ICSAT 2013, Ingolstadt, Deutschland

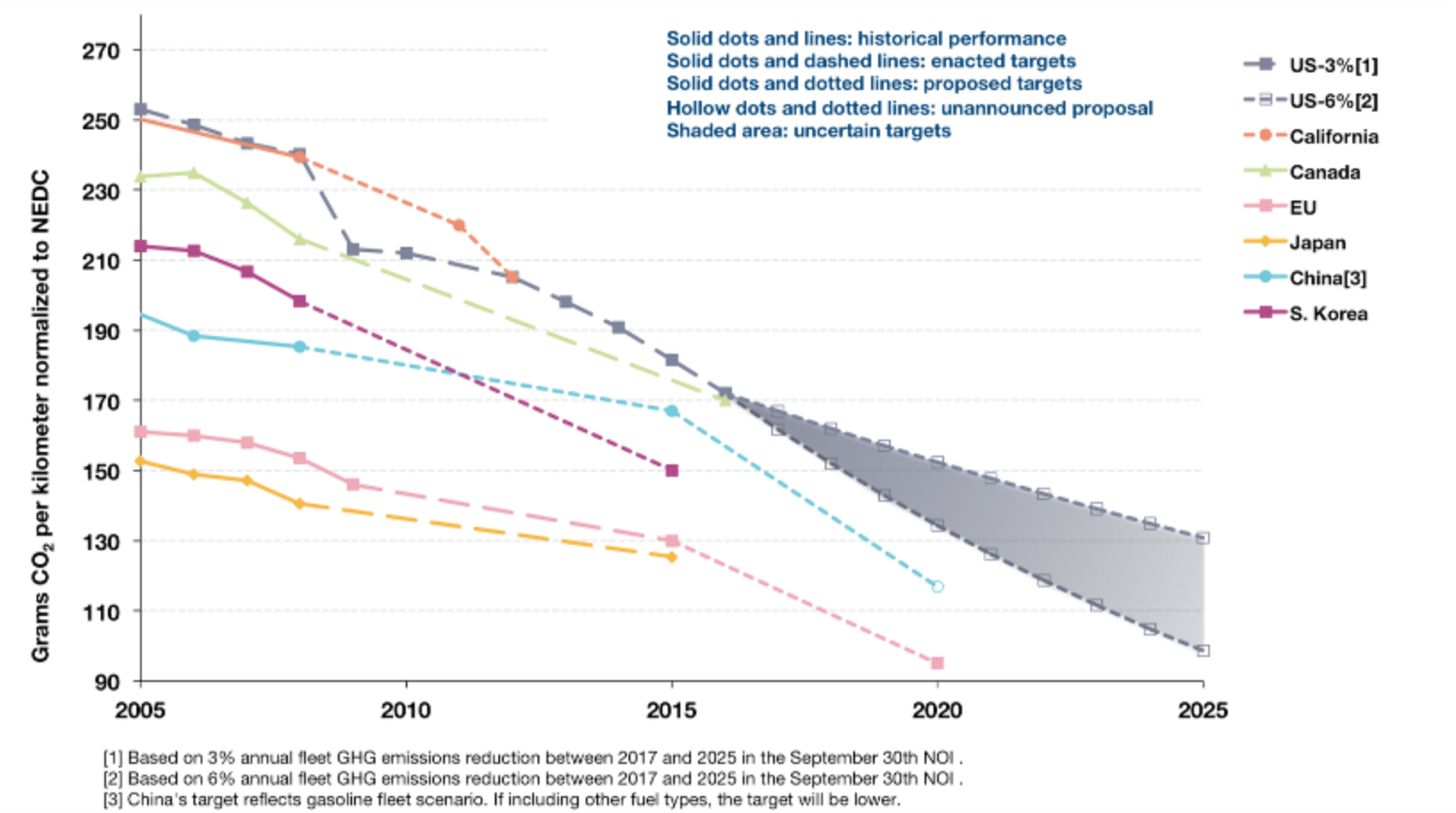
Keynote address:

Fuels and combustion strategies with recovery of waste heat and kinetic energy for a more environmentally friendly vehicle.

Thursday 26 September 2013

Dr. Petros Lappas, School of Aerospace, Mechanical and Manufacturing Engineering - RMIT University, Melbourne, Australia

