ecoSPHERE
TECHNOLOGIES INC.

Case Study

Statistical and “Bottom Line” Comparisons

of Gas Production Yielded by using the Patented Ecosphere Ozonix® Technology Versus Chemical Biocide for the Hydraulic Fracturing of Natural Gas Wells

November 19, 2014

Statistical and "Bottom Line" Comparisons of Gas Production Yielded by using the Patented Ecosphere Ozonix® Technology Versus Chemical Biocide for the Hydraulic Fracturing of Natural Gas Wells

Paul R. Yarnold, Ph.D.
Optimal Data Analysis, LLC

Jamar Blackmon, Ph.D.
Fidelity National Environmental Solutions, LLC

Parag Gogate, Ph.D.
Institute of Chemical Technology

November 19, 2014

ABSTRACT

This extensive 3-year study of 155 natural gas wells assessed the comparative efficacy of water treatment methods for 96 wells treated using Ecosphere Technologies, Inc. patented Ozonix® water treatment process versus 59 wells treated using Chemical Biocide in the Fayetteville Shale in Arkansas. Findings established that the use of Ozonix® in water treatment for the hydraulic fracturing of natural gas wells resulted in broadly greater productivity than liquid Chemical Biocide treatment, as indicated by a greater relative frequency of high-productivity wells; significantly greater overall gas production achieved in the first two months of post-fracturing operations; and consistently greater gas production and monetary returns (added revenue) across all 12 months of post-fracturing operations.

As compared with Chemical Biocide water treatment methods and based on the current market price of gas, Ozonix® returns *$24.9 million dollars* in additional revenue per year for 100 gas wells, *$124.8 million dollars* in additional revenue per year for 500 gas wells, and *$249.7 million dollars* in additional revenue per year for 1,000 gas wells.

This study compares the magnitude of gas production yielded by two distinctly different methods currently being implemented for treating water to control bacteria, scale, microbiologically induced corrosion, and biofilms associated with the hydraulic fracturing process of natural gas wells. One of the water treatment methods is a traditional liquid Chemical Biocide process (Biocide), and the other is a multi-patented, novel Advanced Oxidation Process (AOP) using Ozone, Hydrodynamic and Acoustic Cavitation, and Electro-Oxidation, which is named the Ecosphere Ozonix® process (Ozonix®) [1].

The present study unfolds in four phases. First an appropriate sample of wells is obtained to enable the comparative analysis. Second, the magnitude of gas production achieved by the two competing water treatment methods is compared across each of the first 12 months post-fracturing by conducting separate bivariate statistical analysis for each month: that is, gas production achieved in every month is evaluated independently of gas production achieved in other months. Third, the gas production obtained by the competing methods is compared across all months simultaneously by conducting a multivariate statistical analysis evaluating all of the production data considered in gestalt. Finally, the "bottom line" expressed in terms of excess realized revenue resulting from differential production achieved by the two water treatment methods is assessed for each month, and for all 12 months post-fracturing.

Selecting Wells for Comparison

The experimental design ("design") involved comparison of the first *12 months* of gas production obtained post-fracturing. Accordingly a total sample of *343 wells* for which descriptive information (horizontal, vertical, and production zone length) and 12 months of complete post-fracturing production data were available, was obtained from public records for the Fayetteville Shale in Arkansas.

The design called for comparison of wells that were fractured during approximately the same time period. For the sample of 343 wells, univariate optimal (maximum-accuracy) discriminant analysis (UniODA) identified an optimal discriminant threshold of March, 2012. UniODA is an exact non-parametric classification and discrimination statistical methodology for which no distributional assumptions are required (thus model parameters and Type I error rates—"*p*-values"—are always valid), and that explicitly maximizes the classification accuracy of the discriminant model for the specific sample and hypothesis being evaluated [2,3].

Of the total of 188 wells fractured prior to March, 2012, 180 (95.7%) were chemically treated; and of the total of 155 wells fractured on or after this date, 59 (38.1%) were chemically treated. This difference was highly statistically significant ($p<0.102 \times 10^{-32}$), and indicated a relatively strong temporal or "time-based" bias (ESS=67.2).

The effect strength for sensitivity, or ESS, is a normed index of strength of effect. That is, for any test of a statistical hypothesis, ESS=0 is expected for the sample by chance, and ESS=100 represents perfect discrimination between the groups being compared. For example, if 50% of the wells were treated using Ozonix® prior to and also on/after March, 2012 (and therefore 50% of the wells were treated using Biocide prior to and also on/after March, 2012), then ESS would be zero—indicating the effect strength expected by chance. In contrast, if 100% of the wells were treated using Ozonix® on/after March, 2012, and 100% of the wells were treated using Biocide before March, 2012 (or if the opposite pattern occurred), then ESS would be 100—indicating perfect, errorless discrimination between treatment methods. By convention, ESS$\leq$25 indicates a relatively weak effect; ESS$\leq$50 indicates a moderate effect; ESS$\leq$75 indicates a relatively strong effect; and ESS>75 is a strong effect [2].

Adding wells prior to March, 2012, in an effort to increase the number of Biocide wells and thereby balance group sample sizes, and to increase statistical power to identify between-method production differences, only served to increase temporal bias. Decreasing the number of wells treated via Ozonix® after March, 2012, in an attempt to balance group sample sizes significantly reduced statistical power and increased *systematic* temporal bias.

The resulting sample of *155 wells* (see Exhibit A) provided sufficient statistical power for identification of moderate gas production differences between treatment methods (i.e., 25% to 50% greater than expected by chance alone). For this sample the temporal bias was moderate: ESS=29.2, $p<0.003$. Time- and/or location-based bootstrap analysis involving 50% resampling was inappropriate because of the resulting dramatic decrease in statistical power.

