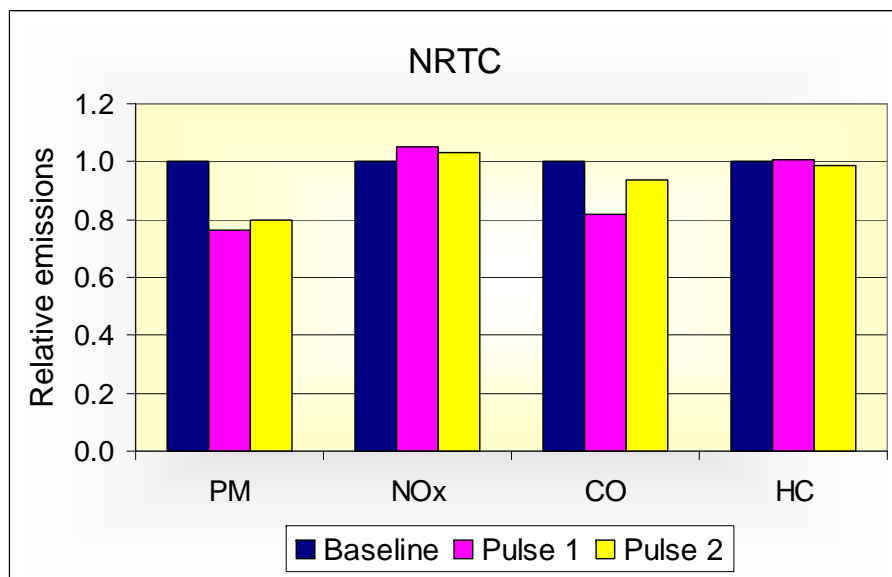
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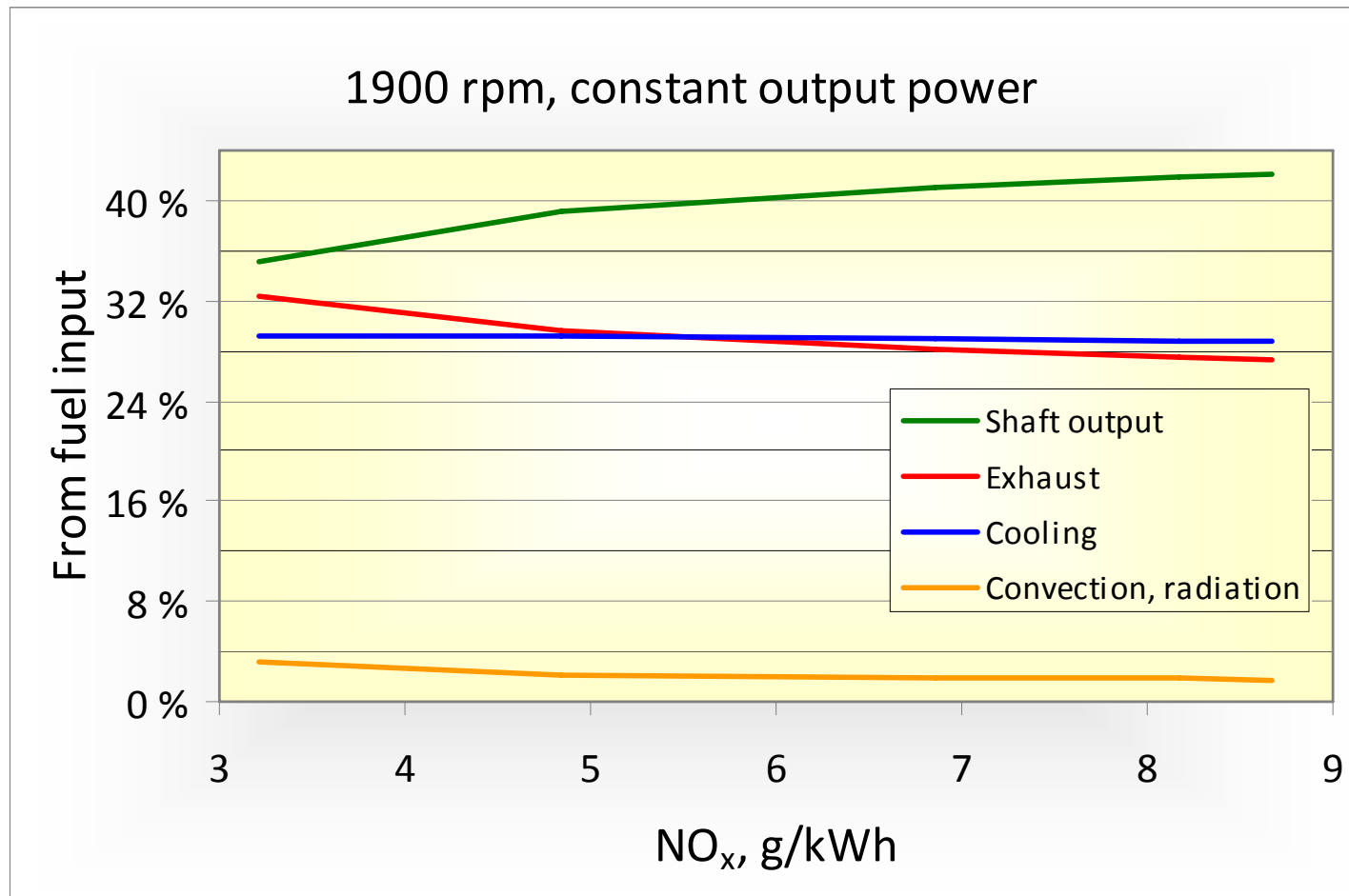