Historical fleet CO_2 emissions performance and current or proposed standards

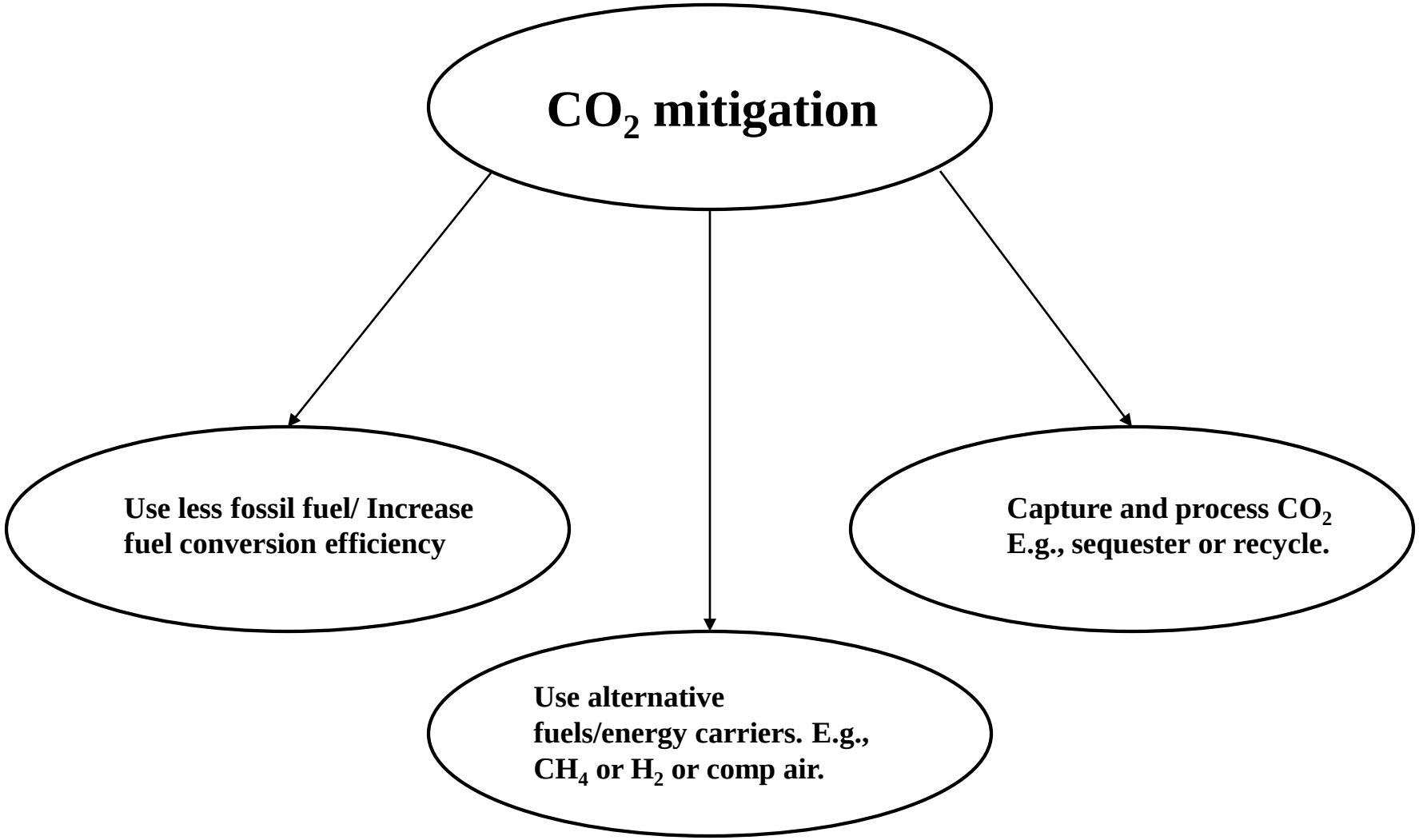


NEDC = New European Driving Cycle

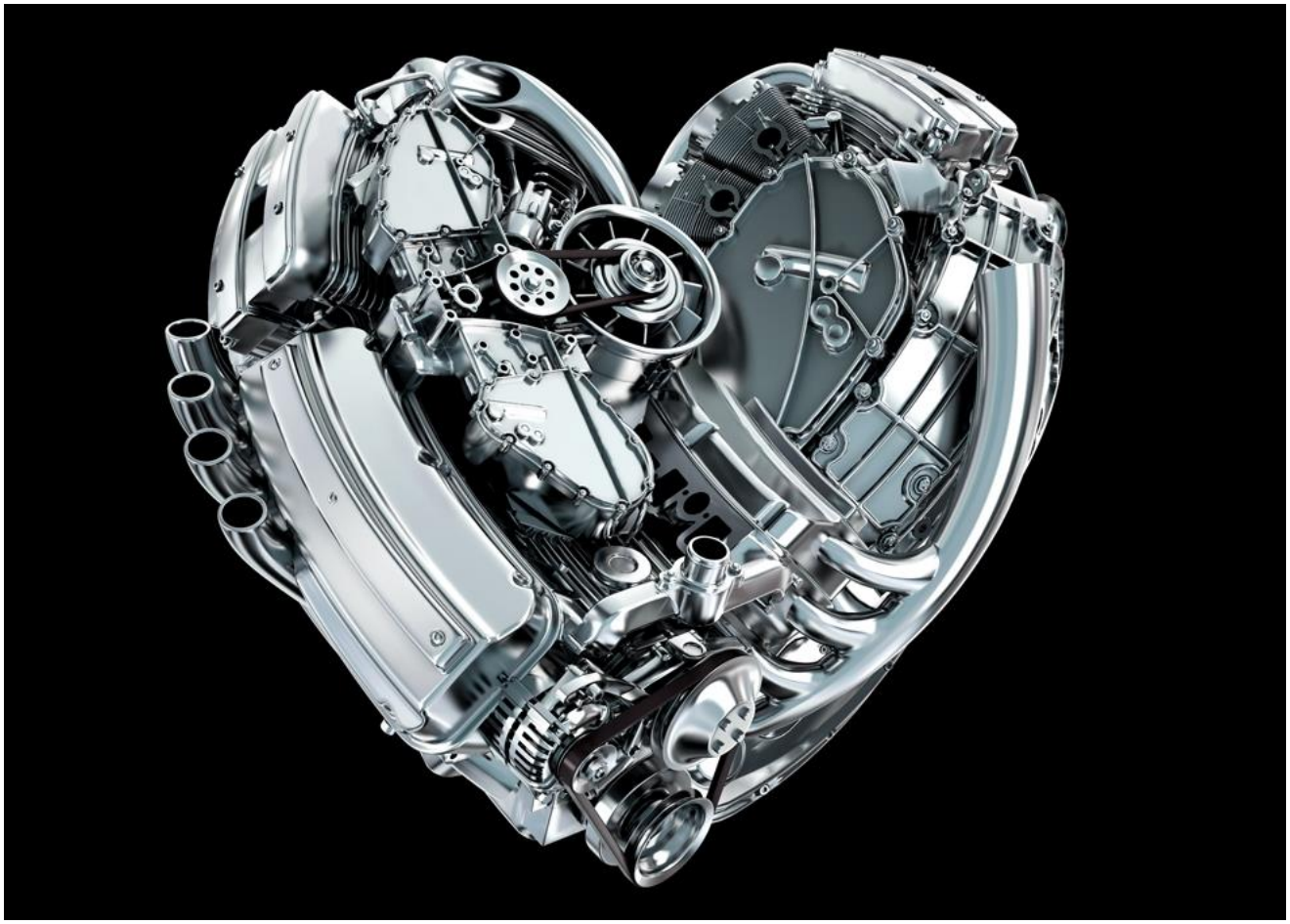
NOI = Notice of Intent

Source: ICCT Jan 2011

Approaches to CO_2 emissions reduction



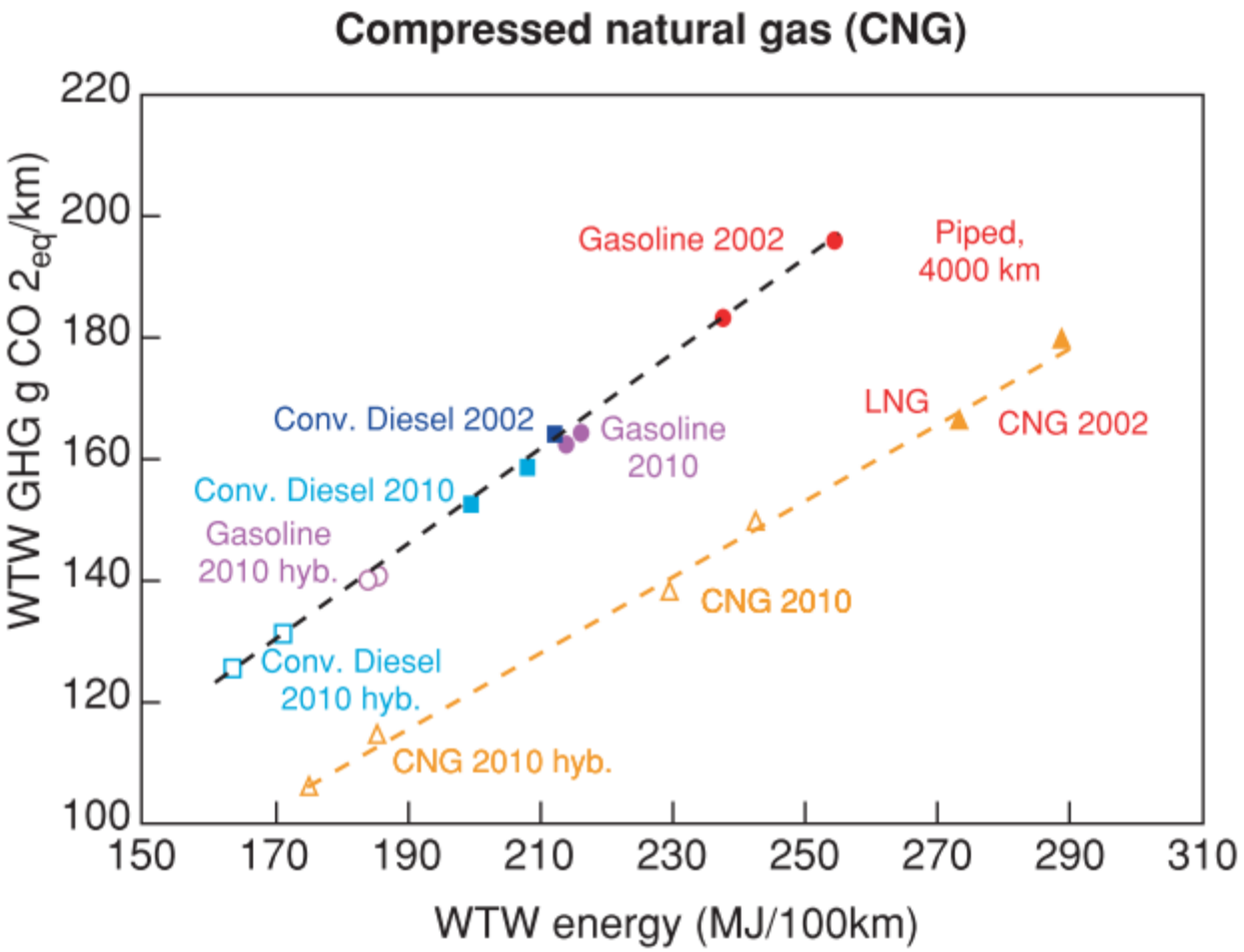
Lets talk ENGINES !



http://mdi-digital.com/pages/project/portfolio/engine-heart

As the engine represents the heart of the motor vehicle, the most important improvements are expected from modifications of the engine