Wells treated using Ozonix® versus using Biocide did not differ significantly in terms of horizontal length ($p<0.20$, ESS=17.2), vertical length ($p<0.18$, ESS=17.9), or production zone length ($p<0.64$, ESS=11.5).

Bivariate Statistical Comparison of Monthly Gas Production

UniODA was used to compare the gas production of wells treated by Biocide versus by Ozonix® separately by month. The normalized unit of measurement of gas production used is MCF divided by length of production zone (MCF/ft). The findings of the analyses are summarized in Table 1.

The second column of Table 1 gives the optimal discriminant threshold for separating "high" versus "low" gas production for each month. This is the threshold value that yielded maximum-accuracy discrimination (highest ESS value) between treatment methods. Note that the highest threshold value occurred in the second month post-fracturing, and the third-highest threshold value occurred in the first month.

The third column of Table 1 gives the number of high-production wells treated using Ozonix® (numerator), and the total number of high-production wells for each month. For example, for month 1 post-fracturing, 52 of the 66 high-production wells, corresponding to 78.8%, were treated using Ozonix®. Note that the majority of all high-production wells in every month—usually a ratio of 2/3 or greater (except in months 5 and 8)—were treated using Ozonix®.

Table 1: Comparing Separate (Individual) Months:
Percentage of High-Production versus Low-Production Wells

Month Post-Fracturing	Discriminant Threshold (MCF/ft)	Ozonix® Wells > Threshold	Biocide Wells > Threshold	Ozonix® Wells ≤ Threshold	Biocide Wells ≤ Threshold	Statistical Significance (*p* ≤)	Effect Strength (ESS)
Month 1	11.00	52/66 (78.8%)	14/66 (21.2%)	44/89 (49.4%)	45/89 (50.6%)	0.0006	30.4
Month 2	18.98	33/42 (78.6%)	9/33 (21.4%)	63/113 (55.8%)	50/113 (44.2%)	0.062	19.1
Month 3	10.68	78/117 (66.7%)	39/117 (33.3%)	18/38 (47.4%)	20/38 (52.6%)	0.167	15.2
Month 4	9.87	77/113 (68.1%)	36/113 (31.9%)	19/42 (45.2%)	23/42 (54.8%)	0.061	19.2
Month 5	9.17	74/113 (65.5%)	39/113 (34.5%)	22/42 (52.4%)	20/42 (47.6%)	0.380	11.0
Month 6	8.59	73/110 (66.4%)	37/110 (33.6%)	23/45 (51.1%)	22/24 (48.9%)	0.248	13.3
Month 7	13.07	23/29 (79.3%)	6/29 (20.7%)	73/126 (57.9%)	53/126 (42.1%)	0.215	13.8
Month 8	7.44	73/112 (65.2%)	39/112 (34.8%)	23/43 (53.5%)	20/43 (46.5%)	0.447	9.9
Month 9	8.81	46/69 (66.7%)	23/69 (33.3%)	50/86 (58.1%)	36/86 (41.9%)	0.521	8.9
Month 10	10.85	24/33 (72.7%)	9/33 (27.3%)	72/122 (59.0%)	50/122 (41.0%)	0.450	9.8
Month 11	9.86	27/38 (71.1%)	11/38 (28.9%)	69/117 (59.0%)	48/117 (41.0%)	0.478	9.5
Month 12	10.18	22/27 (81.5%)	5/27 (18.5%)	74/128 (57.8%)	54/128 (42.2%)	0.192	14.4

The fourth column of Table 1 gives the number of high- production wells treated using Biocide (numerator), and the total number of high-production wells for each month. For example, for month 1 post-fracturing, 14 of the 66 high-production wells, corresponding to 21.2%, were treated using Biocide. Note that the minority of all high-production wells in every month—usually a ratio of 1/3 or fewer (except in months 5 and 8)—were treated using Biocide.

The fifth column of Table 1 gives the number of low-production wells treated using Ozonix® (numerator), and the total number of low-production wells for each month. For example, for month 1 post-fracturing, 44 of the 89 low-production wells, corresponding to 49.4%, were treated using Ozonix®. Note that a modest majority of all low-production wells in every month—usually a ratio of 3/5 or fewer (except in months 1 and 3)—were treated using Ozonix®.

The sixth column of Table 1 gives the number of low-production wells treated using Biocide (numerator), and the total number of low-production wells for each month. For example, for month 1 post-fracturing, 45 of the 89 low-production wells, corresponding to 50.6%, were treated using Biocide. Note that a modest minority of all low-production wells in every month—usually a ratio of 2/5 or more (except in months 1 and 3)—were treated using Biocide.

The seventh column of Table 1 gives the exact probability (Type I error) for the comparison of the ratio of high-production versus low-production wells treated using Ozonix® versus Biocide. For example, for month 1 post-fracturing, wells treated using Ozonix® were more often high-production, and less often low-production, compared to wells treated using Biocide. The probability of a difference as large as was obtained between these water treatment methods happening by chance is $p<0.0006$. Note that the difference between wells treated using Ozonix® versus Biocide was statistically significant only for month 1, and was marginally significant ($p<0.10$) for months 2 and 4. While the proportion of high-production wells was consistently greater for wells treated using Ozonix®, the approximately even distribution of low-production wells treated using Ozonix® and Biocide, in conjunction with the modest sample size (number of wells in the sample) and relatively weak effect strength (recall that the sample size yielded sufficient statistical power to identify effects of *moderate* strength), resulted in few statistically significant findings. Had there been twice as many wells in the sample, and parallel findings emerged, then these comparisons would meet the criterion for statistical significance.

