Ethanol Internal Combustion Engines

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** The use of biofuels (e.g. bio-ethanol and biodiesel) in the transport sector can save significant amounts of fossil fuels and greenhouse gas (GHG) emissions. Internal combustion engines (ICEs) can run on bio-ethanol manufactured from biomass or waste through biochemical processes. Agricultural feedstock such as sugar beet and wheat (in Europe), corn (in the US) and sugar cane (in Brazil and other emerging countries), or even ligno-cellulosic materials such as wood, pulp fibres, papers, agriculture and industrial residues and waste can be broken down by hydrolysis to produce simple sugars, which are then fermented to produce bio-ethanol (see ETSAP TB S05). While ethanol production from primary agriculture feedstock is based on commercial technologies, the use of ligno-cellulosic materials requires technologies that are still under industrial demonstration. Gasoline-ethanol blends with 5% to 10% ethanol (called E5 and E10, respectively) can fuel conventional gasoline vehicles. Above these proportions, ethanol can cause corrosion in certain parts of conventional vehicles. However, corrosion may be avoided with relatively inexpensive engine modifications. A number of manufacturers produce flex-fuel vehicles (FFVs) that are capable to run on gasoline- ethanol blends from 0% to 85% ethanol (E85). Ethanol is mostly blended with gasoline rather than with diesel because of its low ability to ignite (i.e. low cetane rating), which is irrelevant in spark ignition (SI) ICEs, but fundamental in compression ignition (CI), or diesel engines. However, diesel-ethanol blends are also used in CI engines with some engine modifications and the use of cetane improvers.

■ **PERFORMANCE AND COSTS –** The typical efficiency (per unit energy) of vehicles running on blends of ethanol and gasoline is similar to that of pure gasoline vehicles, although further optimisation is possible. SI engines running on high blends may offer higher efficiencies (up to 9%). Potentially all future gasoline vehicles could be made compatible with all ethanol-gasoline blends from E0 to E85 (high blends require FFVs) with modest cost. This is a common practice with many vehicles in the American markets (Brazil and the US). Upgrading conventional cars for use with lower percentage blends would simply cost the sum of the parts which are at risk of corrosion – approximately €350-700. The R&D costs for manufacturers to improve the compression and timing of injection for high-blend flex fuel vehicles (to optimise their efficiency) may be passed on to consumers, but it is hard to project the extent of this with certainty. Ethanol is not as volatile as gasoline or diesel, which means there may be cold starts problems in winter or in cold climates. There are several solutions to these problems, including using additives or lowering the percentage blend. The current estimated costs for bioethanol from sugar beet, wheat, corn and sugar cane range from €0.5- €0.7 per litre of gasoline equivalent. However, costs are highly dependent on feedstock prices. Advanced biofuels from ligno-cellulosic are currently even more expensive to produce, though cost are anticipated to reduce significantly over time.

■ **POTENTIAL AND BARRIERS –** The use of biofuels can theoretically save significant amounts of GHG emissions. However, this is very sensitive to feedstock and methods of production (ETSAP TB S05). With the exception of ethanol from sugar cane, current biofuels from primary agricultural feedstock (sugar beet, wheat, corn) offer moderate CO2 saving in comparison with second generation biofuels. Moreover, bio-ethanol production from agricultural feedstock is constrained by the competition for land use with agriculture for food production. In the mid to long term, advanced biofuels from ligno-cellulosic materials or from micro-algae (also known as second or third generation biofuels) could offer greater emissions saving and production capacity, with modest or no adverse affects on land, water and soil use. At present, in the EU, E5 can be used in regular SI engine vehicles without any modification. In Brazil, E20 is permitted in regular SI engine vehicles and E85 or pure ethanol (E100) are used with FFVs. FFVs are also widely available in the US. Technology is already well developed, so the potential for ethanol ICEs is dependent on feedstock availability. Currently, most car manufacturers focus their research work on developing engines that can make optimal use of different fuels.

PROCESSES AND PERFORMANCE - Biofuels (e.g. bio-ethanol and biodiesel) offer CO_2 reduction benefits relative to fossil fuels because their carbon was absorbed from the atmosphere as the source plants grew, rather than being released from underground storage as with fossil fuels. In theory, with high sensitivity to the production process, biofuels can offer up to a 50% greenhouse gas reduction, although the benefits of bio-ethanol from sugar cane (Brazil) are typically much greater (around 80% reduction) [18].

■ **Bioethanol Production -** Bioethanol is manufactured through a biochemical reaction using hydrolysis to produce simple from sugar beet and wheat (in Europe), corn (in the US) and sugar cane (in Brazil and in other emerging countries). Sugars are then fermented to produce bio-ethanol. In the future, alternative hydrolysis methods could be used to derive ethanol from ligno-cellulosic materials such as wood, pulp fibres, papers, agriculture and industrial residues and waste. Currently, these processes are rather expensive and not yet competitive for market uptake.

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