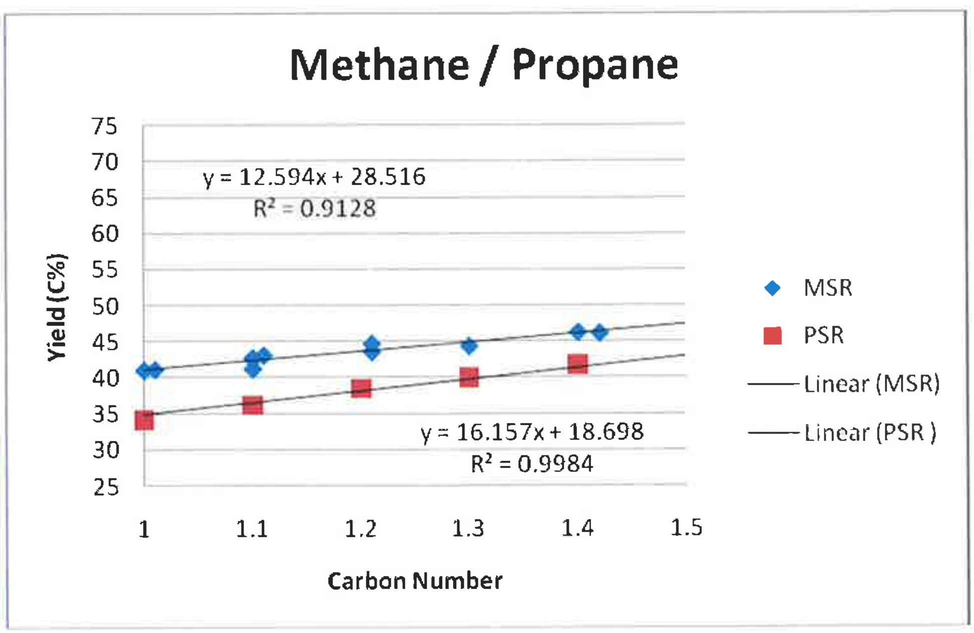
Carbon Conversion and Product Yield for Different Hydrocarbons in the Synfuels Process

The Synfuels GTX process is specially designed to convert a wide range of low molecular weight hydrocarbons into products that include acetylene, ethylene, gasoline, BTX and jet fuel. Hydrocarbons are first converted to acetylene and ethylene in the pyrolysis reactor. The pyrolysis reactor works by generating very high temperature plasma, then moving that plasma past an injection point where hydrocarbons are mixed with the plasma. The hydrocarbons are converted preferentially to acetylene and ethylene. The smallest hydrocarbon, methane, converts almost exclusively to acetylene, but requires temperatures in the range of 2000 C for optimum yield. The Synfuels pyrolysis reactor is specially designed to provide the highest yields of *acetylene and ethylene* (C2=) for gases made primarily of methane.

For natural gas which contains significant amounts of heavier hydrocarbons, the yield of C2= is better than that of pure methane. In early 2009 we discovered that the yield of a methane/propane blend increased in the mid scale reactor (MSR) from 41% to 46% for a carbon number of 1.4. This clearly shows that for a richer gas, the yield of C2= is better for a rich gas than a lean gas.



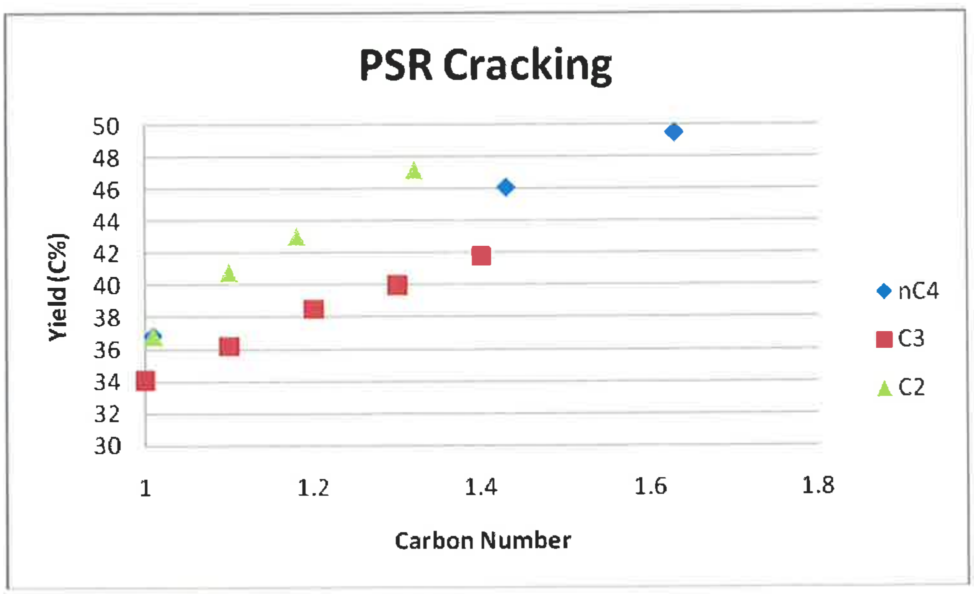
We also tested at that time the conversion of methane/propane mixtures in the pilot scale reactor (PSR). It showed the same behavior, but consistent with all previous tests, the PSR gives lower optimum yields of C2=.

Better yield results from lower heat loss. The small size of the PSR allows 40% of the plasma energy to be lost as heat to the walls of the reactor. The MSR, which has a much larger volume to surface ratio than the PSR, only loses about 18% of the plasma energy as heat. Simple calculations show that for the commercial scale reactor heat loss drops to 8%. About half the absolute improvement in yield is expected for methane in the CSR vs the MSR.

