

# Differences Between LTC Populations

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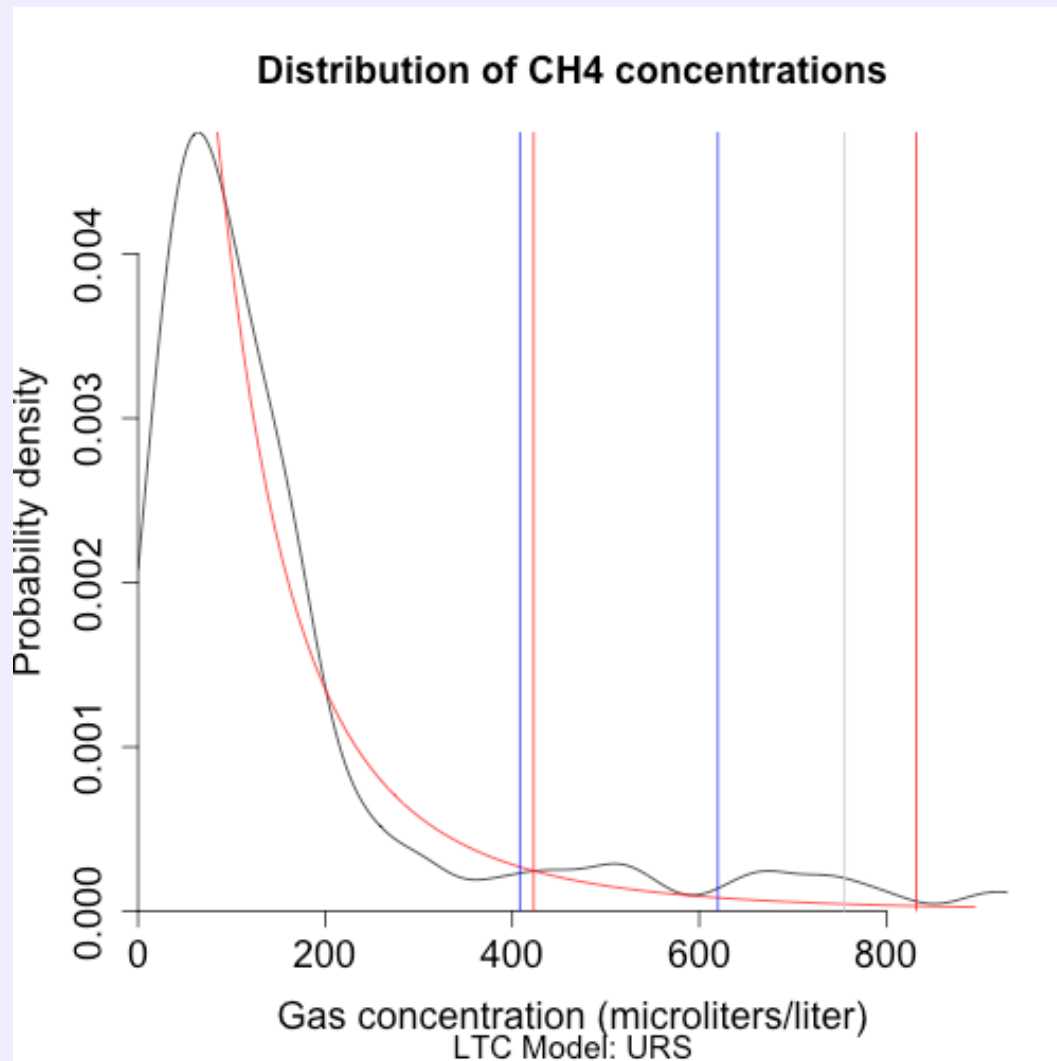
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# Basis for Generic Limits

Work is needed to provide a basis for publishing numeric limits in the guide. In particular, the following questions must be answered:

1. Can generically usable limits be derived from a large database built from many sources? Or are there large differences from one electric utility to the next?
2. Can similar models of LTCs be grouped together and treated as one generic type for purposes of deriving and applying limits?