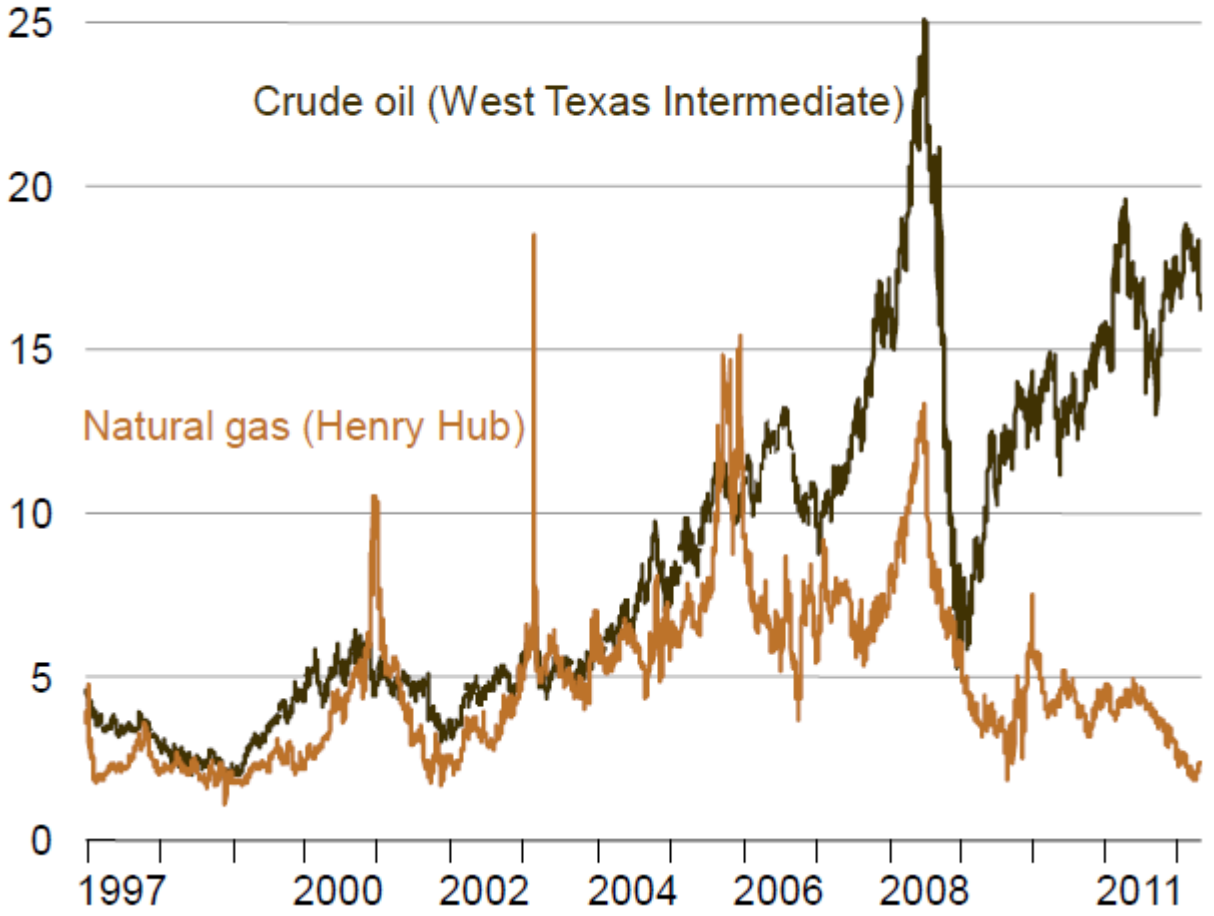
CNG: A good start to CO_2 reduction



Tilagone, R., et al.,"Natural Gas - an Environmentally Friendly Fuel for Urban Vehicles: the Smart Demonstrator Approach," *Oil & Gas Science and Technology - Rev. IFP* 61(1): 155-164, 2006.

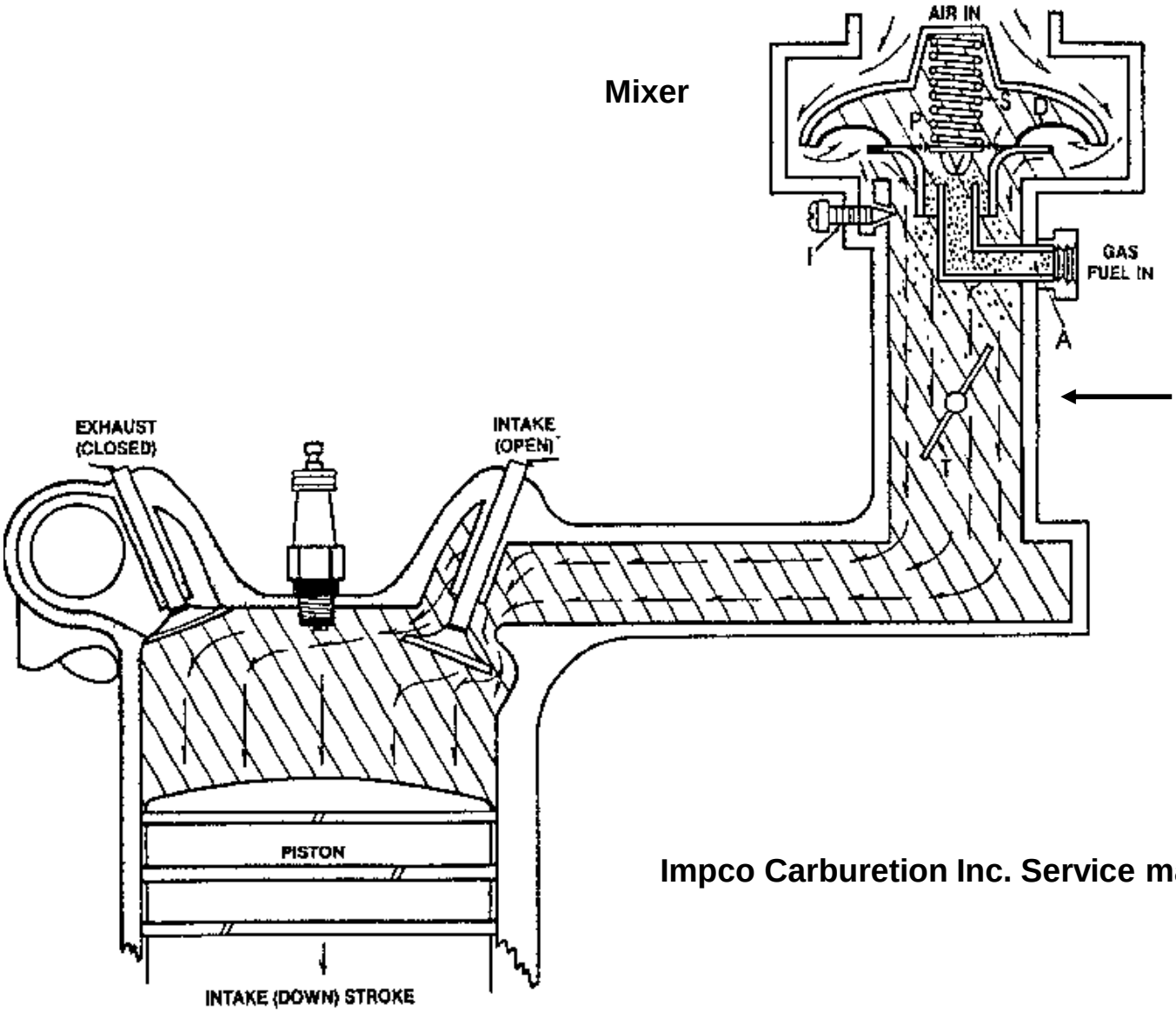
CNG: The dollars make sense

Figure 34. U.S. spot market prices for crude oil and natural gas, 1997-2012 (2010 dollars per million Btu)



