PENNSTATE


# Establishment of an Industry-Driven Consortium Focused on Improving the Production Performance of Domestic Stripper Wells

Sixth Quarterly Technical Progress Report for the Period 01/01/02 to 03/31/2002

By

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# DISCLAIMER

# ABSTRACT

The Pennsylvania State University, under contract to the U.S. Department of Energy, National Energy Technology Laboratory will establish, promote, and manage a national industry-driven Stripper Well Consortium (SWC) that will be focused on improving the production performance of domestic petroleum and/or natural gas stripper wells. The consortium creates a partnership with the U.S. petroleum and natural gas industries and trade associations, state funding agencies, academia, and the National Energy Technology Laboratory.

This report serves as the sixth quarterly technical progress report for the SWC. Key activities for this reporting period include: 1) release of 2002 SWC request-for-proposal, 2) organized and hosted the Spring SWC meeting in Columbus, Ohio for membership proposal presentations and review; 3) tentatively scheduled the 2002 fall technology transfer meeting sites, and 4) continued to recruit additional Consortium members.

In addition, a literature search that focuses on the use of lasers, microwaves, and acoustics for potential stripper well applications continued.

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# 1.0 INTRODUCTION

The Pennsylvania State University, under contract to the U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL) is in the process of establishing an industry-driven stripper well consortium that will be focused on improving the production performance of domestic petroleum and/or natural gas stripper wells. Industry-driven consortia provide a cost-efficient vehicle for developing, transferring, and deploying new technologies into the private sector. The Stripper Well Consortium (SWC) will create a partnership with the U.S. petroleum and natural gas industries and trade associations, state funding agencies, academia, the National Energy Technology Laboratory, and the National Petroleum Technology Office.

Consortium technology development research will be conducted in the areas of reservoir remediation, wellbore clean up, and surface system optimization. Consortium members elected an Executive Council that will be charged with reviewing projects for funding consortium co-funding. Proposals must address improving the production performance of stripper wells and must provide significant cost share. The process of having industry develop, review, and select projects for funding will ensure that the consortium conducts research that is relevant and timely to industry. Co-funding of projects using external sources of funding will be sought to ensure that consortium funds are highly leveraged.

# 2.0 EXPERIMENTAL

A description of experimental methods is required by the DOE for all quarterly technical progress reports. In this program, Penn State is responsible for establishing and managing an industry-driven stripper well consortium. Technology development research awards are made on a competitive basis. Therefore, this section is not applicable to the Penn State contracted activities. Technical reports from the individual researchers will be required to contain an experimental discussion section and will be submitted to consortium members and DOE for their review.

# 3.0 RESULTS AND DISCUSSION

During the last reporting period, the SWC focused the following: 1) release of 2002 SWC request-for-proposal (RFP), 2) organized and hosted the Spring SWC meeting in Columbus, Ohio for membership proposal presentations and review; 3) tentatively scheduled the 2002 fall technology transfer meeting sites, and 4) membership recruitment.

## 3.1 Request for Proposal Solicitation

Once each year, the SWC will solicit proposals from its membership for co-funding. Proposed and selected projects shall be consistent with the objective and goals of the SWC. Technology development will be focused on improving the production performance and shall include, but not limited to, the following areas:

- Reservoir remediation, characterization, and operations;
- Well-bore clean-up;
- Surface and collection optimization.

The SWC formally released its 2002 request for proposal (RFP) solicitation on January 25, 2002. The proposal guidelines are provided in Appendix A. The RFP was sent to the existing SWC membership, posted electronically to the Stripper Well Consortium and the Petroleum Technology Transfer Council websites, and several organizations (e.g. Oklahoma Marginal Well Commission) informed local stripper well operators of the RFP.

The proposal guidelines were made available electronically on the SWC website and hardcopies of the RFP were provided to companies on an as requested basis. The SWC proposals had a due date of March 4, 2002. The SWC received 22 proposals for co-funding consideration. The program breakdown for the 22 projects follows:

Total Project Value: $3,288,816
Amount requested: $2,083,742
% Program Cost Share: 36.7%

The Consortium proposal requests were sent the SWC Executive Council on March 5, 2002. The Executive Council was provided project evaluation guideline form to evaluate the funding requests. Appendix B contains the project evaluation form.

## 3.2 SWC Spring Meeting

The SWC organized and hosted its second Spring meeting on March 12-13, 2002. The meeting was held in Columbus, Ohio at the Adam's Mark Hotel. The meeting was dedicated to reviewing the proposals that were submitted to the SWC for co-funding consideration. Investigators of the proposed projects provided the SWC membership with a 20-minute (15 minute technical discussion, 5 minute question and answer session)

presentation. Of the 22 proposals, the Executive Council approved $1,337,374 in funding for 14 projects. Table 1 summarizes the projects that were approved for co-funding. Appendix C contains a one page executive summary for these projects. The program breakdown for the approved projects follows:

Total Project Value: $2,116,897
Amount Approved for Co-Funding: $779,483
% Program Cost Share: 37%

### 3.3 UPCOMING TECHNOLOGY TRANSFER MEETINGS

In 2002, the SWC will organize and host two regional fall technology transfer meetings. In 2002, the SWC will host a technology transfer meeting in Oklahoma City, OK and one in Pittsburgh, PA. The meeting logistics have not been finalized.

### 3.4 MEMBERSHIP RECRUITMENT

During this reporting period, nine additional full members joined the Consortium. These new members include: Anardko Petroleum Corp (Houston, TX), Murfin Drilling Company, Inc. (Wichita, KS), Markwest Hydrocarbon, Inc. (Englewood, CO), Maness Petroleum Corp. (Mt. Pleasant, MI), West Virginia University National Research Center for Coal and Energy (Morgantown, WV), T&G Technologies Inc. (Placerville, CA), Vortex Flow (Denver, Colorado), Aurora Energy (Traverse City, Michigan), and Pumping Solutions (Albuquerque, NM).

### 3.5 LITERATURE SEARCH

An extensive literature search on the use of lasers, microwave, and acoustics in stripper well applications began continued during this reporting period. Dr. Watson, of Penn State's Department of Energy and Geo-Environmental Engineering, is supervising the day-to-day activities of the literature search. A brief overview of the literature search is presented in Appendix D.

## 4.0 CONCLUSION

During this reporting period, The Consortium focused on soliciting and selecting its 2002 research activities. As the Consortium begins its second year the Consortium infrastructure is in place and is operating smoothly and a diverse membership base has been established.