# Pulse turbocharging



# Heat balance versus NO<sub>x</sub> level



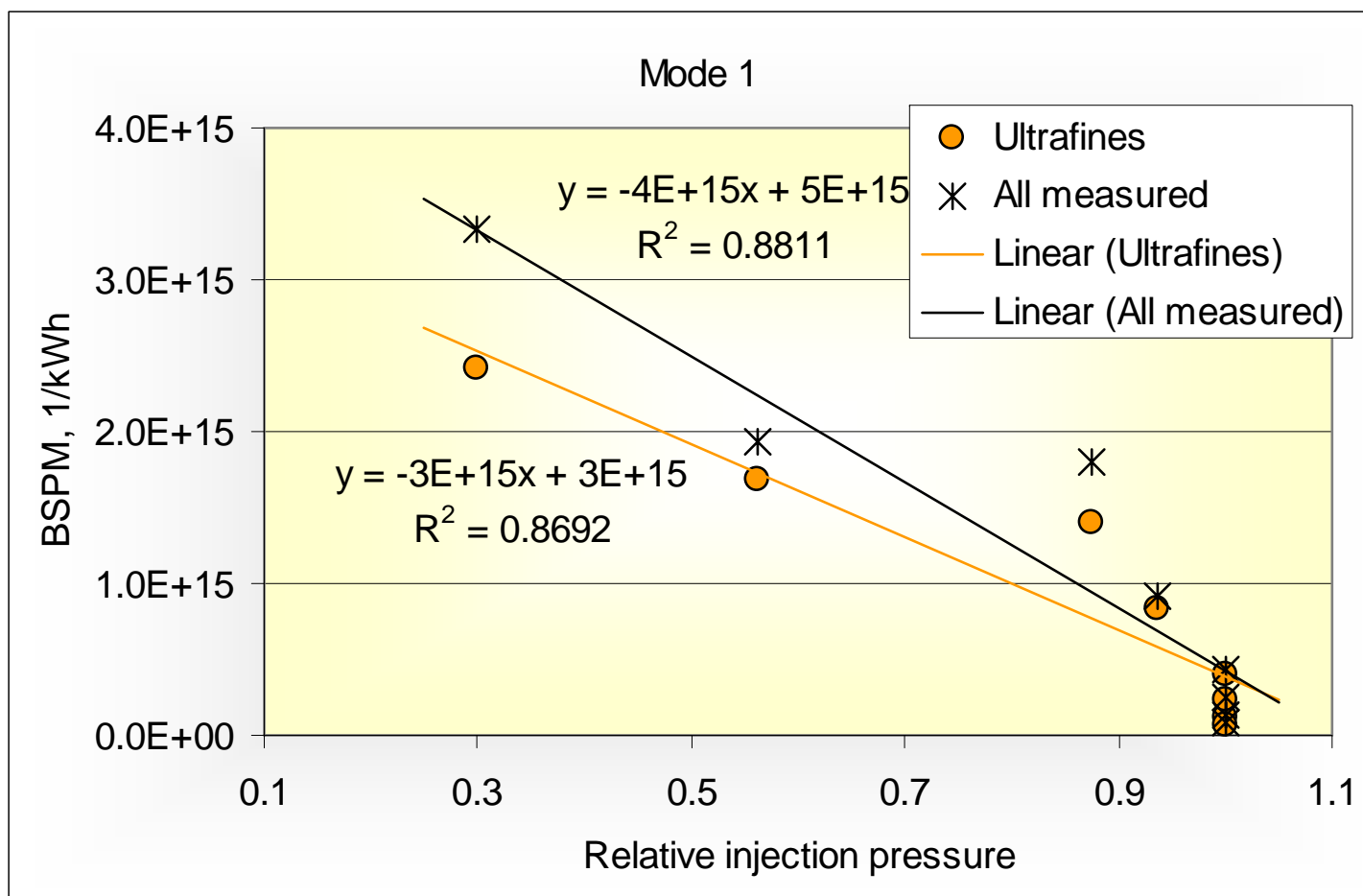
