HAN Automotive

SFEE: Sustainable Fuels, Engines and Emissions

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https://www.han.nl/en/programs/coursefinder.xml#/level-Master

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- This presentation is used to give a brief introduction to the SFEE module. If you would like to know more about the SFEE module or have any questions, please feel free to contact:

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Sustainable Fuels, Engines and Emissions (SFEE)

- Brand NEW Module → SFEE ≠ MES-IPT

ENGINEERING → AUTOMOTIVE ENGINEERING

BACHELOR → *MASTER*

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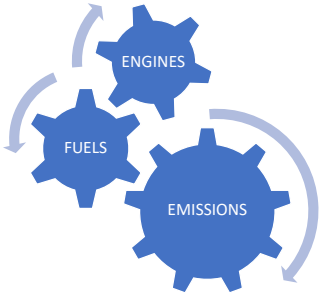
- This is a completely new module
  - Revised specifically to address previous issues and suggestions from students.
  - 1st SFEE module in 2020 was very successful with 100% pass rate

- Improvements include:
  - Dedicated 2 weeks on introduction to ICE (the basic operating principles and features)
  - Updated lecture material, shorter presentations
  - Multiple Lab Assignments related to theory to give students time to grasp and understand the lectures.

- NOTE: It is worthwhile to know that the SFEE module offered by HAN is a unique Master level course on combustion engines as well as sustainable fuels and emissions. Very few courses are available globally for Master level combustion courses. As such, students completing this module have a head start when entering the job market in a engine/fuel related capacity.

Sustainable Fuels, Engines and Emissions (SFEE)

"Engines, fuels and emissions are all explicitly interconnected. The combination of these three have become of particular interest in recent years, due to their potential and role (not only in the automotive industry) in achieving a cleaner and greener future"



	2010 targets (Biofuels Directive)	2020 targets (Renewable Energy Directive)	2030 targets (RED II)	2050 targets (White papers)
Share renewable energy in final energy consumption		20%	32%	
Share renewable energy in transport	5,75%	10%	>14%	
Reduction of GHG-emissies (compared to 1990)		20%	40%	80-95%
Improvement energy efficiency		20%	27%	

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- Although popular belief is that combustion engines will be irrelevant considering the huge effort being placed on vehicle electrification, this is not entirely accurate. Vehicle electrification will play a huge role in meeting emission targets and legislation, but so will combustion engines and alternative fuel vehicles.
- Engines and alternative fuels will still be used for the foreseeable future
- We need ALL options to tackle the climate problem. Relying on the market deployment of battery electric vehicles and hydrogen based vehicles will take too long. it is expected that they will become dominant in the fleets only after 2030, and in the time being we keep emitting too much CO2 in the atmosphere and can not prevent global temperature rise increasing above the 2 degrees Celcius. So alternative, low carbon fuels in the existing fleet are desperately needed.
- Furthermore, there are various sectors (long-haul road trucks, inland and maritime shipping and aviation where energy density of fuels (energy per kg or energy per liter) is crucial. Please note that these sectors often represent more than half of the total energy consumption of a country. the energy consumption of passenger cars is often max 50% of total.
- The introduction of electric mobility (Battery Electric and Fuel Cell EV's is also limited by the renewal rate of cars, so they share will only slowly increase in the coming decade. EU expects that in 2030 23% of the fleet is EV and that one out of three new cars will be electric.