## TABLE 1. PROPOSALS SELECTED FOR SWC CO-FUNDING.

| | | Project Summary | | | | |
|---|---|---|---|---|---|---|
| # | Project Title | Cost Share | Funding Approved | Project Value | % Cost Share | Project Participants |
| | | | | | | |
| 3 | Development of the Vortex Oil and Gas Unit for Downhole Applications | $21,696 | $50,000 | $71,696 | 30.3% | Lead: Vortex Flow<br>Participant: MarkWest |
| | | | | | | |
| 4 | A Low Cost Oil Water Separator for Stripper Wells | $92,620 | $75,000 | $167,620 | 55.3% | Lead: Pumping Solutions<br>Participant: RMOTC |
| | | | | | | |
| 5 | Quantification of Bypassed Gas Reserves and Badly Damaged Production Zones in Gas Stripper Wells in the Wind River Basin, Wyoming | $27,187 | $79,959 | $107,146 | 25.4% | Lead: Innovative Discovery Technologies |
| | | | | | | |
| 9 | Advanced Technology for Infill and Recompletion Candidate Well Selection | $54,000 | $125,277 | $179,277 | 30.1% | Lead: Texas A & M<br>Participant: MGV Energy, & Quicksilver |
| | | | | | | |
| 10 | Review and Selection of Velocity Tubing Strings for Efficient Liquid in Stripper Gas Wells | $24,000 | $51,510 | $75,510 | 31.8% | Lead: Advanced Resources Int.<br>Participant: Great Lakes Energy Partners |
| | | | | | | |
| 11 | Injectivity Improvement of Low Permea-bility Reservoirs Big Sinking Field, Lee County Kentucky | $73,000 | $99,000 | $172,000 | 42.5% | Lead: Surtek, Inc.<br>Participant: Bretagne |
| | | | | | | |
| 12 | Reservoir Characterization of the Wileyville Oil Field | $16,005 | $28,510 | $44,515 | 36.0% | Lead: West Virginia University |
| | | | | | | |
| 14 | Field Test of the Vortex Oil and Gas Unit in Stripper Well Flowlines | $38,386 | $71,180 | $109,566 | 35.0% | Lead: Vortex Flow<br>Participant: Belden & Blake Corp. |
| | | | | | | |
| 15 | Field Testing of New Technologies for Lifting Liquids from Gas Wells | $40,410 | $84,411 | $124,821 | 32.4% | Lead: Colorado School of Mines |

## TABLE 1. PROPOSALS SELECTED FOR SWC CO-FUNDING (CONT'D).

| | | Project Summary | | | | |
|---|---|---|---|---|---|---|
| # | Project Title | Cost Share | Funding Approved | Project Value | % Cost Share | Project Participants |
| 16 | Identification of the Effects of Corrosion on Stripper Wells | $38,475 | $85,225 | $123,700 | 31.1% | Lead: James Engineering, Inc. |
| 17 | Construct, Install, & Test GOAL Pumps in 1 Oil & 6 Gas Wells | $179,942 | $313,263 | $493,205 | 37.0% | Lead: Brandywine Energy & Development Company<br>Participants: Lenape, Artex, & TBD |
| 19 | A Method of Using the Production Pump to Continuously Clean Stripper Wells | $93,184 | $130,000 | $223,184 | 42.0% | Lead: Pumping Solutions<br>Participant: Rocky Mountain Oil Field Test Center |
| 21 | Desalting Production Water | $46,671 | $79,559 | $126,270 | 37.0% | Lead: T & G Technology |
| 22 | Field Test of the Vortex Oil and Gas Unit in Gas Gathering Systems | $33,907 | $64,480 | $98,387 | 34.5% | Lead: Vortex Flow<br>Participant: Cabot Oil & Gas |
| | **Program Totals** | $779,483 | $1,337,374 | $2,116,897 | 37% | |

The Consortium since its inception has approved co-funding for 27 projects that have a total project value of $3,632,109.84. The SWC has provided $2,242,701 in co-funding for these projects and programmatically maintains a cost share of 39%

## 5.0 REFERENCES

A listing of referenced materials is required by the DOE for each quarterly technical progress report. This technical progress for the SWC did not utilize any reference material

APPENDIX A: SWC Proposal Guidelines

# REQUEST FOR PROPOSALS FOR THE STRIPPER WELL CONSORTIUM

## Eligibility

Competition is open to all current Full Members of the Stripper Well Consortium (SWC).

University employees eligible to serve as principal investigators for consortium projects are:

Full-time regular tenure-track and regular faculty
Persons with the title of Research Assistant, Associate, Scientist or Senior Scientist

## Research Focus Areas

The mission of the SWC is to assist in the development, demonstration, and commercialization of technologies to improve the production performance of the nation's natural gas and petroleum stripper wells. Proposals are being solicited from the SWC Full Members in the following three focus areas:

*Reservoir remediation, characterization, and operations*
Examples include, but are not limited to, the identification of by-passed reservoirs/ zones, stimulation/ recompeletion of existing wells, and mitigation/ reduction of water production

*Well-bore clean-up*
Examples include, but are not limited to, dewatering, down hole separation and injection, and removal of solids such as salts, scale, and hydrocarbon precipitation.

*Surface and collection optimization*
Examples include, but are not limited to, disposal/ utilization of solid-liquid waste streams (e.g. brine), surface treatment/ measurement of gas, and pipeline usage/ maintenance and compression.

## Awards

Awards will be made on an annual basis. Subcontracts will be issued from The Pennsylvania State University to the successful applicant. The period of performance for this year's funding will be from May 15, 2002 to May 14, 2003. Members will be permitted to submit future proposals to extend the proposed work; however, this must be performed on an annual basis.

If additional documentation is required prior to issuance of a subcontract, a delay in submission of the May 15 start date may occur.

## Submission

The final deadline for receipt of proposals is 5 PM on March 4, 2002. A signed original and twelve (12) copies should be submitted to the SWC Director at the following address:

Mr. Joel L. Morrison
Director, Stripper Well Consortium
The Pennsylvania State University
C-211 Coal Utilization Laboratory
University Park, PA 16802-2323

## Proposal Format

The format for your SWC proposal follows. The proposal should be on standard 8 1/2" x 11" letter size paper with 1" margins, each copy to be three hole punched and clipped. Please do not staple the proposal. Each page of the proposal should be numbered at the bottom. The type size must be clear and legible, in standard size, 12 points. No smaller than 10 point font size will be accepted with double line spacing.

## Sections of the Proposal

The proposal shall consist of the following sections in order.

***Cover Sheet*** See Attachment B
The cover sheet along with the executive summary will be distributed to the SWC membership as part of the proposal evaluation process.

***Table of Contents*** One (1) page maximum

***Executive Summary*** One (1) page maximum
Provide a one page summary of the proposed research. The executive summary will be distributed among the SWC membership. The summary should be written in the third person and include a statement of objectives and methods to be employed. It should be informative to other persons working in related fields and understandable to a scientifically or technically literate lay reader.

***Project Description*** Five (5) page maximum
The main body of the proposal should outline the plan of work, including the broad design of activities to be undertaken. At a minimum the following should be discussed:

- Statement of the problem;
- Objectives and expected significance of the research;
- Statement of the work plan;
- Relation of the proposed work to comparable work in progress;
- Description of available facilities and major items of equipment available for the work; and reference citations.

***Project Schedule*** One (1) page maximum
A plan which establishes the time schedule for accomplishing the work. The plan should include major milestones of the project in bar chart format and should cover the complete period of performance.

***Anticipated Results*** One (1) page maximum
Discuss the commercialization viability of the proposed project. Discuss how the project will improve the production performance of domestic natural gas/ petroleum stripper wells. Identify any specific groups in the commercial sector that will use the projected results.

***Budget*** See Attachment C
The submission of a reasonable budget is an important part of the proposal.
Your budget may request funds under any of the categories listed on Attachment B so long as the item and amount are considered necessary to perform the work. Proposed equipment expenditures must be justified and are subject to program sponsor approval.