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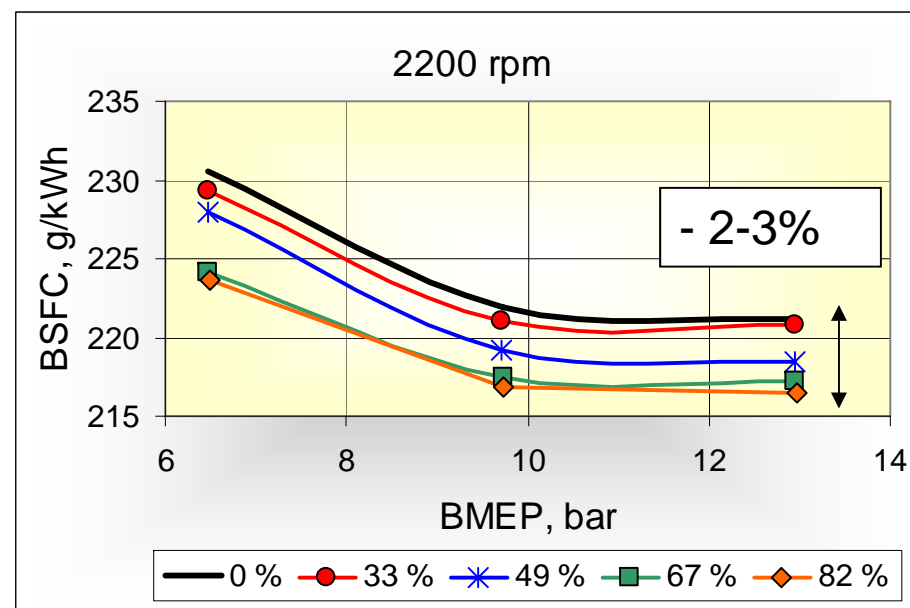
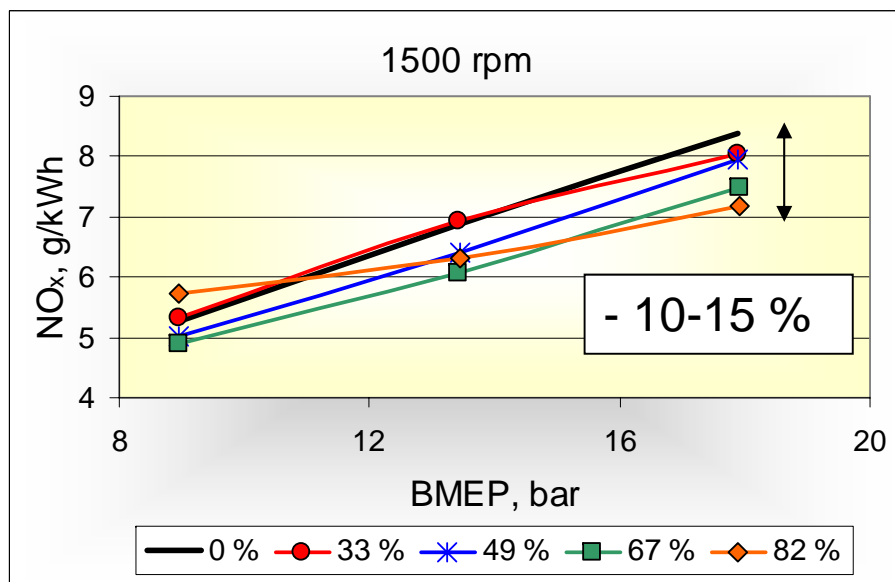
## PM number, effect of