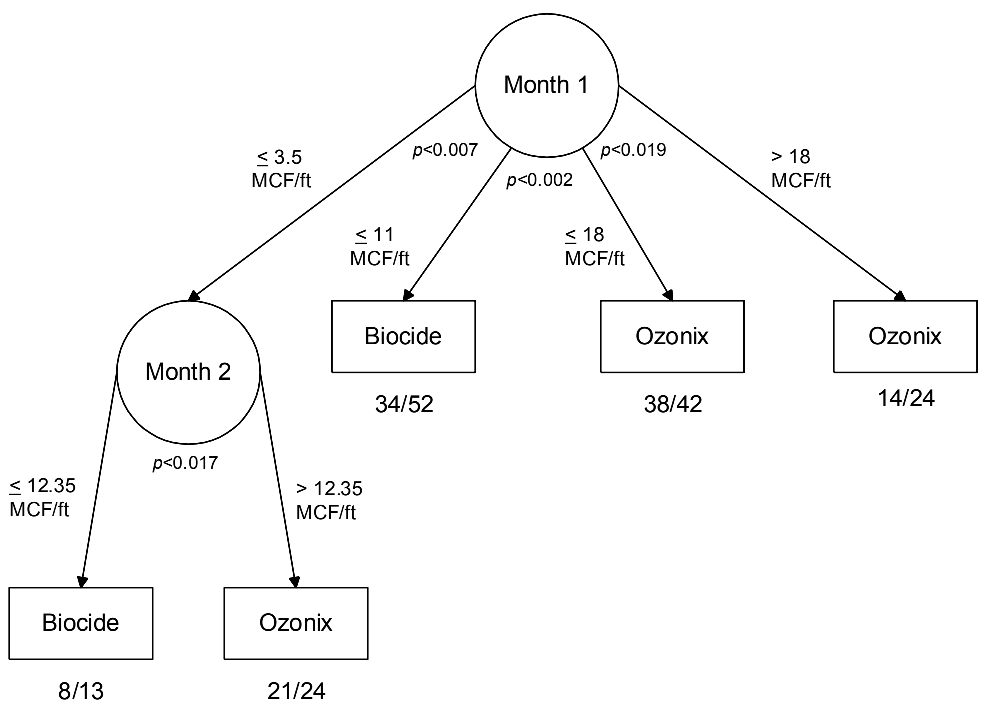
The final column in Table 1 gives the statistical strength of effect (ESS) for each of the monthly comparisons. As seen, the effect strength for month 1 was moderate, and the effect strengths for months 2-12 were relatively weak.

Multivariate Statistical Comparison of Monthly Gas Production

Normalized gas production was next compared between wells treated by Ozonix® versus Biocide, for all 12 months considered simultaneously, using globally-optimal (maximum-accuracy) classification tree analysis (CTA). Like UniODA, CTA is an exact non-parametric classification and discrimination statistical methodology for which no distributional assumptions are required (model parameters and Type I error rates are always valid), and that explicitly maximizes the classification accuracy of the discriminant model for the specific sample and hypothesis being evaluated. In addition, in CTA an integral sequentially-rejective Dunn's Bonferroni-type multiple-comparisons methodology is used to ensure an experimentwise Type I error rate of $p<0.05$. As for UniODA, normed ESS is used to indicate strength of effect [2-5].

A schematic illustration of the resulting CTA model is presented in Figure 1. In the Figure, circles represent attributes (variables used in the CTA model to discriminate wells treated using Ozonix® versus Biocide); rectangles represent model endpoints (wells are predicted by the CTA model to be treated either by Ozonix® or by Biocide); arrows emanating from attributes indicate model branches—pathways from attributes to other attributes and/or to model endpoints; values adjacent to branches indicate the corresponding optimal (maximum-accuracy) discriminant threshold value; exact Type I error rates (*p*-values) are indicated beneath corresponding attributes and at the right-hand side of branches; and fractions given beneath model endpoints indicate the number of correctly classified wells of the type indicated within the endpoint (numerator), and the total number of wells described by the model pathway yielding the indicated endpoint (denominator). As seen, only the gas production in months 1 and 2 were statistically reliable discriminators of wells treated using Ozonix® versus Biocide. Consistent with the findings of bivariate analysis, the other ten months were not statistically reliable discriminators of the different treatment methods.

Figure 1: Schematic Illustration of CTA Model Discriminating Wells Treated using Ozonix® versus Biocide Methods



Interpreting the CTA model is straightforward. For example, imagine that a hypothetical well produced 2.9 MCF/ft of gas in month 1, and 12.3 MCF/ft of gas in month 2. Because the hypothetical well's production in month 1 is less than the threshold value for month 1 in the first (left-most) branch emanating from the root (initial, top) attribute of the model (≤ 3.5 MCF/ft), the first branch from the root attribute is appropriate. And, since the hypothetical well's production in month 2 is less than the threshold value for the model for month 2 (≤ 12.35

MCF/ft), the first branch from the month 2 attribute is appropriate. This branch leads to the endpoint which classifies wells as being treated using Biocide. As seen, of the total of 13 wells classified into this endpoint, a total of 8 wells were in fact treated using Biocide (8/13 = 61.5% accuracy). Therefore, 13 - 8 = 5 wells (100% – 61.5% = 38.5% error rate) in this endpoint were treated using Ozonix®, and thus were misclassified.

Had the production in month 2 for this hypothetical well been > 12.35 MCF/ft, then the well would have been classified into the adjoining Ozonix® endpoint. As seen, of the total of 24 wells classified into this right-hand endpoint, a total of 21 wells were in fact treated by Ozonix®, corresponding to 87.5% accuracy, and a 12.5% error rate.

Illustrated in Figure 2, the overall discrimination accuracy of the CTA model is ascertained by integrating results over all five model endpoints and displaying the results in a so-called "confusion table". As seen, the CTA model correctly classified 88.1% of the wells that were actually treated using Biocide, and 61.5% of the wells that were actually treated using Ozonix®. And, the CTA model was accurate 58.4% of the time that it predicted that a well was treated using Biocide, and 89.4% of the time that it predicted that a well was treated using Ozonix®. This discrimination performance corresponds to an ESS value of 49.6, which lies near the border separating a moderate versus a relatively strong effect.