## Cost-Share Commitments

A minimum of 30% cost-share is required. Applicants are encouraged to provide more than 30% cost share. The Executive Council will be tracking the level of cost share provided in each project. Cost share, which may be in the form of cash and third party in-kind, are acceptable as part of the matching if they meet the following criteria:

- Are verifiable, necessary and reasonable for proper and efficient accomplishment of the project;
- Are incurred within the project performance period, previously expended research, development, or exploration costs are unallowable.
- Are not included as contributions for any other federal project, are not paid by the Federal Government under another award, and be otherwise allowable in accordance with applicable Federal cost principles and DOE regulations governing cost sharing.
- The value of patents and data contributed to the project is unallowable as cost sharing.

All cost-sharing commitments must be supported by appropriate documentation. Failure to provide appropriate documentation can result in the proposal being returned without review.

***Biographical Sketches*** One (1) page per person maximum
Each vitae should include educational background, professional experience, research interest, honors and professional activities.

***Collaborative Work***
All collaborations with individuals not included in the budget should be described and documented with a letter from each collaborator.

***Other***
Letters of support from outside sources are encouraged, but not mandatory.

## Treatment of Proprietary Information

Privileged or confidential commercial or financial information that the applicant does not want disclosed to the public or used by the Government for any purpose other than application evaluation, should be specifically identified by page on the proposal cover sheet.

## Proposal Evaluation/Review Process

The SWC Executive Council will review and select projects for SWC funding. The SWC Director will notify all applicants within fourteen (14) working days of the SWC meeting, by letter, of the final decision regarding their proposals.

## Reallocation of Funds/ Project Modifications

Recipients of SWC Awards will have substantial discretion to reallocate funds should changing conditions demand it. Requests for budget revisions and/or project extensions shall be submitted in writing to the SWC Director.

## Additional Information

Additional questions should be forwarded to the SWC Director. Questions should be submitted via e-mail to swc@ems.psu.edu or contact Mr. Joel Morrison at (814) 865-4802.

## ATTACHMENT A - CHECKLIST

PI _____

Project Title _____

To assure that your application is complete, please complete and paper clip (one copy only) the checklist to the cover sheet of the original (signed) copy of the proposal. Be sure the following items are included in the following order.

_____ Cover page completed and signed by PI and authorized representative.

_____ Executive Summary (one page maximum)

_____ Detailed description of the work proposed (five page maximum)

_____ Project schedule (one page maximum)

_____ Anticipated results/commercial potential (one page maximum)

_____ Budget on specified form with justification as required

_____ Cost-Share Commitments

_____ Biographical Sketches (one page per person maximum)

_____ Collaborative Documentation

_____ Letters of Support (encouraged, not required)

_____ Required number of copies (original + 12)

## ATTACHMENT B - COVER SHEET

**Proposal Submitted to**: Stripper Well Consortium
The Pennsylvania State University
C-211 Coal Utilization Laboratory
University Park, PA 16802-2308

Date of Submission _____

Title of Proposal _____

Amount Requested from SWC $ _____

Cost Share Commitments (Minimum 30% Required)
Cash $ _____
In-Kind $ _____

Total Project Costs $ _____

Principal Investigator _____

Phone: _____ Fax: _____ Email _____

Address: _____

Other Participants: _____

PROPRIETARY INFORMATION: Does this proposal contain Proprietary or Confidential Information?

_____ NO _____ YES (if yes, complete box below)

**Notice of Restrictions on Disclosure and Use of Data**

The data contained on pages _____ of this proposal are submitted in confidence and contain privileged or confidential commercial and/or financial information. Such data may be used or disclosed only for evaluation purposes. If funded, the Government would have the right or use or disclose data from this project to the extent provided the DOE/PSU Cooperative Agreement. This restriction does not limit the Government's right to use or disclose data obtained without restrictions from any source, including the proposer.

Submitted by: Approved by:

_____ _____
Signature of PI Authorized Representative

## ATTACHMENT C - BUDGET

Name of PI: _____

| | REQUESTED SWC | COST-SHARE |
|---|---|---|
| Salaries and Wages<br>List individually all personnel identified in the proposal. Include title and percent of effort<br>NOTE: The use of undergraduate and graduate students is encouraged, and appropriate.<br>The basis for proposed percent of effort or labor hours should be identified (historical hours, engineering estimates). | $ _____ | $ _____ |
| Fringe Benefits | $ _____ | $ _____ |
| Materials and Supplies<br>List types required and estimated costs.<br>NOTE: State whether amounts proposed are based on catalog prices or other cost estimating. | $ _____ | $ _____ |
| Equipment<br>Items exceeding $5,000 and 1 year's useful life are defined as permanent equipment. List item and dollar amount for each amount. Justify and/or provide quotation. | $ _____ | $ _____ |
| Travel<br>State the type and extent of travel and its relation to the project. Itemize by destination and estimated costs. | $ _____ | $ _____ |
| Publication/Information Dissemination<br>Estimate costs of documenting, preparing, publishing and sharing research findings. Show estimates. | $ _____ | $ _____ |
| Other Direct Costs<br>Itemize and justify. (*See note below) | $ _____ | $ _____ |
| _____ | $ _____ | |
| _____ | $ _____ | |
| Facilities and Administration (F&A)<br>Specify current rate(s) and base.<br>Note: A copy of the negotiated agreement should be included with the proposal. If none exists, a disclosure of the contents of the rate should be made. | $ _____ | $ _____ |
| TOTALS | $ _____ | $ _____ |

**Attach up to two additional pages of justification covering all items**.

*NOTES:

1) Purchased Services, consulting or subcontracts proposed to non-consortium members shall not be more than 2.5% of the SWC requested funding without the prior approval of the SWC program coordinator.

2) Subcontracts to current consortium members must be less than 50% of the requested SWC funding. Budgets and work statements from each subcontractor, in the format above, should be included.
3) Fees or profits will not be paid on any award resulting from this solicitation. Nor can fee or profit be considered as cost-sharing.
4) The Stripper Well Consortium will host two technology transfer workshops in the October/December, 2002 timeframe. The workshops will be held in Oklahoma City, OK and in Pennsylvania (most probable location is Pittsburgh, PA). Recipients of SWC funding must attend both of these meetings to provide a presentation on the status of their project. The costs of attending these SWC technology transfer meeting are to be included in the travel budget.

APPENDIX B: Project Evaluation Form

# PROPOSAL EVALUATION FORM

**PROJECT TITLE:**

1. **Mission Fit.** The mission of the Stripper Well Consortium is to co-fund projects that will improve the production performance of the nation's natural gas and/or petroleum stripper wells. Projects should be focused in one or more of the following technical areas: 1) reservoir remediation, characterization and operations, and 3) surface and collection optimization.

