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CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

The Research Council of Norway

BIO4FUELS

Scientific Presentations-Bio4Fuels Value Chain SP4

Department of Energy and Process Engineering

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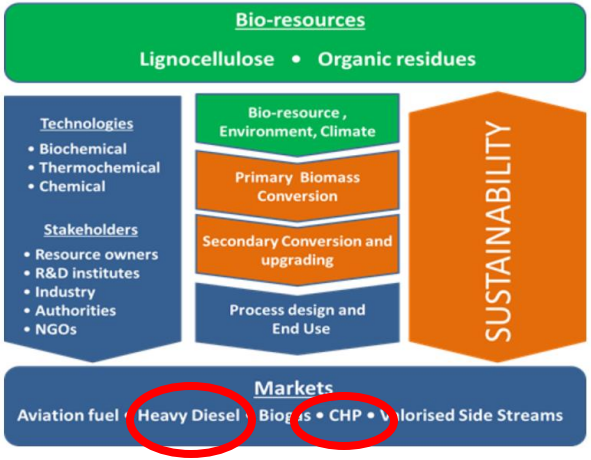
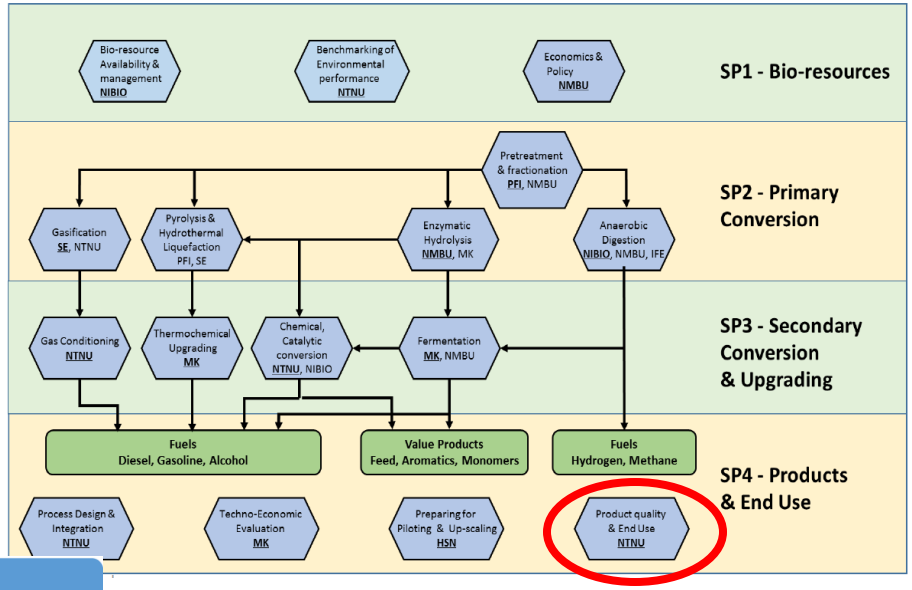
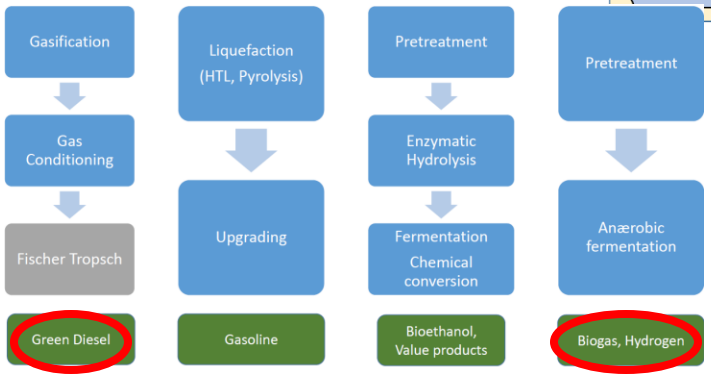
Objectives

- Where do we fit into Bio4Fuels
- Compression ignition engines a.k.a Diesel engines
- The good- the bad-the ugly
- The work we are conducting in MotorLab, Comkin, NTNU (Terese Løvås group)
- Current campaigns
  - Fuel surrogates
  - Soot
- Ask the question- "What can we do NOW for the FME, what should we do for the FME?"