Figure 2: Confusion Table Summarizing CTA Model Discrimination Performance

	Predicted Treatment Method		
Actual Treatment Method	Biocide	Ozonix®	Sensitivity
Biocide	52	7	88.1%
Ozonix®	37	59	61.5%
Predictive Value	58.4%	89.4%	

Figure 3 presents a staging table created as an aid to enhance conceptual clarity of the findings of the CTA model.

Figure 3: Staging Table for CTA Model

Month 1 Production	Month 2 Production	Number of Wells	Percent of Wells Ozonix®	Percent of Wells Biocide
≤ 3.5 MCF/ft	≤ 12.35 MCF/ft	13	38.5	61.5
≤ 3.5 MCF/ft	> 12.35 MCF/ft	24	87.5	12.5
≤ 11 MCF/ft	-----	52	34.5	65.4
≤ 18 MCF/ft	-----	42	90.5	9.5
> 18 MCF/ft	-----	24	58.3	41.7

"Bottom Line" Analysis of Monthly Gas Production

The issues of statistical significance and strength of effect don't address the issue of the "bottom line"—that is, the excess realized revenue resulting from differential production achieved by the two treatment methods. Accordingly, Table 2 presents monthly mean, SD, and total gas production (MCF/ft), for high-production and low-production wells, treated using Ozonix® versus Biocide methods, based on the *bivariate* discriminant models.

Table 2: Monthly Mean (SD) and Total Returns from High-Production versus Low-Production Wells

Month Post-Fracturing	High-Production Ozonix® Wells	High-Production Biocide Wells	Low-Production Ozonix® Wells	Low-Production Biocide Wells
Month 1	16.53 (4.97) 859.5	20.46 (4.60) 286.5	4.31 (3.04) 189.5	5.63 (3.02) 253.8
Month 2	23.60 (3.99) 778.9	24.01 (2.55) 216.1	13.11 (3.63) 825.6	13.53 (3.41) 676.3
Month 3	16.15 (4.74) 1259.9	15.64 (3.36) 609.8	7.81 (2.34) 140.5	8.43 (1.39) 168.6
Month 4	14.69 (4.01) 1131.3	14.71 (3.28) 529.5	7.93 (1.32) 150.7	7.74 (2.00) 178.1
Month 5	13.71 (4.04) 1014.2	13.31 (2.91) 518.9	7.43 (1.26) 152.3	7.62 (1.08) 152.3
Month 6	12.93 (3.68) 944.6	12.35 (2.56) 457.0	6.49 (1.38) 149.2	7.04 (1.41) 154.9
Month 7	16.07 (2.47) 369.7	15.17 (1.44) 91.0	8.77 (2.09) 640.5	9.31 (2.37) 493.4
Month 8	11.50 (3.11) 747.4	11.83 (2.58) 378.5	6.46 (1.26) 200.3	6.47 (1.58) 174.8
Month 9	11.78 (2.56) 542.0	12.36 (3.24) 284.2	6.35 (1.76) 317.5	6.66 (1.69) 239.7
Month 10	12.99 (2.10) 311.8	12.06 (1.20) 108.5	7.14 (1.99) 514.7	7.57 (2.26) 378.7
Month 11	12.26 (2.69) 318.73	12.39 (1.41) 136.3	6.53 (2.07) 451.1	7.02 (1.79) 336.8
Month 12	12.07 (1.92) 265.5	11.47 (1.10) 57.4	6.52 (1.74) 482.3	6.851.65) 370.1

Note that for wells treated using Ozonix® and using Biocide methods, highest mean production occurs in month 2. For both treatment methods, mean production generally declines thereafter, except for an uptick in month 7. For high-production wells the mean production for wells treated using Ozonix® were greater than corresponding mean production for wells treated using Biocide for six months, and were lower for six months. And, for low-production wells the mean production for wells treated using Ozonix® was greater than corresponding mean production for wells treated using Biocide for month 4, and means were lower for the other months. No comparisons between corresponding means were statistically significant as evaluated using UniODA or analysis of variance.

In order to determine overall production the mean production values presented in Table 2 must be weighted by the number of wells. Table 3 presents monthly total and mean production over all (high-production and low-production) wells. Note that for wells treated using Ozonix® and Biocide methods, overall production across all wells, and mean production per well, was greatest in month 2, and systematically declined over months. In every month, the total production and mean production per well was greater for wells treated using Ozonix® versus Biocide (indicated as a mean difference greater than zero).

Table 3: Monthly Total Gas Production and Mean Gas Production Per Well

Month Post-Fracturing	Ozonix® Total Production (MCF/ft)	Ozonix® Mean Production (MCF/ft/well)	Biocide Total Production (MCF/ft)	Biocide Mean Production (MCF/ft/well)	Difference in Mean Production (MCF/ft/well)
Month 1	1049.0	10.93	540.3	9.16	1.77
Month 2	1604.5	16.71	892.4	15.13	1.58
Month 3	1400.4	14.59	778.4	13.19	1.40
Month 4	1282.0	13.35	707.6	11.99	1.36
Month 5	1177.6	12.27	671.2	11.38	0.89
Month 6	1093.8	11.39	611.9	10.37	1.02
Month 7	1010.2	10.52	584.4	9.91	0.61
Month 8	947.7	9.87	553.3	9.38	0.49
Month 9	859.5	8.95	523.9	8.88	0.07
Month 10	826.5	8.61	487.2	8.26	0.35
Month 11	778.4	8.11	473.1	8.02	0.09
Month 12	747.8	7.79	427.5	7.25	0.54

Excess Realized Revenue Obtained Using Ozonix® Water Treatment

Ascertaining the excess realized revenue resulting from differential production achieved by the two water treatment methods requires multiplying the difference in mean gas production between treatment method times the market dollar value of gas (because this analysis assumes that the energy companies pay the same price for Ozonix® as for Biocide, the additional revenue accrued by using Ozonix® treatment is marginally *underestimated*).