   The objectives or goals of the project with respect to clarity and consistency with SWC goals are:

   1. Very Unclear
   2. Unclear
   3. Clear
   4. Very Clear
   5. Exceptionally Clear

2. **Anticipated Results**. The proposal should discuss the potential commercialization and impact of the proposed work. The potential commercialization and impact of the project is:

   1. No impact
   2. Very small impact
   3. Moderate impact
   4. High impact
   5. Exceptional impact

3. **Project Achievability.** Projects should be achievable with respect to time and budget. Please refer to project budget and project milestone contained within the proposal. With the approach suggested and time and budget allotted, the objectives are:

   1. Not Achievable
   2. Possibly Achievable
   3. Likely Achievable
   4. Most Likely Achievable
   5. Certainly Achievable

4. **Project Methodology.** Project methodology should be clear and easily understood. The quality of the project methodology displayed in the proposal is:

    1. Well Below Average
    2. Below Average
    3. Average
    4. Above Average
    5. Well Above Average

5. **Project Budget.** Projects require a minimum of 30% cost share and show commitment from the parties submitting the proposal. Given the budget request relative to the outlined work plan, the project is of:

    1. Very Low Value
    2. Low Value
    3. Average Value
    4. High Value
    5. Very High Value

6. **Project Presentation.** Members that request co-funding have been asked to make a brief presentation to the entire consortium membership. This is to allow the membership and program sponsors the opportunity to listen and ask questions about the proposed project. How would you rate the quality of the presentation and the ability of the presenter to address questions from the membership:

    1. Very poor
    2. Poor
    3. Acceptable
    4. Very good
    5. Exceptional

7. **Project Management.** Projects should contain a management structure that is technically and logistically capable of executing the proposed work plan. The project management structure of this project is:

    1. Very poor
    2. Poor
    3. Acceptable
    4. Very good
    5. Exceptional

# Project Score Tabulation

| Criteria | Relative Weighting | Rating | Project Score |
|---|---|---|---|
| | | | |
| Mission Fit | 5 | | |
| Anticipated Results | 3 | | |
| Project Achievability | 3 | | |
| Project Methodology | 3 | | |
| Project Budget | 2 | | |
| Project Presentation | 2 | | |
| Project Management | 2 | | |
| | | Total | |

Project Score = Relative weighting x Evaluator rating

## Illustrative Example

| Criteria | Relative Weighting | Rating | Project Score |
|---|---|---|---|
| | | | |
| Mission Fit | 5 | 3 | 15 |
| Anticipated Results | 3 | 3 | 9 |
| Project Achievability | 3 | 3 | 9 |
| Project Methodology | 3 | 3 | 9 |
| Project Budget | 2 | 4 | 8 |
| Project Presentation | 2 | 4 | 8 |
| Project Management | 2 | 3 | 6 |
| | | Total | 64 |

APPENDIX C: Executive Summary for Co-Funded Projects

## Advanced Technology for Infill and Recompletion Candidate Well Selection

**Lead Organization:** Texas A&M University
**Key Contact:** Duane McVay (979-862-8466 or mcvay@spindletop.tamu.edu)
**Other Participants:** MGV Energy and QuickSilver
**Total Project Cost:** $179,277
**Level of SWC Funding:** $125,277

Quantifying the remaining potential in marginal oil and gas fields and basins is difficult due to variable rock quality, well completion, and stimulation practices, as well as databases that are inadequate for reservoir characterization. In lieu of time-consuming and expensive conventional reservoir studies, statistical analyses of production data can be used to aid in reservoir characterization and to select locations for infill drilling and wells for recompletion and restimulation.

In this project, researchers from Texas A&M University and MGV Energy will seek to develop improved technology to rapidly assess infill and recompletion potential in marginal oil and gas fields. Because most statistical methods of production data analysis have been developed for primary depletion processes, the technology will be extended to include multiphase displacement processes. This will allow the technology to be used in waterflooding projects, where many stripper oil wells are located. Statistical analysis of production data will be enhanced by incorporating seismic data, which has significant potential due to its large coverage and because such data can be related to interwell reservoir properties.

In conjunction with an operating company, Quicksilver Resources, researchers will demonstrate the utility of production data analysis in stripper oil and gas fields by applying the enhanced procedures in South Central Cut Bank Unit of Cut Bank Field, Montana. Much of this unit has been waterflooded and most active wells produce less than 5 STB/D. A primary objective of the project is to develop a specific list of infill and recompletion candidate wells and enhancement strategies for this unit. Candidates and enhancement strategies will be implemented in field tests in Year 2 of the project.

The advanced techniques developed and used in this project, techniques for rapid and cost-efficient assessment of drilling and recompletion potential, will be valuable reservoir development and management tools that can be widely applied by independent operators in stripper oil and gas fields.

## Construct, Install, & Test GOAL Pumps in 1 Oil & 6 Gas Wells

**Lead Organization**: Brandywine Energy & Development Company (BEDCO)
**Key Contact**: Paul Yaniga (610-388-3824 or YanigaPM@aol.com)
**Other Participants**: Lenape, Artex, and TBD
**Total Project Cost:** $493,205.05
**Level of SWC Funding:** $313,263

Much of the known oil and natural gas reserves of the United State are not readily or cost effectively recoverable by conventional techniques. Demand for oil is constantly increasing with an expected 30% increase in demand by 2020. US marginal oil wells currently supply less than 25% of the nations needs. Natural gas usage in the United States is expected to double[2x] over the next two decades. Tens of thousands of "Stripper Wells" lie dormant or under producing due to inefficient methods for producing the down hole fluids to the surface. U. S. natural gas stripper wells currently supply ~8% of the nations needs. These under produced oil and gas stripper wells could supply more of the existing and projected increased demand for oil and gas if more efficient methods of fluid recovery of oil and removal of brines to foster natural gas production were available to operators.

The primary objective of this study will be to concurrently construct, deploy, monitor and economically evaluate five [5] Gas Operated Automatic Lift Pumps [GOAL PetroPump][Figure#1] in under performing oil or oil/gas and gas stripper wells. Well performance/improvement will be quantified and compared to current industry standard tools and techniques. Value of improved production and reduced well service cost will be developed for use in projecting the upside economic impact on the stripper well industry.

Current testing of similar prototype tool[s] in part funded by NYSERDA & an existing SWC Subcontract #2052-BEDC-DOE-1025 has shown the technical applicability of the prototype tool with results showing greater than 60% to a two fold improvement in natural gas production from watered out gas stripper wells. This improved yield is notable in that the prototype GOAL PetroPump required less than 20% of the service needed to operate the predecessor casing swab technology deployed in the well. The main objectives of this work is to take the current grant program to an economic conclusion with multiple concurrent test in 5 wells.

The GOAL PetroPump is configured with a unique on tool pressure controlled valve. This tool/valve assembly utilizes natural down hole geologic formation pressure to automatically lift fluids to the surface. The simple elegant design of the tools on board valve control allows it to free travel with in the well bore accumulating a predetermined volume of fluid above the tool closing the self actuating valve and delivering that fluid to the surface. The tool is 'smart" in both directions, dropping down hole when pressure at the well head is low/reduced by downhole fluid accumulation. The tool further passes through a preset column/volume of fluid down hole then automatically closes the on tool valve. The tool is "smart" up hole using below tool formation pressure to lift tool and fluid [oil brine] to the surface, subsequently free floating in the well head lubricator allowing down hole pressure/gas to flow to the process unit. At such time as pressure has declined below on tool control pressure, the tool drops once again repeating the automatic pumping cycle.

This work plan will use the well survey forms developed by SWC Subcontract #2042-JE-DOD-1025 as one of the screening mechanisms for selection of candidate wells. Wells will be chosen to represent differing 'Geology, Geography and Depth'. It is anticipated to achieve the desired geographic, geologic and depth mix of wells that 3 or more well owner/operator entities may be required to provide the needed test wells. Targeted states under consideration include New York, Ohio, West Virginia, Pennsylvania, Michigan, Oklahoma, Tennessee, Kentucky, Texas or other state with stripper well production.

The project given successful application of the GOAL Tool in all wells could have significant economic impact on the industry. Preliminary research on tool applicability for gas stripper wells show some 60,000+ wells to be potential candidates for the GOAL PetroPump Tool. Average stripper gas well production was quantified at ~15MCF/D in 19971, a 60%+ improvement, as noted in preliminary tool test, on that average production applied to 60,000 wells could yield more than 197,000,000MCF/Year. At a value of $2.50/MCF for that gas it could represent more than $450,000,000 in additional gross economic benefits.