# Distributions of Gas Concentrations

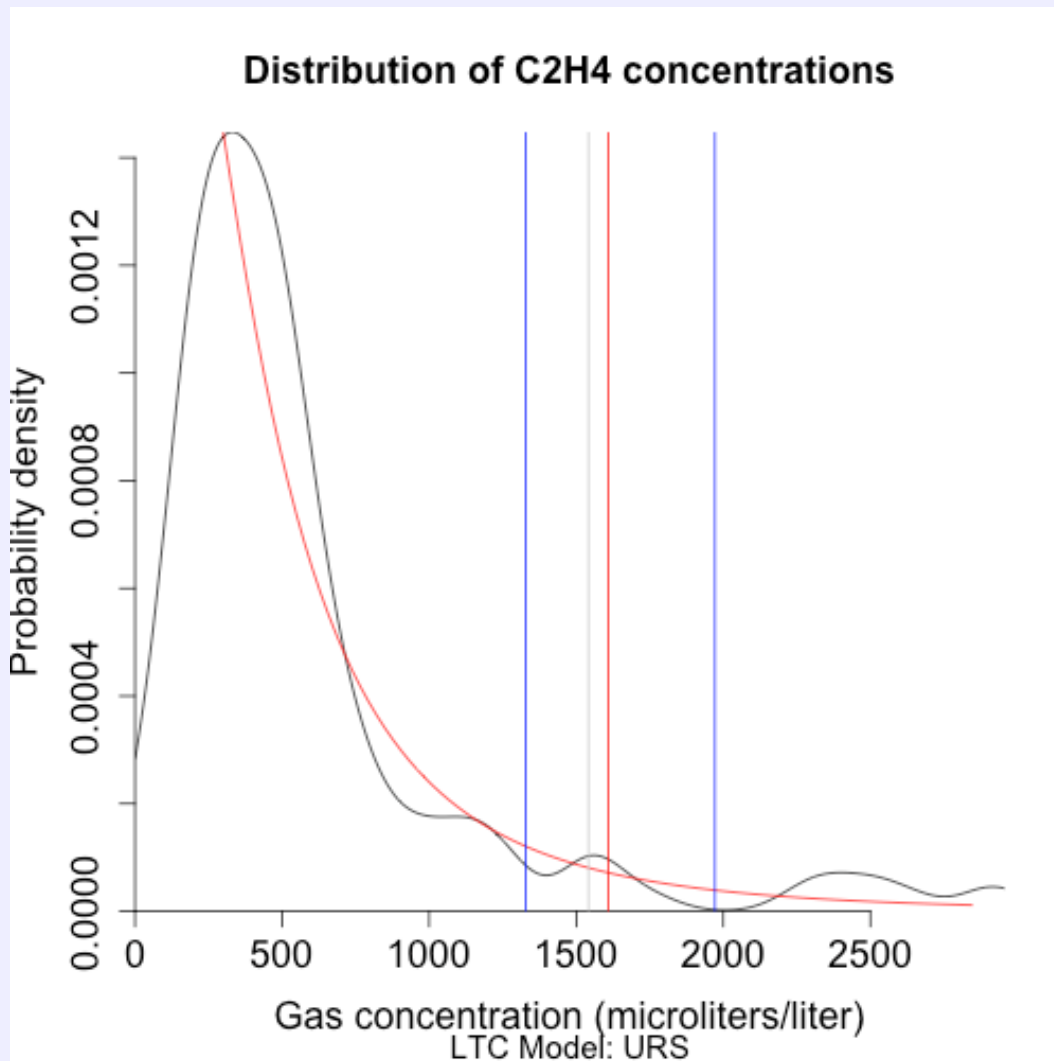


In this chart, the distribution of methane concentrations from one LTC model at one electric utility is shown as a lumpy but smooth curve (black) showing the relative abundance of various numerical values in the data.

The blue line at 620 ppm is the U2 outlier limit, calculated from the data for use as a caution limit.

Distributions of other gases are similar, but scaled differently and more or less uneven.

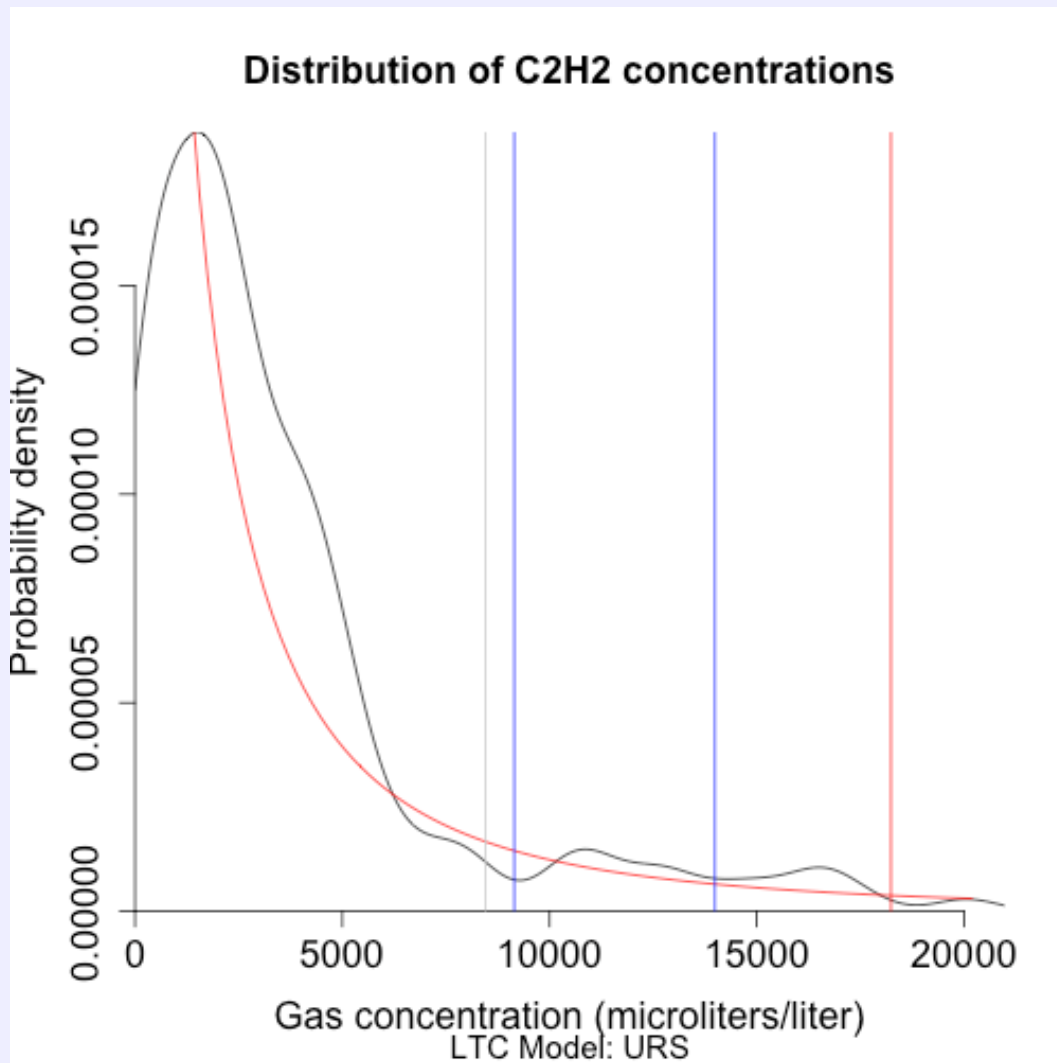
# Distributions of Gas Concentrations



Here is the distribution of ethylene (C<sub>2</sub>H<sub>4</sub>) concentrations from the same LTC population as in the previous slide.

The blue line at 1972 ppm is the U2 outlier limit calculated from the ethylene data.

