Solution Gas Flaring and Venting in Alberta:

Volume Trends and Conservation Costs

Report to: CASA Flare/Vent Project Team

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Introduction

In 2002, the CASA Flare/Vent Project Team recommended that further data on flaring and venting in Alberta be collected and analysed for use by the Project Team. The Alberta Energy and Utilities Board (EUB) subsequently issued ID 2002-02. In accordance with this ID, economic data related to the conservation of flared and vented solution gas was collected by the EUB. This new data has been analysed in this report, along with other production data from the EUB, to present recent flaring and venting conditions, as well as an outlook for the period of 2003-2012.

Recent Solution Gas Flare/Vent Rates

Information on recent solution gas flaring and venting is based largely on information submitted by industry, in response to ID 2002-02, as well as EUB production data. Figure 1 shows a breakdown of solution gas flaring for the year 2002, and Figure 2 shows a breakdown of solution gas venting for the year 2001. In both cases, almost all volumes have been accounted for, and the small percentage of the volume not submitted is likely composed of facilities being shut-in.

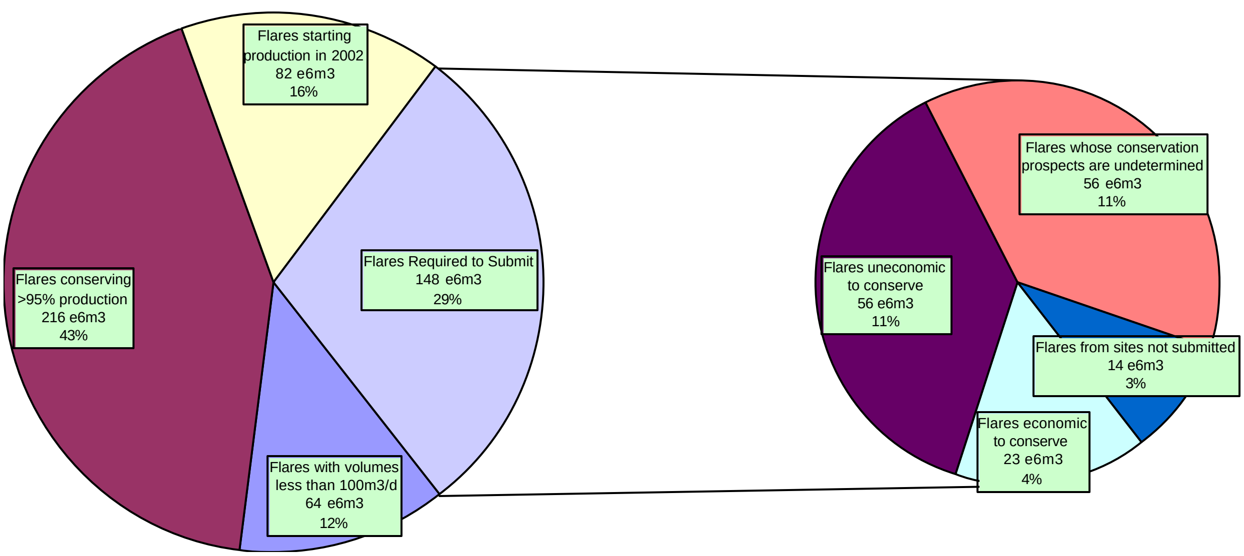


Figure 1 Solution gas flaring 2002

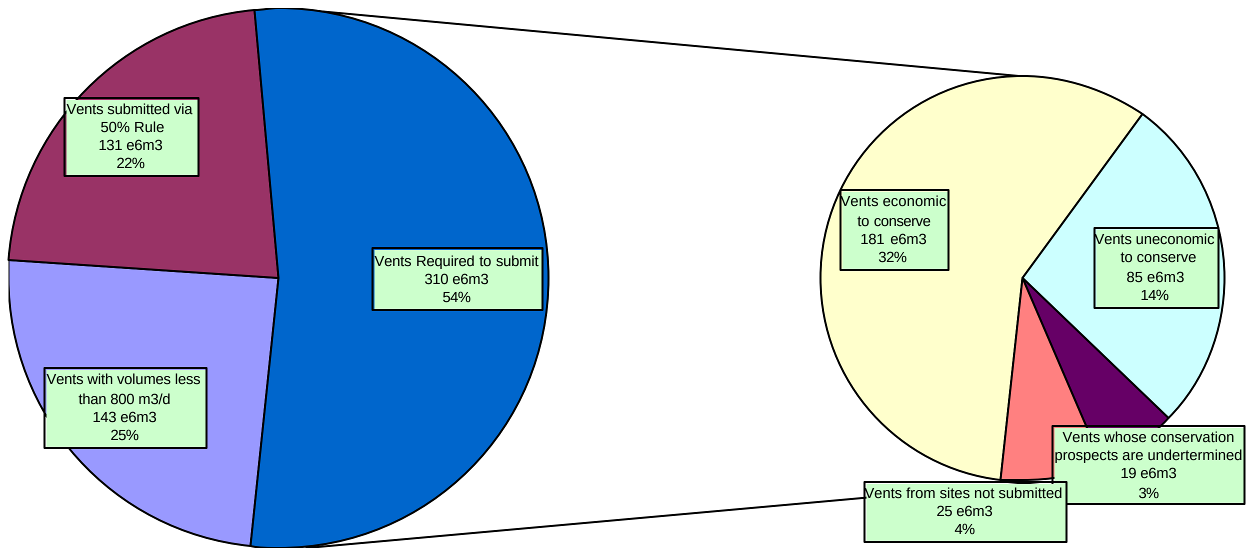


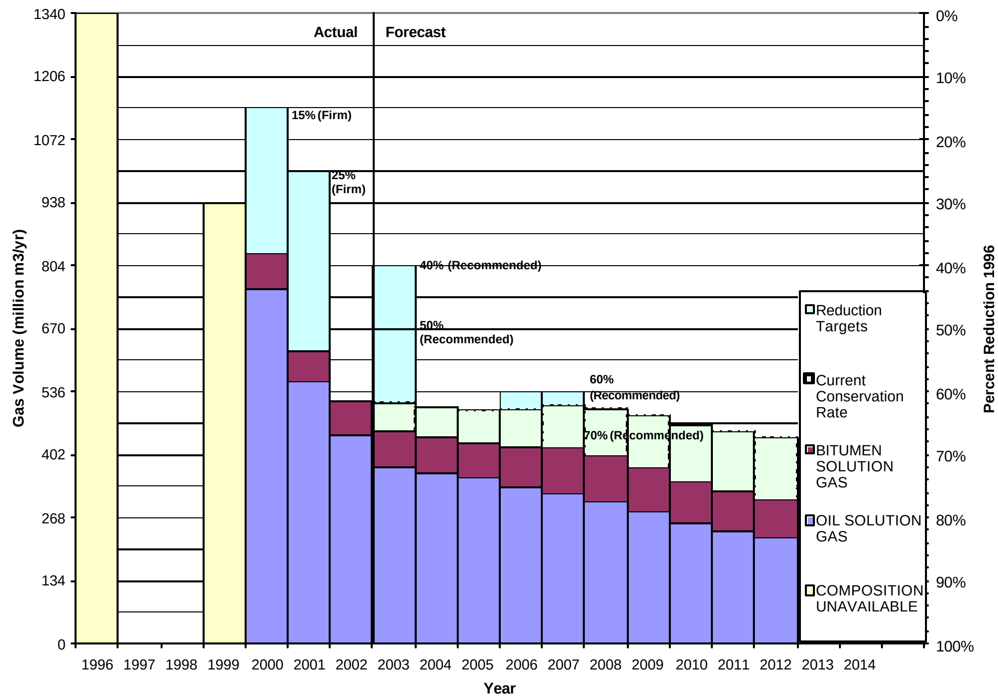
Figure 2 Solution gas venting 2001[1]

