

***Implementation Benefits of the
IQ Solar-Electric Chemical Injection Pump -
Propane Driven Pumps in Sour Gas Applications***

Prepared by:

MCI Solutions, Fort St. John, B.C.

Table of Contents

1	Executive Summary	- 3 -
1.1	Overview	- 3 -
2	Introduction	- 3 -
2.1	History	- 3 -
3	The Task – Innovate Field Operations.....	- 4 -
3.1	Mechanical Driving Force – Venting Gas.....	- 4 -
3.2	Compression Packing	- 5 -
3.3	Primary Seal Technology	- 6 -
3.4	Metering Accuracy	- 6 -
3.5	Brushed DC Motor	- 6 -
3.6	Electrical Motor Control.....	- 6 -
3.7	Component Design	- 7 -
3.8	Bulk Injection.....	- 7 -
3.9	Flow Volume.....	- 7 -
3.10	System Configuration.....	- 7 -
3.11	Optimization	- 7 -
4	The Solution – Technological Advancement.....	- 8 -
4.1	Vented Gas	- 8 -
4.2	N-Seal	- 8 -
4.3	Chemical Containment.....	- 9 -
4.4	Metering Accuracy	- 9 -
4.5	Brushless DC motor	- 9 -
4.6	Electronic Motor Control.....	- 9 -
4.7	Plug and Play Design.....	- 9 -
4.8	Continuous Injection.....	- 10 -
4.9	Flow Volume.....	- 10 -
4.10	System Programming with CS	- 11 -
4.11	Well Optimization	- 11 -
5	The Financial Analysis	- 11 -
5.1	Capital Cost.....	- 11 -
5.2	Accumulated Savings.....	- 12 -
6	Recommendation	- 13 -
6.1	Annual Cost.....	- 13 -
6.2	The N-Seal Alternative.....	- 13 -
7	Implementation.....	- 14 -
7.1	Installation Time	- 14 -
7.2	Installation and Commissioning	- 14 -
7.3	Delivery Lead-time	- 14 -

1 Executive Summary

1.1 Overview

Pipeline injection of various production enhancement chemicals is crucial to an uninterrupted flow of product to market. Industries worldwide have benefited from system performance improvements through evolution and innovation. This is equally true of positive displacement Chemical Injection Pump technology for the oil and gas industry.

Responsible stewardship of our Planet is front and centre. In the past, operations could result in chemical leaks, drive gas venting and surplus chemical injection. Today these environmental concerns can be greatly reduced or eliminated with the deployment of currently available and field proven technology.

The use of Solar-Electric powered Chemical Injection pumps and retrofitting N-Seal Adaptors can save thousands of dollars per pump per year, reduce/ eliminate environmental discharging, increase chemical delivery performance and pay for their implementations within months. Further these savings are cumulative amounting to \$100,000s over the life of each well.

2 Introduction

2.1 History

Remote oil and gas pump locations in Canada offer numerous technical challenges for pneumatic positive displacement Chemical Injection (CI) Pump technology. Powering the pumps with conventional electricity is very often unfeasible or prohibitively expensive. Pump design has been equally challenging. Historically the use of a V-packing seal or compression packing, designed to seal the metering plunger and prevent chemical leaks, results in many reoccurring problems.

Traditionally sweet gas wells provide the pneumatic “drive gas” to power chemical injection pumps. In sour gas well applications sweet gas is piped in or propane is imported to site, at considerable added cost, to power the pumps. In all cases the drive gas is then vented directly to the atmosphere. Historically these drive gas solutions were readily available, cost effective and technically sound. However heightened environmental concerns and technological innovations have made these practices questionable.

Conventional compression packing results in ongoing maintenance, chemical leaks and pump stalls. Operators have learned to cope with these inherent negative traits. However they do result in an overall decrease in effective time management resulting in a decreased focus on more important maintenance tasks.

3 The Task – Innovate Field Operations

The evolution of pneumatic positive displacement Chemical Injection (CI) pumps has resulted in a solar- electric solution. Further developments led to significant refinements in compression packing, chemical delivery volume accuracy and power efficiencies.