# Distributions of Gas Concentrations

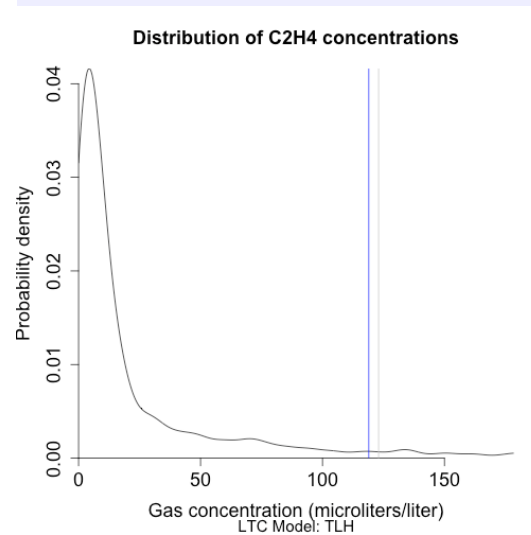
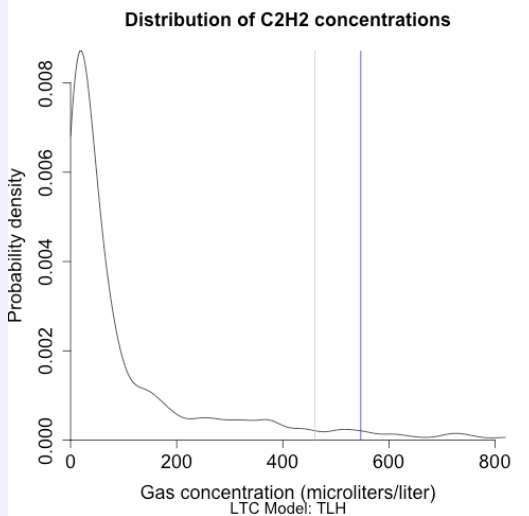
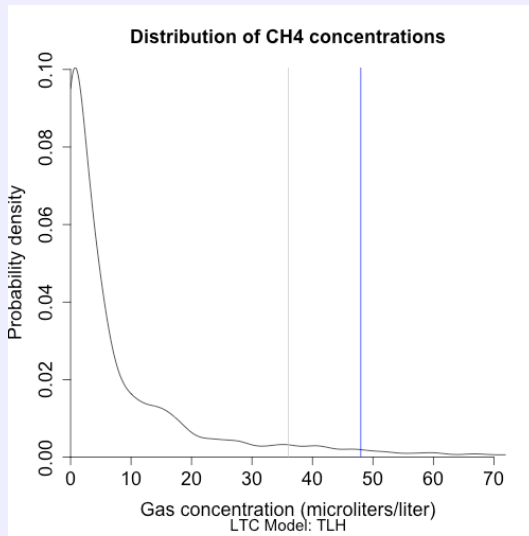


Here is the distribution of acetylene (C<sub>2</sub>H<sub>2</sub>) concentrations from the same LTC population as before.

The blue line at 13990 ppm is the U2 outlier limit calculated from the acetylene data.

Note that the horizontal scale of each of these gas concentration distributions is very different.

# Gas Concentration Caution Limits

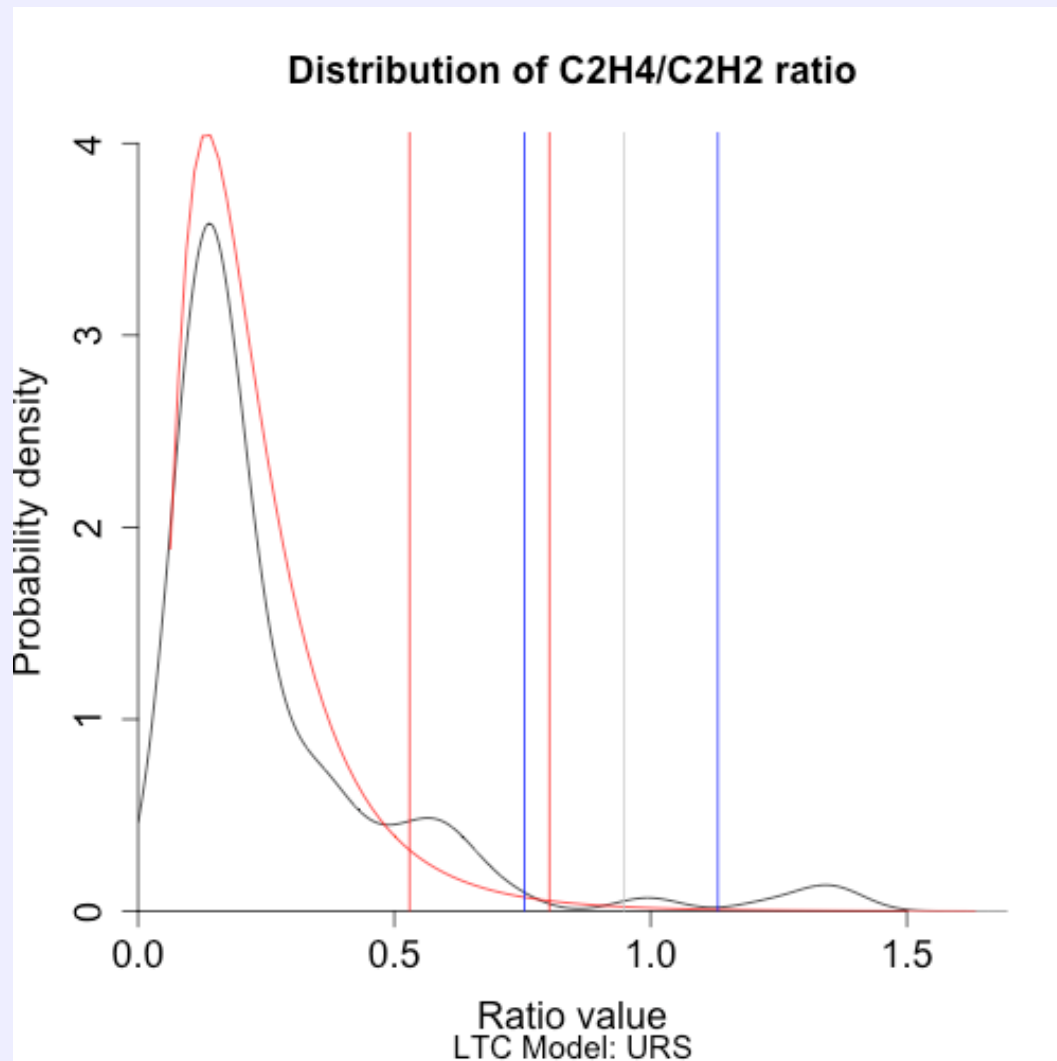


We know that

- There is data from faulty LTCs in our database, and
- Some faulty LTCs generate more combustible gas than healthy ones in the same population do.
- Most of the extremely high gas concentrations belong to faulty or highly stressed LTCs.