Forecasted Solution Gas Flare/Vent Rates

Solution gas production was forecasted using data from EUB's Alberta's Reserves 2002 and Supply/Demand Outlook 2003-2012 (ST 2003-98). Flaring and venting was then forecasted by modelling the effect of G60 regulations (based on the results of the analysis of the data submitted in compliance with EUB ID 2002-02) on the resulting solution gas production forecast. Figure 3 shows historical and projected solution gas flare volumes. Solution gas flaring is projected to steadily decline from 2003 to 2012 to a level roughly 76% below 1996 levels. Figure 4 shows historical and projected solution gas vent volumes. Solution gas venting is expected to stay stable at or below 2002 values until 2008 and then to decline[2]. Figure 5 shows historical and forecasted percent solution gas conserved for all solution gas produced. The conservation of solution gas produced from crude oil is currently around 96.6% and projected to reach 97.8% by the year 2012. The conservation of solution gas produced from crude bitumen is currently around 72.0% and projected to improve significantly to reach 87.6% by the year 2012.

[1] Some assumptions were required to deal with volumes from paper batteries and the composition of sites submitted through the 50% rule to generate these volumes.

[2] There is a possibility that solution gas venting may increase significantly beyond current volumes if improved conservation practices required by G60 are delayed in implementation.

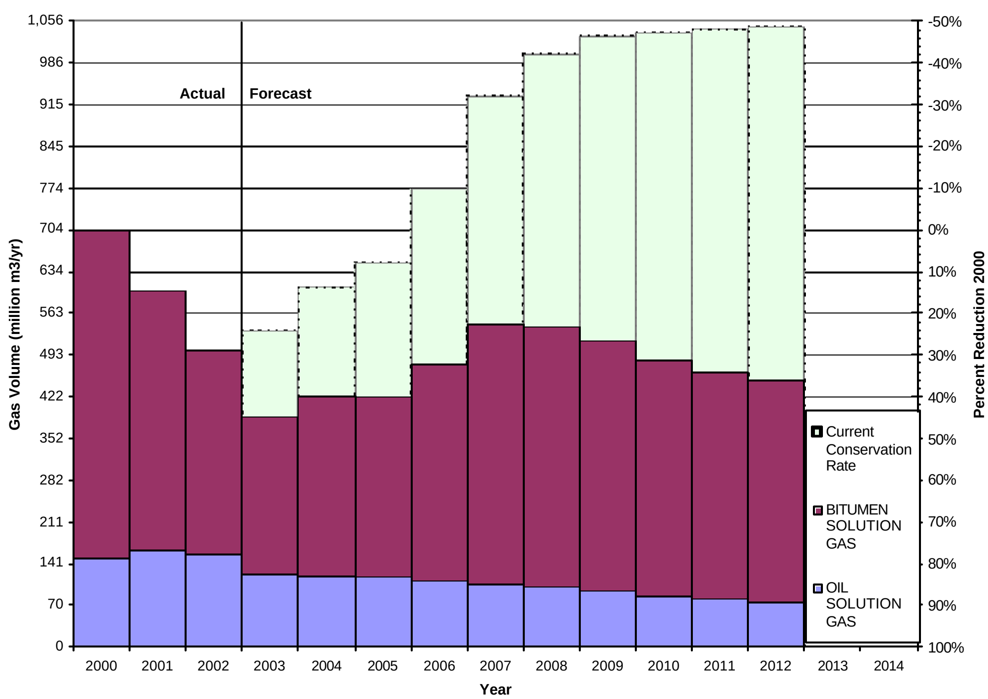


Note: Reduction targets are based on 1998 CASA FVPT recommendations.

Note: Current conservation rate shows solution gas forecast if percent produced solution gas conserved remains unchanged from 2002 values.

Note: Forecasted vent volumes are split based on their sources, oil or bitumen.

Figure 3 Solution Gas Flaring: Historical and Forecast



Note: Current conservation rate shows solution gas forecast if percent produced solution gas conserved remains unchanged from 2002 values.

Note: Forecasted vent volumes are split based on their sources, oil or bitumen.

Figure 4 Solution Gas Venting: Historical and Forecast

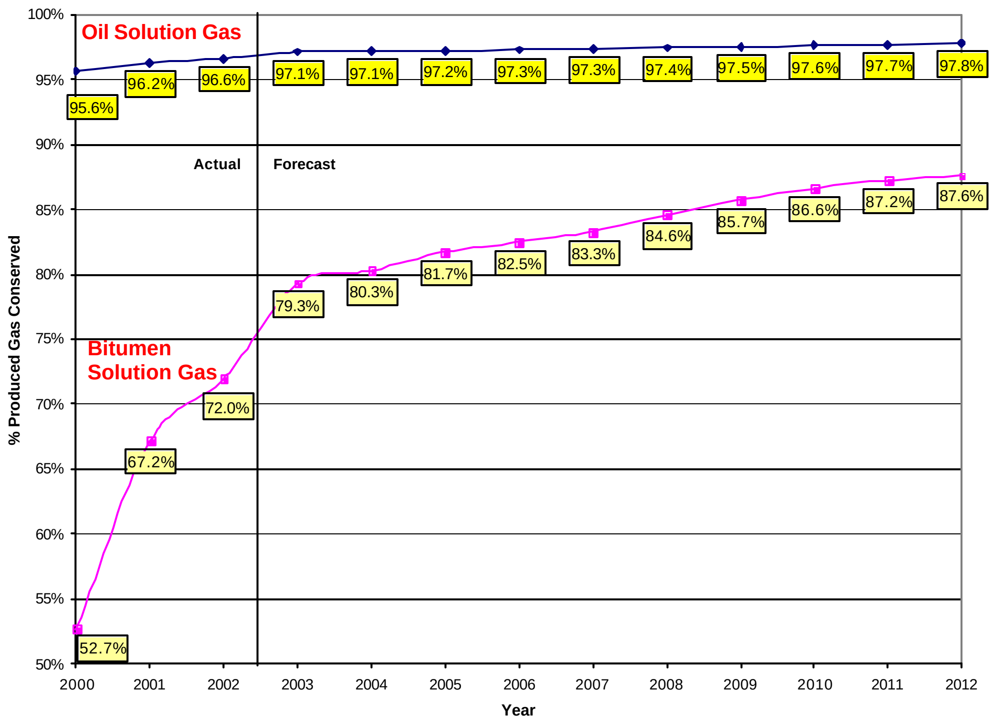


Figure 5 Solution Gas Conservation Percentage: Historical and Forecast

Cost to Conserve Existing Solution Gas Flares/Vents

The cost to conserve solution gas existing solution gas flares and vents was estimated using data submitted as per EUB ID 2002-02. To provide a second estimate (as a check) the conservation costs have also been calculated based on project characteristics and solution gas available. Figure 6 shows the cost to conserve solution gas at solution gas flares existing before 2003. For approximately $60 million, solution gas flaring could be reduced by an estimated 80,000 10^3 m^3 per year in 2003. It should be noted that a large portion of the solution gas flared currently comes from facilities already conserving most of the solution gas, and flaring primarily in upset conditions. The cost to reduce this type of flaring has not been examined in this report. Figure 7 shows the cost to conserve solution gas from vents existing before 2003. For approximately $10 million, solution gas venting could be reduced by roughly 50,000 10^3 m^3 per year in 2003.