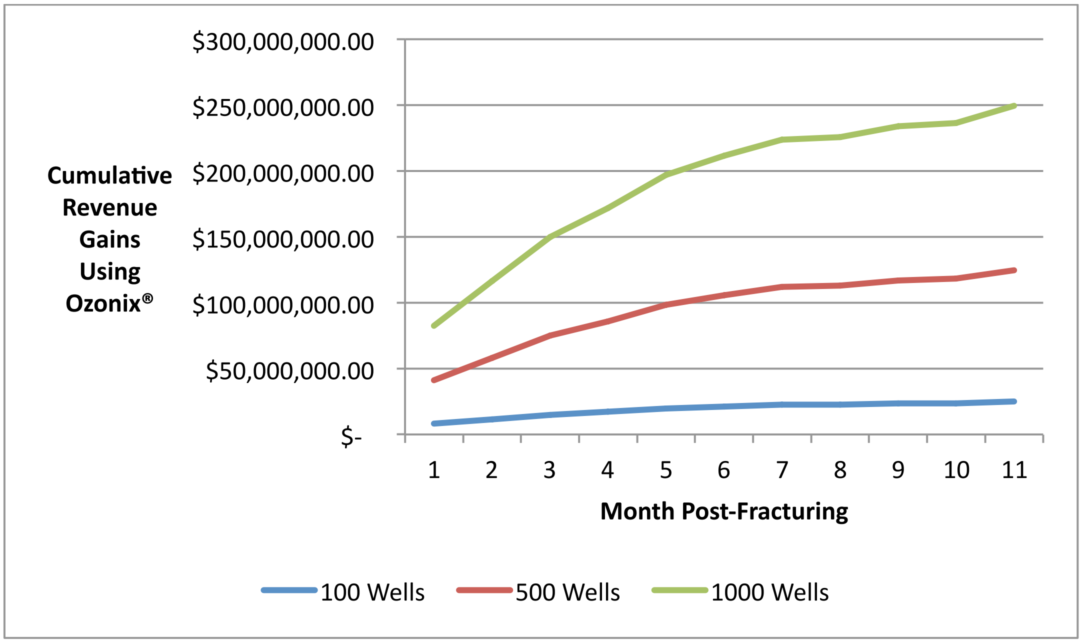
For illustrative purposes, the November 2014 price of gas ($5.1753/MCF) charged to customers of Consumer's Energy was used [6]. Based on the grand mean of 4742 feet of production zone per well (recall that this mean was not significantly different between wells treated using Ozonix® versus Biocide), Table 4 presents the excess realized revenue realized *per well* by using Ozonix® treatment versus Biocide treatment. Based on bivariate analyses and the November 2014 market price of gas, on average *each well* treated using Ozonix® will yield a total of $249,669 more revenue than *each well* treated using Biocide over 12 months of post-fracturing operation.

Table 4: Monthly Dollar Gain Per Well Using Ozonix® Treatment

Operational Month Post-Fracturing	Dollar Gain per Well per Foot	Mean Dollar Gain per Well
Month 1	9.16	43,437
Month 2	8.18	38,790
Month 3	7.25	34,380
Month 4	7.04	33,384
Month 5	4.61	21,861
Month 6	5.28	25,038
Month 7	3.16	14,985
Month 8	2.54	12,045
Month 9	0.36	1,707
Month 10	1.81	8,583
Month 11	0.47	2,229
Month 12	2.79	13,230

Figure 4 illustrates the total excess realized revenue (USD $) across 12 cumulative operational months achieved post-fracturing using Ozonix® for 100, 500, and 1,000 gas wells.

Figure 4: Cumulative Total Dollars of Excess Realized Revenue Over 12 Months Post-Ozonix®-Based Treatment, for 100, 500 and 1,000 Gas Wells, Based on November 2104 Price per MCF



As seen in Figure 4, as compared with Biocide methods, based on the current market price of gas, hydraulic fracturing operations using Ozonix® returns *$24.9 million dollars* in additional revenue per year for 100 gas wells, *$124.8 million dollars* in additional revenue per year for 500 gas wells, and *$249.7 million dollars* in additional revenue per year for 1,000 gas wells.

For comparative purposes, a parallel analysis was conducted to determine the cumulative monthly added revenue gains realized using Ozonix® versus Biocide water treatment for 500 wells and for 1,000 wells, for four different market prices of gas: $3/MCF, $8/MCF, $11/MCF, and $14/MCF. These values were selected to illustrate the comparative superiority of Ozonix®-based treatment for a range of market prices for gas that have occurred in recent years. Summarized in Table 5, the findings reveal that 12-month revenue gains from using Ozonix® for 1,000 wells ranges from *$72.4 million dollars* for gas priced at $3/MCF, to *$675.4 million dollars* for gas priced as $14/MCF.