- 3.1 Conventional CI pumps require a mechanical driving force to actuate the plunger and deliver the measured chemical. Traditionally this is provided by electricity, where available, sweet gas from the pipeline, or, in the case of sour gas wells, compressed air, piped sweet gas or propane trucked to site. Unfortunately the drive gas, once used, is vented directly to atmosphere.
- The environmental cost of venting gas directly to the atmosphere will be debated by scientists and politicians for years. However there will be some absolutely irrefutable conclusions: i) industry will be blamed, ii) industry will be charged with the responsibility to create the very best alternative solution and iii) industry will be penalize for noncompliance.
 - The financial cost of venting drive gas is easily quantified. In the case of a Texsteam 5100 style gas-driven CI pump using propane, excluding the transportation to site cost, the consumption rate can be as much as 1.0 mmcf per year for each non-optimized pump. Assuming a propane price of \$0.60 CDN per litre (1L = 10 scf) this will result in an operating cost, per pump, of **\$60,000 per year**.

Piston Size	Strokes per Minute	Litres of Methanol per Day	Scf Required per Litre	Scf per Day	Cost of Propane per Day	Cost of Propane per Year
1/4 "	6	8	66	546	\$ 32.76	\$ 11,957
	12	11	66	744	\$ 44.64	\$ 16,293
	18	17	66	1116	\$ 66.96	\$ 24,440
	24	23	66	1488	\$ 89.28	\$ 32,587
	30	26	66	1736	\$ 104.16	\$ 38,018
3/8 "	6	11	39	444	\$ 26.64	\$ 9,723
	12	23	39	888	\$ 53.28	\$ 19,447
	18	38	39	1480	\$ 88.80	\$ 32,412
	24	53	39	2072	\$ 124.32	\$ 45,376
	30	62	39	2442	\$ 146.52	\$ 53,479
1/2 "	6	23	15	342	\$ 20.54	\$ 7,497
	12	47	15	713	\$ 42.78	\$ 15,614
	18	68	15	1026	\$ 61.56	\$ 22,469

Cost of operation assumes a propane cost of \$0.60 CDN per 1L. Additionally, 1L of propane equals 10 scf. Calculations based on 1" stroke at 500 psi injection pressure and an optimized pump. Analysis based on Texsteam brochure (7.07) and converted to propane.

Table 1 – Texsteam 5100 Series **PROPANE** Consumption Cost Analysis

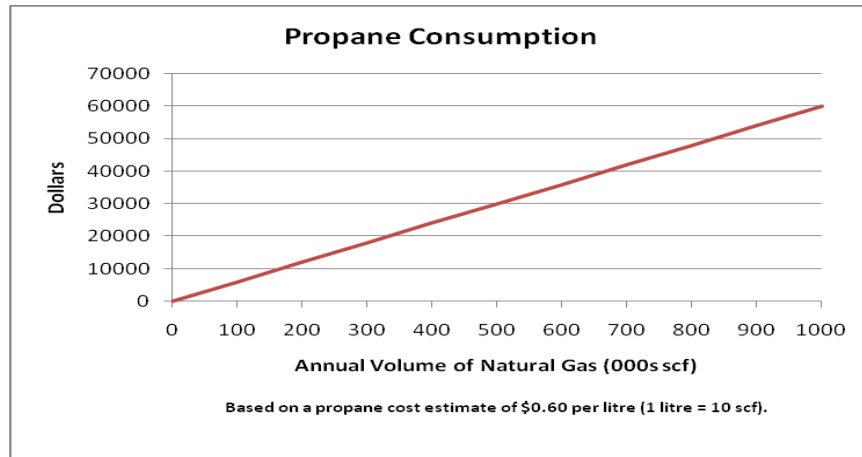


Chart 1 – Annual propane consumption versus cost.

- Natural gas or propane powered compressed air can be used onsite to provide the pneumatic drive force for CI pumps. However the environmental and financial costs of this method must be considered in accessing the overall fitness of compressed air.