The U2 outlier limit is a standard statistical marker separating what is very unusual from what is commonplace.

# Distributions of Gas Concentration Ratios



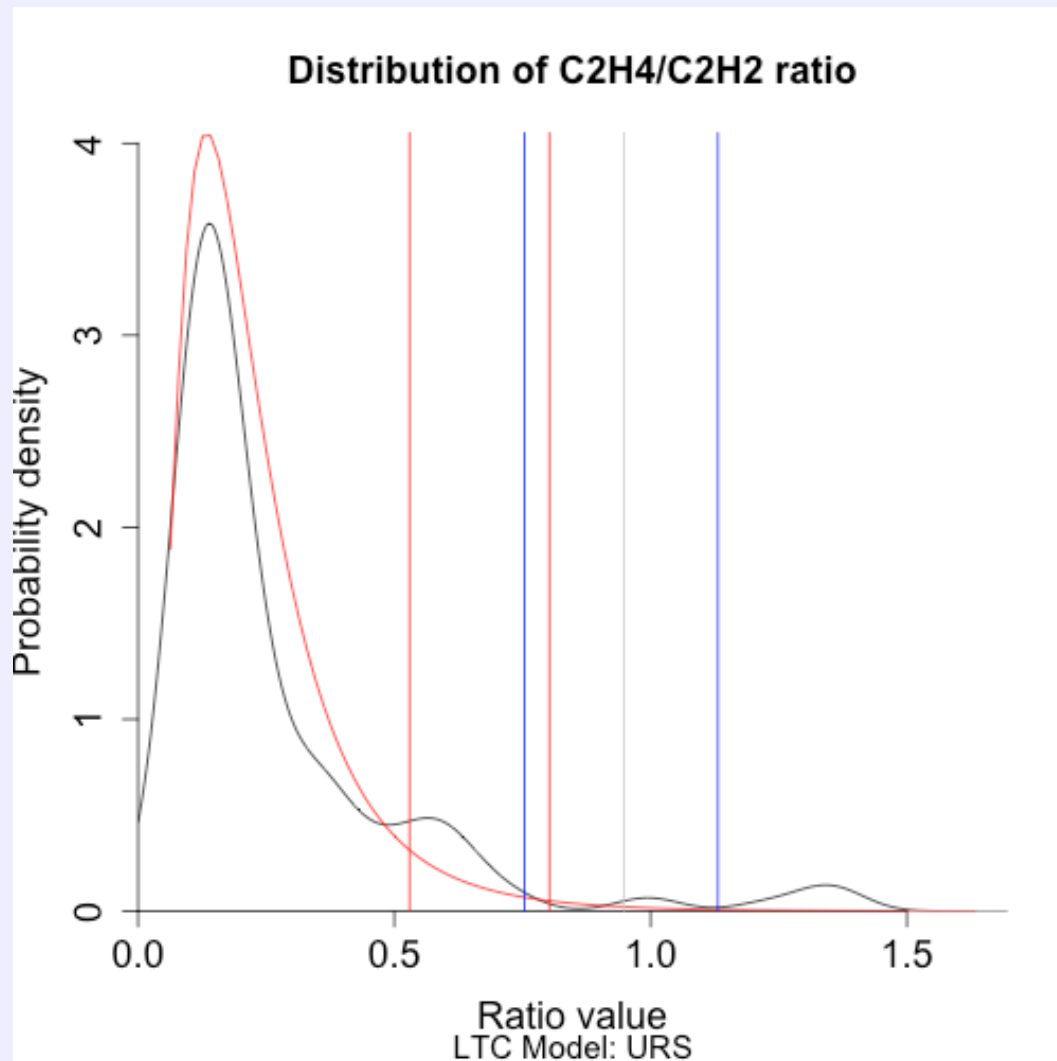
This same idea of looking at a distribution and defining what is very unusual can be applied to gas ratios.

To calculate gas ratios, we use only samples where both gases are at least 10 ppm. (We do not interpret ratios of trace amounts of gas).

From the database of 182 samples we can calculate 180 **ethylene/acetylene** ratios, forming the black distribution curve.

The U2 outlier limit is 1.13.