Table 5: Cumulative Monthly Revenue Gains (*Million $*)
Obtained by Ozonix® Water Treatment at Different Market Gas Prices

Month Post-Fracturing	$3/MCF 500 Wells	$3/MCF 1000 Wells	$8/MCF 500 Wells	$8/MCF 1000 Wells	$11/MCF 500 Wells	$11/MCF 1000 Wells	$14/MCF 500 Wells	$14/MCF 1000 Wells
1	12.6	25.2	33.6	67.1	46.2	92.3	58.8	117.5
2	23.8	47.7	63.6	127.1	87.4	174.8	111.2	222.4
3	33.8	67.6	90.1	180.3	123.9	247.8	157.7	315.4
4	43.5	87.0	115.9	231.9	159.4	318.8	202.9	405.7
5	49.9	99.6	132.8	265.6	182.4	364.8	232.4	464.9
6	57.1	114.1	152.2	304.4	209.0	418.0	266.3	532.6
7	61.4	122.8	163.8	327.5	224.9	449.8	286.6	573.2
8	64.9	129.8	173.1	346.1	237.7	475.4	302.9	605.7
9	65.4	130.8	174.4	348.8	239.5	479.1	305.2	610.4
10	67.9	135.8	181.0	362.0	248.7	497.3	316.8	633.6
11	68.5	137.1	182.7	365.5	251.0	502.0	319.8	639.6
12	72.4	144.7	193.0	385.9	265.1	530.2	337.7	675.4

Finally, an excess realized revenue analysis performed only for the statistically reliable findings of the multivariate CTA analysis reveals that on average *each well* treated with Ozonix® will yield a total of *$82,492* more revenue than *each well* treated using Biocide *in the first two months* of post-fracturing operation. This agrees relatively closely with the two-month estimate of *$82,227 per well* that was obtained in bivariate UniODA analysis.

TECHNOLOGY DISCUSSION

Fundamentals on Expected benefits using Ecosphere's patented Ozonix® water treatment technology. Water treatment by the Ozonix® process employs a hybrid Advanced Oxidation Process (AOP) reactor, which can be effectively used for the treatment of various types of water. The reactor is based on the principle of degradation/disinfection and uses a combination of Hydrodynamic Cavitation, Acoustic Cavitation, Ozone (O3) Injection and Electrochemical Oxidation/Precipitation. The combination of different zones is based on the fundamental analysis of limitations of individual operations and hybrid reactor uses simultaneously acting mechanisms eventually giving synergistic effects.

For example, success of Ozonation alone or for that matter any chemical biocide is limited significantly due to the mass transfer limitations and/or mixing effects in the large-scale treatment. Use of Cavitation allows the generation of turbulent conditions so as to minimize the mass transfer limitations leading to exponentially better utilization of Ozone (O3) in the process. Also the combination of cavitation with Ozone (O3) is expected to generate Hydroxyl

Radicals (OH-) as well as many other oxidizing agents based on the number of radical reactions occurring in the collapsing cavity and region surrounding these cavities. Theoretical studies have demonstrated uniform distribution of the cavitational activity and enhanced generation of Hydroxyl Radicals (OH-) in the cavitation zone, as well as higher turbulence in the main reactor zone [1].

The combination of these different oxidation technologies result in enhanced water treatment ability, which can be attributed to the generation of Hydroxyl Radicals (OH-), enhanced contact of Ozone (O3) and contaminants, and the elimination of mass transfer resistances during electrochemical oxidation/precipitation. Compared to the use of individual approaches, the hybrid reactor intensifies the treatment process by 5 to 20 times, depending on the specific application.

The microscale turbulence generated due to the cavitating conditions also help in reducing the scale formation as well as enhanced flowability of the treated water. Scale formation is typically based on the calcium carbonate but also supplemented by other salts of metals such as magnesium. The microscale turbulence avoids settling of any particles on the wall responsible for scale formation and also it results in the formation of more favourable form of calcium carbonate which does not deposit on the walls. The micro jets formed due to the collapsing cavities also help in continuous cleaning of all the surfaces leading to beneficial results. Cavitation also helps in improving the flowability of the treated water based on the changes in the liquid physicochemical properties mainly the viscosity and the surface tension.

The use of Ozonix® has been successfully proven while processing fresh water sources in addition to recycled fluids at commercial sites on over 1,200 oil and natural gas wells during hydraulic fracturing operations in the United States. The superiority of the hybrid process treatments in terms of bacteria and scale reduction as well as increased water flowability and better chemical compatibility, which is a key requirement for oil and gas applications, has been reported [1].

CONCLUDING REMARKS

The present extensive research of 155 wells over a 3-year time period, establishes that the use of Ozonix® in water treatment for natural gas wells additionally results in greater productivity as measured by the greater relative frequency of high-productivity wells, and by significantly greater overall production achieved in the first two months of post-fracturing operations, compared to wells treated using liquid Chemical Biocide. In addition, when considered from a monetary (added revenue) perspective, the productivity of gas wells treated using Ozonix® is consistently superior to the productivity of wells treated using Biocide, not only in the first two months post-fracturing, but also in each of the 12 months of post-fracturing operations.

The findings reveal that when compared with liquid Chemical Biocide methods, a drilling program that utilizes Ecosphere's patented Ozonix® technology returns *$24.9 million dollars* in additional revenue per year for 100 gas wells, *$124.8 million dollars* in additional revenue per year for 500 gas wells, and *$249.7 million dollars* in additional revenue per year for 1,000 gas wells, based on the current market price of gas.

REFERENCES

[1] P.R. Gogate, S. Mededovic-Thagard, D. McGuire, G. Chapas, J. Blackmon, R. Cathey. Hybrid reactor based on combined cavitation and ozonation: From concept to practical reality. Utrasonics Sonochemistry. 21 (2014) 590.

[2] P.R. Yarnold, R.C. Soltysik. Optimal data analysis: Guidebook with software for Windows. Washington, D.C.: APA Books, 2005.

[3] P.R. Yarnold, R.C. Soltysik. Theoretical distributions of optima for univariate discrimination of random data. Decision Sciences. 22 (1991) 739.

[4] P.R. Yarnold. Discriminating geriatric and non-geriatric patients using functional status information: An example of classification tree analysis via UniODA. Educational and Psychological Measurement, 56 (1996) 656.

[5] P.R. Yarnold, R.C. Soltysik, C.L Bennett, C.L. (1997). Predicting in-hospital mortality of patients with AIDS-related *Pneumocystis carinii* pneumonia: An example of hierarchically optimal classification tree analysis. Statistics in Medicine. 16 (1997) 1451.