3.2 Compression packing is a seal accomplished by tightening a gland along the top ring of a stuffing box that squeezes against the pump’s plunger. Packing is employed to prevent the flow of chemicals outside the closed injection system. There are a number of inherent shortcomings with this design:

- A compression seal cannot provide constant pressure. Over time the seal pressure is reduced on the plunger resulting in chemical leaks. Generally additional maintenance is employed in one of two leak prevention methods: i) when leaks are physically evident the compression ring is tightened, or ii) the compression ring is tightened on a regular basis without evidence of leakage. In either case, when properly adjusted, packing seals can leak upwards of 50 litres (125mL per day) of chemicals per year. Wear through normal use will allow substantially more to escape as “leakage.” The overall cost of discarding production chemicals will vary depending upon your commitment to environmental stewardship.
- To overcome the additional fiction, as a result of the over compressed packing, the stroke rate is increased in an effort to reduce the likelihood of “stalling.” The resulting increased stroke rate delivers more chemical than required thereby increasing costs. A conservative estimate is 1 litre of additional chemical per day. Chemical costs vary widely but an average cost of \$2 per litre is conservative. The resulting added cost is over **\$600 per year**. Again, the overall cost of injecting excess production chemicals into the pipeline will vary depending upon your commitment to environmental stewardship.
- In less than ideal cases the over tightened ring can stop, or stall, the pump entirely. The losses of production enhancement chemicals will result in corrosion, increased deposit formation, increase unscheduled maintenance and, eventually, stop the flow of product to market entirely.
- CI pumps will leak toxic chemicals through the compression packing creating unsafe working environments and increased maintenance costs.

- 3.3 Primary seal technologies (packing, O-ring, etcetera) will leak over time. This is consistent throughout the industry. Pump force exerts tremendous pressure on the seal, hundreds or thousands of pounds per square inch. However, of critical importance is how the technology recovers this leak.
- Leaking pumps will: i) inaccurately deliver production enhancers potentially shutting down the flow of product, ii) waste chemicals thereby increasing costs, iii) pollute confined working environment endangering operators, and iv) increase maintenance costs through leak/ spill cleanup. These issues will result in several hundred to thousands of dollars in additional operating cost.
 - Without a leak containment system, leaking CI pumps may be subject to intervention by the Oil & Gas Commission.
- 3.4 Metering accuracy at low chemical volume has become a target of cost conscious, environmentally sensitive installations. Generally pump technology currently employed in the field today cannot meter accurately enough to deliver low volumes (< 1 litre) of production enhancer and guarantee pump operation stability – prevent stalling.
- Current “best practices” involve increasing drive gas pressure to guarantee production enhancer delivery and ensure pump reliability. This process delivers excessive chemical to the pipeline and vents excessive drive gas to the environment. Unfortunately this wasteful practice increasing costs.
- 3.5 Solar-electric CI pumps use a DC (direct current) motor. Most common is the brushed DC motor. The term brushed refers to the method in which the motor generates the torque necessary to do work.
- Inherently brushed motors have a reduced initial cost. Unfortunately they also require more maintenance including regular replacement of brushes, springs and the commutator. An additional disadvantage is low life-span for high intensity uses.
 - High motor current draw from the batteries reduces the autonomous runtime of solar-electric systems. To overcome this effect many manufactures simply add batteries, and eventually solar panels, to replenish the added batteries, in an effort to meet the application requirement. These technical alterations increase cost.
 - The key to minimizing motor problems is scheduled routine inspection and service. Brushed DC motor may require additional or more frequent attention if a breakdown would cause severe loss of production.
- 3.6 For many years electrical motor control (on/ off) has been accomplished by contactors (often referred to as relays or starters). These mechanical devices are useful but do have associated weaknesses.
- Moving parts such as electrical contacts require regular inspection to ensure they are not worn. These devices have been prone to welding or sticking in the “on” position. This would cause the continuous operation of the CI pump resulting in a waste of production enhancer through excess chemical delivery

and eventual depletion of the storage tank. Additionally the battery system drainage, in the case of solar-electric systems, would result in a CI pump system shutdown.