injection pressure





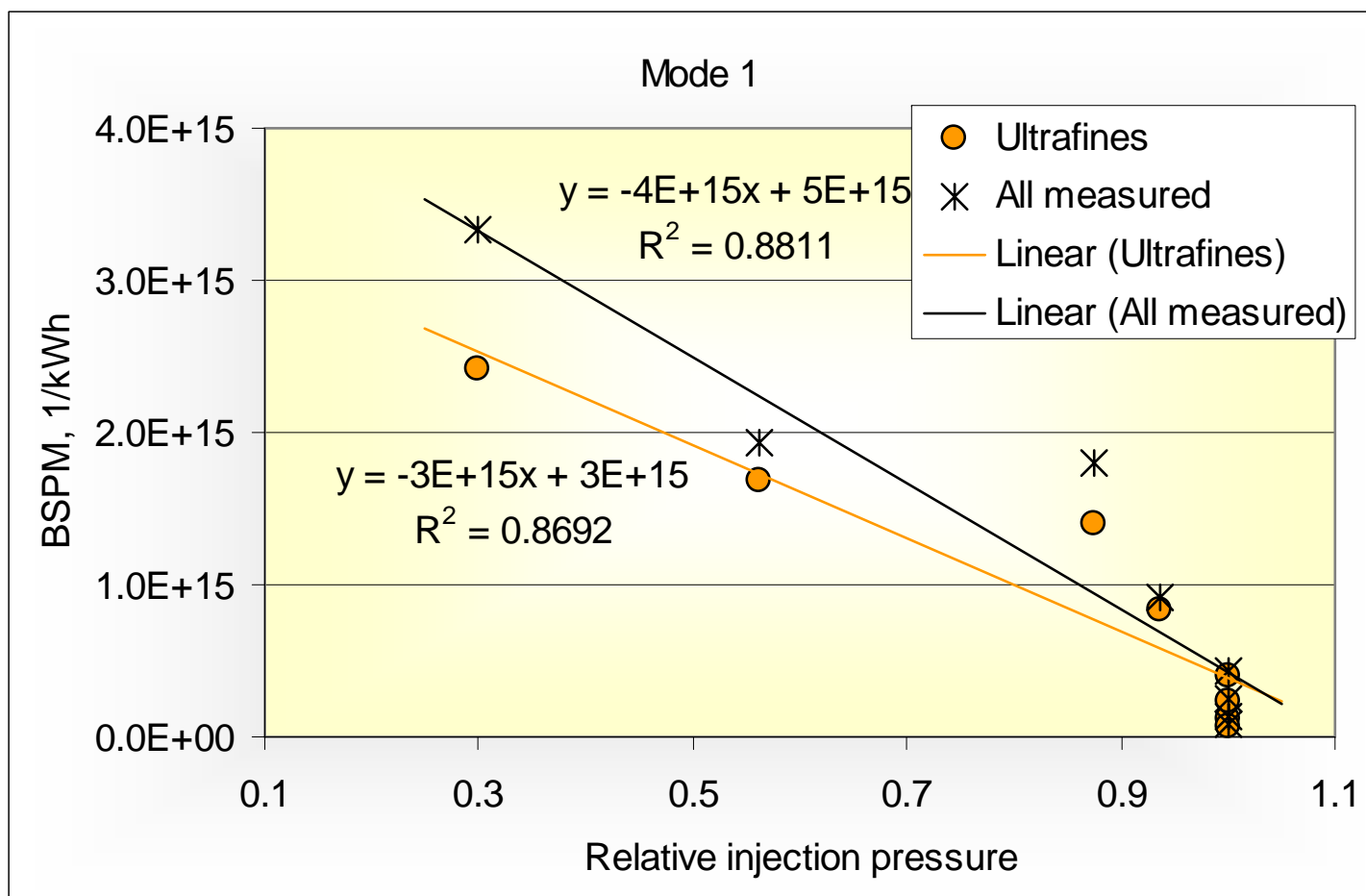
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# Miller timing