[6] http://www.consumersenergy.com/content.aspx?id=1254

Exhibit A

List of Sample Wells by Name

1 Allen, Arthur 09-10 8-3H34, A
2 Allen, Cecil 10-12 10-25H24, A
3 Allen, Cecil 10-12 11-25H24, A
4 Allen, Cecil 10-12 12-25H, A
5 Allen, Cecil 10-12 13-25H, A
6 Allen, Cecil 10-12 14-25H, A
7 Allen, Cecil 10-12 15-25H, A
8 Allen, Cecil 10-12 16-25H, A
9 Allen, Frank 10-01 1-24H, A
10 Barber, Jeff 09-13 10-2H3, A
11 Barber, Jeff 09-13 8-2H35, A
12 Barber, Jeff 09-13 9-2H3, A
13 Biggs 10-15 6-30H, A
14 Biggs 10-15 7-30H, A
15 Cenark Properties 09-13 4-7H, A
16 Cenark Properties 09-13 5-7H, A
17 Cenark Properties 09-13 6-7H, A
18 Collums Family Trust 10-13 15-34H3, A
19 Cornett 10-13 13-30H, A
20 Cornett 10-13 14-30H19, A
21 Cornett 10-13 15-30H19, A
22 Cornett 10-13 16-30H19, A
23 Davis 09-06 3-13H1, A
24 Davis 09-06 4-13H1, A
25 Davis 09-06 5-13H1, A
26 Davis 09-06 6-13H, A
27 Davis 09-06 7-13H, A
28 Davis 09-06 8-13H, A
29 Davis 09-06 9-13H, A
30 Edwards, Ronnie 09-14 3-15H, A
31 Edwards, Ronnie 09-14 4-15H, A
32 Edwards, Ronnie 09-14 5-15H, A
33 Edwards, Ronnie 09-14 6-15H, A
34 Flordia 10-08 10-28H33, A
35 Flordia 10-08 11-28H33, A
36 Flordia 10-08 6-28H21, A
37 Flordia 10-08 7-28H21, A
38 Flordia 10-08 8-28H21, A
39 Flordia 10-08 9-28H33, A
40 French 09-14 10-11H14, A
41 French 09-14 11-11H14, A
42 French 09-14 12-11H14, A
43 French 09-14 13-11H2, A
44 French 09-14 7-11H2, A
45 French 09-14 8-11H2, A
46 French 09-14 9-11H2, A
47 Gordon 09-06 5-25H, A
48 Gordon 09-06 6-25H, A
49 Gordon 09-06 7-25H, A
50 Gordon 09-06 8-25H, A
51 Graddy, Betty Trust 10-12 10-15H, A
52 Graddy, Betty Trust 10-12 8-15H, A
53 Graddy, Betty Trust 10-12 9-15H, A
54 Green Bay Packaging 10-08 10-13H12, A
55 Green Bay Packaging 10-08 11-13H12, A
56 Green Bay Packaging 10-08 12-13H12, A
57 Green Bay Packaging 10-08 13-13H, A
58 Green Bay Packaging 10-08 14-13H, A
59 Green Bay Packaging 10-08 15-13H, A
60 Green Bay Packaging 10-08 16-13H, A
61 Green Bay Packaging 10-08 17-13H, A
62 Green Bay Packaging 10-08 18-13H24, A
63 Green Bay Packaging 10-08 6-13H12, A
64 Green Bay Packaging 10-08 7-13H12, A
65 Green Bay Packaging 10-08 8-13H12, A
66 Green Bay Packaging 10-08 9-13H12, A
67 Harlan 09-10 2-12H1,A
68 Harlan 09-10 3-12H1,A
69 Harlan 09-10 4-12H1,A
70 Hays-Chasteen 09-07 2-36H25, A
71 Hays-Chasteen 09-07 3-36H25, A
72 Hays-Chasteen 09-07 4-36H25, A
73 Hays-Chasteen 09-07 5-36H31, A
74 Hays-Chasteen 09-07 6-36H31, A
75 Hight, Ricky 09-06 5-17H8, A
76 Hight, Ricky 09-06 6-17H, A
77 Hight, Ricky 09-06 7-17H8, A
78 Hight, Ricky 09-06 8-17H8, A
79 Hight, Ricky 09-06 9-17H8, A
80 House 09-06 8-9H, A
81 Houston 10-08 6-23H11, A
82 Howell 07-16 2-1H, A
83 Howell 07-16 3-1H, A
84 Howell 07-16 4-1H, A
85 Howell 07-16 5-1H, A
86 Hurst 08-13 6-5H, A
87 Hurst 08-13 7-5H32, A
88 Hurst 08-13 8-5H32, A
89 Hutchins 09-13 10-22H21, A
90 Hutchins 09-13 6-22H15, A
91 Hutchins 09-13 7-22H15, A
92 Hutchins 09-13 8-22H15, A
93 Hutchins 09-13 9-22H21, A
94 King 09-08 2-24H13, A
95 King 09-08 3-24H13, A
96 King 09-08 4-24H13, A
97 King 09-08 5-24H13, A
98 King 09-08 6-24H13, A
99 King 09-08 7-24H13, A
100 King 09-08 8-24H13, A
101 Lacy-Miller 08-06 1-6H31, A
102 Lacy-Miller 08-06 2-6H31, A
103 Lee, Kenny 09-13 5-27H21, A
104 Lee, Kenny 09-13 6-27H22, A
105 Lee, Kenny 09-13 7-27H22, A
106 Lee, Kenny 09-13 8-27H22, A
107 Lester 10-11 10-19H12, A
108 Lester 10-11 11-19H12, A
109 Linder 10-09 5-25H, A
110 Linder 10-09 6-25H, A
111 Linder 10-09 7-25H1, A
112 Linder 10-09 8-25H1, A
113 Linder, Perry 10-09 4-36H25, A
114 Linder, Perry 10-09 5-36H1, A
115 Linder, Perry 10-09 6-36H1, A
116 Linder, Perry 10-09 7-36H1, A
117 Linn 10-12 5-8H, A
118 Linn, Linda 08-12 3-23H14, A
119 Linn, Linda 08-12 4-23H14, A
120 Linn, Linda 08-12 5-23H14, A
121 Mayfield 09-14 6-33H21, A
122 Mayfield 09-14 7-33H21, A
123 McMillen, R L 08-14 2-34H27, A
124 McMillen, R L 08-14 3-34H27, A
125 Merryman 10-14 6-19H18, A
126 Merryman 10-14 7-19H18, A
127 Merryman 10-14 8-19H24, A
128 Merryman 10-14 9-19H24, A
129 Nelson 10-11 10-28H21, A
130 Nelson 10-11 11-28H21, A
131 Nelson 10-11 9-28H21, A
132 Prince, Judy 09-15 5-15H16, A
133 Prince, Judy 09-15 6-15H, A
134 Prince, Judy 09-15 7-15H17, A
135 Prince, Loui 09-15 5-22H10, A
136 Prince, Loui 09-15 6-22H10, A
137 Prince, Loui 09-15 7-22H10, A
138 Prince, Loui 09-15 8-22H10, A
139 Prince, Loui 09-15 9-22H27, A
140 Sneed 09-11 10-31H19, A
141 Sneed 09-11 11-31H19, A
142 Sneed 09-11 8-31H19, A
143 St. Souver 10-08 4-25H24, A
144 St. Souver 10-08 7-25H36, A
145 Ward, Blanche 09-13 3-9H, A
146 Ward, Blanche 09-13 4-9H, A
147 Ward, Blanche 09-13 5-9H10, A
148 Whisenhunt 10-12 10-10H, A
149 Whisenhunt 10-12 11-10H, A
150 Whisenhunt 10-12 12-10H11, A
151 Whisenhunt 10-12 13-10H3, A
152 Whisenhunt 10-12 14-10H3, A
153 Whisenhunt 10-12 7-10H3, A
154 Whisenhunt 10-12 8-10H3, A
155 Whisenhunt 10-12 9-10H, A