In 2010, 2012 and 2013 Synfuels tested the ability of their pilot scale pyrolysis reactor (PSR) and the mid-scale reactor (MSR) to convert **pure** heavier hydrocarbons to C2=. The optimum yields for ethane, propane, butane and naphtha are significantly better than that of methane.

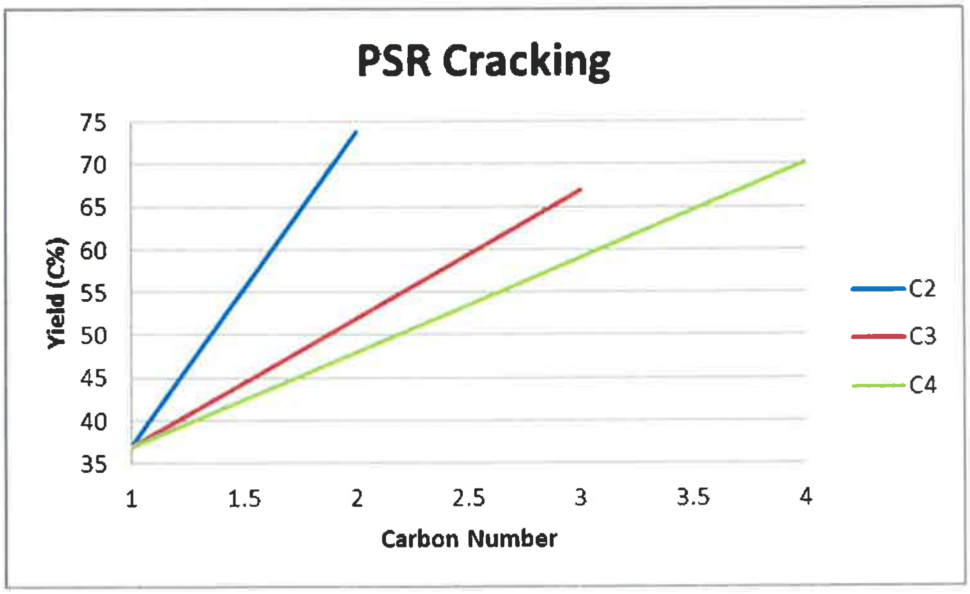
Feed	C#	Yield (C%)
Natural Gas	1.01	36.9
Ethane	2	73.8
Propane	3	67
n-Butane	4	70.2
Naphtha	5.93	68.5

Several tests were then run of mixtures of methane with ethane, propane, or butane in the PSR. The calculated maximum yield for each of these mixtures is shown for comparison.

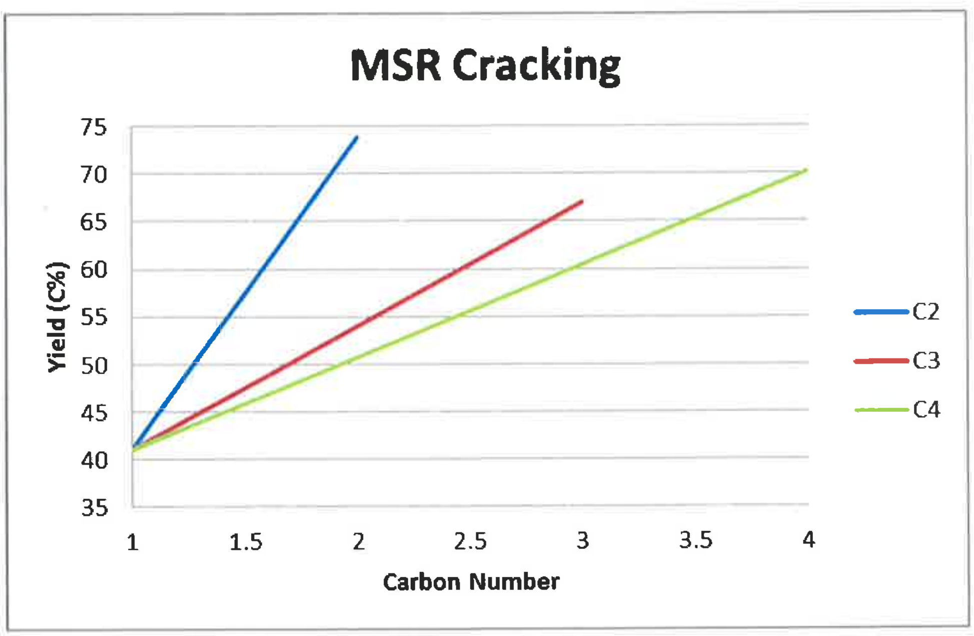


We also found that the heavier the C2+ component, the lower the temperature to achieve optimum conversion to C2= products. Separating natural gas feeds into C1 and C2+ fractions has a cost, but in most cases, C3+ can be separated from C1 + C2 affordably. In cases where the C2 fraction is significant, the cost of making the C1/C2+ split may be justified by the increased product yield from a comparatively small and much less expensive process plant.

The graph below displays the actual yield results for the various mixtures as a function of compound and carbon number.



The graph below shows the yield results from gas mixtures charged to the MSR. The increased conversion of methane is the only significant change between the reactors.



For the sake of numerical comparison, the table below shows the percent carbon yield of the MSR at 1 MMSCFD using an average carbon number feed of 1.28 and 1.5 made up of different heavy components in combination with methane.

	Carbon Number 1.5	Carbon Number 1.28
Ethane	57.4	50.2
Propane	47.5	44.6
Butane	45.9	43.7