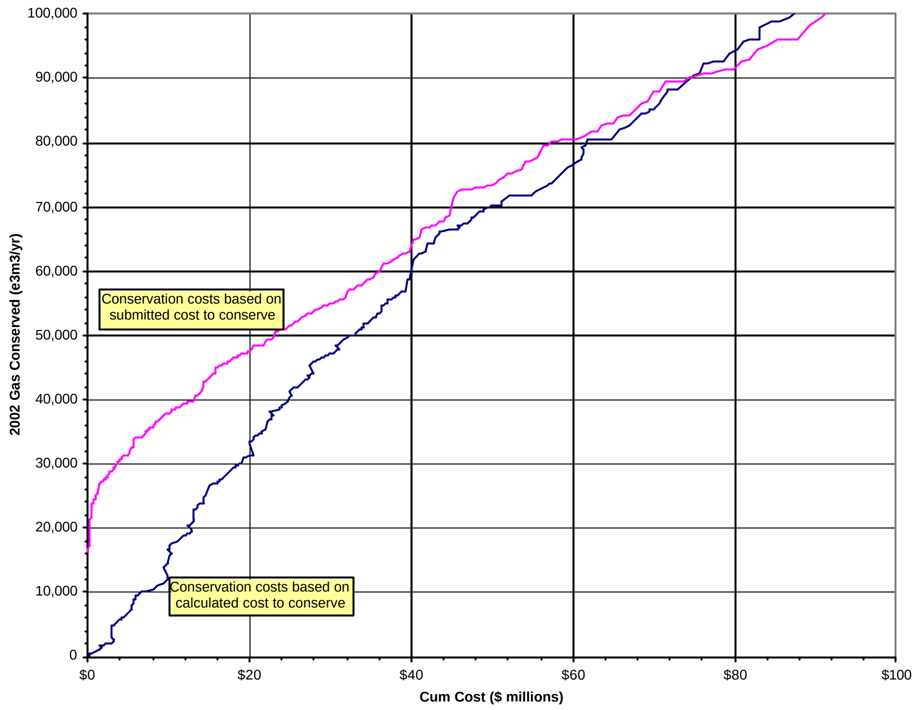


Figure 6 Cost to conserve pre 2003 solution gas flares

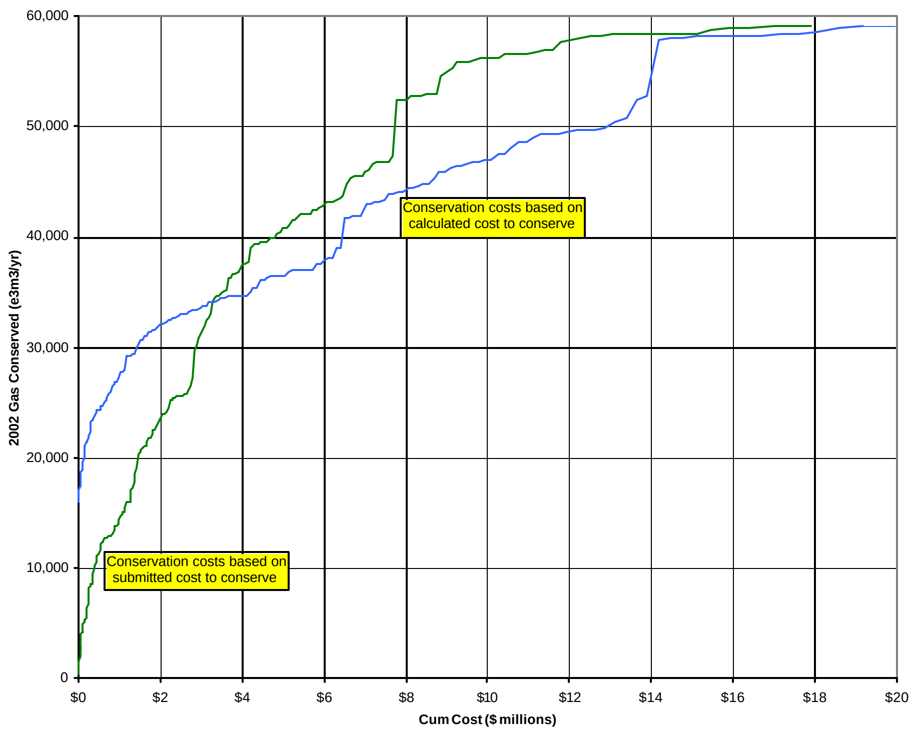


Figure 7 Cost to conserve pre 2003 solution gas vents

Cost to Conserve New Solution Gas Flares/Vents

The cost to conserve solution gas from new solution gas flares and vents starting production in 2003 to 2012 has been estimated using probability-based risk analysis techniques based on estimates of the cost to implement sales or fuel gas projects. The economic model as found in the EUB G60 has been used consistently throughout the report. As part of the analysis, the projects were determined to be either economic on a standalone basis (i.e. the costs of the project were offset by the revenues from the sale of the solution gas conserved[3]) or, where the value of the solution gas was insufficient to justify the required capital, the cash flow from the oil/bitumen was sufficient to make the project, as a whole, economic. If the project was not economic on a standalone basis, and oil/bitumen cash-flow (oil/bitumen revenue minus oil/bitumen operating costs) was not sufficient to cover the costs of operating a sales or fuel gas project, then the oil/bitumen production was assumed to be shut-in. Figure 8 shows the estimated cost to conserve all solution gas from new flares in 2003 dollars. As an example, it is estimated that there is a 50% probability that the cost to society to conserve all solution gas from new flares for the period 2003 to 2012 would be less than $76 million; lost crude oil production would be less than 530,000 m^3; and lost crude bitumen production would be less than 200,000 m^3. Figure 9 shows the cost to conserve solution gas from new vents greater than 800 m^3/day in 2003 dollars. It is estimated that there is a 50% probability that the cost to society to conserve all solution gas from new vents greater than 800 m^3/day for the period 2003 to 2012 would be less than $7 million; lost crude oil production would be less than 2,000 m^3; and lost crude bitumen production would be less than 80,000 m^3. Figure 10 shows the cost to conserve solution gas from new vents less than 800 m^3/d in 2003 dollars. It is estimated that there is a 50% probability that the cost to society to conserve all solution gas from new vents less than 800 m^3/d for the period 2003 to 2012 would be less than $97 million; lost crude oil production would be less than 50,000 m^3; and lost crude bitumen production would be less than 460,000 m^3.

[3] This includes only solution gas sales based on pricing from Chenery Dobson Hydrocarbon Priceforecast January 2003. Revenue from natural gas liquids (or condensates) are not included in these estimates.