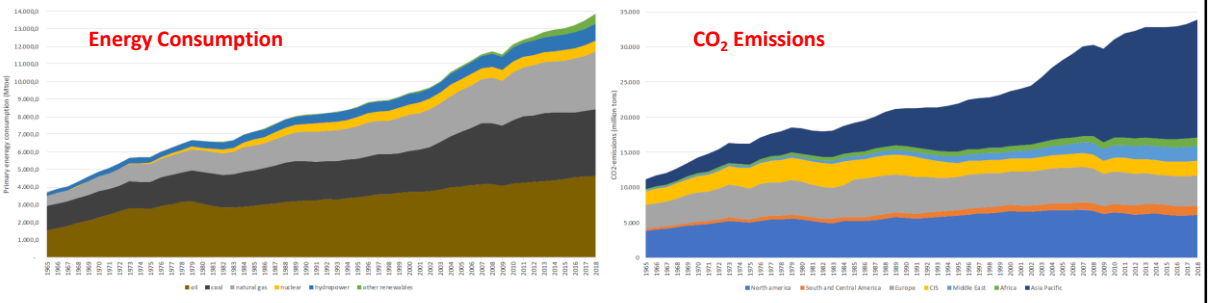
- Share of Diesel in New Passenger Cars: https://www.acea.be/statistics/article/Share-of-diesel-in-new-passenger-cars

Sustainable Fuels, Engines and Emissions (SFEE)

- Why study sustainable fuels??

"The deployment of alternative energy in transport is expected to grow, representing roughly half of energy demand in 2050. Reliance on liquid fuels however persists, leading to a high demand for alternative liquid fuels as a result (around one quarter of transport energy demand)."

~ The European Commission



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- Current global emission reduction targets rely on converting the fleet of fossil fuel powered vehicles to run on alternative fuels. Sustainable fuels is rapidly growing popularity not only in the automotive industry but also in other areas of industry which rely on power generation (the marine, aviation industry for example). Fuels is a very useful topic that may be applied in many different fields of work

- NOTE: For general information regarding emission targets, goals and policies → Read up on The Paris Agreement. This agreement is not limited to the automotive industry but for the world in general (including all areas of work which produce emissions on a larger scale)

- It is also important to note that there is no single fuel source that can replace diesel and gasoline outright. This reduction of fossil fuel vehicles will be a gradual change and fossil fuel powered vehicles will be replaced (in part) by various alternative fuel vehicles as opposed to a 100% Hydrogen car fleet.

- QUOTE: https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetailDoc&id=34592&no=1 – Page 7

Topics Covered – Sustainable Fuels

- Emission Legislation & Targets
- The Role of Alternative Fuels in the Automotive Industry
- Clean Energy/Renewable Energy/ Alternative Fuel Directives
- Alternative Fuel Possibilities
  - Fuel Characteristics & Properties
  - Feedstocks + Production Pathways + Fuel
  - Mixture & Composition
  - Potential as Automotive Fuel
  - Impacts & Considerations of Introducing a 'New' Fuel

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- The alternative fuels covered in this module include:
  - Hydrogen
  - DME
  - Biodiesel
  - HVO
  - LNG
  - CNG
  - LPG
  - …
- As well as discussing the combustion related properties of the various fuels, the production pathways of these fuels and the implications (cost, infrastructure, etc.) of adopting these fuels are discussed. This gives a greater sense of the future requirements and possibilities with respect to meeting the emission targets.
- Considering that the EHFCP covers vehicle electrification and component sizing for electric powertrains, the combination of the SFEE module and the EHFCP gives the full scope of future automotive powertrains.

Sustainable Fuels, Engines and Emissions (SFEE)

- Why study engines??

"To reduce carbon emissions globally, many countries have decided to ban fossil fuel powered vehicles in the next 20-30 years. This is a massive and global initiative that will take years to implement. Until then, a great deal of effort is being placed on improving the performance, fuel consumption and emissions of conventional engines running on diesel and gasoline, as well as engines running on alternative fuels."

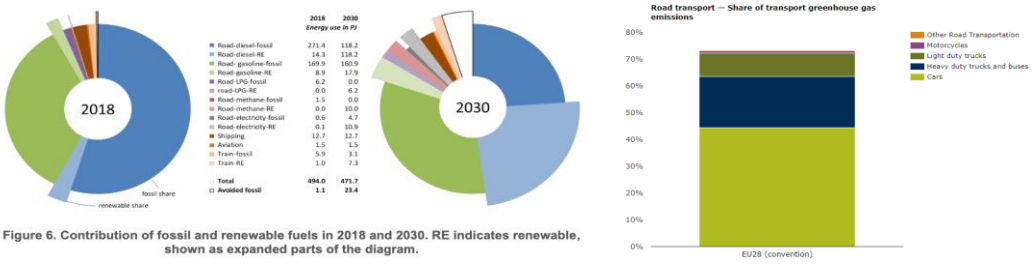

Figure 6. Contribution of fossil and renewable fuels in 2018 and 2030. RE indicates renewable, shown as expanded parts of the diagram.