# Distributions of Gas Concentration Ratios

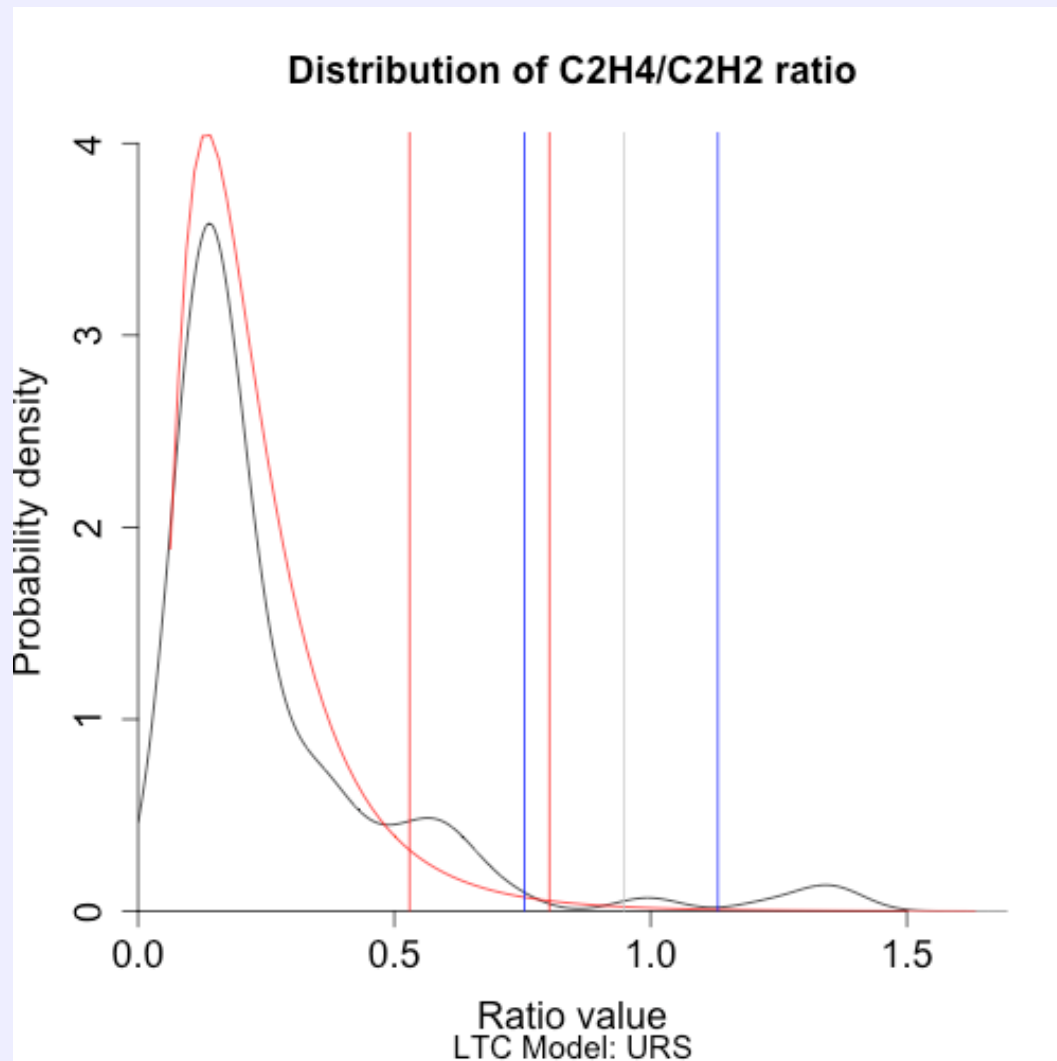


When we first started looking at LTC DTA data this way, Shuzhen Xu noticed something very useful:

**The lower part of the ratio distribution (e.g. below the U2 limit) usually fits a lognormal probability distribution.**

Since extreme ratio values are known to belong mainly to faulty LTCs, the non-outlier part of the distribution mostly represents non-faulty LTCs. The lognormal distribution (red) gives us a mathematical model for them.

# Distributions of Gas Concentration Ratios

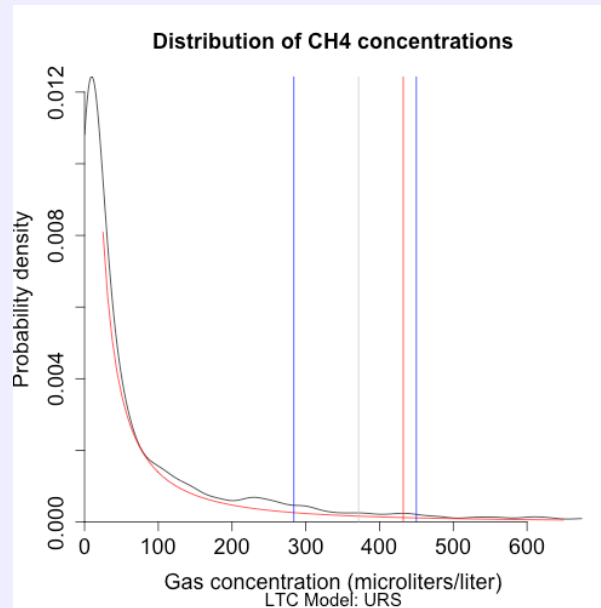
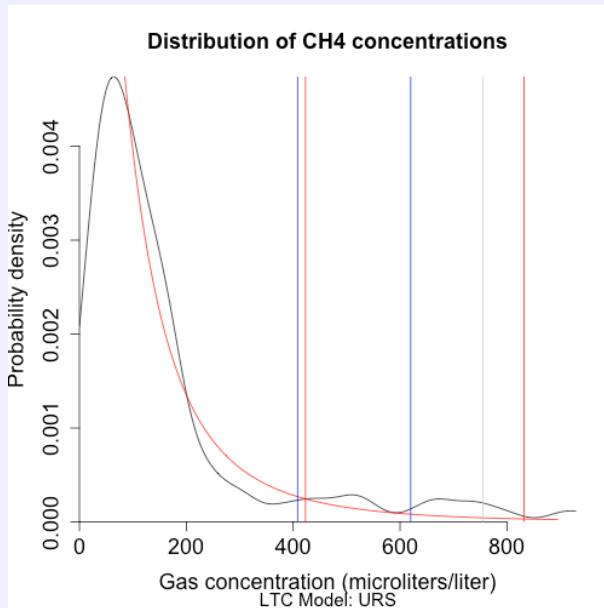
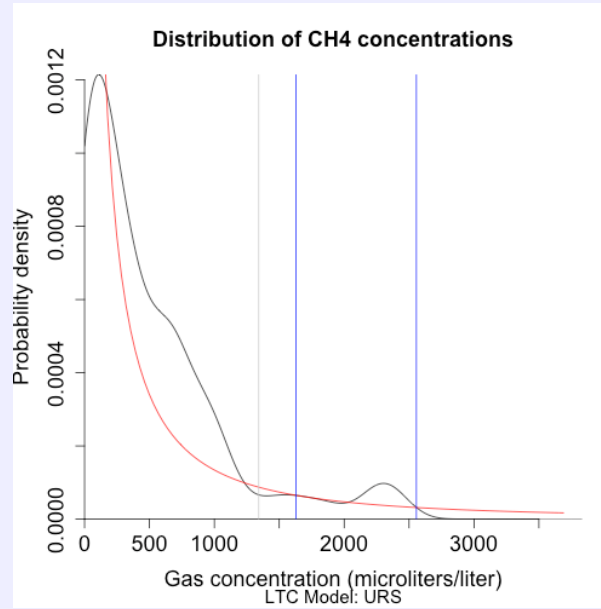
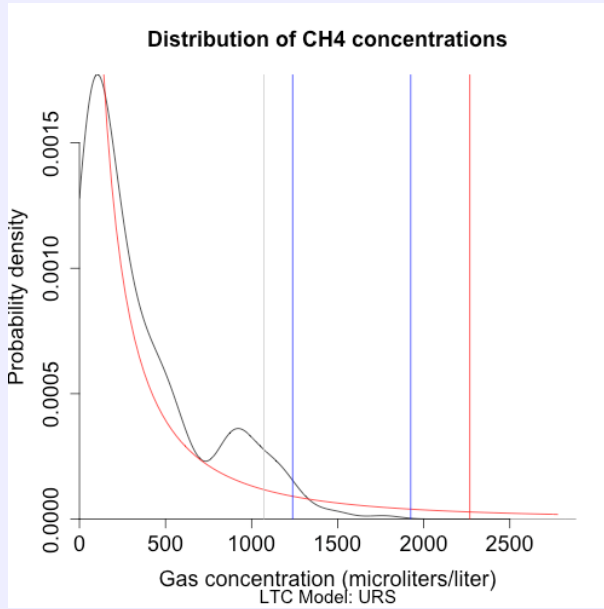