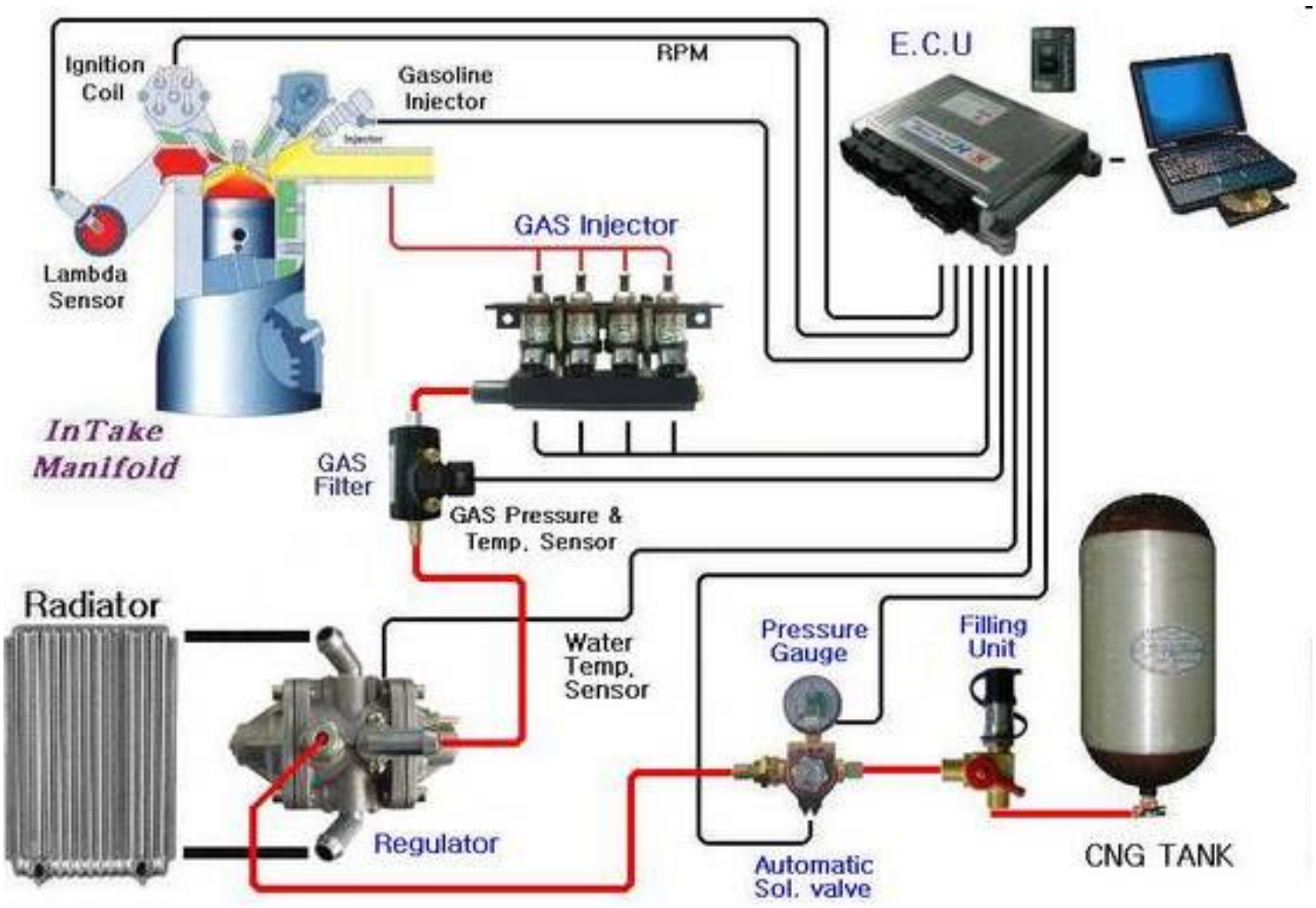
energyforumonline.com

CNG: The status quo (homogeneous charging)



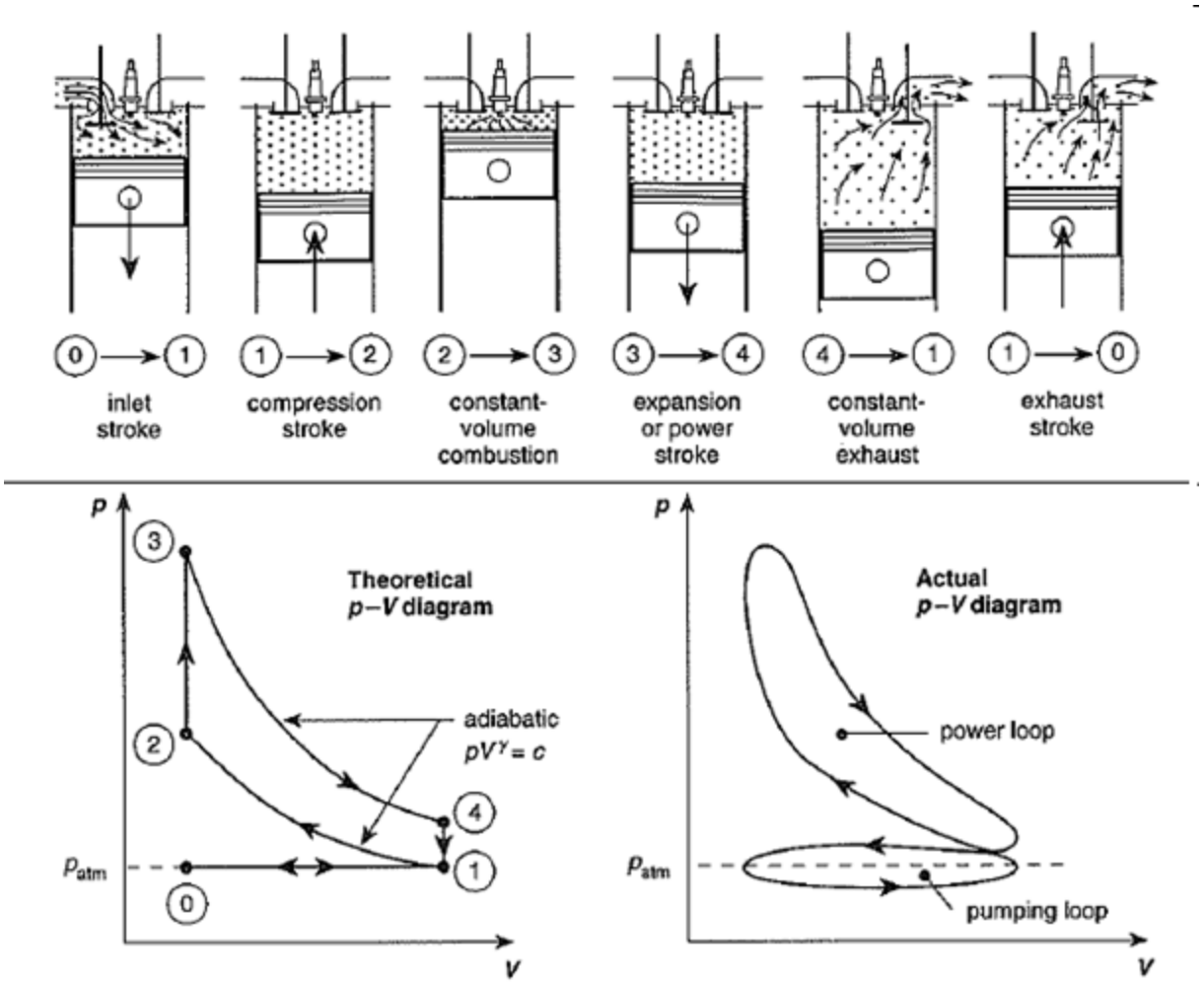
Impco Carburetion Inc. Service manual

CNG: The status quo (homogeneous charging)



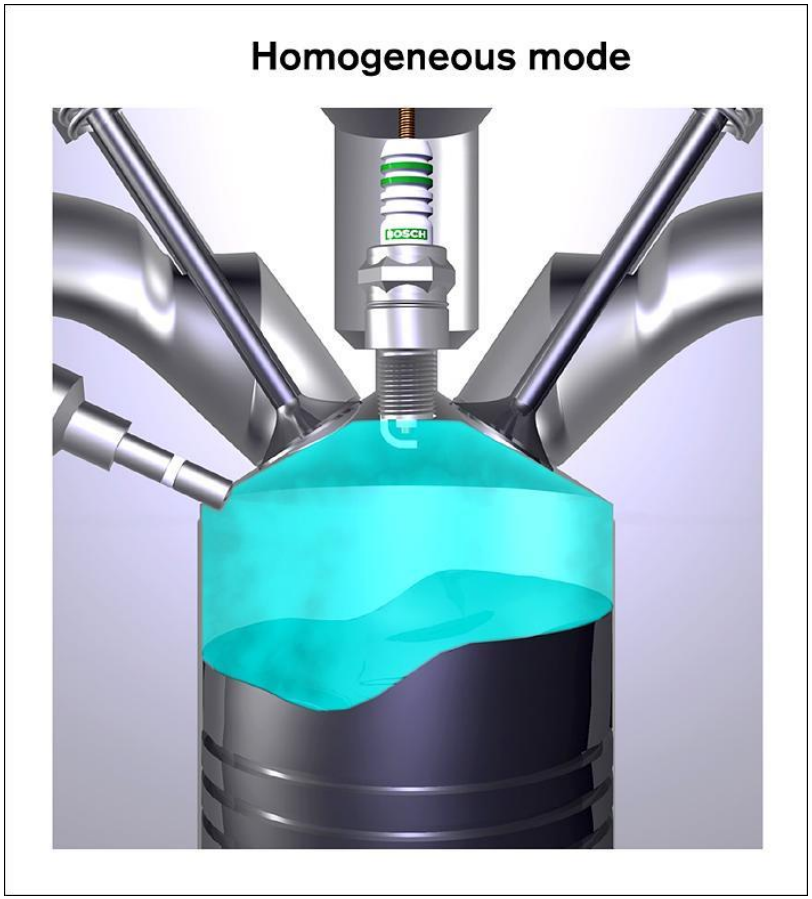
http://hanalpg.en.ec21.com/GAS_Injection_System--5065665.html

