Methanol: a future transport fuel based on hydrogen and carbon dioxide?

Options Brief

This briefing note is based on the STOA project on Methanol: a future transport fuel based on hydrogen and carbon dioxide? The project discusses the technological, environmental and economic barriers for producing methanol from carbon dioxide, as well as the possible uses of methanol in car transport in Europe. Costs and benefits are evaluated from a life-cycle perspective in order to compare different feedstocks for methanol production and to account for the potential benefits of CO2-derived methanol in the transition to a more diversified fuel mix in the transport sector. Benefits in terms of reduced dependence on conventional fossil fuels and lower risks to security of supply can be envisioned in the medium and long term. It is nonetheless evident that considerable and sustained research efforts are necessary to turn CO2 into an efficient and competitive prime material, which would be attractive not only for the transport sector, but also other industries. The competitiveness of CO2-derived methanol will largely depend on how effective future policies will be in addressing several critical issues and drivers, namely:

- The level of priority that transport policy assigns to environmental considerations – first of all CO2 abatement - and to security of supply concerns.
- The uncertainty of future technology developments in the transport sector and the need to avoid stranded investments in the medium and long-term.
- The need for bringing down the costs of captured CO2 and stimulating its potential uses, among them methanol production.
- The perspectives of sizeable improvements in the competitiveness of methanol fuel cells within a free market framework.
- The opportunity of promoting a diversified range of solutions for different types of transport fleets taking into account the high likelihood of competition for fuels between all transport sectors.

Four policy options are outlined hereafter, reflecting as many different approaches to balancing free market rules with the ambition to support and promote the development of a CO2-derived methanol sector.

Policy Option 1 - The market-driven approach

Since there is no clear picture for the moment as to which alternative fuels and powertrain technologies will ultimately prevail in the market, the option of creating a "level playing field" for all technologies – as proposed by the promoters of the Open Fuel Standard Act in the US – is appealing, as it would oblige the car industry to put a substantial number of vehicles in the market, which can run on natural gas, hydrogen, biodiesel, methanol, as well as flexible fuel or plug-in electric drive vehicles, among others. Proponents argue that this legislation would leave the decision on the type of car and fuel used to the final customer. The US methanol producers support this initiative, but some shortcomings of this policy initiative should be considered. Both hydrogen and methanol produced from CO2 are still far from being competitive fuels, and thus unlikely to gain significant market shares in the next decades, unless there is a drastic increase in prices for gasoline and conventional diesel. Open standards could increase the "food or fuel" dilemma associated to the use of first generation biofuels, i.e. biocrops, and the competition for land and water resources.

A second critical point for this strategy is to assure that customers are well aware of the advantages and disadvantages of different fuels in terms of performance (km/l) and environmental impacts, among them CO2 emissions, so they can make informed choices. This has considerable implications for policy making, since the numerical evidence for comparing different fuels and car performance is not presently available. Even values given by carmakers for CO2 emissions from cars and fuels already in the market have been questioned repeatedly (ICCT 2012). Getting the right values directly affects consumer purchases and calculations, as CO2 emission levels are frequently used by authorities to establish vehicle ownership taxation levels.

Policy Option 2 – Regulatory push for Carbon Capture and Use (CCU)

Should Europe choose to set very clear rules for competition between different types of fuels and vehicle technologies, based on a comprehensive and comparable well-to-wheel life-cycle analysis and considerations of security of supply, this would favour CO2 recycling. It would also imply embracing the idea of CO2 as an important future prime material and setting up a powerful CCU industry, similar to the Chinese approach, once CO2 capture costs can be brought down to a competitive level (estimated at around 20€/t of CO2 captured) and once the environmental and energy balance of methanol production from CO2 has been considerably improved.

The advantage of this strategy lies in the opportunity of exploring additional potential markets for captured CO2 – not only road transport – and in the opportunity for gaining leadership it provides to European technology. The risks associated to this strategy are the need for sustained investment in R&D – notably to identify and validate new options for obtaining value from CO2 - and the uncertainties associated to the time to market of CO2-derived and competitive products.