The lognormal distribution (red) fitted to the "non-faulty" part of the gas ratio distribution conceptually represents all of the C<sub>2</sub>H<sub>4</sub>/C<sub>2</sub>H<sub>2</sub> ratio data that could be collected from a population of healthy LTCs like these under similar operating conditions.

We can use percentiles of the probability distribution as limits to say what ratio values would be very exceptional for a normal LTC in this population.

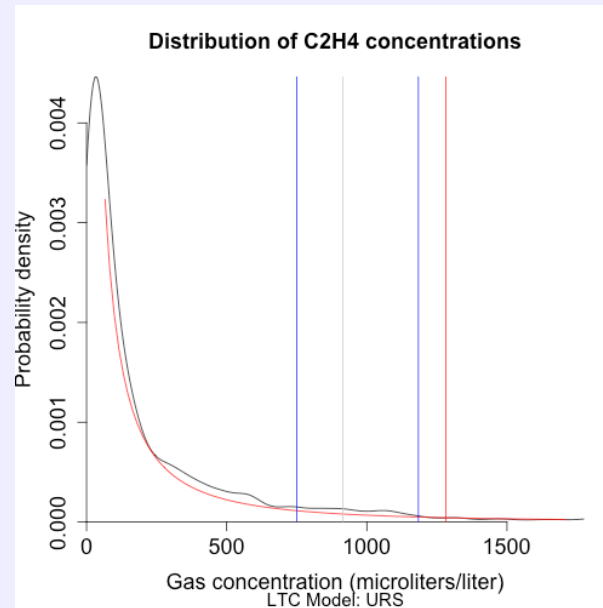
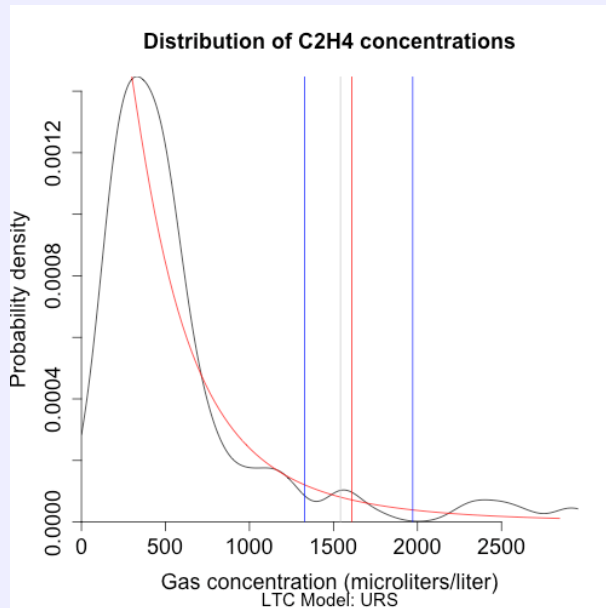
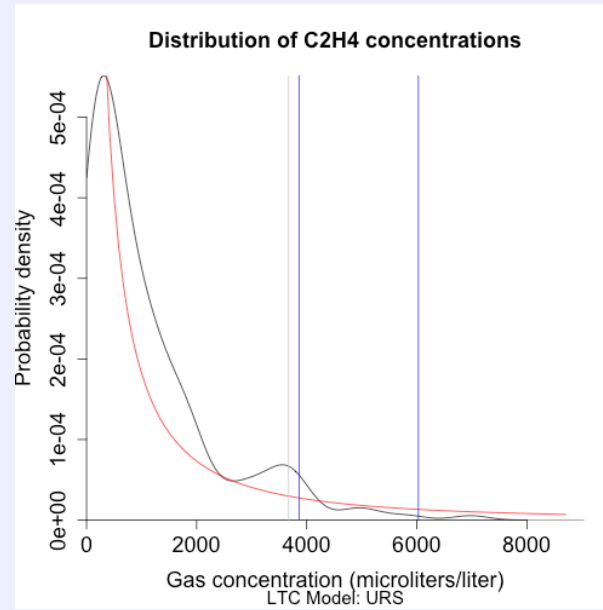
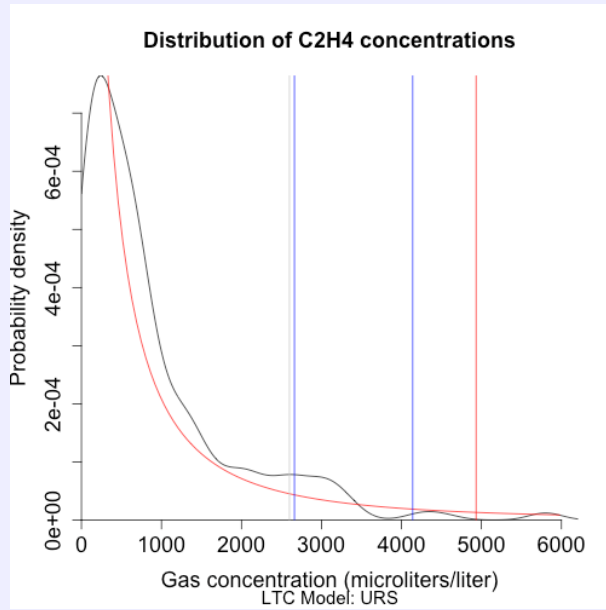
Here, Caution = 0.53 and Warning = 0.80 (red lines).

