Horizon Technologies for the ICEV

echnology	Description	Fuel Efficiency Improvement/ CO2 Reduction	Comments
Dedicated EGR		15-20% CO2 reduction	HC traps needed; stability at high dilution a challenge
Gasoline Direct Compression Ignition (GDCI)	"CI engine is run on low-octane gasoline. This makes it significantly easier to control particulates and NOx because the fuel does not ignite as quickly as diesel and will have more time to mix with oxygen in the cylinder before combustion starts thereby almost eliminating soot formation. NOx can then be controlled by using exhaust gas recirculation (EGR). Such a low-octane fuel would need much less processing in the refinery compared to conventional diesel or gasoline and is expected to be more easily available in the future. Work would be needed on cold start and idle, acceptable transient operation, adequate emissions control- particularly of HC and CO, stability at low load and controlling pressure rise rate/noise at high and medium loads. Hardware developments to optimize the combustion chamber, the EGR system, injectors, turbocharger/supercharger, the after-treatment system and injection strategy will be needed to meet the required targets for emissions, efficiency, noise and stability. This optimization should ideally be for a fixed fuel of known RON and volatility characteristics though with adequate control, the engine could be made tolerant to minor changes in fuel properties."[1] Can be coupled with hybrization.	30% fuel efficiency improvement according to Aramco; others have estimated 15-25%	More work needs to be done in this area: • Cold start and idle; • Stability at a low load; • Acceptable transient operation; • Noise and pressure rise rate at medium and high loads via fuel injection strategies; • Emissions, particularly co and hc control, lowtemperature oxidation and DPF; • Hardware optimization: combustion chamber design; • Injectors, injection system and injection strategy; • Cooled EGR; • Turbocharger + supercharger to obtain high boost pressure at high EGR; after-treatment; • Fuel quality (lubricity and detergency), which means that additive technology has to be adapted to the different conditions encountered in GCI engines.[2]
Lean -Burn GDI/Super lean-burn		5-15% fuel efficiency improvement	Indicated thermal efficiency of 46% was demonstrated using a single-cylinder engine, for super lean burn.
Mobile Carbon Capture (MCC)	Can capture up to 25 percent of the CO2 emitted from a vehicle's exhaust. The CO2 is stored on board the vehicle, and can be used in a variety of industrial and commercial applications once offloaded.		Aramco's goal is to target a 50% CO2 avoidance in its next demonstration in a class 8 Volvo heavy-duty truck this year.

[1] Gautam Kalghati, "Is It Really the End of Internal Combustion Engines and Petroleum In Transport?", Applied Energy 225 (2018) 965-974 https://doi.org/10.1016/j.apenergy.2018.05.076.

[2] Kalghati and Johannsen, "Gasoline Compression Ignition Approach to Efficient, Clean and Affordable Future Engines," Proc IMechE Part D:J Automobile Engineering 1–21, DOI: 10.1177/0954407017694275journals.sagepub.com/home/pid.

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Octane on Demand	Improves the overall GHG footprint of spark ignition (SI) engines whose efficiency is limited by knock. Higher octane fuel allows the SI engine to avoid knock and run at higher efficiency but such fuel is required only at high loads where knock might be a problem. In OOD the engine has two fuel injection systems and will carry a high and low octane fuel.		
Opposed Piston Engine	The engine uses two pistons per cylinder, working in opposite reciprocating motion. This design reduces friction and heat losses, bringing greater efficiency, which in turn improves fuel economy and reduces emissions. This is a versatile solution – the opposed piston engine can be configured to use either spark or compression ignition, and run on gasoline or diesel fuels.	25-35% CO2 improvement	Being tested by Aramco now. Would require conventional DPF and SCR
Reactivity Controlled CI (RCCI)	Being developed to get high, diesel-like, efficiency but with very low PM and NOx while using fuels currently available in the market. A fuel that is resistant to autoignition such as gasoline or ethanol or natural gas is injected in the port and the mixture is ignited by directly injecting diesel into the cylinder. The ratio of gasoline to diesel used changes according to the requirements of the engine. The amount of diesel used is higher at low loads where ignition is more difficult but lower at higher loads. However, over a normal operating cycle, the amount of diesel used is less than 20% of the total fuel consumption and this would help mitigate the expected future demand imbalance between diesel and gasoline	20-30% CO2 reduction	Challenge is operating load range, higher HC+CO
Spark Controlled Compression Ignition (SPCCI)	A variation of homogeneous charge compression ignition (HCCI) technology	20-30% CO2 reduction	Mazda's SkyActiv technology with SPCCI expected to be introduced for MY 2020. The company promises 30% more torque and a 20% improvement in fuel economy.
Thermal Barrier Coating	Most of the heat generated during combustion process is absorbed by piston and the walls of the combustion chambers. This is the direct heat loss to the piston and surrounding walls, and it reduces the power generated and in turn the performance of the ICEV. To overcome this problem thermal barrier coatings are used. Using the coated piston the required temperature in the combustion chamber will be maintained. This will reduce the heat loss to the piston, which will be used to burn the unburnt gases thereby reducing exhaust gases.		
Turbulent Jet Ignition (TJI)	Works by premixing a small quantity of air and fuel in a pre-chamber – a small cavity that is separate from the main combustion chamber. This mixture is then ignited, generating turbulent jets of hot radicals which enter the main combustion chamber, providing a wider distribution of ignition sources than a traditional spark plug.		Aramco is working on this technology now and plans to showcase the vehicle in 2020.
Water Injection	Water, having high latent heat of vaporization, acts	5-10% CO2	Low exhaust temperatures, low NOx,

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	as a heat sink and reduces temperatures in the end gas zone, thereby reducing the tendency for auto-ignition. The added water also changes the ratio of specific heats of the charge mixture, and slightly dilutes the oxygen concentration. These changes greatly reduce the tendency to knock or detonate, in addition to reducing NOx emissions.	reduction	but high HC