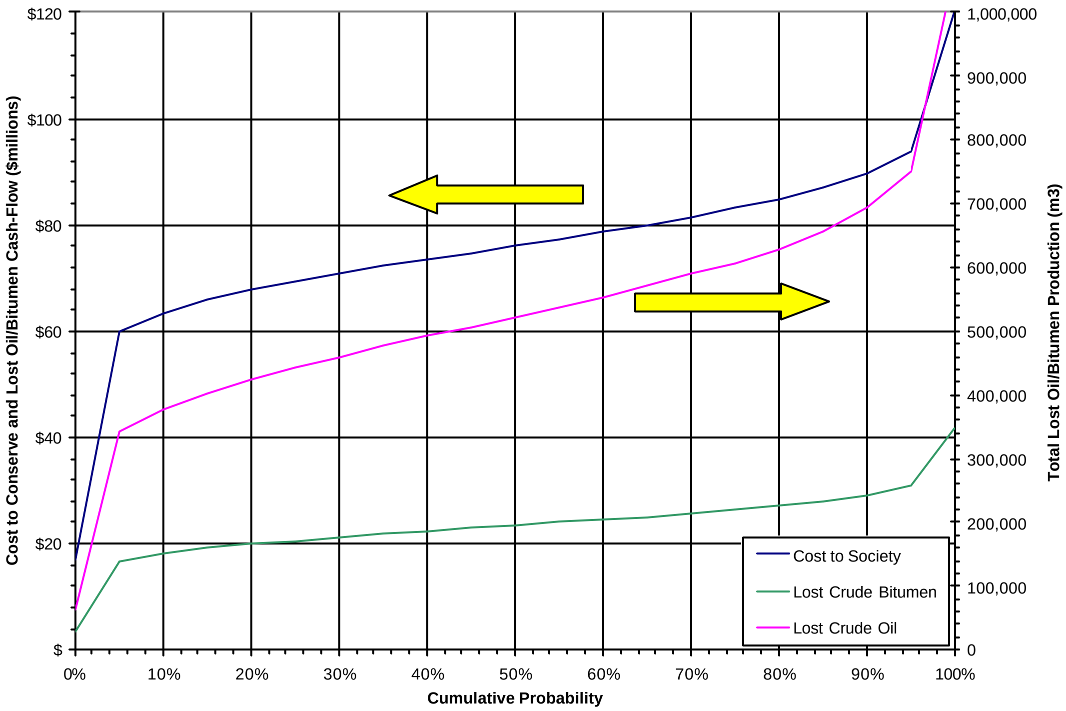


Figure 8 Cost to conserve 2003-2012 new solution gas flares

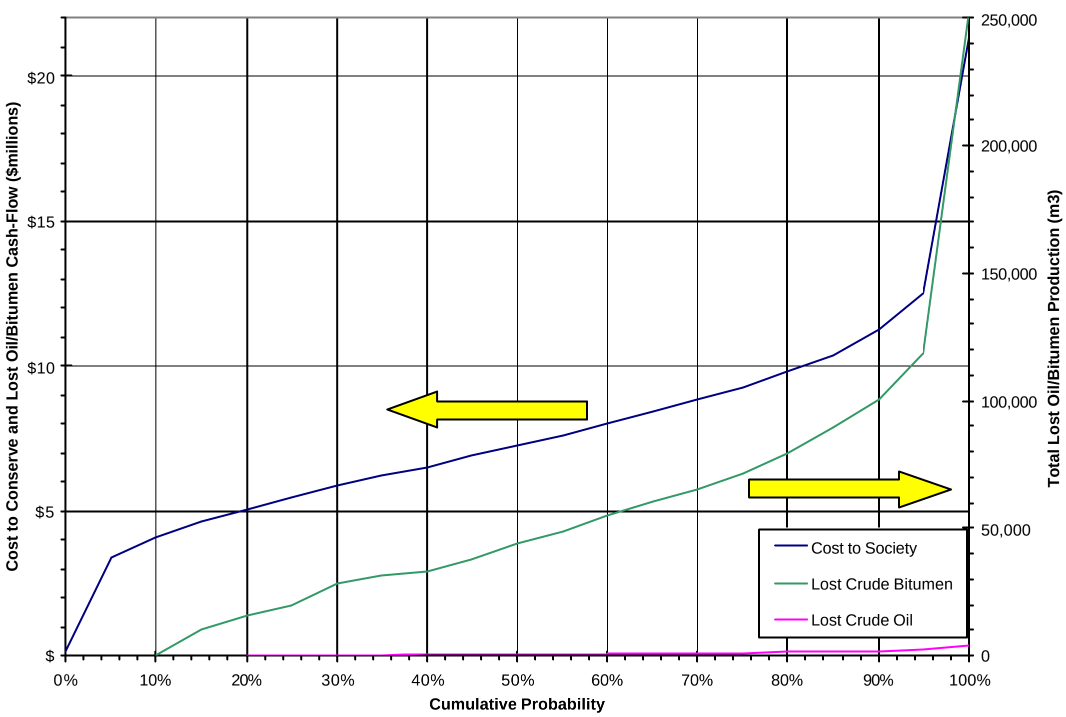


Figure 9 Cost to conserve 2003-2012 new solution gas vents greater than 800 m^3/day

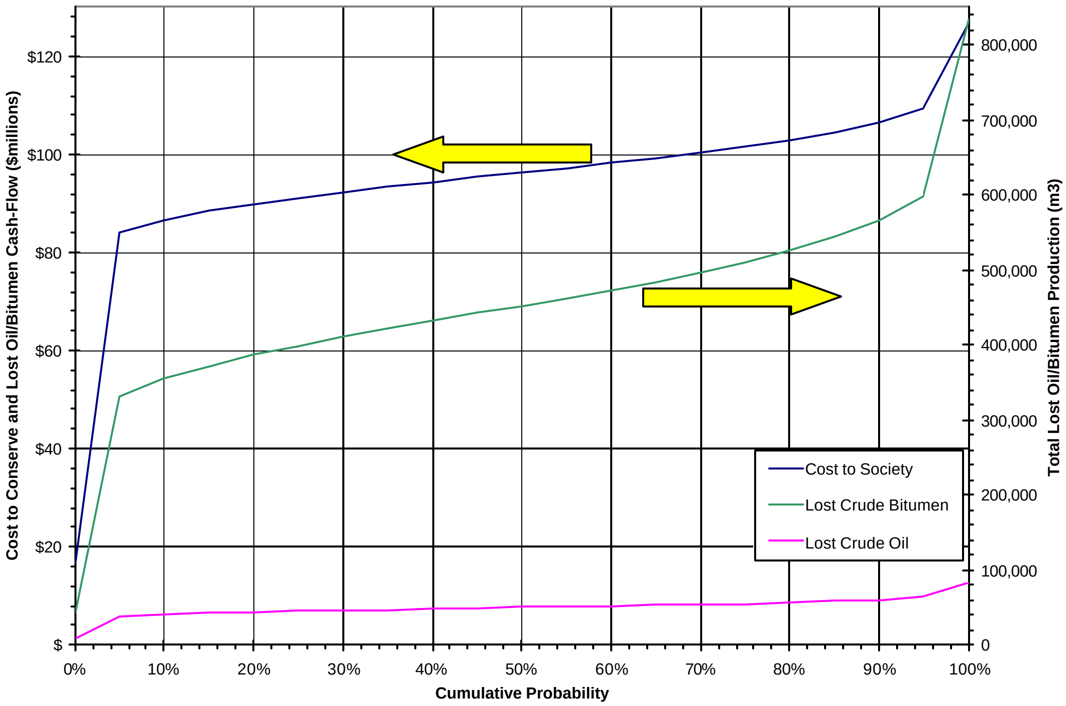


Figure 10 Cost to conserve 2003-2012 new solution gas vents less than 800 m3/day

1 Introduction

1.1 CASA Flare/Vent Project Team Recommendations Leading to this Study

In June 2002, the CASA Flaring/Venting Project Team (FVPT) made recommendations for the upstream petroleum industry on flaring and venting. One of the recommendations called for further data collection and analysis on flaring and venting. It was noted that cost estimates for conserving solution gas flaring and venting were required before proceeding further on several action items deferred to 2003. These deferred items include recommendations on future solution gas flaring and venting reduction targets, and recommendations on possible cost sharing initiatives for uneconomic conservation projects. Discussion on several other items on flaring and venting was also deferred; these items would wait till 2003 when economic data for evaluations required to be conducted by EUB G60 could be analyzed to allow better understanding of solution gas flaring and venting, and the associated economics of solution gas conservation.

1.2 What Gas was Studied?

This study dealt only with solution gas. Solution gas is defined by the EUB as follows:

> All gas that is separated from oil or bitumen production.[4]

Solution gas thus comes from several different types of petroleum production, ranging from light conventional oil to non-flowing bitumen. Distinguishing the type of petroleum the solution gas is produced with gives more information about conservation options available and disposal options generally practiced by the industry, which usually are flaring and venting.