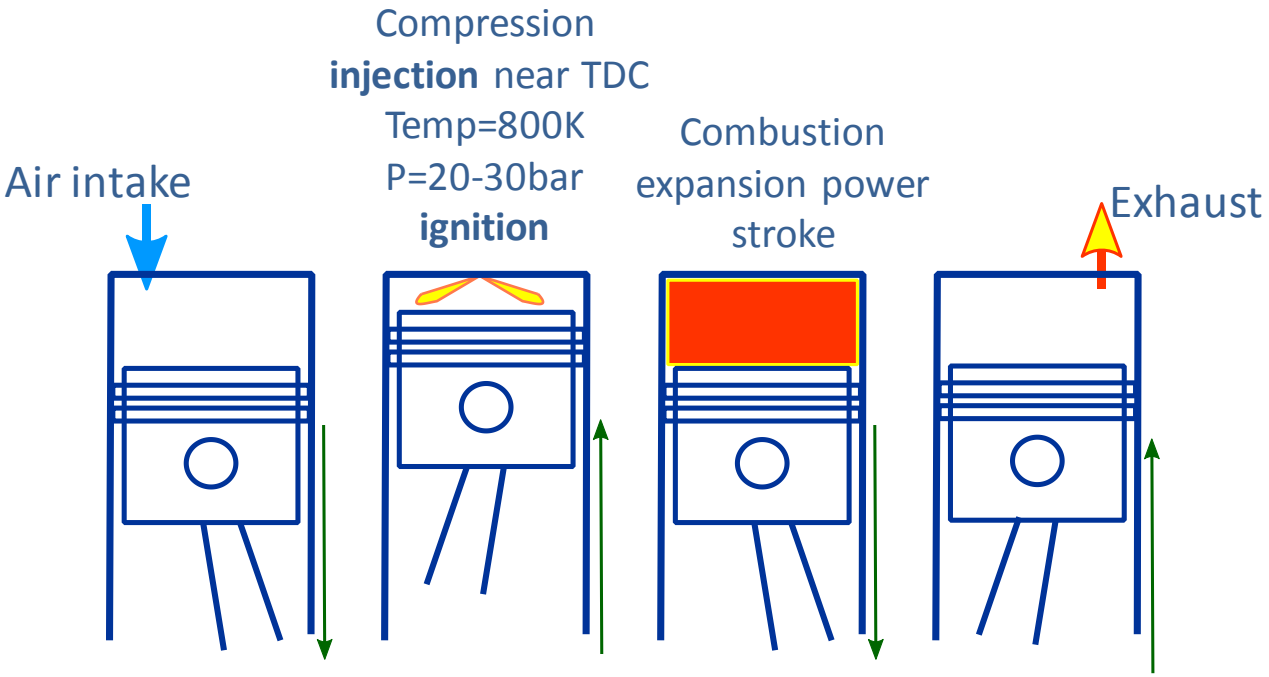
Where do we fit in the FME?







Compression ignition engines a.k.a Diesel engines



- The destination of some of the fuels being produced in the FME will be Diesel engines
- We have an opportunity to match the fuels or develop chemical additives that can lead to real improvements in the engine.

The Good

- Only air during intake-
  - can be compressed more- higher compression ratio- more efficient- less CO_2 per km!!!
  - No throttle on the air intake system- more efficient
- Fuel flexibility- lower ‘grade’
- High torque
- Heavy duty- shipping (most efficient engines)
- Ironing out of the issues over the years- noise, smoke, after treatments

The Bad

- **Mixing controlled** combustion (spray combustion)
  - Inhomogeneous mixture, range of equivalence ratios (local ϕ)- fuel rich, oxygen lean regions
  - Range of temperatures- some very high temperatures
- Fuel rich regions can produce soot, carbonaceous solid- particulate matter (PM) emission
- High temperature regions result in NOx formation (Zeldovich mechanism)
- Sulphur in fuel- now much reduced- PM.
- Globally lean- cannot use a three way catalytic converter- too much oxygen in the exhaust

The Ugly

#Dieselgate

- Cast a long shadow over the industry and the engine
- Likely to be phased out in light duty-cars
- City bans
- Corresponded with a measured increase (over preceding years) in NOx and PM at the roadside.