Policy Option 3 – Methanol islands

Under very specific circumstances, such as e.g. in Iceland with its very low electricity prices, methanol produced from CO2 is already competitive with gasoline. Further key opportunities for bringing down production cost for methanol from CO2 can also be seized, such as using electricity from wind farms that cannot be evacuated to the grid, or employing solar electricity generated in isolated but sun-rich regions for hydrogen and methanol production. The proximity of the CO2 emission source to the hydrogen and methanol production sites can further help avoiding the high costs of transporting both types of gas. Ultimately, this highlights an interesting potential for circular economy and industrial symbiosis concepts, which could be explored in large-scale demonstration sites.

This strategy largely relies on a systematic exploration of market niches for methanol, including e.g. "premium applications" such as the equipment of vehicles used in defence duties, or the powering commercial ships, but also, beyond the transport sector, in consumer electronics and in the oil and gas industry.

This policy option would therefore combine smart strategies for bringing down the cost of methanol produced from CO2 with the support of market innovations requiring the use of methanol fuel cells, matching growing demand with increased supplies. The advantage of such a strategy consists in limited initial investment needs and a greater independence from developments in the transport sector, which would allow for bridging the time necessary for bringing down the costs of methanol produced from CO2 and improving the fuel cell technologies. Policy measures would have to respect free market rules, though, and implementation may therefore be complex.

Policy Option 4 – Scenario-driven transition strategies

A broader transition strategy for reducing dependence on oil-derived products in the European transport sector will necessarily have to look into all types of transport model and fuels, as well as mobility behaviours. The risk of increasing scarcity and dependence of the entire European transport sector creates an obligation to carefully consider all potential alternative prime materials, including CO2 captured from flue gases. Mainstream reference scenarios assume that prices for oil and coal will double between 2010 and 2050 in real terms, while price increases for natural gas are expected to be slightly lower.

According to Eurostat (2013), the overall contribution of the road gasoline sector to energy demand in transport has decreased since 1990, notably as an effect of the recent crisis. The largest, long-term increases of fuel demand have come from the diesel road sector and aviation. For the former, DME (Dimethyl Ether) seems to be a viable substitution option, whereas the aviation sector – now also subject to CO2 reduction targets – is still considering alternative fuels carefully. Pioneer companies such as Clean Tech Aviation are promoting blending strategies similar to those experimented in the road transport sector, which involve methanol from renewable sources.

Should flexible fuel vehicles succeed in significantly raising methanol use in private transportation thus leading to the recycling of larger amounts (in the order of 100 M tons) of CO2, this could help the entire transport sector to better cope with increasing fuel demand and prices. But positive effects in terms of security of supply would even be greater, if further amounts of CO2 were similarly recycled in other sectors (diesel road, maritime and, possibly, some aircrafts).
This policy option basically implies putting a price on energy security, which can be defined by evaluating the direct and indirect macroeconomic effects of rising transport prices throughout Europe. Higher fuel prices increase the price levels of all types of goods and affect the competitiveness of export-oriented companies, and of vulnerable regional economies and consumer groups alike.

Putting a price on energy security does, however, not invalidate the need for finding more efficient conversion processes for alternative fuels, including hydrogen and methanol, nor for promoting the most suitable uses of all types of energy sources, recycled CO2 included, so that energy remains affordable for all economic players.

The table below summarizes the main pros and cons of the four policy options.

POLICY OPTION	ADVANTAGES	RISKS
MARKET DRIVEN	▪ Level playing field keeps all options open	▪ Early failure of CO_2-based hydrogen and methanol markets due to lack of short term competitiveness ▪ Open fuel standards could aggravate food Vs energy tension created by first generation biofuels ▪ Unreliable or incomplete LCA evidence on fuel cycles hinders informed decision-making
REGULATORY PUSH FOR CCU	▪ Encouraging CO_2 recycling ▪ Promoting diversification of CCU and methanol markets and the establishment of a strong EU industry	▪ Requires high and sustained R&D spending ▪ Uncertainties on realistic time-to-market
FOCUS ON NICHE MARKETS	▪ Bringing down costs with limited initial investments ▪ Exploiting immediately available opportunities	▪ Ensuring full respect of market rules might prove complex
SCENARIO DRIVEN TRANSITION	▪ Increased security of supply in the medium and long term	▪ Short and medium term threat to competitiveness of vulnerable sectoral and regional economies

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