1.2.1 Conventional Oil Solution Gas

Conventional Oil Solution Gas is defined by this report as (referred to as Oil Solution Gas henceforth):

> Gas separated from conventional crude oil production.

Conventional crude oil consists of light, medium and heavy classifications. In general, solution gas from light to medium crude oil production is flared when it is not being conserved, whereas solution gas from heavy crude oil production is vented when it is not conserved. This venting often occurs from the casing of the well, and thus the gas

[4] EUB Guide 60: Upstream Petroleum Industry Flaring, Incinerating and Venting (Draft December 2002)

is also known as casing gas. Solution gas is reported as gas coming from Battery Facilities with EUB Facility Sub Type Codes 311, 321 and 322 (Crude Oil Batteries).[5]

1.2.2 In-Situ Crude Bitumen Solution Gas

In-Situ Crude Bitumen Solution Gas is defined by this report as (referred to as Bitumen Solution Gas henceforth):

> Gas separated from in-situ crude bitumen production.

In Alberta, bitumen production is defined by geographic region. Any crude oil production from this fixed geographic region is classified as bitumen. Generally speaking, bitumen production can be subdivided in two distinct types:

1. Surface mined bitumen production (e.g. the oilsands mining projects near Ft. McMurray).
2. In-situ bitumen production, i.e. bitumen produced by processes that do not involve mining, but instead recover the oil "in-situ", i.e. from the formation of origin, at depth.

In-situ bitumen production can be further subdivided into recovery by primary (e.g. cold production) or thermal (e.g. Steam Assisted Gravity Drainage or SAGD) methods. For the purposes of this study, in-situ crude bitumen solution gas refers to the gas separated from the production of bitumen from primary/cold production wells. When this gas is not conserved, it is most often vented. As this venting often occurs through the casing, it is also known as casing gas. In-situ crude bitumen solution gas is reported as gas coming from Battery Facilities with EUB Facility Sub Type Codes 331, 341, 342 and 343 (Crude Bitumen Batteries)[6]. Bitumen solution gas should not be confused with natural gas produced from gas wells in the oil sands region or with natural gas released during bitumen refining.

1.3 Scope of Study

It should be noted that, while flaring and venting occurs from various other sources in the upstream petroleum industry, including gas plants, gas pipelines and distribution systems, and well testing; this report focuses only on crude oil and in-situ crude bitumen solution gas flaring and venting. The report contains the results of a study commissioned by the CASA Flare/Vent Project Team, and has been written under the guidance of members of the Economics Sub-Group of that Team. Every effort has been made to present information as requested by the CASA Flare/Vent Project Team.

[5] EUB Guide 7: Production Accounting Handbook – Part 1 Draft (September 2002)

[6] EUB Guide 7: Production Accounting Handbook – Part 1 Draft (September 2002)

1.4 Some Limitations and Assumptions

The following describes some of the major simplifying assumptions involved in the performing the calculations in this study:

1. Detailed data with respect to the composition of the flared and vented gas was not available. For the economics calculations, the heating value of the gas was assumed to be 33.37 GJ/m^3, since this was the reference value in the price forecasts used.
2. Since only monthly flare and vent data was available, there was no way to discern whether the flared volumes were from continuous or intermittent flaring and venting (i.e. "routine" flaring/venting vs flaring/venting during unusual/upset conditions). As a result, monthly data were assumed to represent an average continuous value for most calculations.
3. Flared gas is generally measured using metering systems, but not in all cases. Venting on the other hand is often estimated using the results of gas/oil ratio (GOR) tests. As a result, there can be significant error in cases where flaring and venting are estimated. There was no way to account for possible errors estimation and/or measurement errors when performing this study, so reported flare and vent data were assumed to be accurate.

2 Processing ID 2002-02 Data

2.1 CASA Data Request

In 2002, the CASA FVPT made a recommendation to the EUB that data be gathered from the solution gas flare/vent conservation evaluations required to be completed by EUB G60. The CASA project team intended to analyze the information collected to better understand solution gas conservation and the factors affecting it. The EUB thus issued GB 2002-05 and ID 2002-02 to require industry to submit the required information and arranged for the collection of this data.

2.2 Submission Process

ID 2002-02 provided instructions to industry to submit, to the EUB, summary economic evaluations via email in a standard excel file. The EUB originally issued a deadline of January 31, 2003 for all economic evaluations. However, for a variety of reasons, this deadline was extended several times, with the final date falling on April 15, 2003. After the last deadline, the EUB issued letters to the few remaining operators who had not yet complied, but the majority of data had been submitted prior to the last extension. Only data submitted prior to the April 15 deadline has been used in this report.

2.3 Data quality issues

The data submitted to the EUB had many issues dealing with its quality and interpretation. This was the first attempt at gathering solution gas conservation project data from a wide variety of upstream petroleum producers, ranging from large multi-nationals to small producers. The design of the collection form, led to some interpretation issues. For example, one such issue was how many different projects were submitted in one evaluation. Many sites evaluated sales gas projects in conjunction with power generation projects and submitted the data together. They included capital costs for both the compression equipment and generation equipment, with one set of data representing the sales project and the other the generation project. In such a case, distinguishing, with any degree of certainty, how much capital was attributable to the power generation project and how much was attributable to the sales gas project was not possible. As well, several issues with units used in reporting information were also found. One issue involved H_2S values reported in units other than the specified mol/kmol. A review of the data indicated that some of the data had obviously been reported in ppm and some in percent H2S. As a result, judgement was used to correct some values where they were obviously incorrect. However, it is quite likely that some data were reported using incorrect units but the error were not obvious and so were not corrected. The year of past production data submitted was also questionable in some cases. The evaluations required a submission of the gas produced, flared and vented and oil production in the past year, but the form did not specify which year was the past year. As many evaluations were delayed and conducted in the year 2003 instead of the originally requested year 2002; some of the production volumes may represent year 2002 volumes instead of the originally intended year 2001. This affects cumulative production volumes in the analysis of the data. Several operators also decided to leave some information out if they believed the project was uneconomic. Thus, some capital costs and net present value (NPV) values were not submitted.

2.4 Editing Process

To deal with most of the issues affecting data quality, data was edited to remove the inconsistencies and bring all the evaluations to a standard level, as much as possible. A number of steps were involved in this process:

1. The first step in editing the data involved identifying and separating all sites with insufficient information to ascertain project status. Some criteria for determining these evaluations were i) missing battery codes, ii) no textual or numerical data to determine economics, iii) no capital costs submitted, and iv) no information other than site/facility identifiers.
2. Next, all unit errors were corrected based on judgement, and comparing with other production information available.
3. For projects reporting power equipment costs, a power or sales project label was assigned based on the size of the project and other information available (usually textual notes).
4. All previous year production volumes were assumed to be from year 2001, although checks were taken to ascertain whether the battery existed in 2001 before using the production information.

3 Recent Solution Gas Flare/Vent Volumes

3.1 EUB's Classification System for Compliance Purposes

During the EUB's review of the data submitted as a result of ID 2002-02, several criteria were used in deciding whether or not to take enforcement action for failing to comply with the ID. It was decided that flares less than 100 m^3 per day in volume were too small to conserve, and that no enforcement would be taken for failure to submit data for these flares. Batteries conserving 95% of the solution gas produced at the battery were deemed to already be conserving. The requirement for this definition arose from the statement in the ID that conserving facilities need not submit an evaluation. The definition of conserving had not been clarified in G60 or related documents. The 95% conserving rule was designed to exclude most facilities that were already conserving (and thus would likely be unable to further conserve). Thus, flares greater than 100 m^3 per day in volume and facilities conserving less than 95% of the solution gas produced were the only ones subject to enforcement action with respect to the requirement to submit economic evaluation data. Volumes and conservation percentages used for classifying solution gas flares were based on January 2002 production data.