As fuel producers-especially FME fuels (designer fuels) it would be foolish to ignore these developments

Some good news

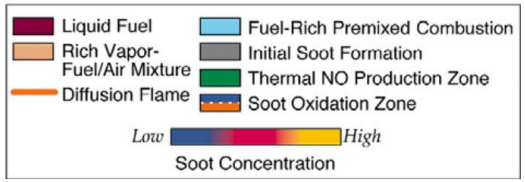
- In many applications- there simply is no alternative to Diesel engine- it will be used for many years and will need suitable fuel
- Problems are solvable
- It is likely that the same problems will hit gasoline engines
- New combustion strategies- HCCI and hybridisation- combinations.

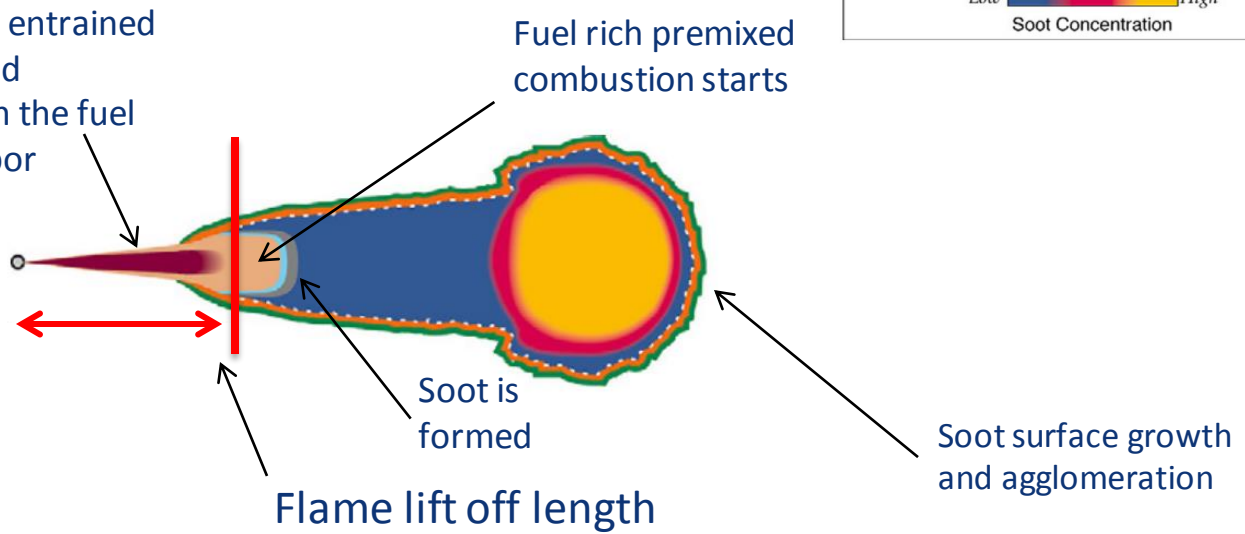
FME fuels, need to address emissions- no PAH, chain length-alkanes-alkenes- oxygenates-aromatics?

What work are we conducting in FME- SP4

- NOx and PM are controlled in after treatments BUT these systems are expensive and need careful control to operate efficiently -refilling of urea or regeneration.
- Reduce emissions formation- from fuel perspective- this really relates to soot and PM.
- FME delivers new fuel to us- we want to try and understand the soot formation process of the fuels combustion.
- Feed back into the FME

Soot formation in CI flame



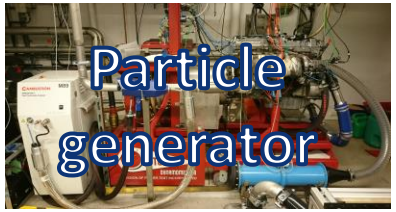


Determines the equivalence ratio where combustion starts, important parameter when studying soot in sprays flames- FME controllable? To some extent!

Poly aromatic hydrocarbons- soot precursors- FME controllable.

Dec, J. E. (2009). Advanced compression-ignition engines - Understanding the in-cylinder processes. *Proceedings of the Combustion Institute*, *32 II*, 2727–2742.

