



**Carbon Recycling International**

## ***FFVs - The Next High Efficiency and Ultra Low Carbon Frontier***

***Testimony to Governor's Office Five Pillars Symposium "Rethinking  
Transportation in California - Sacramento, CA - July 8, 2015***

Good Afternoon. I am Paul Wuebben, Senior Director of Renewable Fuels for Carbon Recycling International. I am pleased to present comments today on behalf of both the Methanol Institute and CRI.

One of the defining cornerstones of California environmental and energy policy over the past four decades has been the consistent push for increasing levels of energy efficiency.

- *From refrigerators to industrial combined heat and power;*
- *From light fixtures to cogeneration;*
- *From "nega-watts" to vehicle CO<sub>2</sub> emission standards:*

California has stood at the gateway of progress and led the entire world by example. It is a legacy which all Californians should be proud of. Another important chapter should be added to this history of energy efficiency and clean fuels leadership:

- ***Enabling the wide scale use of intrinsically high energy efficient and clean liquid fuels – the twin alcohol fuels of methanol and ethanol - through a trivial \$100 - \$200 modification of new car designs using 21st century Flexible Fuel Vehicle (FFV) technology.***

California's history of innovation has always demonstrated the ability to discern and apply the best lessons learned from past efforts and the vision to make adjustments when necessary.

- Such was the case with the 1990 ZEV mandate;
- And the ZEV Bus rule;
- And we've seen it recently with the LCFS schedule.

It is therefore appropriate to re-examine California FFV policies in light of numerous new facts on the ground:

- There is a pressing need to maximize the near term deployment of all available low NOx and low PM technology due to updated SIP compliance needs.

- The inherently cooler combustion properties, combined with the highest H:C ratios of any liquid fuels place alcohol fuels – especially methanol - at the top of the priority list to realize inherently lower NO<sub>x</sub> and PM emissions.
- Technology is now proven at an industrial scale for the conversion of CO<sub>2</sub> emissions in combination with renewable electricity generation into renewable methanol;
- Higher octane fuels are now being sought by auto manufacturers which allow tremendous synergies in terms of engine / fuel architecture. Specifically, alcohol fuels enable an impressive array of high efficiency engine design possibilities:
  - Higher octane
  - Engine downsizing
  - Higher compression ratios
  - Higher knock tolerance
  - Cooler but faster combustion
  - Higher latent heat properties → charge cooling → denser charges → more efficient turbo charging.
  - Easily integrated with PHEV architectures.

In addition to these energy efficiency advantages of alcohol fuels wedded to optimized engine technology, there are a wide range of environmental benefits from their use:

- Both methanol and ethanol fuels have been shown to emit much lower NO<sub>x</sub> and PM emissions compared to gasoline vehicles.
- They exhibit lower toxic emissions, particularly benzene, toluene and xylene;
- On a toxicity weighted basis, these benefits are significant even when aldehyde emissions are factored in.<sup>1</sup>
- And perhaps most importantly, FFVs compatible with both ethanol and methanol – so called GEM<sup>2</sup> FFVs - enable a path to renewable methanol.

It is especially noteworthy that just 2 days ago the parent company of Volvo - GEELY - decided to invest over \$45 million in CRI's Renewable Methanol technology. With the appropriate regulatory and policy signals, we would look for a major application of our technology here in California. Of course, fossil methanol and renewable methanol are readily mixed, so a gradual and commercially viable transition to a "CO<sub>2</sub> Economy" could be anchored by a GEM FFV mandate. Placing a commercial value on the utilization of CO<sub>2</sub> as a fuel feedstock can greatly hasten the transition away from petroleum based fuels.

During the inevitable transition period, there would be substantial consumer benefits from alcohol-on-alcohol competition brought on by a vehicle fleet compatible with both ethanol and methanol. Such competition could be achieved at an extremely affordable price point of under \$150 per vehicle. CARB can unleash such innovation through a simple mechanism of incentives + compliance options which ensure the existence of an FFV market. We would

<sup>1</sup> One major spin-off of the original CA methanol FFV program was the world's 1<sup>st</sup> application of close coupled catalysts, which was deployed in the Volvo 940 Environmental Concept Car in the early 1990s. Virtually all vehicles now utilize similar catalyst pre-heating strategies.

<sup>2</sup> Gasoline-Ethanol-Methanol mixtures.

GEM = Gasoline - ETOH - MeOH

like to work with CARB and all stakeholders toward that end.

To sum up:

1. GEM FFVs open up a lot of dexterity to leverage high octane alcohols for higher efficiency and low C methanol / ethanol.
2. There is a huge consumer advantage to fuel on fuel competition.
3. Fossil methanol is a transition to renewable methanol.
4. GEM blends enable the maximum gasoline displacement of gasoline.
5. The migration of PHEV technology to FFVs optimized for high octane / high knock tolerance / increased compression ratios with inherently cooler burning combustion (hence lower NOx) offer tremendous synergies.
6. While ultra low carbon 2<sup>nd</sup> generation biofuels face "biofuel limits" due to concerns about iLUC, topsoil loss, fossil fertilizer use, and aquifer water requirements, ultra low carbon methanol produced using renewable H<sub>2</sub> and recycled CO<sub>2</sub> is inherently scalable far beyond the "biofuel limit", as defined in several SAE paper by Lotus.
7. The incremental consumer cost of FFVs is trivial – far less than a stereo upgrade.
8. Marine applications of methanol are advancing quickly, and tests by MAN and Stena confirm its low NOx and low PM potential.

For all these reasons CA should move to mandate a transition to a fleet of GEM FFVs as soon as possible. The 21st century is rapidly demonstrating that old notions of technology - such as rotary phones and carbureted engines - are simply outdated. Greater diversity of choice exists now in virtually every corner of consumer products. Except for transportation fuels. It is now time to re-examine the 21<sup>st</sup> potential of FFV technology in the context of both advanced ethanol and renewable methanol.