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- Vehicle electrification is one method (currently very popular in media) which is being explored to reduce emissions. There are issues with vehicle electrification however. For example:
  - How to deal with the task of electrifying a massive cargo ship diesel engine?
  - How to convert the massive fleet of diesel and gasoline powered vehicles to electric, and how to deal with the power drain on the national grid(with households charging 2-3 cars each)?
  - Fossil fuel is also used in the production and supply of electric vehicles and vehicle components? This is shifting the emission problem from the vehicle to the production plant, but is not eliminating the problem.
  - Increase in electricity cost
  - Engines are also used as power generators in most developing countries.

- Not all countries have voted to ban fossil fuel vehicles. Global emission reduction is still important however and these countries need alternatives to electric vehicles. These countries will therefore still rely on combustion powered vehicles using alternative fuels.

- Although Diesel and Gasoline engines have been extensively developed over many years, companies are still putting a large focus on improving diesel and gasoline engines as they will still support the larger automotive industry for long-term future. While alternative fuel vehicles have existed for many years, the recent need to reduce emissions has placed a huge emphasis on these alternative fuel engines to develop innovations and advancements.

Topics Covered – Engines

- Compression Ignition (CI) Engines
- Spark Ignition (SI) Engines
- Dual Fuel Engines
- Advanced Combustion Strategies
  - Homogeneous Charge Compression Ignition (HCCI)
  - Pre-Mixed Charge Compression Ignition (PCCI)
  - Reactivity Controlled Compression Ignition (RCCI)

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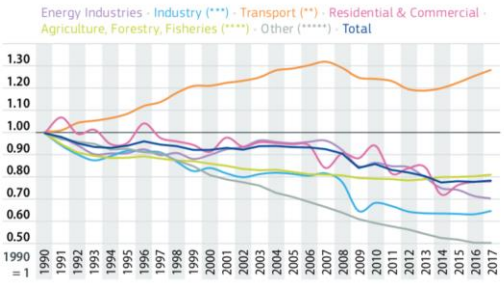
Sustainable Fuels, Engines and Emissions (SFEE)

- Why study emissions??

"The world must do much more to slash emissions if it is to defuse the climate change time bomb and deliver sustainable energy for a growing population."

~ The International Energy Agency



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- Emissions have both health and environmental concerns. The growing threat of global warming and climate change s however putting additional pressure on emission reduction however. This is partly responsible for the growing popularity of vehicles powered by sustainable fuel sources. Current projections suggest an unsustainable trend in emission output that will have severe consequences. As a result, a massive global effort is underway to combat the emission problem. The automotive sector shares a significant portion of the total emissions produced and this needs to be corrected/controlled.

Topics Covered – Emissions

- Air Pollution & Global Warming
- Exhaust Gas Recirculation (EGR)
- Exhaust Aftertreatment Systems (EAS)
  - CI Engines
  - SI Engines

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SFEE Learning Outcomes

- The student is able to:
  - Understand the application of alternative fuels in Internal Combustion Engines.
  - Understand the influence of these fuels on emissions, climate change, and overall fuel chain sustainability.
  - Evaluate advanced and innovative configurations of engines & fuels and make conceptual design choices concerning them.
  - Analyze, define and create models of problems in the field of combustion engines by using state of the art Computer Aided Engineering (CAE) tools.

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- These are general learning outcomes briefly summarized.
- Not only will the student be able to analyze and model these combustion engine and fuel related problems, but the students will also be provided with the tools and opportunity to implement their own solutions practically and analyze the results. Giving the student “real world” experience.