- 3.7 Plug and play component design enhances system functionality and should be considered a tangible asset when determining the overall cost of system maintenance. When technology advancements are made is the system receptive to field retrofitting? Can you maintain a minimal spare parts site inventory while ensuring production reliability?
- Costs associated with the removal and re-installment of pump components for repair/ maintenance, firmware upgrades and mechanical retrofitting will vary greatly depending on the engineered design. To assume that all systems are created equally advantageous for operators and technicians will result in disappointment.
- 3.8 Bulk injection of the production enhancing chemical results from the CI pumps inability to control volume versus time. Traditional brushed DC motors used in solar-electric pump solutions operate at a fixed speed. To accommodate the injection of small amounts of chemical the motor is started and stopped many times per day. This operating style “bursts” chemicals into the pipeline for brief periods followed by long periods in idle. These bursts occur at a typical rate of approximately 1-5 seconds “ON” per minute.
- The bulk injection technique results in a less effective dispersion method for combining the production enhancer with the well product. The resulting intermittent injection pattern could result in an increased chance of pipeline corrosion, product contaminants and a well shutdown.
- 3.9 Flow volume is inversely proportional to pressure at constant power consumption. Therefore solar-electric CI pumps can deliver 400 litres of chemical per day at low pressure or they can inject into a 5000 psi pipeline at low volume. However it is uncommon for the same cost effective pump to supply both high volume and high pressure simultaneously.
- For solar-electric CI pumps to produce an injection solution that is both high pressure and high volume would require the addition of vast amounts of extra batteries and solar panels. In most cases the resulting solution would prove to be prohibitively expensive.
- 3.10 System programming represents a key aspect of today’s automated chemical delivery systems. To effectively evaluate a CI pump the programming methodology should be consider among the critical features.
- Counting blinking lights, properly selecting DIP switches or referring to some arcane nomenclature to effectively implement and maintain systems is part of a vanishing past. Technical procedures that require the operator to recall these programming techniques months later are costly, frustrating and potentially dangerous.
- 3.11 *Well* specific optimization fine-tunes a CI pump package. This method effectively integrates discharge pressure and chemical flow volume.

- Power consumption is significantly reduced after the optimizing procedure. Alternatively, during harsh Canadian winters, additional power system resources can be added to the solar-electric skid – extra batteries and solar panels. However this will result in additional cost.

4 The Solution – Technological Advancement

4.1 Vented gas from one propane gas-driven chemical injection (CI) pump can account for tens of thousands of dollars in operating cost per year (see [Table 1, page 4](#)). Responsible oil and gas corporations have been the driving force in developing a solution. Industry willingness to adopt innovated technologies resulted in the solar-electric CI pump. On the drawing board this technology is ideal – total elimination of drive gas.

- MCI Solutions IQ Solar-electric CI pumps are standalone units with zero drive gas emissions. They operate on DC voltage generated by solar panels and stored in deep cycle gel batteries.

4.2 Compression packing will add thousands of dollars in unnecessary annual costs per CI pump – chemical over injection and leaks, added drive gas consumption due to excessive plunger friction, and unscheduled maintenance (leak containment/ cleanup, compression ring tightening, packing replacement, and chemical tank recharging).

- MCI Solutions has developed and patented unique plunger seal technology that entirely eliminates compression packing – the *N-Seal*. The cost reducing benefits to the oil and gas industry from this proprietary technology are clear:
 - i) Virtually zero chemical leaking to the environment,
 - ii) 50% less drive power to operate due to 90% less friction than conventional packing, and
 - iii) Zero unscheduled maintenance.

N-Seal technology is integrated into all MCI CI pump solutions. Additionally **conventional gas-drive pumps (Arrow, Bruin, Texsteam, etc) can be field retrofitted with N-Seal adaptors resulting in the same benefits listed above**. Under normal conditions N-Seal will pay for itself in weeks.

- Ideally an adjustable compression ring keeps the packing at a pressure sufficient to maintain the seal without adding excess resistive force to the plunger. In practice, often, the ring is grossly over tightened to prevent chemical leaking. The resultant increased friction on the plunger restricts its movement. Additional force is then required to operate the pump – increased drive gas, added cost. For example, consider two identically configured CI pumps. One set to operate at 5 psi and one at 25 psi drive gas pressure. When we adjust them for atmospheric pressure (14.7psi) we can see that there is a 50% reduction in operating consumption. Taking an average annual gas consumption of 0.50 mmcf (1370scf / day) at \$0.60/CND per 1 litre of propane (1L = 10scf) we see a total **annual savings over \$30,000**.