For vents, the ID was more explicit in the requirements to submit evaluations. All vents greater than 800 m^3 per day were required to submit, with exceptions made regarding the 50% volume submission option for operators with large numbers of vents (see the ID for exact details). Volumes and conservation percentages used for classifying solution gas vents were from ID 2002-02 data and January 2002 production data.

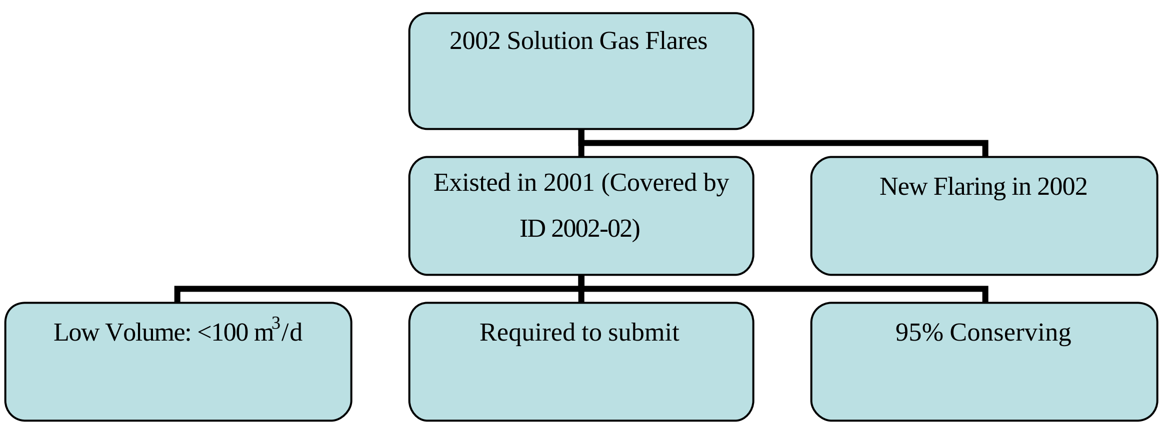


Figure 3.1 EUB Classification for ID 2002-02 Flares in 2002

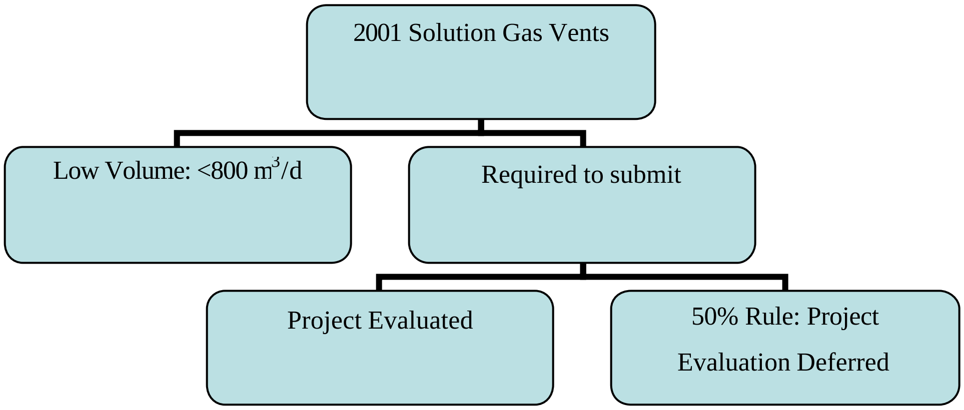


Figure 3.2 EUB Classification for ID 2002-02 Vents in 2001

3.2 Project Evaluations Classification System

Projects for which information was received were first classified according to the EUB classification system. For those required to submit by the EUB, they were further subdivided into three categories: i) economic to conserve, ii) uneconomic to conserve, and iii) undetermined economics. G60 defines a project as economic to conserve if its NPV is zero or greater than zero based on the flare decision tree process economics. This definition has been used for projects with NPV information submitted. For those sites without NPV's submitted, interpretations have been made, based on textual notes in the submission, as to whether the project is economic or uneconomic. If no interpretation can be made, the project was classified as having undetermined economics.

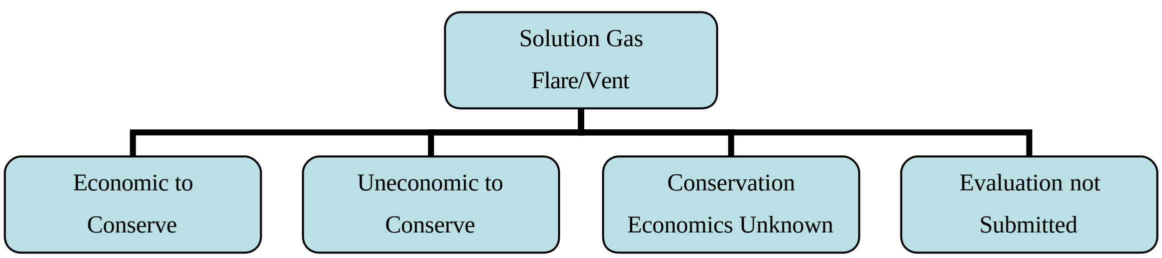


Figure 3.3 Project Evaluation Classification

3.3 2002 Flare Volumes

3.3.1 Calculation Method

Flare volumes were calculated for the year 2002, as it is the most recent year for which EUB production data was available. Volumes were calculated based on provisional ST 2002-60A data containing only non-confidential batteries. Batteries that were flaring were looked up on the submitted ID 2002-02 data to find out if it had been evaluated and, if evaluated, what the conservation prospects for the site were. Since ID 2002-02 covered only flares existing in 2001, all new batteries that became operational in 2002 were dealt with separately and were not classified based on conservation evaluations.

3.3.2 Volumes

Solution gas flare volumes are shown in the following tables and figures. Table 3.1 shows solution gas flares classified according to both EUB's compliance classification and this report's project evaluation status. Figure 3.14 shows a pie chart of 2002 solution gas flare volumes. Table 3.2 shows the percentage of solution gas flares that are economic, based on crude oil and crude bitumen solution gas sources. Table 3.3 shows solution gas flare conservation by EUB Field Centre. A number of conclusions can be drawn from the information contained in these tables and figures:

1. A relatively small volume of the solution gas flared met the EUB criteria with respect to enforcement action under ID 2002-02. The small volume that did not submit and met the criteria may be mainly composed of solution gas flares due to be shut-in 2002.
2. Further conservation was economic at some sites conserving 95% or more of the solution gas produced.
3. Some sites with low flare volumes also found that economic conservation options were available.
4. By volume, a large portion of sites required to submit evaluations had undetermined economics. In fact, this volume is slightly greater than the total volume of uneconomic sites required to submit. It is the author's opinion (based on observation of the conservation economics evaluations, but otherwise unsubstantiated) that it is likely that most of the 56,000 10^3 m^3 classified as "undetermined" within the "Submissions Required" category would be uneconomic to conserve.
5. A higher percentage improvement in conservation of flared solution gas is likely for crude oil solution gas flares (13%) than crude bitumen solution gas flares (5%).
6. Flared solution gas conservation will likely improve most in the St. Albert field center (15%) while the Midnapore field center (5%) will see the least improvement.