CAMBUSTION DMS500
Particulate Analyser
Particle
size/number/mass



Instrumented Engine

6-cylinder, 3.2 litre turbo charged compression ignition engine

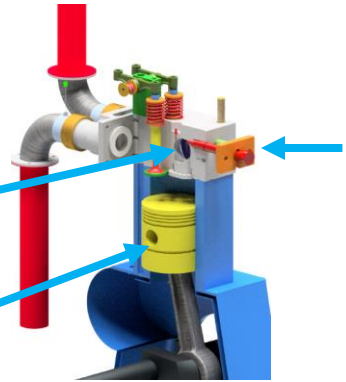
Horiba MEXA-ONE RS

Optical Accessible Compression Ignition Chamber

Motored 4-stroke direct injection 1.8 L engine, Bore = 130 mm, compression ratio-adjustable-up to 18:1

External combustion chamber, 50 mm optical access

Piston



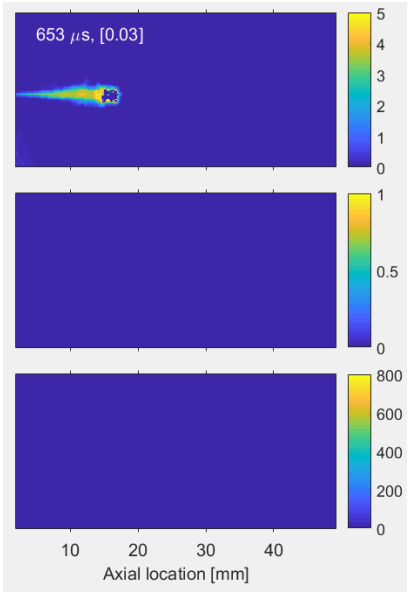
Bosch CR solenoid injector, single hole nozzle, Max injection pressure: 1500 bar

oacic

1. In-flame soot-high speed imaging
2. Flame OH* emissions
3. Ignition delay
4. only need small volumes
5. NOx, PM

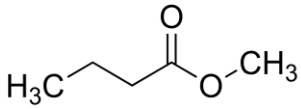
Current campaigns

- **Biodiesel surrogates**
  - Shorter methyl esters
  - Saturated/unsaturated (double bonds)
  - Different reactivity (cetane number)
  - Different sooting tendencies