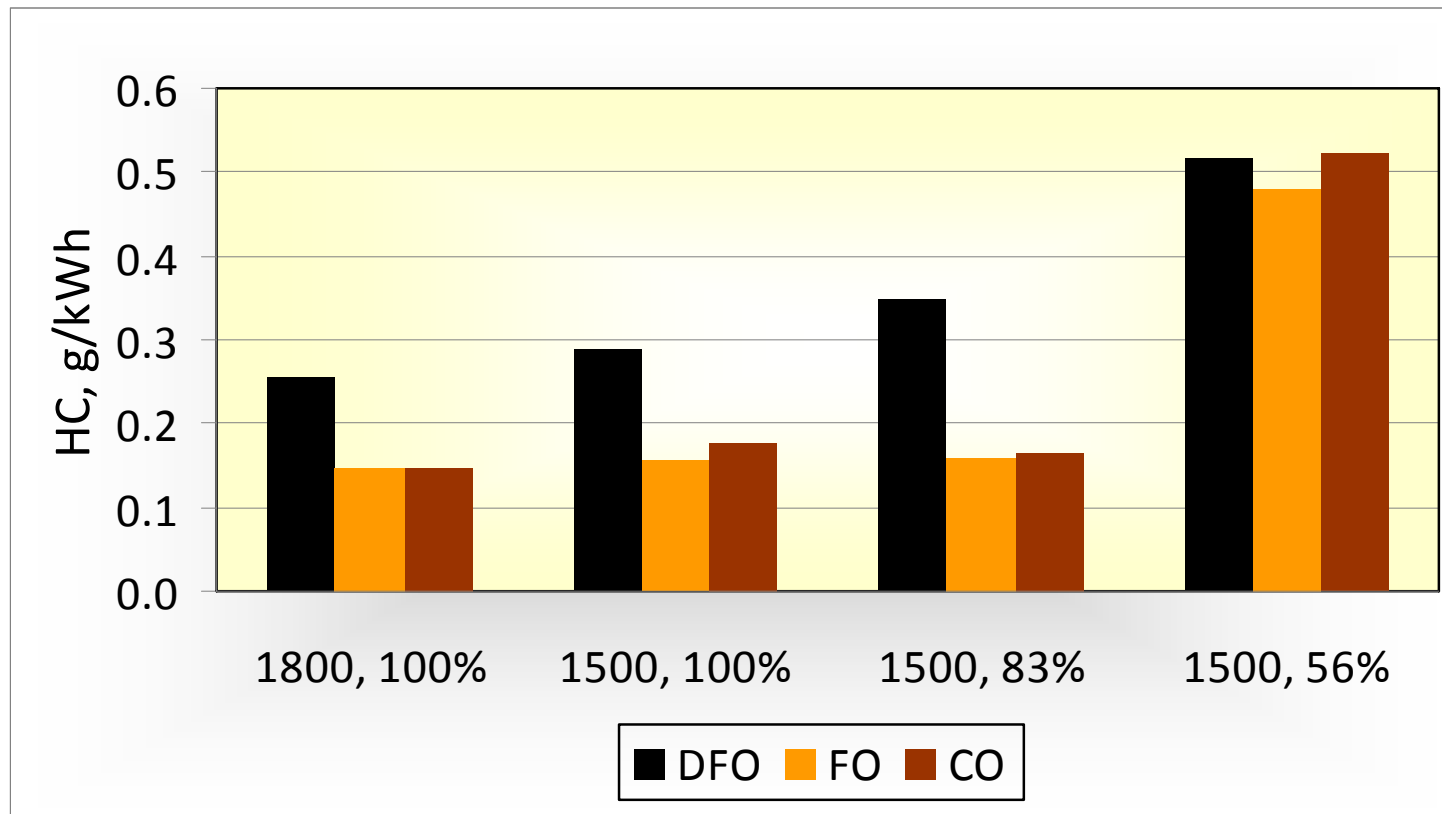
## PM number, effect of injection pressure





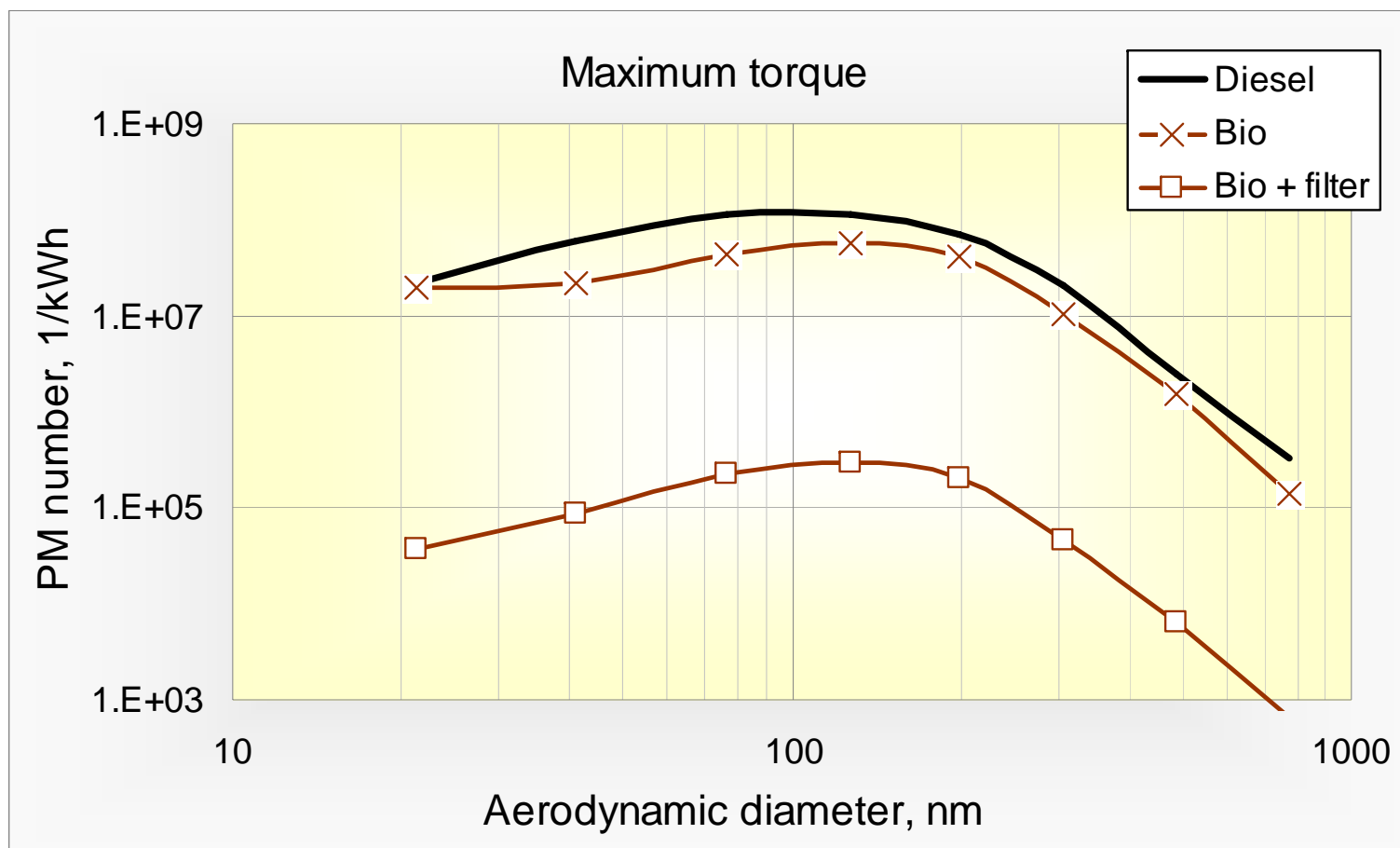