# Methane Distributions for Four Utilities



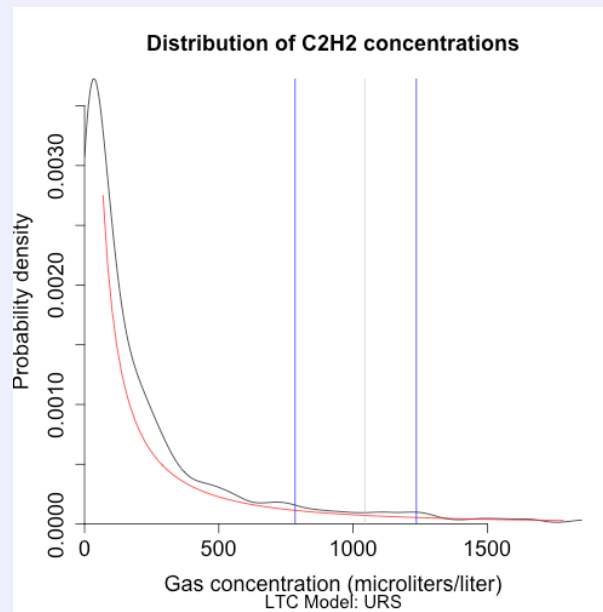
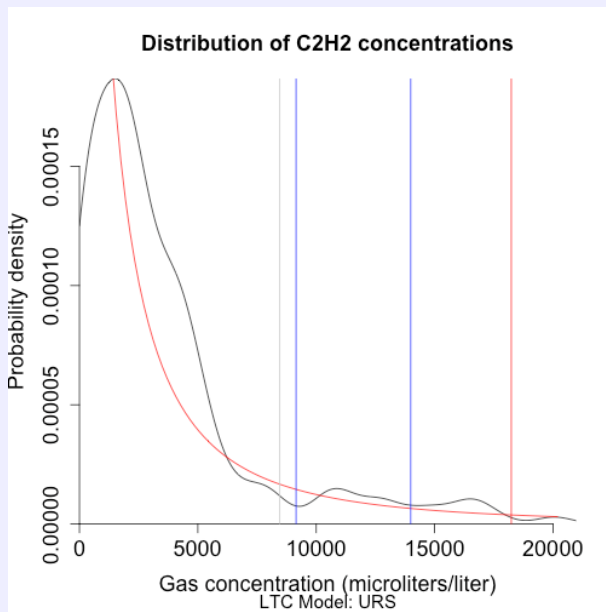
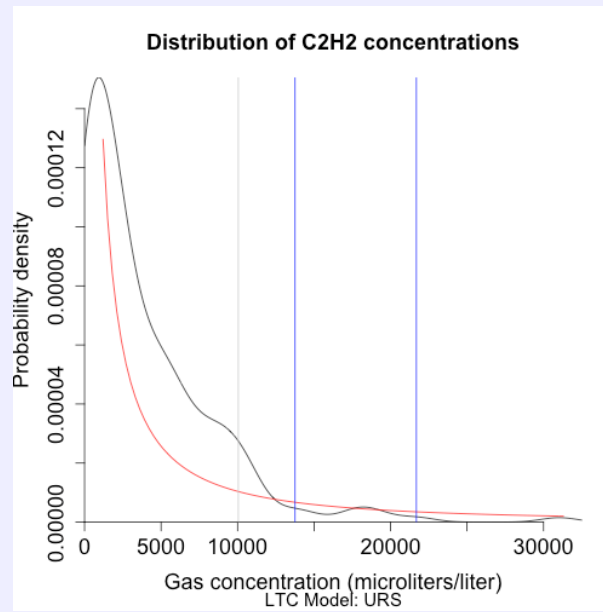
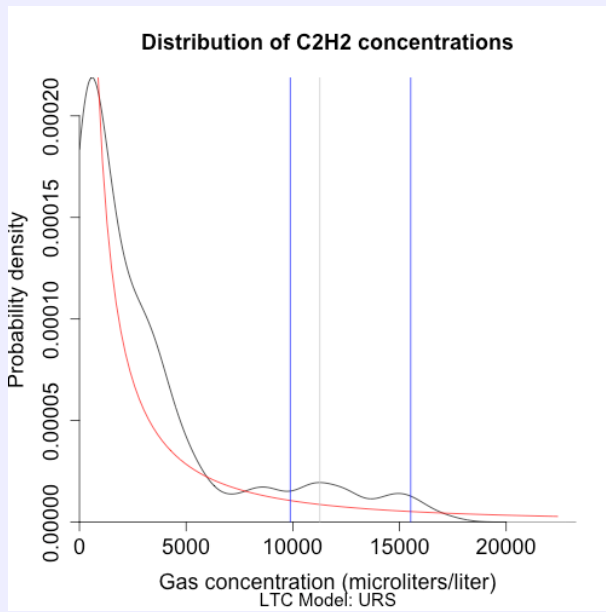
|     |      |      |      |     |
|-----|------|------|------|-----|
| N   | 2844 | 309  | 221  | 182 |
| U2  | 450  | 1925 | 2557 | 620 |
| P90 | 372  | 1072 | 1342 | 755 |