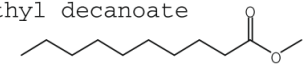
Surrogates

Methyl butanoate



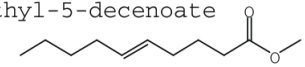
C4:0

methyl decanoate



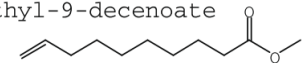
C10:0

methyl-5-decenoate



C10:1

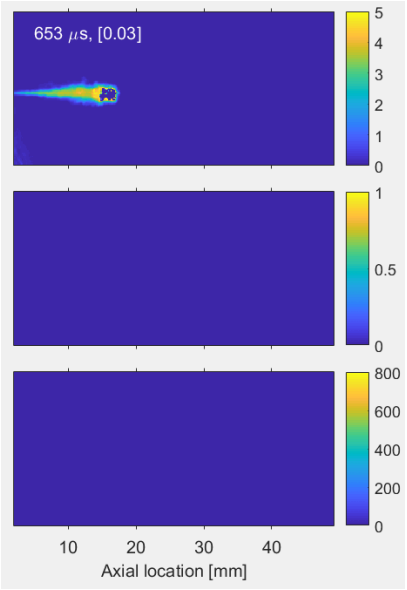
methyl-9-decenoate



C10:1

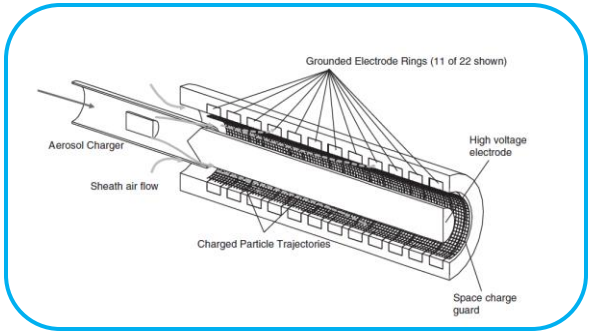
Detailed mechanisms

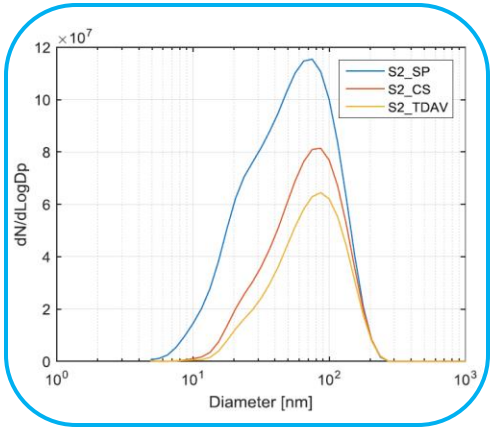
- Methyl butanoate
  - Fisher, Pitz, Curran and Westbrook in 2000
- Methyl decanoate
  - Herbinet, Pitz, Westbrook in 2008
- Methyl 5-decenoate, methyl 9-decenoate
  - Herbinet, Pitz, Westbrook in 2010
- Longer methyl esters (C18)
  - Westbrook et al. in 2011

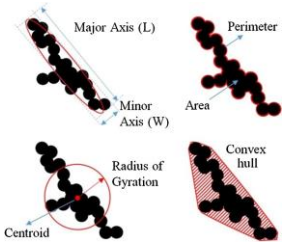


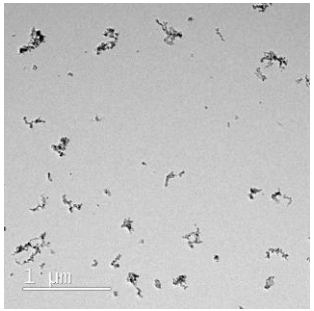
Current campaigns

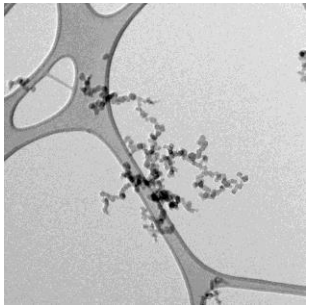
Differential Mobility Spectrometer and TEM of soot