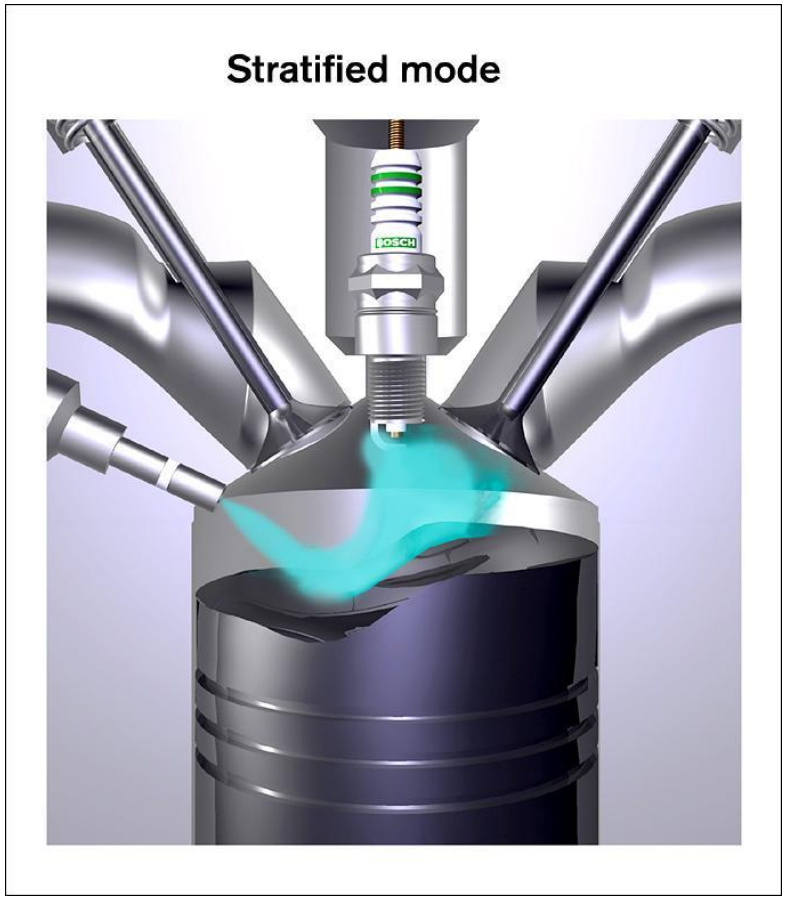
CNG: The status quo--Shortcomings



http://www.skinnerscience.com/Year%2012,13/module5.gif

CNG: Towards higher thermal efficiencies



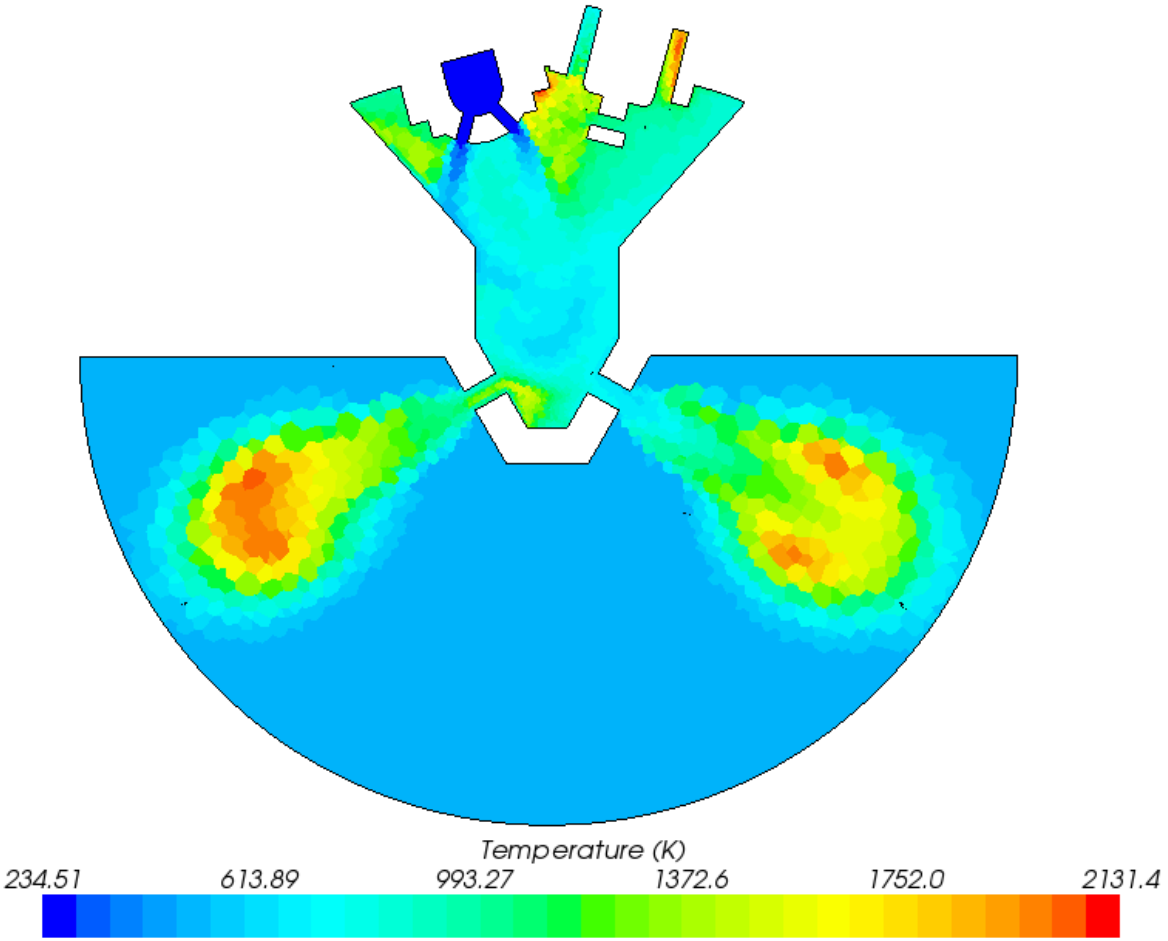


http://www.autospeed.com.au/cms/gallery/article.html?slideshow=0&a=1761&i=2

High pumping losses at part load
Charge is warm without direct injection

Low pumping losses at part load
Fuel/air charge is relatively cool

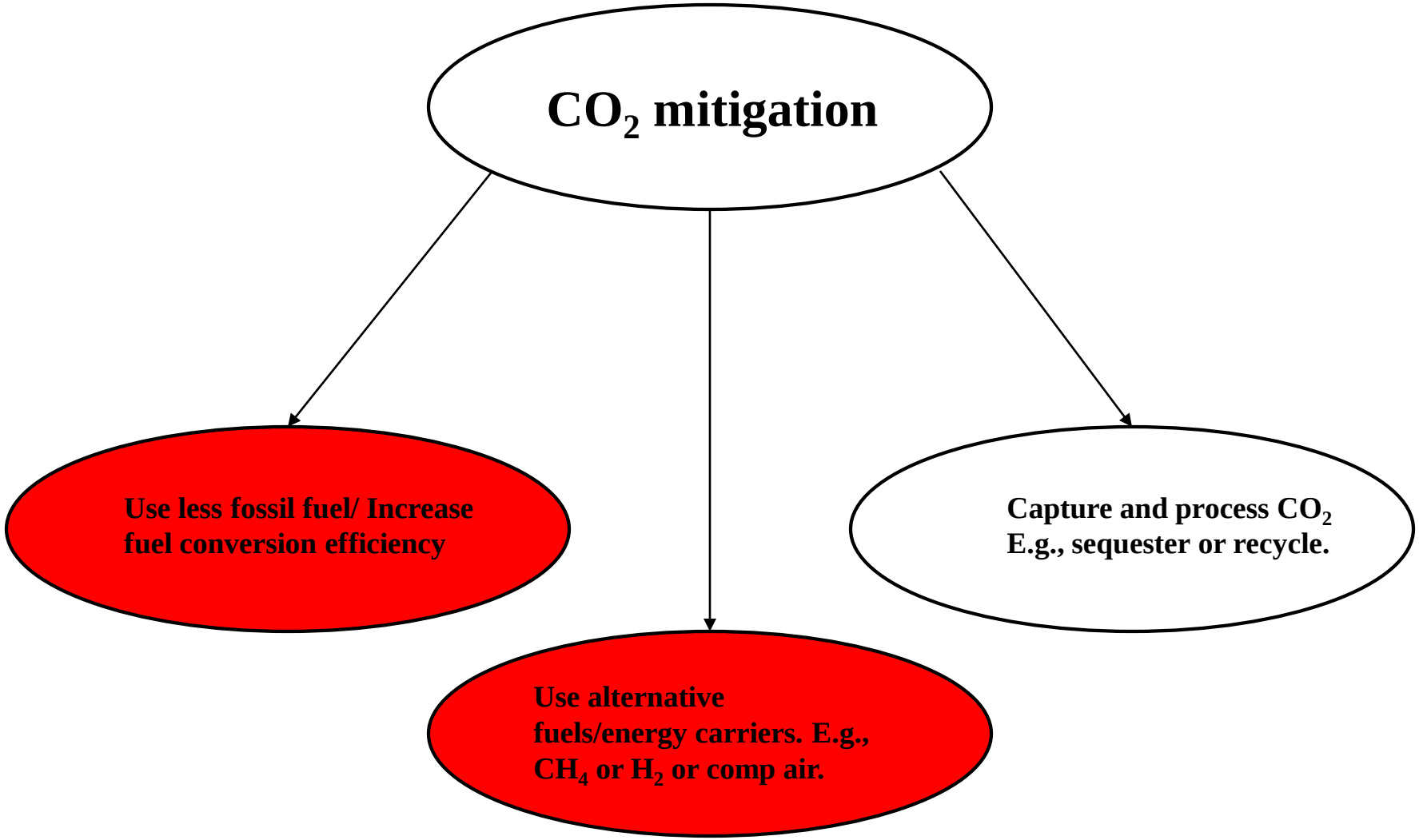
CNG: Towards even higher thermal efficiencies