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# Biofuels



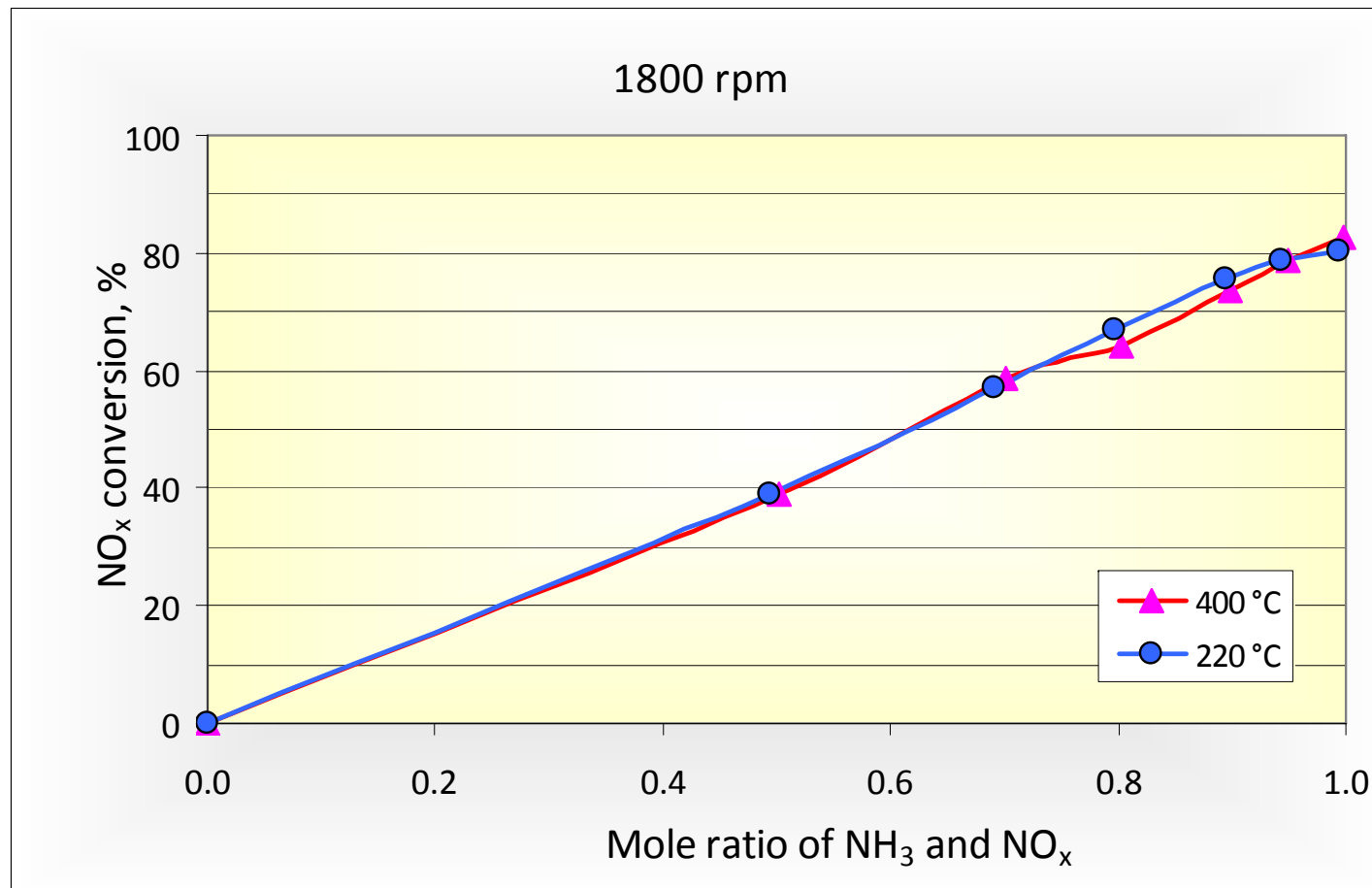


## PM number, biofuel and filter





# SCR performance at different temperatures





# HC-SCR development



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