_____

[1]Interstate Oil and Gas Commission. Marginal Oil and Gas Report: Fuel for Economic Growth, 1999

## Desalting Production Water

**Lead Organization:** T&G Technologies
**Key Contact:** Timothy R. Stout (530-672-2983 or timstout@inreach.com)
**Total Project Cost:** $109,566
**Level of SWC Funding:** $71,180

T and G Technologies, Inc. (T&G), a late stage R and D Company and Principal Investigator of the project has developed improved desalination technologies which reduce significantly the cost of desalination. U.S. Patent 5,423,952, was given to Tim Stout, president of T&G and assigned to it; additional improvement patents in desalination technology are pending. A prototype has been built using the concepts disclosed in the above numbered patent and tested with satisfactory results; tests were run on the prototype by an independent consultant of world-wide reputation in the desalination industry, who stated that the possibilities of this new technology were "exciting." The target market for the equipment historically has been seawater desalination for community wide domestic drinking water.

T&G recently became aware of the saltwater problem in the oil and gas industries. It appears that Company technology has the potential to separate production water into two streams, a pure distilled stream and a concentrated stream. The distilled stream would have its suspended and dissolved solids reduced by a factor of over 1,000, easily meeting standards for surface disposal, including agricultural use. The remaining concentrated stream would need to be injected or possibly dried in an evaporation pond.

The cost to produce a barrel of the pure distilled water stream is expected to be about 12 cents to 15 cents per barrel. Desalination modules can be built in units with capacity ranging between 100 barrels and 2,500 barrels of water per day. Small units allow a module to be installed at a well-site, eliminating the need for trucking water to a disposal site. Since trucking water costs a minimum of 50 cents a barrel, reducing disposal costs down to 15 cents a barrel can be of great economical benefit to an operator.

The technology developed by T&G uses aluminum heat exchanger tubes in its distillation process. The behavior of aluminum in seawater is well known and aluminum heat exchangers have given decades of satisfactory service. However, in transferring this technology to the oil industry, two questions arise: 1) How does the corrosiveness of production water compare to that of seawater? 2) How effective are known anti-scalants in treating production water as opposed to treating seawater?

There are three goals of this project: 1) to build a demonstration unit of 125 barrel per day capacity using aluminum heat exchanger tubes based on T&G's proprietary technology and field test it at an oil well or gas well site. This would match the water output of many small stripper wells. 2) To study the corrosion rates of aluminum exposed to production water from a variety of wells and compare this to seawater as a standard. The loss of aluminum in test samples over a period of time after exposure to different waters will be determined by accurate weighing. 3) To study the effectiveness of various traditional anti-scaling compounds in treating a number of sources of production water, compounds which are known to be effective with seawater but are unknown within this environment. The anti-scalants will be tested both in the demonstration unit and with aluminum samples suspended in test pot solutions, the weight of scale build up on test pot samples will be accurately measured.

## Development of the Vortex Oil and Gas Unit for Downhole Applications

**Lead Organization:** Vortex Flow
**Key Contact:** Brad Fehn (303-343-0601 or bfehn@vortexflowllc.com)
**Total Project Cost:** $71,696
**Level of SWC Funding:** $50,000

In 2000, U.S. Patent 6,155,751 – Flow Development Chamber for Creating a Vortex Flow and a Laminar Flow was issued to Walter Prince and Darrin Lane. The patent assignee is Ecotech Systems International. The technology was originally developed to convey solids (such as coal) over long distances by creating very specific flow characteristics within a pipe carrying the material. Initial attempts were made to translate the technology to the natural gas industry but were abandoned due to lack of resources. In late 2001, Vortex Flow LLC signed an exclusive licensing agreement with Ecotech to further develop and commercialize the technology.

Initial versions of the Vortex Oil and Gas Unit (Unit) have been fabricated and field-tested in flowline applications on a very limited basis with favorable results. The unit has been shown to improve the flow characteristics in stripper well flowlines, thereby increasing well production of both gas and oil.

The proposed research program will further develop and test versions of the unit for use in downhole applications as a means of improving the production of stripper wells. The proposal calls for design and development of downhole units along with some initial testing to prove efficacy of the unit in increasing production in stripper wells. This technology should broadly apply to a vast majority of all stripper wells.

***Objectives.***

There are four key objectives of the project:

1) Complete design and development of a downhole version of the Vortex Oil and Gas Unit.
2) Fabricate downhole units for field-testing as proof of manufacturability.
3) Install and test 4 – 8 downhole units in actual operating wells to measure efficacy.
4) Collect and analyze data from design and operating tests as a basis for future design enhancements and clarification of optimal operating conditions.

***Methods to be Employed.***

- Design and test units in the Vortex Flow LLC test facility.
- Manufacture units to determine manufacturability and commercial unit costs.
- Field test units and collect associated data.
- Data analysis as a means of generating transfer and operating functions for the unit.

## Field Test of the Vortex Oil & Gas Unit in Gas Gathering Systems

**Lead Organization:** Vortex Flow
**Key Contact:** Brad Fehn (303-343-0601 or bfehn@vortexflowllc.com)
**Other Participants:** Cabot Oil and Gas
**Total Project Cost:** $99,387
**Level of SWC Funding:** $65,480

In 2000, U.S. Patent 6,155,751 – Flow Development Chamber for Creating a Vortex Flow and a Laminar Flow was issued to Walter Prince and Darrin Lane. The patent assignee is Ecotech Systems International. The technology was originally developed to convey solids (such as coal) over long distances by creating very specific flow characteristics within a pipe carrying the material. Initial attempts were made to translate the technology to the natural gas industry but were abandoned due to lack of resources. In 2001, Vortex Flow LLC signed an exclusive licensing agreement with Ecotech to further develop and commercialize the technology.

Initial versions of the Vortex Oil and Gas Unit (Unit) have been fabricated and field-tested in flowline applications on a very limited basis with favorable results. The unit has been shown to improve the flow characteristics in stripper well flowlines, thereby increasing well production of both gas and oil.

The proposed program is designed to complete a commercial evaluation of the Vortex Oil and Gas Unit technology as a means of improving the throughput of stripper well gas gathering systems. The proposal calls for field testing of actual units in controlled conditions to prove efficacy of the unit in increasing throughput in operating gathering systems.

***Objectives.***

There are two key objectives of the project:

1) Measure the efficacy of the Vortex Oil and Gas Unit when installed in a gas gathering system in a field setting.

2) Determine optimal operating conditions in gathering systems for the Vortex Oil and Gas Unit through analysis of field test data.

***Methods to Be Employed.***

- Installation of the Vortex Oil and Gas Units on an operating gathering system at various positions in the line configurations to determine optimal installation design and prove/disprove efficacy of technology application.

## Field Test of the Vortex Oil and Gas Unit in Stripper Well Flowlines

**Lead Organization:** Vortex Flow
**Key Contact:** Brad Fehn (303-343-0601 or bfehn@vortexflowllc.com)
**Other Participants:** Bleden and Blake Corporation
**Total Project Cost:** $109,566
**Level of SWC Funding:** $71,180

In 2000, U.S. Patent 6,155,751 – Flow Development Chamber for Creating a Vortex Flow and a Laminar Flow was issued to Walter Prince and Darrin Lane. The patent assignee is Ecotech Systems International. The technology was originally developed to convey solids (such as coal) over long distances by creating very specific flow characteristics within a pipe carrying the material. Initial attempts were made to translate the technology to the natural gas industry but were abandoned due to lack of resources. In late 2001, Vortex Flow LLC signed an exclusive licensing agreement with Ecotech to further develop and commercialize the technology.