- 4.3 CI pumps employ a primary seal – compression packing. It is a physical barrier designed to ensure that pressurized chemical does not escape to the environment. Unfortunately its containment characteristics are limited (see [section 3.2 and 3.3, page 5](#)). Once the primary seal is breached chemical leaks occur.
- The MCI Solutions' N-Seal uses reliable, long-lasting, spring energized chemical seal technology to offer a true containment solution. A small amount of primary seal (high pressure) chemical bypass is expected throughout the life of the seal. N-Seal integrates the industry's first *secondary containment seal*. Bypassing chemical is captured in a low pressure chamber. From there it is reintroduced into the injection system. This process virtually eliminates all environmental concerns surrounding CI pumps.
- 4.4 CI pump metering accuracy should be a point of precision, not concern. Annual cost savings are realized by the exact delivery of the production enhancer, reduced drive energy consumption, and reduced environmental impact.
- MCI incorporates a drive system that can accurately inject chemicals at substantially lower volumes than the industry norm. All standard MCI pump solutions can deliver chemical injection rates as low as 1/10 litre per day at pressures up to 3000 psi. Current chemical concentration may not require volumes in this range, today. However evolution in the chemical industry may result in the demand for minute quantities in the future. MCI's standard CI pump packages are prepared for this advent.
- 4.5 Common solar-electric CI pump packages incorporate a cost effective brushed DC motor drive (discussed in [section 3.5, page 6](#)). These motors are less expensive, less efficient, require higher maintenance and have a shorter life span than the more advanced and proven motors currently available today.
- MCI has built their solar-electric CI pump solution around an innovative, unique and energy efficient design. The drive is a brushless DC stepper motor. This technology eliminates drive motor maintenance, provides a longer life span (increased by years), and integrates into MCI's electronic motor control system.
- 4.6 Commonly, brushed DC motors are controlled by standard mechanical motor control called contactors. Generally they are inexpensive but do have associated issues. These devices have inherent maintenance needs over their life span.
- Conversely brushless DC motors are operated by an electronic controller. They require zero maintenance, are totally configurable to the oil and gas well application, and can command precise chemical delivery by the CI pump.
- 4.7 Plug and play is just a buzz word, until you need the functionality. Systems without this benefit can be difficult to field retrofit, maintain and repair.
- MCI's component design offers a plug and play methodology. As they evolve the technology your installation can take part with easily exchangeable component pieces. For example, upgrade your pump controller to gain the latest chemical delivery accuracy.

4.8 Bulk injection techniques can reduce the chemical dispersion effectiveness. Ideally the production enhancer should be injected at a constant rate to ensure homogeneous dispersion. Constant dispersion enables the chemical enhancing process.

- MCI's IQ chemical injection technology drives dispersion. This electronic control system injects chemical at a programmable rate. The suction stroke is 1.6 seconds. We can use this to calculate the total dispersion time per minute. It is not 100% continuous but on low volume applications it will be near continuous. For example, to inject 3 litres of chemical per day into at 1500 psi pipeline the IQ pump will inject at a rate of 1.1 strokes per minute. Based on this the system is in the injection mode for 95% of the time.

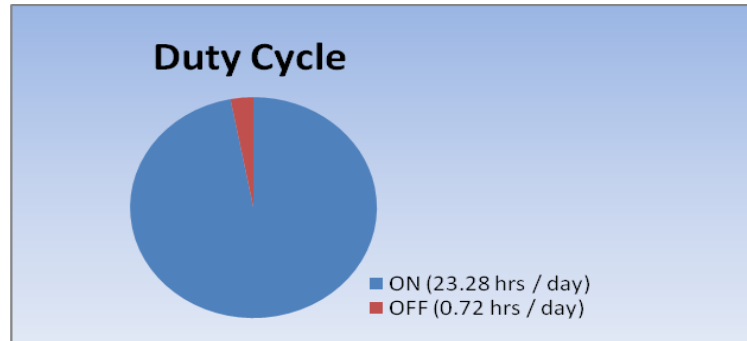


Chart 2 – MCI IQ solar pump duty cycle.

4.9 Solar-electric CI pumps are, practically speaking, limited in their ability to produce power and remain cost effective. However, if money is no object, additional solar panels and batteries can be added to meet any power need.