# Ethylene Distributions for Four Utilities



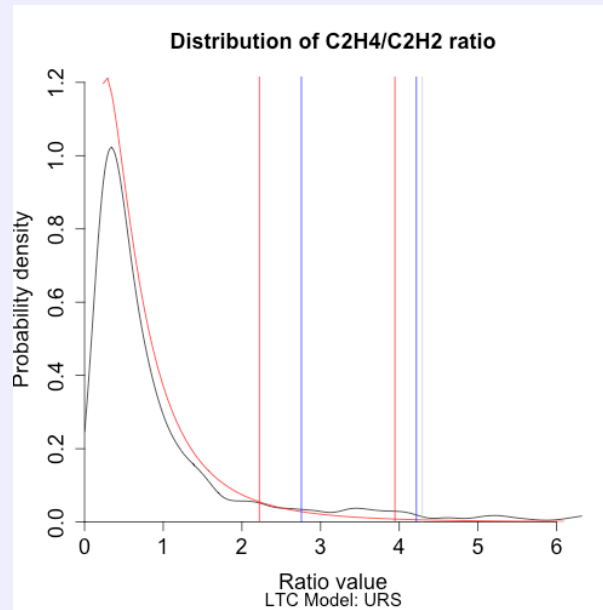
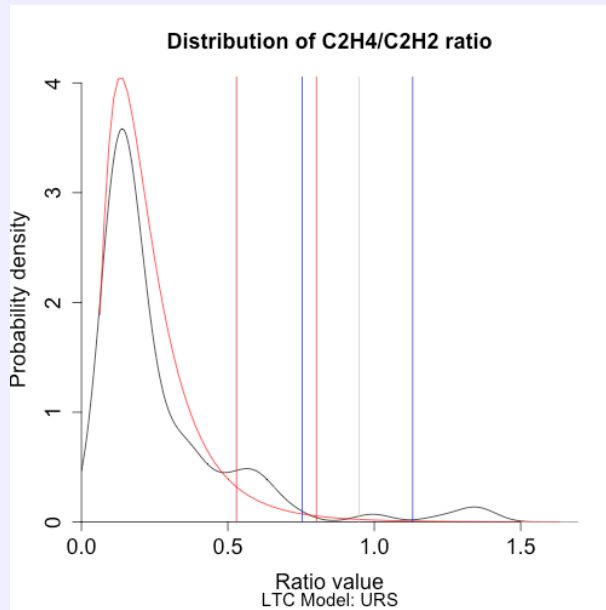
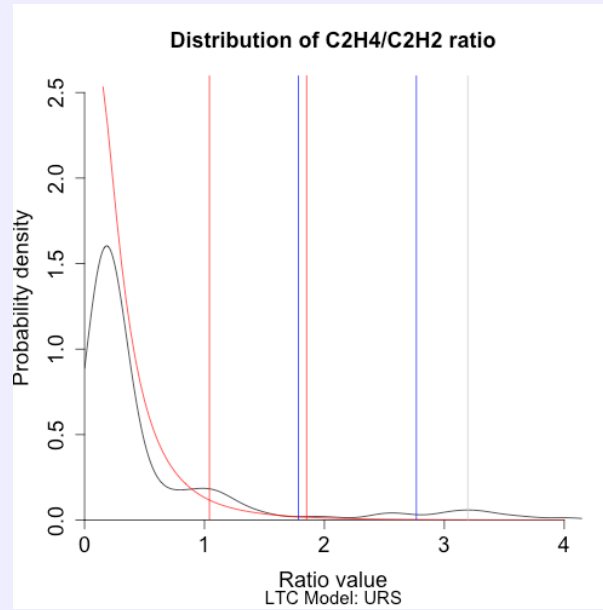
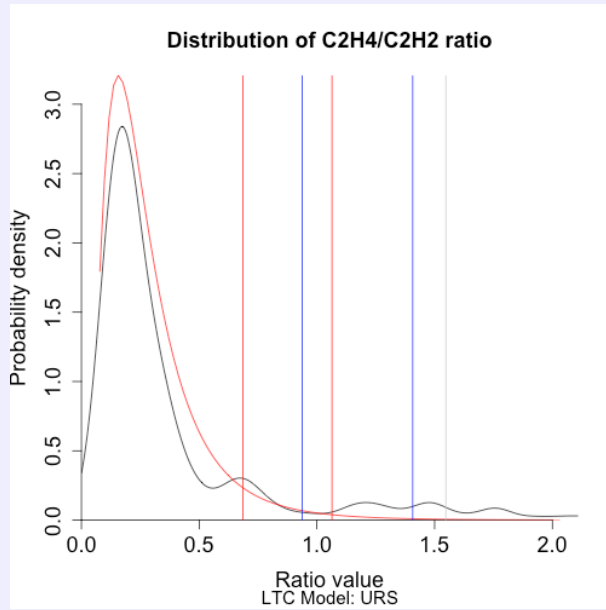
|     |      |      |      |      |
|-----|------|------|------|------|
| N   | 2844 | 309  | 221  | 182  |
| U2  | 1184 | 4141 | 6030 | 1972 |
| P90 | 915  | 2600 | 3671 | 1542 |

# Acetylene Distributions for Four Utilities



|     |      |       |       |       |
|-----|------|-------|-------|-------|
| N   | 2844 | 309   | 221   | 182   |
| U2  | 1236 | 15528 | 21689 | 13990 |
| P90 | 1044 | 11270 | 10050 | 8461  |

# C2H4/C2H2 Distributions for Four Utilities



|      |      |      |      |      |
|------|------|------|------|------|
| N    | 2331 | 289  | 203  | 180  |
| C095 | 2.22 | 0.69 | 1.04 | 0.53 |
| C099 | 3.94 | 1.06 | 1.85 | 0.80 |
| P90  | 4.29 | 1.55 | 3.20 | 0.95 |