Initial versions of the Vortex Oil and Gas Unit (Unit) have been fabricated and field-tested in flowline applications on a very limited basis with favorable results. The unit has been shown to improve the flow characteristics in stripper well flowlines, thereby increasing well production of both gas and oil.

The proposed program is designed to complete a commercial evaluation of the Vortex Oil and Gas Unit technology as a means of improving the production in operating stripper wells of various operating conditions. The proposal calls for field testing of actual units in controlled conditions to prove efficacy of the unit in increasing gas/oil production in stripper wells. We will also use existing technology designs as a base for a small amount of further design optimization. We will also develop a PVC version of the unit in an effort to lower the unit cost and make the technology economically viable for even the least productive stripper wells.

***Objectives.***
There are four key objectives of the project:

1) Measure the efficacy of the Vortex Oil and Gas Unit when installed in a stripper well in a field setting.

2) Determine optimal operating conditions for the Vortex Oil and Gas Unit through analysis of field test data.

3) Manufacture a low cost version of the unit from PVC material.

4) Perform additional design work to determine if design improvements are possible.

***Methods to be Employed.***

- Field tests of the Vortex Oil and Gas Units on wells of varying conditions to prove/disprove efficacy.
- Design and proof of manufacturing concept for fabrication of a low cost Vortex Oil and Gas Unit made of PVC for low-pressure applications.
- Design optimization of the Vortex Oil and Gas Unit design though testing at the Vortex Flow LLC demonstration center.

## Field Testing of New Technologies for Lifting Liquids from Gas Wells

**Lead Organization:** Colorado School of Mines
**Key Contact:** Richard L. Christianen (303-273-3965 or rchristi@mines.edu)
**Total Project Cost:** $124,821
**Level of SWC Funding:** $84,411

***Objective.***

Field-test new technologies for lifting liquids from natural gas wells, focusing on devices that use vibration, rotation, and two-fluid nozzles to produce small liquid drops.

***Motivation.***

When initially complete, many natural gas wells are capable of lifting liquids to the surface. But with depletion of the reservoir pressure, there comes a time when liquids can no longer be lifted to the surface and they begin to accumulate in the bottom of the well, dramatically inhibiting or stopping gas production. The cause of diminished liquid-lifting ability is the decline of liquid droplet production at gas flow rates below the turner-Hubbard-Dukler critical velocity.

***Specific Directions.***

In an on-going project supported by SWC, devices for stimulating droplet production are being developed in the laboratory through bench-top and flow-loop testing. The next logical stage in development of these devices is field testing. Listed below are the two proposed tasks for this stage of the project.

1. Field testing of new technologies. Using the results of the current SWC project, proceed to field testing of the most promising technologies. Choose a suitable business partner for these tests. Continue tests in the flow loop as needed to support field tests.
2. Integrated modeling of gas well production. Continue to develop numerical models that combine the complexities of two-phase flow in the wells and the adjacent reservoir with the droplet-stimulation technologies. Use these models to design and interpret field tests.

## Identification of the Effects of Corrosion on Stripper Wells

**Lead Organization:** James Engineering, Inc.
**Key Contact:** Timothy S. Knobloch (740-373-9521 or jeitsk@ee.net)
**Total Project Cost:** $123,700
**Level of SWC Funding:** $85,225

James Engineering, Inc., a petroleum engineering consulting firm in Marietta, Ohio presents the following proposal to the Stripper Well Consortium to develop and deliver a study on the effects of corrosion on stripper well operations.

James Engineering, Inc. proposes leveraging its years of experience with stripper wells combined with prior work performed for the Department of Energy to develop a procedure guide to address the effect of corrosion on the premature abandonment of stripper wells.

A prior study performed for the Department of Energy yielded the surprising fact that the largest problem contributing to abnormal production decline in stripper gas wells was the result of fluid accumulation in the wellbore. Furthermore, mechanical failures, also identified in the study, accounted for 23% of the major problems contributing to abnormal production decline. Mechanical failures were in general observed to be corrosion related, either in the surface or down hole equipment. This study proposes to develop methodologies including decision trees and a procedure guide to identify the most effective technologies for corrosion mitigation for stripper wells. The application of systematic methodologies and techniques will increase the efficiency of problem assessment and implementation of corrective measures to minimize the effects of corrosion on stripper wells. Effective corrosion mitigation and treatment methods for stripper wells will benefit every producer by increasing production and ultimate recoveries since it is one of the most common problems leading to production decline.

Field research will be conducted on several hundred wells in Ohio and West Virginia available to James Engineering, Inc. to identify critical factors affecting rates of corrosion and the methods currently employed. Specifically, wells that were identified in the previous study as experiencing mechanical failure will be reviewed in addition to wells where little or no corrosion has been observed. Previous methods of corrosion mitigation and repair will also be investigated. As a result of the filed research, a decision tree and application guide will be prepared to help operators mitigate the effects of corrosion on the production performance of stripper wells. The field research will attempt to determine when a particular type of corrosion treatment method is effective.

The culmination of the study will develop an application guide detailing potential areas of corrosion and cost effective corrosion mitigation procedures.

The results of this study will be presented at Petroleum Technology Transfer Council meetings, as a Society of Petroleum Engineer's paper to be presented at the Society of Petroleum Engineers Eastern Regional Meeting, and on the Internet.

## Injectivity Improvement of Low Permeability Reservoirs in Big Sinking Field, Lee County Kentucky

**Lead Organization:** Surtek, Inc.
**Key Contact:** Malcolm J. Pitts (303-278-0877 or pitts@surtek.com)
**Other Participants:** Bretagne
**Total Project Cost:** $172,000
**Level of SWC Funding:** $99,000

Mature oil fields offer the operator two choices: plug and abandon wells that are no longer economic, or increase oil production to levels at which wells are profitable. Abandonment leaves the operator with no future options. The objective of this study is to develop a low cost technique that operators can use to improve oil production and, therefore, profitability.

Big Sinking oil field in Lee County, Kentucky is a mature oil field. It's waterflood is approaching the end of its economic life. The percent of oil produced at each well is low while the percentage of water is high. One way oil production can be increased is by increasing the volume of total fluid produced. Total fluid produced is usually directly related to the volume of water injected in a waterflood. However, Big Sinking oil field is a low permeability reservoir so water injection rates cannot simply be increased without some intervention.

A second method to increase oil production is to inject a solution into the reservoir that alters the affinity of the reservoir rock for oil and treating the entire reservoir. Both methods to improve oil production can be achieved by decreasing the oil saturation. The difference is the volume of reservoir treated.

Bretagne and Surtek are proposing to increase the rate of water injection by decreasing the oil saturation near the injection well bore. Decreasing the oil saturation will stimulate the rate at which water flows into the formation by increasing the net cross sectional area occupied by water. A larger water cross sectional area increases the effective permeability to water and, therefore, injection rate. Oil saturation around the injection well will be decreased by injecting an interfacial tension lowering chemical solution. Treatment volume will be approximately 50 ft around the well where the majority of the injection pressure is developed. The relative permeability to water will be increased by reducing the oil saturation near well bore.