- Given the practical limitations of this technology it is critical to consider energy efficiency in the design. MCI manufactures the very best pump in the market today based on flow volume versus energy efficiency. The IQ controlled CI pump can deliver from 0.12 litres per day (1/4" plunger up to 3000 psi) to 60 litres per day (1/2" plunger up to 750 psi) with our standard pump package.

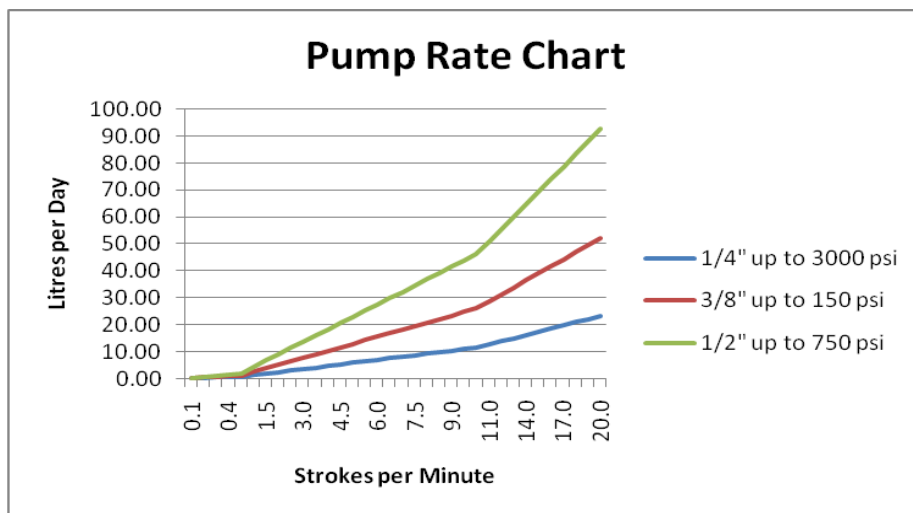


Chart 3 – MCI IQ solar pump rate chart.

- 4.10 CI pump system controllers vary throughout the industry. Ideally the controller is easily programmable, satisfies a wide variety of pumping applications and is field replaceable.
- MCI utilizes the IQ controller on all CI pump systems. The IQ incorporates a single power switch (on/ off), two programming buttons (inputting stroke rate), and an LED screen to confirm stroke rate. Communications to the drive motor via a quick connect cable. The controllers are interchangeable between CI pump systems keeping inventory costs at a minimum.
 - Reliable operation at cold temperatures (-40°C) have posed problems for “outdoor” CI technology in the past. All IQ controllers are equipped with the unique *Cold Start (CS)* that ensures consistent operation in northern Canada’s subzero conditions. CS’s *cold temperature compensation technology* maintains bulletproof pump reliability while providing the industry desired 7-10 day autonomous runtime.
- 4.11 *Well- CI Pump* optimization guarantees consistent power consumption and optimal chemical delivery over a defined volume rate and discharge pressure.
- The MCI IQ controller limits system power consumption through using a well specific optimized configuration. This is particularly significant during winter months where low peak sunshine (< 2 hours per day) puts a strain on the solar-electric power system. The benefit is increased runtime. During the harshest Canadian winters MCI solar-electric chemical injection pump keeps product flowing.

5 The Financial Analysis

- 5.1 Capital cost investment requires sound financial support to guarantee the requested funds are beneficially utilized. Initial investment payback per single well site is shown in Chart 5 – Solar Pump Payback, page 12. Using conservative propane consumption data and varying the chemical injection volume the payback potential ranges from 3 to 11 months.