The SFEE Team

Gholam Farman
(FMNG)

Eric van den Heuvel
(Guest Lecturer)

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(PTQ)

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(MRTS)

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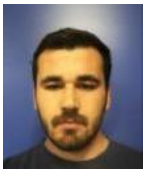

Adam Daya
(DAYAA)

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SFEE Theory

- Term 3

Week	Topic	Lecturer
1	Module Introduction & Carousel	DAYAA/PTQ
2	ICE Working Principles, Operating Parameters & Types	FMNG
3	CI Combustion Process & Fuels	FMNG
4	LAB: Energy Flow in ICE	DAYAA/PTQ
5	LAB: Energy Flow in ICE (Presentations)	DAYAA/PTQ
6	SI Combustion Process & Fuels	FMNG
7	Transport in the Context of Climate Change: The Role of Renewable & Alternative Fuels	HVLEJ
8	Fuels: Properties, Application, Mixture Preparation & Combustion	MRTS

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- In the first 2 weeks of Term 1, an introduction to Internal Combustion Engines is given to ensure you have the automotive specific knowledge required for this course.
- 2 weeks (week 4 & 5) are dedicated to a LAB Assignment. In week 4, testing will be conducted in the lab under supervision. You will then have 2 weeks in which to prepare a presentation of your findings. The presentations will be held during the week 5 lectures.
- In week 7, you will receive a very interesting and informative guest lecture from Eric van den Heuvel of AMF. He is a very enthusiastic and knowledgeable person in the field of alternative and renewable fuels.

SFEE Theory

- Term 4

Week	Topic	Lecturer
1	Introduction to Engine Indicating	FMNG
2	Engine Indicating & Calibration	MRTS
3	LAB: Engine Indicating	DAYAA/PTQ
4	LAB: Engine Indicating (Presentations)	DAYAA/PTQ
5	Advanced Combustion Strategies	FMNG
6	Introduction to Exhaust Aftertreatment Systems	FMNG
7	Exhaust Aftertreatment Systems LAB: Exhaust Aftertreatment System	FMNG/PTQ
8	LAB: Exhaust Aftertreatment System (EAS)	HVLEJ

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- 2 weeks (week 3 & 4) are dedicated to a LAB Assignment. In week 3, testing will be conducted in the lab under supervision. You will then have 2 weeks in which to prepare a presentation of your findings. The presentations will be held during the week 4 lectures.

Guest Lectures

- *Transport in the Context of Climate Change* by Eric van den Heuvel of AMF

ADVANCED MOTOR FUELS
IEA-AMF
Technology Collaboration Programme on
Advanced Motor Fuels

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Lab Assignments (LA) & Capita Selecta (CS)

- Related to one or more of the topics from theory
- Practical hands on knowledge → APPLIED science!!
- Real test experience on a real engine

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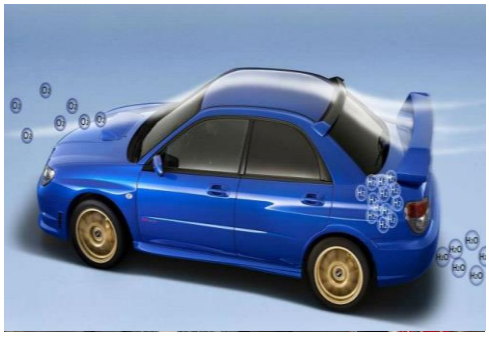
- IMAGE: The first lab assignment involves analyzing the energy flow in different ICEs to see where the different engines preform better/worse as well as showing the student how to derive a Sankey diagram. The picture above is a Sankey (Efficiency) Diagram which depicts where the major losses occur in a specific engine and how much effective power (as a percentage) is available.