The technology will be applied in Big Sinking oil field by studying the waterflood performance in the field, and selecting an area for a field test and taking a core. The core and reservoir fluids will be used in a series of laboratory experiments to develop a low interfacial tension solution. Fluid-fluid testing and coreflood evaluations will be performed to define the optimum solution for decreasing oil saturation near the injection well bore. Finally, a field test will be performed to demonstrate injectivity improvement by injecting an interfacial tension lowering solution.

A successful demonstration project could significantly increase the oil production from stripper wells by providing a method to increase water injectivity and, therefore, total produced oil plus water volume.

## A Low Cost Oil Water Separator for Stripper Wells

**Organization:** Pumping Solutions
**Key Contact:** Leland Traylor (505-933-4653 or Leland@psipump.com)
**Other Participants:** Rocky Mountain Oilfield Test Center
**Total Project Cost:** $167,620
**Level of SWC Funding:** $75,000

Separating the oil from the water downhole has many advantages, such as a significant education in surface equipment, energy savings and environmental protection. For years, many approaches to downhole separation have been tried, some coupled with downhole water disposal. Most efforts have been focused on wells that produce large volumes, and use Electrical Submersible Pumps (ESPs) coupled to hydrocyclone separators. Other approaches using dual acting pumps and gravity separation have been aimed at lower production rates but have not found wide acceptance for most stripper wells because of high costs in excess of $15,000 per installation.

The use of low volume ESPs that have recently come on the market allow for a whole new class of downhole separators, called tubing separators. A tubing separator uses the volume of the production tubing between the pump and the surface as a gravity separator, allowing the oil to separate from the water after it pumped, instead of before. This technique allows the use of a single pump that operates conventionally, injecting the mixture of oil and water into the tubing at a point near the vertical center of the tubing separator, allowing the water to accumulate toward the bottom, oil toward the top. These tubing separators are amazingly cheap. They can be built for less than $100, because they use the production tubing as the majority of the structure and are mechanically very simple.

This project will build this new design and evaluate it under test well and field conditions. The field testing will be conducted at the Rocky Mountain Oil Field Test Center under an existing CRADA formed to test submersible pumps. Because this test program is part of an ongoing test program at RMOTC, it will be “piggybacked” on the existing CRADA at no cost to the project. When completed, this separator design and the results of the testing will be made available to the stripper well community at no cost, with plans posted on the Internet. If successful, stripper well producers will, after the completion of this project, have the ability to deploy a fully developed, fully tested, practical downhole separation system that costs less than $100 to build.

## A Method of Using the Production Pump to Continuously Clean Stripper Wells

**Lead Organization:** Pumping Solutions
**Key Contact:** Leland Traylor (505-933-4653 or Leland@psipump.com)
**Other Participants:** Rocky Mountain Oilfield Test Center, To be announced
**Total Project Cost:** $223,184
**Level of SWC Funding:** $130,000

Almost all oil and gas wells will produce sand and other debris along with formation fluids. Add to that scale, gypsum, and paraffins of various types, and you have a typical situation where solids concentrations and accumulations must be reduced to produce the well effectively. Traditional approaches use chemicals, well bailing, scraping and other periodic treatments to deal with the problem. These traditional approaches are relatively expensive and almost always lead to production disruptions as the well is brought off line.

A better approach is to use a new type of pump based on a hydraulically driven diaphragm, has proven to be very tolerant of debris, and has allowed placement of the pump inlet below the perforations in sandy wells. This low placement has dramatically increased production of sand and other debris through the pump, and into the tubing.

A logical extension of this phenomenon would be to produce the debris to the surface, where it could be removed without taking the well out of service or employing any additional equipment or expense. To do this, this project proposes the use of small diameter reinforced plastic tubing that increases pumped fluid velocity in the tubing to sweep debris to the surface where it can be removed. This process would also allow for greater well drawdown due to the lower placement of the pump in the well, which would increase production, and the use of light weight wire-line equipment to place the pump in the well and perform workovers.

The direct result will be a large reduction in the cost of operations to the stripper well producer, leading to a reduction in abandonments, and higher profits. This system can be used over a wide variety of well conditions and flow rates, making it usable in practically every stripper will in the country. The system is made from materials readily available in the field, using techniques already employed in the field such as wire-line deployment. It is very simple and robust, building on new, but already proven pump technology. This idea, which is relatively simple and easy to implement, will if successful, have an immediate and substantial impact on the viability of stripper well operations in the United States and world wide.

## Quantification of Bypassed Gas Reserves and Badly Damaged Production Zones in Gas Stripper Wells in the Wind River Basin, Wyoming

**Lead Organization:** Innovative Discovery Technologies
**Key Contact:** Ronald C. Surdam (307-745-4464 or rcsurdam@idt-gti.com)
**Total Project Cost:** $107,148
**Level of SWC Funding:** $79,959

Many gas stripper wells in the Rocky Mountain Laramide Basins (RMLB) result when an underpressured section occurs between normally pressured rocks above and overpressured rocks below. Operators typically use an overcompensated mud program as they approach the transition from normal to anomalous pressure, in anticipation of overpressuring, which results in gas-charged, underpressured rock/fluid systems being badly damaged or bypassed. The Innovative Discovery Technologies (IDT) team has observed this scenario in 30 of 45 wells studied in the Wind River (WRB) and Green River (GRB) basins.

The essential problem is how to delineate underpressured, gas-charged rock/fluid columns just below the regional velocity inversion surface in the WRB. This basin was chosen for study because the following data are available to IDT: (1) ~3000 mi of 2-D seismic lines; (2) 200 log suites and thousands of mud logs and DSTs; and (3) U.S.G.S. depositional models and detailed analyses of the stratigraphic frameworks.

This work will include the following tasks: (1) isolate those portions of the Lance (uppermost Cretaceous) and Fort Union (lowermost Tertiary) formations below the regional velocity inversion surface characterized by anomalously slow sonic/seismic interval velocities (i.e., gas-charged rock/fluid systems); (2) construct a 3-D volume of gas-charged rock/fluid systems; (3) integrate mud logs and DSTs with the volume to determine underpressured areas; (4) determine the spatial distribution of commercial gas reservoirs in the study interval; (5) determine where Lance-Fort Union potential reservoir rock volumes intersect the underpressured gas-charged volume; and (6) evaluate the size of the unexploited gas resource in underpressured, gas-charged sections of the Lance-Fort Union reservoir volume by approximating petrophysical properties of the Lance-Fort Union clastic reservoir rocks.

The results from the project will allow operators to:

- Determine the size, configuration, and importance of underpressured, gas-charged hydrocarbon resources beneath the regional velocity inversion surface in the WRB;
- Delineate sections likely to contain badly damaged or bypassed productive zones;
- Design new drilling and completion strategies that will allow the maximum gas production from underpressured, gas-charged reservoirs; and
- Determine the potential for similar assets in RMLB other than the Alberta and San Juan basins.

## Reservoir Characterization of the Wileyville Oil Field

**Lead Organization:** West Virginia Geological Survey
**Key Contact:** Douglas G. Patchen (304-594-2331 or patchen@geosrv.wvnet.edu)
**Other Participants:** East Resources
**Total Project Cost:** $44,515
**Level of SWC Funding:** $28,510

The Wileyville field in northern West Virginia is one of about two dozen fields in southwestern Pennsylvania and West Virginia that have produced oil from the Upper Devonian Gordon and Gordon Stray sandstones. A line drive water injection project in that field started producing oil only after approximately 5 million gallons of water were injected starting in February 1997.