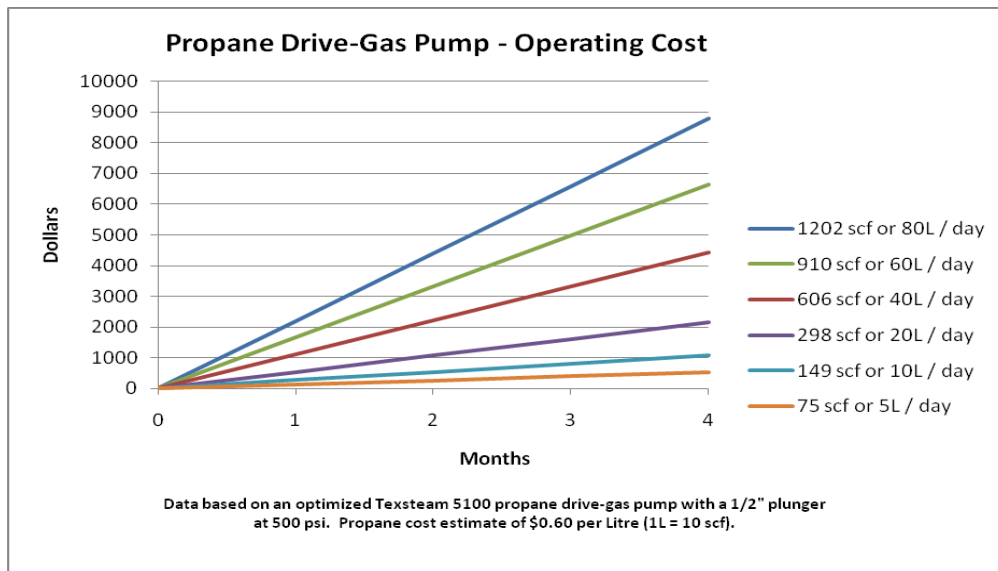


Chart 4 – Operating costs based on various operating conditions.

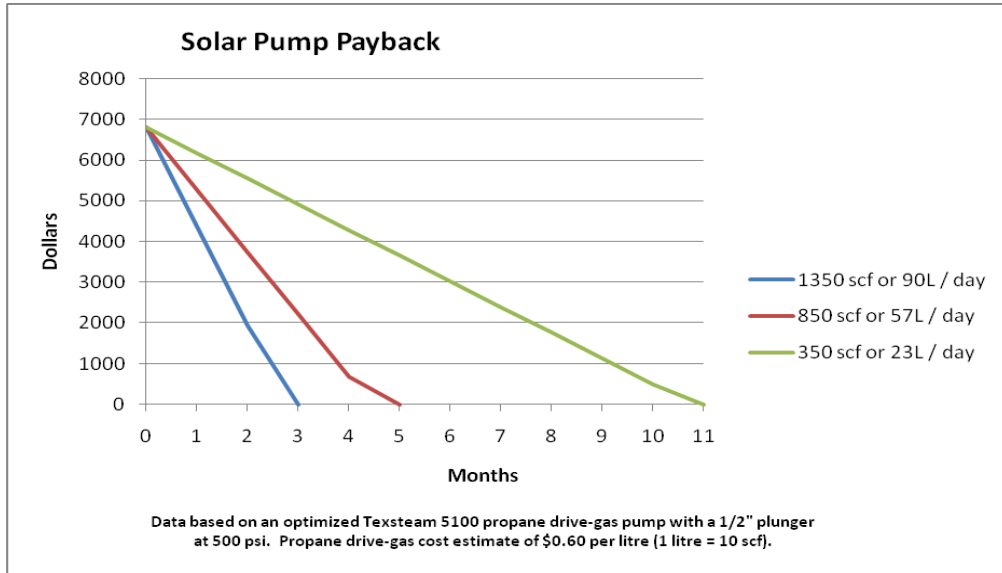


Chart 5 – Solar pump payback at varying operating conditions.

5.2 Solar-electric CI pumps are entirely electrically self-sufficient. Zero drive gas is required to operate the system. The resulting financial savings are applied to payback the initial capital expenditure for the pump. However these savings continue to accumulate over the life of the system. Chart 6 below represents the savings over ten years. An estimate yearly maintenance cost of \$200 has been subtracted from the chart. Accumulated savings per year fall somewhere within the “blue” wedge.