Author Biographies

Paul R. Yarnold, Ph.D.

Optimal Data Analysis, LLC

Paul Yarnold received his Ph.D. in academic social psychology at the University of Illinois at Chicago in 1984, and joined the faculty of Northwestern University Medical School (Internal Medicine) and the University of Illinois at Chicago (Psychology). Paul remained working there (primarily in the Departments of Internal Medicine, Cardiology, Surgery, Psychiatry, Emergency Medicine, Infectious Disease, Pharmacy, Physical Medicine and Rehabilitation, Geriatrics, Comparative/Translational, Cancer, and Allergy/Immunology) until 2010, when as Research Professor of Medicine, and Professor of Psychology, he left to become an entrepreneurial scientist. During his tenure he was elected as a Fellow of the Society of Behavioral Medicine, and Fellow of Divisions 5 (Measurement, Evaluation, and Statistics) and 38 (Health Psychology) of the American Psychological Association. Paul remains on the editorial boards of Perceptual and Motor Skills (Consulting Editor), and Archives of Physical Medicine and Rehabilitation (staff statistics reviewer), and in 2011 he founded the e-Journal Optimal Data Analysis. Paul co-discovered the Optimal Data Analysis paradigm; published more than 300 journal articles on a myriad of topics largely in the areas of statistics, medicine and psychology; authored three best-selling statistics books and more than a dozen software systems; obtained more than $16M in grant awards; and earned several patents. His H-index is 49, and his work has been cited in more than 11,400 publications.

Jamar Blackmon, Ph.D.

Fidelity National Environmental Solutions, LLC

Jamar Blackmon completed his B.S. in Computer Engineering, M.S. in General Engineering and Ph.D. in General Engineering from University of Arkansas, located in Fayetteville, Arkansas. The main research interests of Jamar include Artificial Intelligence, Water and Wastewater treatment, Design and implementation of Advanced Oxidation Processes (AOP) for Water and Wastewater Treatment, Water Compatibility and increased Efficiency with Oil and Gas Chemicals using AOP's for Water and Wastewater Treatment. After completing his M.S. studies in 2006 Jamar entered the Oil and Gas industry as an engineer for BJ Services, where through the years he designed and oversaw several completions operations, including: Fracturing, Cementing, Acidizing, and Coiled tubing. Jamar has an extensive knowledge of chemicals used in the Oil and Gas completions process and his research has proven that many of those chemicals can be replaced using AOP processes for water and wastewater treatment. In 2010 Jamar left BJ Services to join the Fidelity National Environmental Solutions (FNES) team, where he is currently employed. He serves as Manager of Operations and Engineering for FNES.

Parag Gogate, Ph.D.

Institute of Chemical Technology

Dr. Gogate completed his B.S. in Chemical Engineering, M.S. in Chemical Engineering and Ph.D. (Tech.) from The Institute of Chemical Technology, Mumbai, India and is also currently associated with ICT as a full Faculty in Chemical Engineering. The main research interests of Dr. Gogate include Cavitation phenomena, Wastewater treatment, Design of Multiphase reactors, Separation Processes and Process Intensification.

Dr. Gogate has published 160 research papers in International journals and has also written 14 chapters in books. Dr. Gogate is a well-cited researcher with 4750 citations and an H-index of 39. Dr. Gogate has given 45 invited talks/seminars and also participated in 11 national/international conferences. Dr. Gogate is also consultant to a few industrial organizations in the area of process intensification, process improvement and Wastewater treatment. Dr. Gogate has contributed extensively to the development of the profession by virtue of organization of refresher courses/seminars for participants from academic institutes/industries and also competitions for student community.