Proposed work will establish the nature and degree of heterogeneity within the Gordon interval in Wileyville field through reservoir characterization, and evaluate any uphole potential. The product will be a three-dimensional model of depositional and lighologic units within the field. Work performed will comprise nine tasks: data acquisition; analysis of field development; geophysical log digitization; core description; measurement of permeability in cores; defining lithologic and depositional units; determining electrofacies; identification of types and scales of reservoir heterogeneity and compartmentalization; and determining uphole potential.

The study will complement current work on the Wileyville field being carried out by Dr. Robert Watson at Pennsylvania State University with funding from the Stripper Well Consortium. New data made available to the proposed project will include a core of the Gordon interval from a new well; geologic study of this core forms part of work to be performed.

Detailed knowledge of lithologic units, depositional units, electrofacies, and reservoir heterogeneity will help geologists and engineers explain trends in production, guide the placement of future injection and production wells; uphole potential discovery and completion could improve the economics of marginal wells.

## Review and Selection of Velocity Tubing Strings for Efficient Liquid Lifting in Stripper Gas Wells

**Lead Organization:** ARI
**Key Contact:** George J. Koperna, Jr. (703-528-8420 or gkoperna@adv-res.com)
**Other Participants:** Great Lakes Energy Partners, LLC
**Total Project Cost:** $75,510
**Level of SWC Funding:** $51,510

For low-productivity (stripper) gas wells, the accumulation of liquid in the wellbore can be detrimental to the well's productive life. Quite often, the operator may turn to means other than the natural reservoir energy to lift the accumulated fluids. These may include mechanical pumping, adding wellhead compression, plunger lift, gas lift, soaping, siphon strings or a variety of other methods that can require significant capital investment as well as increased operating costs and equipment maintenance. However, the installation of smaller diameter tubing strings (velocity tubing), if properly identified, can minimize cost while improving well productivity.

When using small diameter completion strings (<3 inches), large pressure drops that can be associated with two-phase (gas-liquid) flow in the tubing and the potential lack of tensile strength may be important factors to consider. Nonetheless, for stripper gas wells, the impact of frictional losses may be minimal due to the well's small production rate while the implementation of coiled tubing may provide the strength necessary for deeper and smaller applications.

Today, the production engineer has a wide-variety of small diameter completion options at his disposal. These include tubing or coiled tubing applications. However, a comprehensive source of performance data and alternatives for use in optimizing the liquid lifting methodology may not be readily available.

This project proposes to survey tubing and coiled tubing suppliers in order to obtain performance measures such as the outer diameter, wall thickness, thread type (tubing), relative roughness and tensile strength for compilation into a stand-alone reference. In addition, regional availability of tubing and coiled tubing providers as well as inventory will be determined.

Further, literature will be reviewed to identify those two-phase correlations that are most applicable for stripper gas wells and small diameter production tubing. This review will serve as the basis for the construction of liquid lifting performance curves for use in sizing tubing strings for low rate gas wells. Also, general guidelines for use in selecting the liquid lifting technique that best fits an operator's given well condition will be provided in the form of a decision matrix.

The project team will test the liquid lifting performance curves on a candidate pool of wells provided by Great Lakes Energy Partners, LLC. From this pool, three test wells will be chosen. These test wells will have their existing completion string pulled in order to install a smaller diameter tubing string. Well production will be monitored for the remainder of the project to verify gas production and liquid lifting capability. At the end of the project, the Consortium will be provided with a comprehensive report including a table of tubular and coiled tubing performance data, liquid lifting performance charts and a the liquid lifting technology decision matrix.

APPENDIX D: Literature Search

**Prepared by:**
Mr. Abdallah Sadegh

The Pennsylvania State University

# Application of Lasers, Microwave and Acoustics to Stripper Wells and Other Oil/Gas Applications

**Progress Report**

**Prepared by:**

**Abdallah A. Sadegh**
**The Pennsylvania State University**

## Overview

The progress that has been made in collecting, summarizing, and analyzing literature during the past quarter will be presented in this report. First, the interaction of acoustic waves with a porous medium will be described. Second, the conclusions drawn from an extensive survey of the use of acoustic energy for stimulation of marginal wells will be presented. Finally, planned future work will be outlined.

## A Brief Background on Acoustic Stimulation

Acoustic energy results from the transformation mechanical energy to sonic or ultrasonic waves. Acoustic waves only propagate through a media, which is elastic. The propagation of such a wave provokes oscillation of the elements of the medium. The oscillation amplitude decreases until the elements revert to their equilibrium state.

The propagation of these elastic waves through a fluid saturated porous medium causes several important outcomes. The pressure generated due to the energy dissipation can cause the mechanical destruction of undesired formations of matter that are blocking the flow of fluid from the rock matrix to the wellbore. As a result, frequently encountered deposits such as drilling muds, scales, paraffin, asphaltenes, salt, and polymers can be removed. Also, the removal of fines can occur at the previously mentioned conditions. The removal occurs if the pressure is high and is localized. Other desirable outcomes that occur at lower pressure include increased permeability to oil, more efficient displacement of oil by water or gas, mobilization of stagnant oil droplets. The following section will discuss the conclusions reached from reviewing various reported laboratory and field data that definitively show the positive results of stimulation.

## Conclusions

Although enough empirical data is available to show that acoustic stimulation causes beneficial results, the mechanisms by which this phenomenon occurs are not well understood. Most of the reported investigations provided little or no explanations to the observations. Also, The fundamental understanding of this physical phenomenon is partial at best. The formulation of sound mathematical models has been attempted but more work is needed to verify the validity of the presuppositions imbedded in the development of these important developments. One can make a clear correlation between this partial understanding and the wide range of reported outcomes of various laboratory and field tests.

It is important to state that this phenomenon is very complex. The parameters listed below are some of the many that have contributed to the reported observations:

- Characteristics of the hydrocarbon bearing formation
- Intensity distribution of the acoustic field
- The frequency of the waves
- The presence of natural geological anomalies such as faults and fractures
- The saturation distribution of the water, oil, and gas phases
- The conditions of thermodynamic equilibrium under no stimulation and the changes due to stimulation
- The mode of operation of the stimulation device (pulsed, continuous, localized, etc.)
- The method of coupling of the device with the rock formation
- The characterization of flow inhibitors

As a result of the complexity of this phenomenon and of the previously mentioned gaps in the work performed in previously investigations, several recommendations are proposed to advance this technology

**Recommendations**

- Work towards having a better understanding of the physical fundamentals that contribute to this phenomenon
- More in-depth analysis of the available literature to identify the mechanisms at work and to determine the necessary laboratory work necessary to validate that these mechanisms are in fact causing the observed outcome
- After sufficient work has been done in the two previously mentioned areas design of the next generation of prototypes of simulation tools can commence
- It is clearly advantageous to exploit computer modeling both to reduce the cost of the experimental work as well as to aid in the selection of the optimum scenarios for field tests, and also to predict the outcomes based on the data available prior to the testing.

**Future work**

Our group at Penn State has commenced an in-depth analysis of the available experimental data from previous investigations on acoustic stimulation. Also, We have started an investigation of the reported literature on the use of lasers for applications in the oil and gas industry.