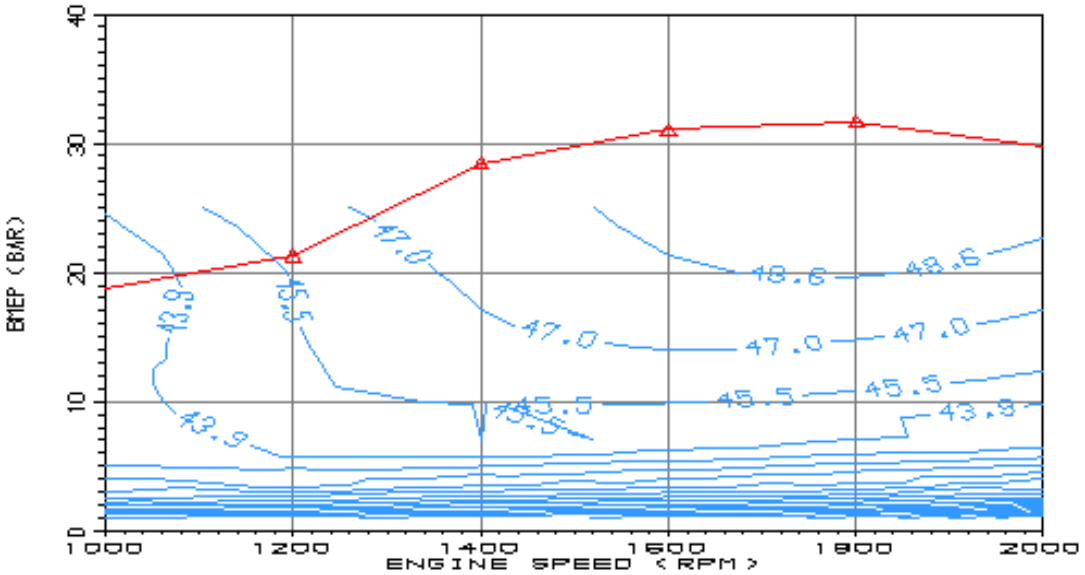
Computed temperature field 0.1 ms after SOC (propane)

Boretti, A.and Watson, H., ***International Journal of Hydrogen Energy*** **34(18): 7835-7841, doi: 10.1016/j.ijhydene.2009.07.022**

Approaches to CO_2 emissions reduction



Simulation Results (preliminary)



Brake efficiency map – CNG direct injection jet ignition engine

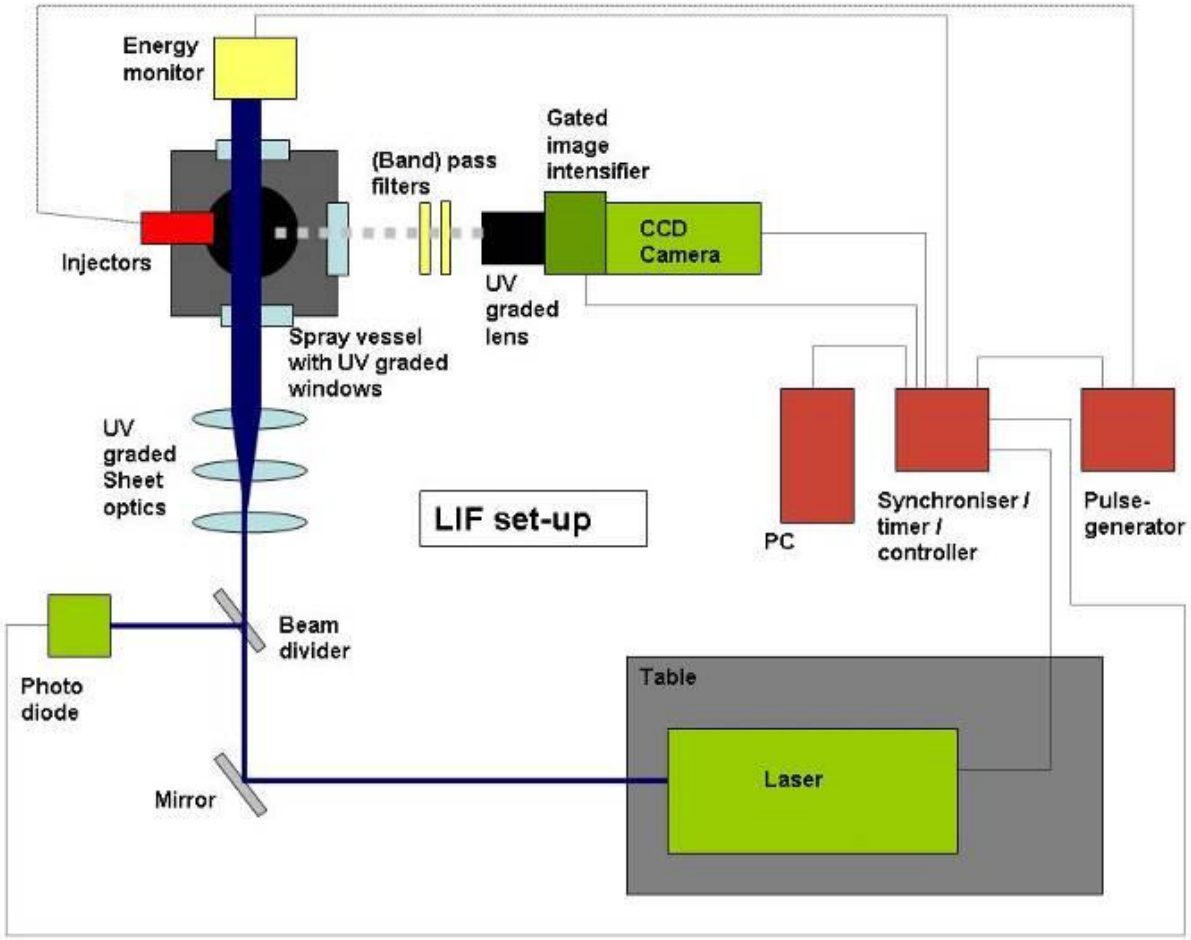
Results have been obtained with an integrated ICE and WHR system GTSUITE model

The RMIT Green Engines Lab

- RMIT “GEL” has an AVL Single-cylinder research engine.
- FTIR emissions measurements.
- High-speed data acquisition for combustion analysis.
- Highly flexible fuel injection system.

Spray vessel

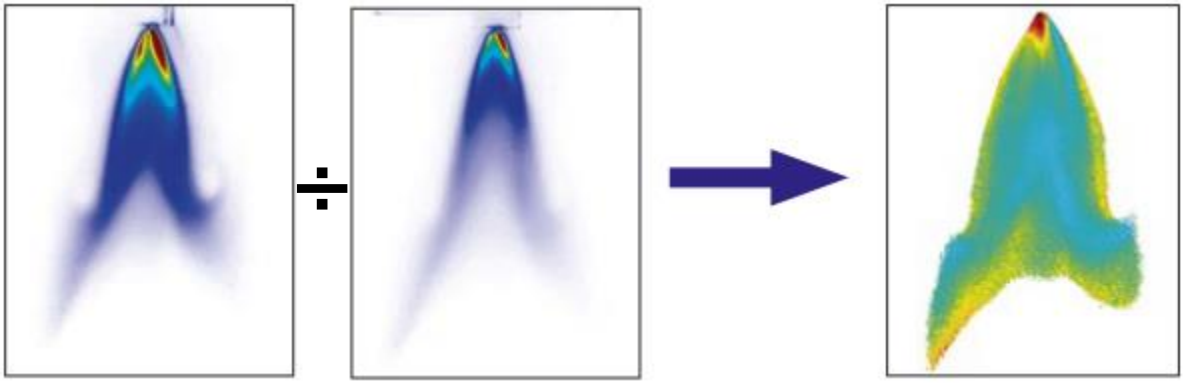
Gas and liquid fuel spray property measurement set-up