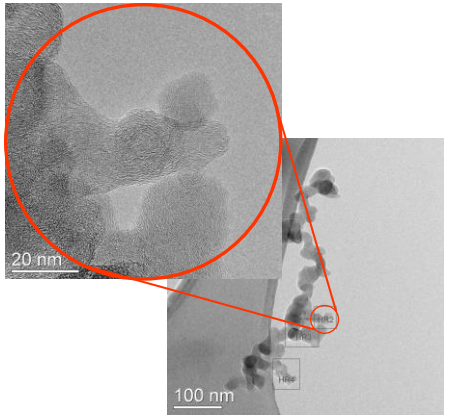




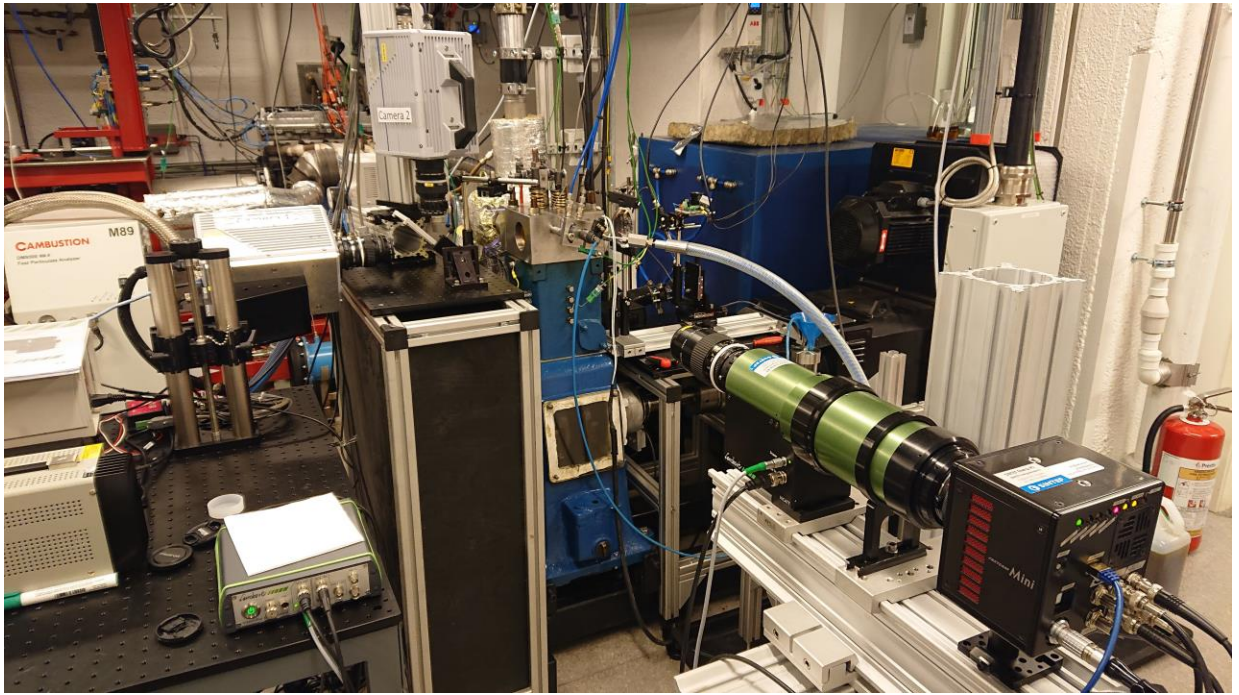








What can we do NOW for the FME, what should we do for the FME?



Bio4Fuels Autumn Workshop 2018

BIO4 FUELS

Welcome to the Bio4Fuels 2018 Autumn workshop at NTNU - the Norwegian University of Science and Technology, Trondheim, Norway, November the 5th.

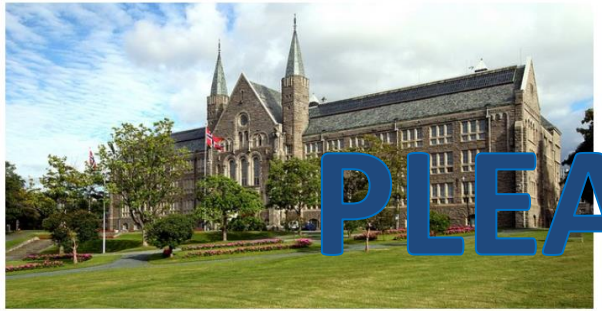


Foto: Mentz Indergaard/NTNU

Contact

Professor and Head of Department, Terese Løvås

Post Doctoral Fellow, David Emberson

Deadline for registration is November 1.

Preliminary programme

PLEASE JOIN US

https://www.ntnu.edu/comkin/bio4fuels-workshop

BIO4 FUELS

Bio4Fuels Autumn Workshop 2018

NTNU, Trondheim

Institutt for energi- og prosessteknikk

The FME mission statement

"The Centre aims to develop innovative technology and support industries to realize economic and sustainable conversion of lignocellulosic biomass and organic residues to **transportation fuels**, along with added value chemicals, heat and power"

The workshop has been designed to introduce FME partners to some of the external considerations that the biofuels community need to consider concerning transportation fuels. This workshop will introduce some of the issues around Diesel engines.

9:00-9:30	Meet up, coffee, informal introductions
9:30-10:00	**Presentation 1**: Diesel, the current situation, emissions, legislations, possible future scenarios. **Karl Idar Gjerstad from Vegdirektoratet**
10:00-10:10	Break 1– informal discussions of any points raised in the first presentation .
10:10-10:40	**Presentation 2**: Diesel emissions– the public health aspect. **Johan Øvrevik from Folkehelseinstituttet**
10:40-10:50	Break 2-informal discussions of any points raised in the second presentation
10:50-[illegible]	**Presenta[illegible] 3**: Die[illegible]re. **David Emberson from NTNU**
[illegible]-11:20	Break 3
11:20-[illegible]	**Presenta[illegible] 4**: Die[illegible] treatment, current and future. **Timo Murtonen[illegible]T**
[illegible]-13:00	Lunch
13:00-13:30	**Presentation 5** : Diesel FME fuels response. **Bernd Wittgens SINTEF**
13:30-13:40	Break 4
13:40-14:10	**Presentation 6**: Commercial fuels response to the diesel situation. **TBA**
14:10-14:20	Break 5
14:20_14:30	Round up of presentations– description of the activities to follow
14:30-15:15	**Activity 1**– How should the FME respond-what is the technical argument for the use of biofuels in the face of the Diesel engine problems
15:15-15:30	Discuss outcome of act 1
15:30-16:00	**Activity 2–**As a counter point– so we can have a discussion on this into the future- what are the real technical and social arguments against biofuels, think of the arguments that policy makers, journalists and the public are likely to hear.
16:00-16:15	How do we respond to this?
16:15-17:00	Lab tours
18:30	Dinner