Table 3.1 Year 2002 Solution Gas Flare Volumes: Detailed Project Status

	Economic (10^3 m^3)	Uneconomic (10^3 m^3)	Undetermined (10^3 m^3)	Not Submitted[7] (10^3 m^3)	Total (10^3 m^3)
<100m^3/d	2,000	13,000	8,000	41,000	64,000
Submissions Required	23,000	55,000	56,000	14,000	148,000
95% Conserving	32,000	73,000	28,000	84,000	217,000
New 2002 Flares				82,000[8]	84,002
Total[9]	57,000	142,000	92,000	220,000	509,000

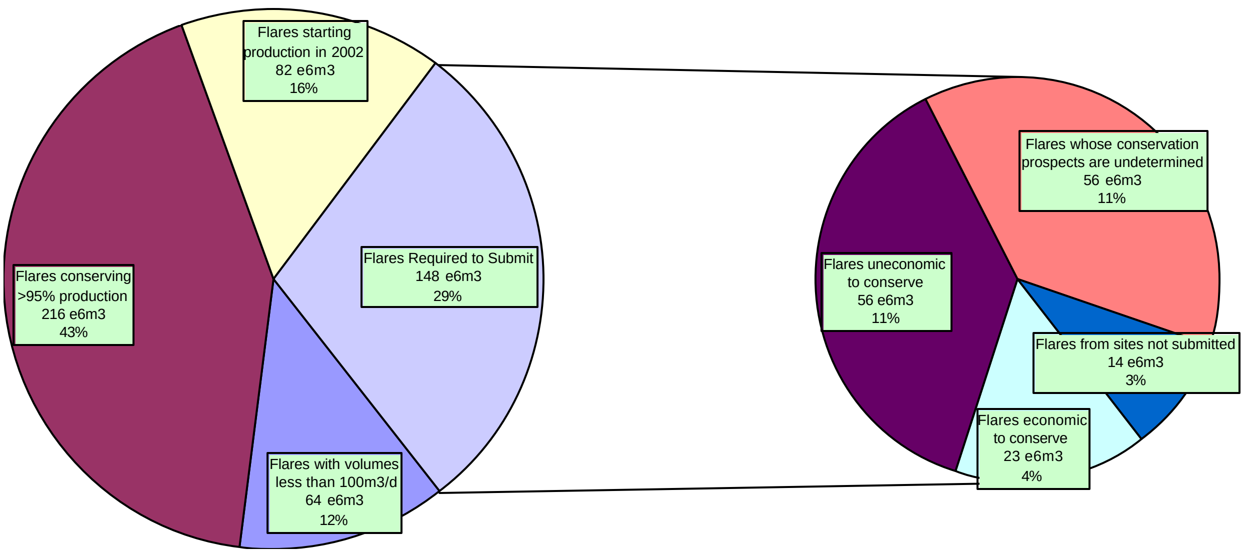


Figure 3.4 Year 2002 Solution Gas Flare Volumes

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7 Status as of June 26, 2003.

8 Not required to submit.

9 May not sum exactly due to rounding.

Table 3.2 Year 2002 Solution Gas Flare Economics by Source

Source	% Economic	% Others	Flare Volume (10^3 m^3)	% Provincial Total
Crude Oil	13%	87%	403,000	79%
Crude Bitumen	5%	95%	106,000	21%

Table 3.3 Year 2002 Solution Gas Flare Economics by EUB Field Centers

Field Center	Field Center Flared (10^3 m^3)	% Economic	% Others	% Provincial Total
BONNYVILLE	62,000	7%	93%	12%
DRAYTON VALLEY	39,000	8%	92%	8%
GRANDE PRAIRIE	108,000	11%	89%	21%
MEDICINE HAT	68,000	13%	87%	13%
MIDNAPORE	29,000	5%	95%	6%
RED DEER	43,000	13%	87%	8%
ST. ALBERT	97,000	15%	85%	19%
WAINWRIGHT	65,000	13%	87%	13%

3.4 2001 Vent Volumes

3.4.1 Calculation Method

Since a large percentage of the solution gas that is vented in Alberta is attributable to “paper batteries” (paper batteries are groups of wells that were reported as a single entity to simplify accounting procedures; this has now been changed with the recent modifications to the EUB accounting procedures) individual vent rate data was not available from the EUB for many sites. As a result, the calculations and tabulations represented by the tables and figures shown in this section were done using data submitted under ID 2002-02 and are representative of rates and volumes for the year 2001. It was assumed that for any paper battery from which a submission was received, all vent sources requiring evaluations from the battery were evaluated. The remaining unevaluated volumes were assumed to be from vents less than 800m^3/day. For batteries not submitted, data from the ST60A-2001 was used in place of evaluation data.

3.4.2 Volumes

Solution gas vent volumes are shown in the following tables. Table 3.5 shows solution gas vents classified according to both the EUB's compliance classification and this report's project evaluation status. Figure 3.2 shows a pie chart of 2001 solution gas vent volumes. Table 3.4 shows the percentage of solution gas vents that are economic based on crude oil and crude bitumen solution gas sources. A number of conclusions can be drawn from the information contained in these tables and figures:

1. An evaluation was submitted for nearly all venting sites that were required to submit by ID 2002-02. It was not possible to make a precise determination of these statistics because of the paper batteries issues (see note attached to Table 3.4).
2. Approximately 60% of evaluated vent volumes were found to be economic to conserve.
3. Some sites that were evaluated with volumes less than 800 m^3/d were found to be economic to conserve.
4. Volumes with undetermined economics represent a small percentage of total solution gas venting. It is the author's opinion (based on observation of the conservation economics evaluations, but otherwise unsubstantiated) that it is likely that most of the 25,000 10^3 m^3 classified as "undetermined" within the "Submissions Required" category would be uneconomic to conserve.
5. .A higher percentage of solution gas is economic to conserve for crude bitumen solution gas vents (31%) than for crude oil solution gas vents (19%).

Solution gas vents sources were not analysed by EUB field center sources due to issues arising from paper batteries and the 50% submission rules.

Table 3.4 Year 2001 Solution Gas Vent Volumes

	Economic (10^3 m^3)	Uneconomic (10^3 m^3)	Undetermined (10^3 m^3)	Not Submitted[10] (10^3 m^3)	Total (10^3 m^3)
<800m^3/d[11]	3,000	16,000	5,000	120,000	144,000
Submissions Required	181,000	85,000	19,000	25,000[12]	310,000
50% Rule			131,000		131,000
Total[13]	184,000	100,000	155,000	145,000	600,000[14]

Note: Vents less than 800m^3/d were not required to submit.