0.2-30 bar, 300 degC

4 x 150mm fused silica windows

Spray vessel



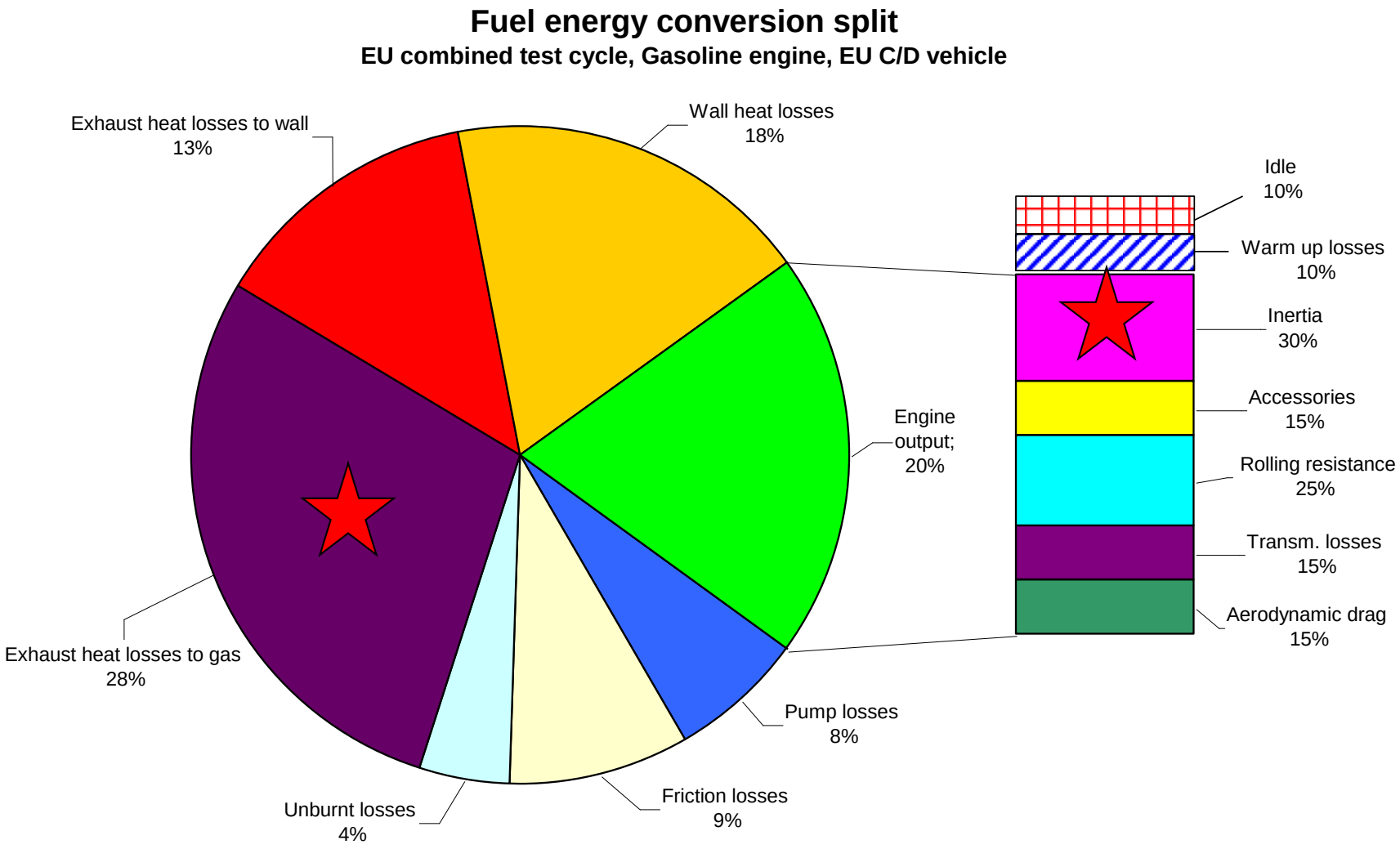
LIF signal

MIE signal

Sauter Diameter distribution

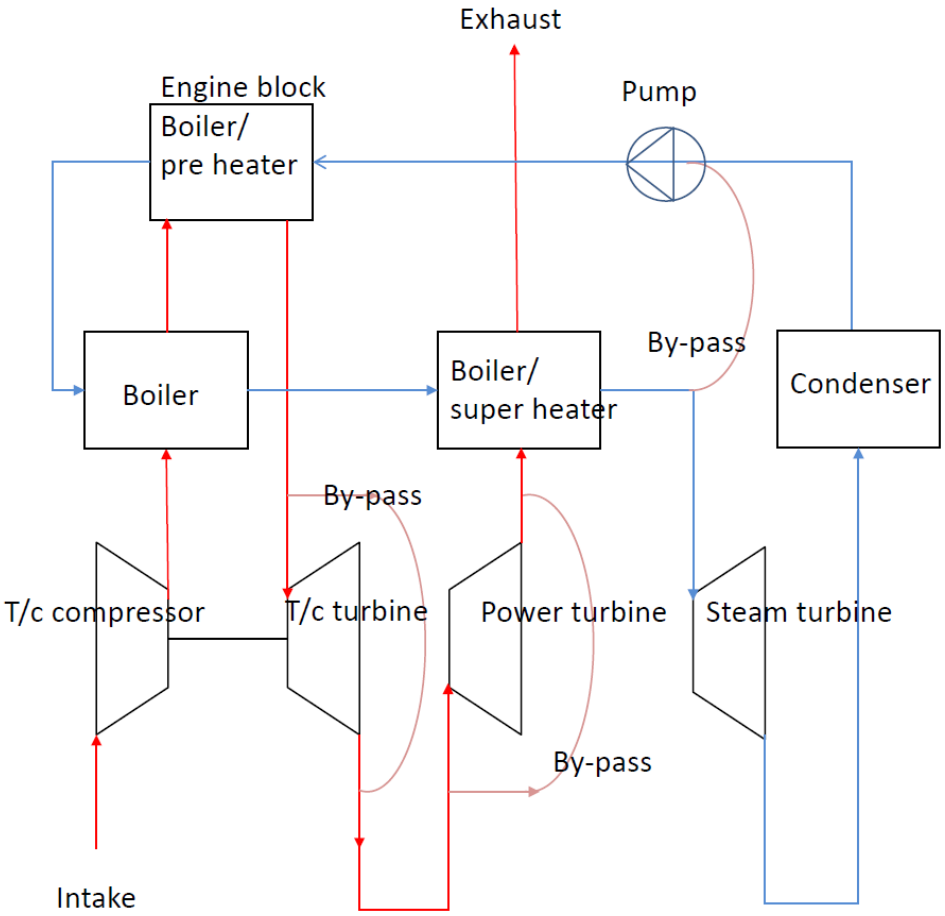
Where SD = d_v^3/d_s^2

Recovery of Waste Energy



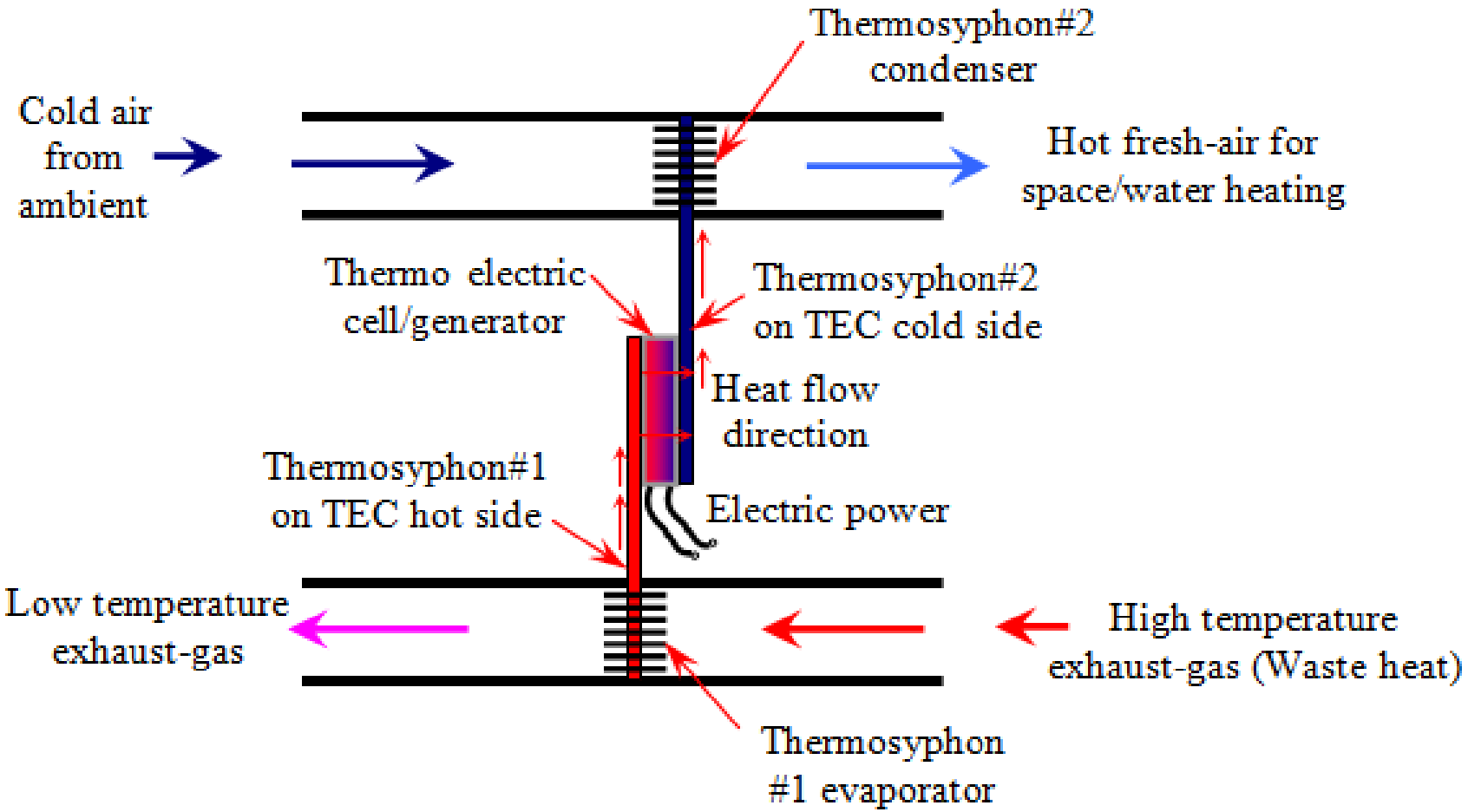
Source: Volvo Car Corporation

Recovery of Waste Energy (exhaust heat)



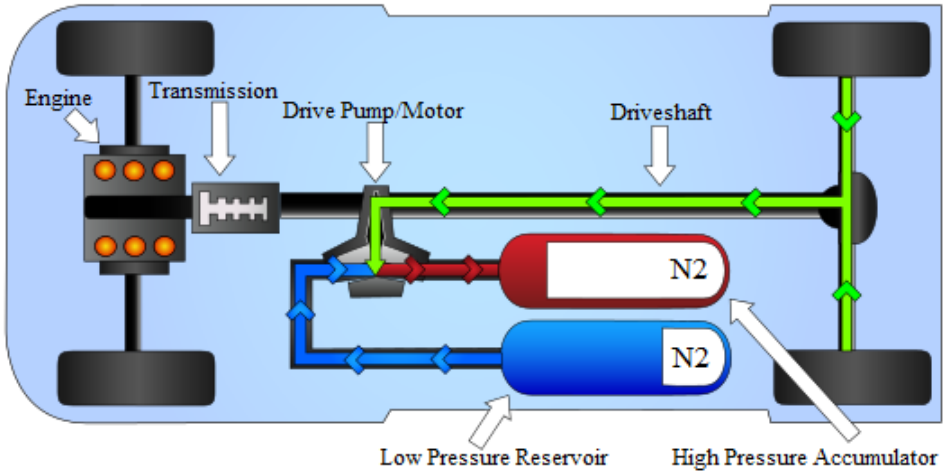
Schematic of waste heat recovery (WHR) system.

Recovery of Waste Energy (exhaust heat)

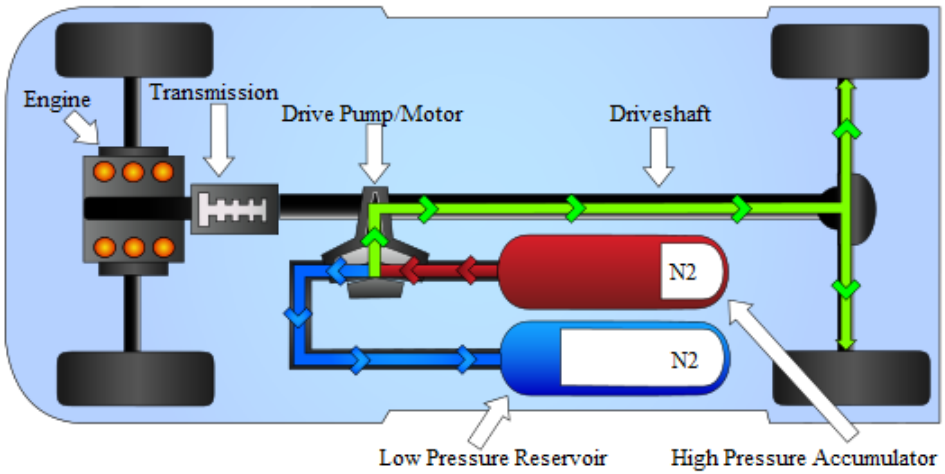


- Expected to produce ~100 W of “free power” in typical passenger car operating at cruise condition.

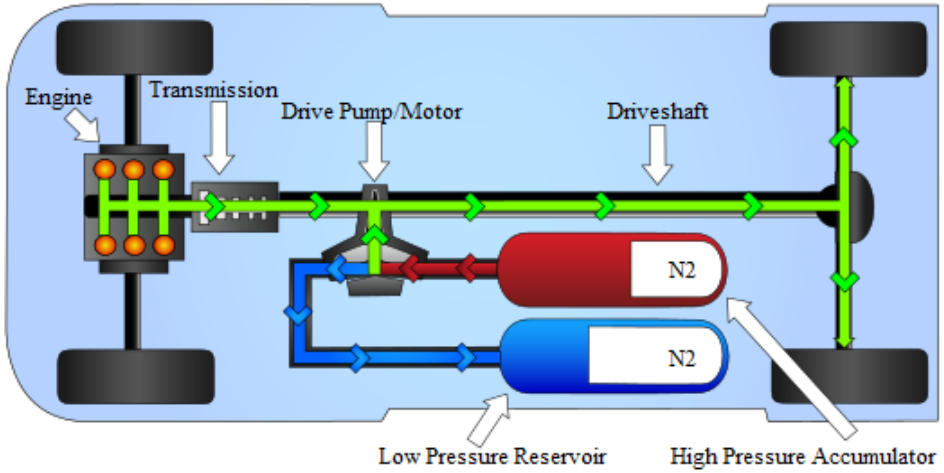
Recovery of Waste Energy (kinetic energy)



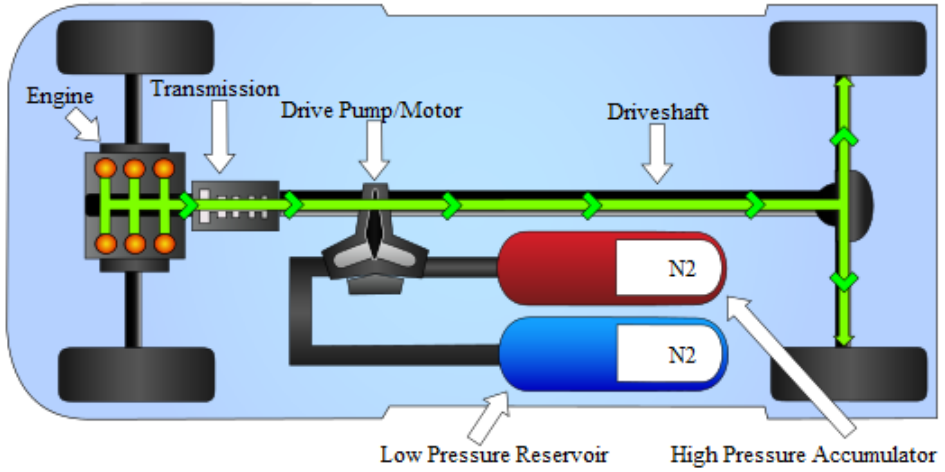
Regenerative Braking



Light Acceleration



Extended Acceleration



Cruising

www.epa.gov/otaq/technology/research/how-it-works-parallel.htm

Recovery of Waste Energy (hydraulic hybrids)

- EPA has been able to improve city fuel economy of a UPS package car by 70% and
- reduce CO_2 greenhouse gas emissions by 40%.
- reduce brake wear by 75%.
- At current fuel prices, this technology will pay for itself in two to three years.

Source: US EPA report EPA420-F-06-043
http://www.epa.gov/otaq/technology/publications.htm#hhvs

Summary

- CNG is clearly a cheap and environmentally friendlier fuel for automobiles.
- Stratified charge with WHR can improve efficiency in part load and full load conditions by up to 50%
- Another method to achieve WHR is by using TEGs. 100 W for typical cruising car.
- Use of pneumatic/hydraulic energy storage can greatly increase city fuel economy. E.g., 70% for UPS courier truck
  - reduce CO_2 greenhouse gas emissions by 40%.
  - reduce brake wear by 75%.
  - pay for itself in two to three years.