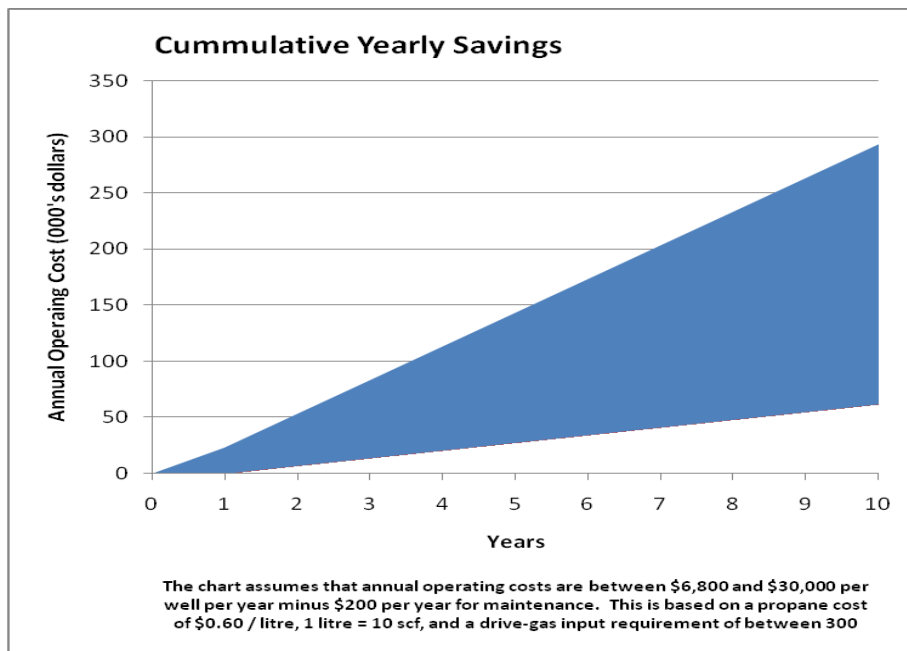


Chart 6 – Solar pump cummulative savings.

6 Recommendation

- 6.1 Annual propane costs to operate one gas driven CI pump vary widely - \$6,500 to over \$30,000. The quick reference chart below illustrates the tremendous financial incentive to establishing a CI pump upgrade program.

Annual Cost Per Pump	Total Wells	10	20	30	40	50
	\$6,500		\$65,000	\$130,000	\$195,000	\$260,000
\$30,000		\$300,000	\$600,000	\$900,000	\$1,200,000	\$1,500,000

Table 2 – Annualized Cost Per Well

The implementation of an effective solar-electric CI pump solution is a fiscally justifiable, environmentally responsible and industry leading business decision. Corporate vision determines your fitness for tomorrow. With fluctuating commodity prices it has never before been so important to pioneer innovative solutions for the long-term wellness of your business.

MCI Solutions offers system configurations and options to satisfy nearly every installation. If you are convinced that we are the correct manufacturer to provide chemical injection solutions for your installations, MCI has a variety of creative payment terms and financing options.

- 6.2 The N-Seal advanced leak containment technology is at the heart of MCI's products. This revolutionary seal system allows our solutions to operate unlike any other manufacturers' equipment available today. MCI offers the N-Seal technology in a field retrofitable adaptor package for most commonly applied pneumatic CI pumps.

	1200 Series	4300 Series	5100 Series
Arrow	10 Series	430 Series	510 Series
Bruin	BR1200 Series	BR4300 Series	BR5100 Series
CVS		4300 / 4400 Series	51 Series
Flomore	1300 Series	Ecomax Pump	5300 Series
Texsteam	1200 Series	4300 Series	5100 Series

Table 3 – N-Seal Compatibility Schedule

Installing the N-Seal adaptor on your CI pump will decrease your drive gas consumption by 50%. With a capital investment payback ranging between 2 weeks and 2 months the adaptor is perfectly suited to assist your company in moving forward towards a zero emissions future.

7 Implementation

- 7.1 All MCI Solutions' products are easily installable by site personnel. The estimated time to install and configure a CI pump package, resting in its final site location, is 1 hour. The N-Seal adapter, installed on pneumatic chemical injection pumps, can be installed in 30 minutes.
- 7.2 History indicates that the plug and play system design is virtually impossible to undermine. However MCI Solutions can provide complete system installation, onsite technical assistance, or telephone support to aid in the trouble free installation and commissioning of its products.
- 7.3 MCI Solutions is a customer centric manufacturer with a demanding vision – “exceed our customer’s expectations by providing innovative industry leading technology, unparalleled customer service, and a dedication to superior quality.” While special circumstances require varied measures MCI is committed to maintaining our 7 – 10 day delivery lead-time on standard orders.

BLANK