Minor Project

1. Hydrogen Subaru: Water Injection & Recuperation
2. DME: Blend Ratio Determination & Operation



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- Minor project activities include:
  - Problem analysis
  - Literature study
  - Project Management Plan
  - Modelling + Simulation (MATLAB or GT)
  - Practical testing
  - Analysis + validation of results
  - Presentation of Findings
  - Thesis style documenting/reporting

- NOTE: The partners listed above are within the Netherlands and have a long existing relationship with the HAN and the automotive building. There are other companies however, and many students have even found thesis projects abroad. As such there are many opportunities available for thesis projects at the HAN, but also within Netherlands as well as further away. With assistance and insight from the SFEE team, you will be able to find the right thesis project for you which kick start your future in the automotive job market.

Teaching Philosophy

- Just in Time Teaching & Peer Instruction
  - Focus on 2-way communication

- Weekly “WarmUp Tests”

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- We want our MES students to be:
  - self-directed
  - critical
  - focusing on understanding NOT memorizing
- It is NOT a presentation. It is a DISCUSSION → 2-way communication!

Warm-Up Tests

- 10 minute multiple choice warm-up test conducted at the start of each lecture
- The test will cover the reading material suggested for the current lesson
- Tests are conducted online using your own smartphone/laptop
  - https://socrative.com/

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The warm-up tests are part of a teaching philosophy that has been implemented successfully by the HAN.

The purpose of the test is to introduce the student to the lecture material beforehand so the student can focus and engage with the lecturer during the lesson. This is part of our effort to encourage 2-way communication between the student and the lecturer.

Career Prospects

- Engine & Combustion Expert
- Calibration Engineer
- Application Engineer
- Project Engineer
- Test Engineer (R&D)
- Mechanical Engineer
- Noise, Vibration & Harshness (NVH) Engineer
- Combustion Engineers
- Fuel Engineers

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- There are many career paths other than the ones mentioned above. With the MES degree, you have a wide range of possibilities for career paths (not only related to the SFEE module). The SFEE module is unique however in the sense that there are very few courses worldwide that provide a Master level education in the field of combustion engines and alternative fuels.

- When looking at career prospects, it is important to consider where you are hoping to work geographically?
    - For example: India has not publicly voted to ban fossil fuel vehicles and is a country that will potentially rely on combustion engines and alternative fuels for the foreseeable future. India is also a country which is not currently looking to implement smart vehicles and smart infrastructure.

- Within the field of Automotive Engineering is also the need for combustion specialists involved in the design of engines and engine control systems.

Module Combinations: SFEE + ?

AUTOMOTIVE SYSTEMS IN A NUTSHELL

Automotive Systems is a track within the Master in Engineering Systems. It includes 2 compulsory modules:

- Systems Modelling
- Applied Control

And 2 elective modules from:

- Advanced Vehicle Dynamics
- Big Data and Small Data
- Electric, Hybrid and Fuel Cell Powertrains
- Smart Infrastructure
- Sustainable Fuel, Engines and Emissions
- Smart Vehicles

The final part of the program is your major project. Here you do research on an automotive issue.

https://www.han.nl/en/programs/master/engineering-systems-automotive-systems/fulltime/program/

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- SFEE + VD gives a full and broad scope for work in the automotive industry focusing on all aspects of the car. Engine and the vehicle.
- SFEE + BigDataSmallData gives the combustion and fuels knowledge with the skills gained in BDSD is valuable as a research/test engineer
- SFEE + EHFCP gives a complete overview of potential future powertrains for the automotive industry.

Sustainable Fuels, Engines, & Emissions – Introduction Video

https://www.youtube.com/watch?v=lxfDKHZW7LU

THANK YOU!!

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- In conclusion:
- The future of internal combustion engines in the automotive industry can not be explained in a single PowerPoint presentation. But the future of internal combustion engines in the automotive industry is secure! The combustion engine and alternative fuels will play a big role in the automotive industry for the foreseeable future and there is a demand for engineers (with the knowledge provided by the SFEE module) in the automotive industry right now, and will still be for the foreseeable future.
- If you would like to know more about the SFEE module or have any questions, please feel free to contact:
    - Adam Daya: Adam.Daya@han.nl