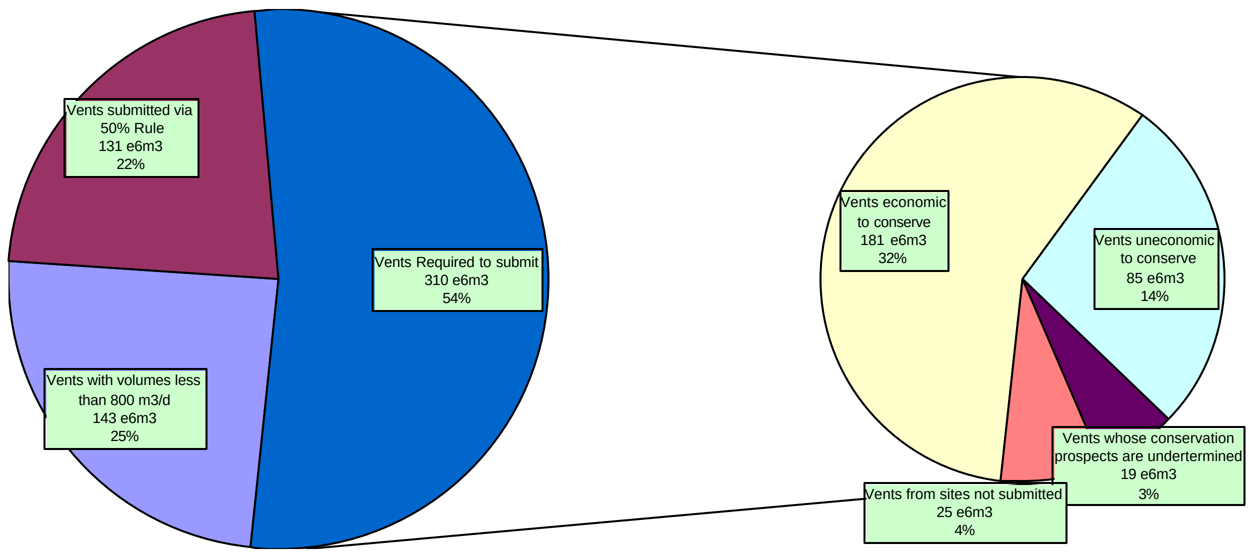

Figure 3.5 Year 2001 Solution Gas Vent Volumes

10 Status as of April 15, 2003.

11 Does not include paper battery and CNRL <800 m^3/d sites.

12 Includes <800 m^3/d sites from paper batteries. Exact composition and volume of these sites cannot be determined

13 May not sum exactly due to rounding.

14 Volume sums to higher number due to confidential sites.

Table 3.5 Year 2001 Solution Gas Vent Economics by Source

Source	% Economic	<800 m^3/d	% Others	Vent Volume (10^3 m^3)	% Provincial Total
Crude Oil	19%	57%	24%	164,044	28%
Crude Bitumen	31%	25%[15]	44%	436,124	72%

[15] Includes <800 m^3/d volumes from sites that used the 50% rule.

4 Conservation Project Evaluation Statistics

4.1 Statistics Compilation

4.1.1 Data Source

The statistics for this section were generated from the ID 2002-02 evaluation data and EUB production data, with interpretation and editing applied as outlined in previous sections. The statistics for percentile, quartiles and mean values shown in the tables represent the number of sites less than that value, rather than the proportion of total volume less than that value. The proportion of total volume is show in the corresponding figures in each section.

4.1.2 Projects Used

Conservation projects currently being undertaken by industry fall into two general categories: i) sales/fuel gas, and ii) electrical power generation projects. Electrical power generation projects were identified within the dataset by using the ID 2002-02 data “CAPITAL COST FOR GENERATION EQUIPMENT” and “CAPITAL COST POWER TIE-IN” fields. If either of these two capital costs was greater than zero, the project was classified as a power generation project. Overall, electrical power generation projects comprised only a small quantity in terms of both the number of evaluations submitted and the volume of solution gas involved. The compiled statistics, therefore, do not include electrical power generation projects; only sales/fuel gas projects have been used to generate the statistics.

4.1.3 Dataset

Table 4.1 shows the number and volume of evaluations received for economic and uneconomic projects. More data was received for uneconomic project evaluations than economic project evaluations (Note that the volumes presented in the Table 4.1 are less than the volumes for economic and uneconomic projects in Table 3.1 because only evaluations that were complete were used).

Table 4.1 Flare Dataset

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	74	372
Sample Total Volume (10^3 m^3/yr)	38,558	99,362

4.1.4 Volume Distributions

Table 4.2 and Figure 4.1 contain volume distribution statistics for evaluated flare projects for which volume information was available. The following conclusions can be drawn from these statistics:

1. Flares that are economic to conserve are typically larger in size, with a mean value of 309 10^3 m^3/yr as opposed to 120 10^3 m^3/yr for flares that are uneconomic to conserve, and a 95th percentile value of 1971 10^3 m^3/yr as compared to 1043 10^3 m^3/yr, respectively.

2. Flares that are economic to conserve represent roughly 17% (74 sites) of the sites submitted and 28% (38,558 10^3 m^3) of the volume flared.

Table 4.2 Flare Volume Distribution Statistics

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	74	372
Sample Total Volume (10^3 m^3/yr)	38,558	99,362
5th Percentile (10^3 m^3/yr)	10.9	1.0
1st Quartile (10^3 m^3/yr)	93.5	45.0
Mean (10^3 m^3/yr)	309.0	120.5
3rd Quartile (10^3 m^3/yr)	656.3	322.5
95th Percentile (10^3 m^3/yr)	1,971.1	1,042.6
Maximum (10^3 m^3/yr)	3,904.0	3,624.0
Minimum (10^3 m^3/yr)	0.0	0.0
Average (10^3 m^3/yr)	521.1	267.1

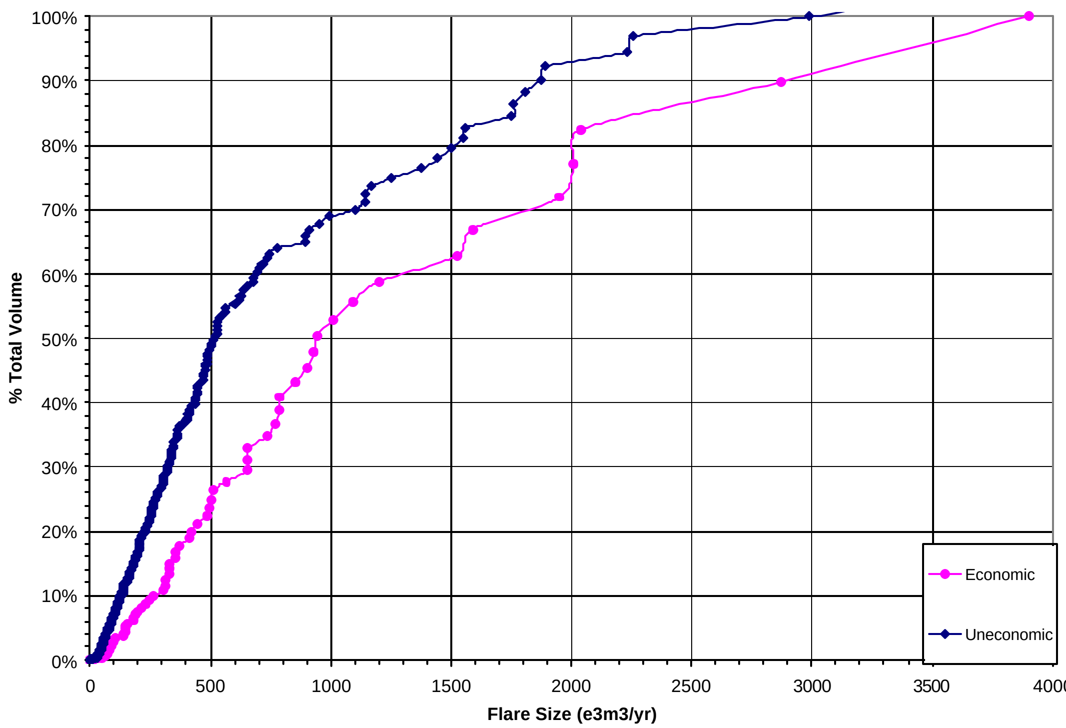

Figure 4.1 Flare Projects Volume Distribution

4.1.5 NPV Distributions

Table 4.3, Figure 4.2, and Figure 4.3 contain NPV statistics for evaluated flare conservation projects for which NPV information was available. It should be noted that the number of sites and total volume statistics shown in Table 4.3 differ from those shown in Table 4.2 because some evaluations gave text rather than numerical values to indicate that they were economic; these evaluations could not used in compiling the statistics for Table 4.3.

Table 4.3 Flare NPV Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	68	372
Sample Total Volume (10^3 m^3/yr)	38,132	99,362
5th Percentile ($)	8,700	-6,000
1st Quartile ($)	47,800	-50,000
Mean ($)	119,000	-122,500
3rd Quartile ($)	206,300	-228,000
95th Percentile ($)	619,000	-679,000
Maximum ($)	2,629,000	-3,874,000
Minimum ($)	1,700	Just less than Zero
Average ($)	218,000	-219,900

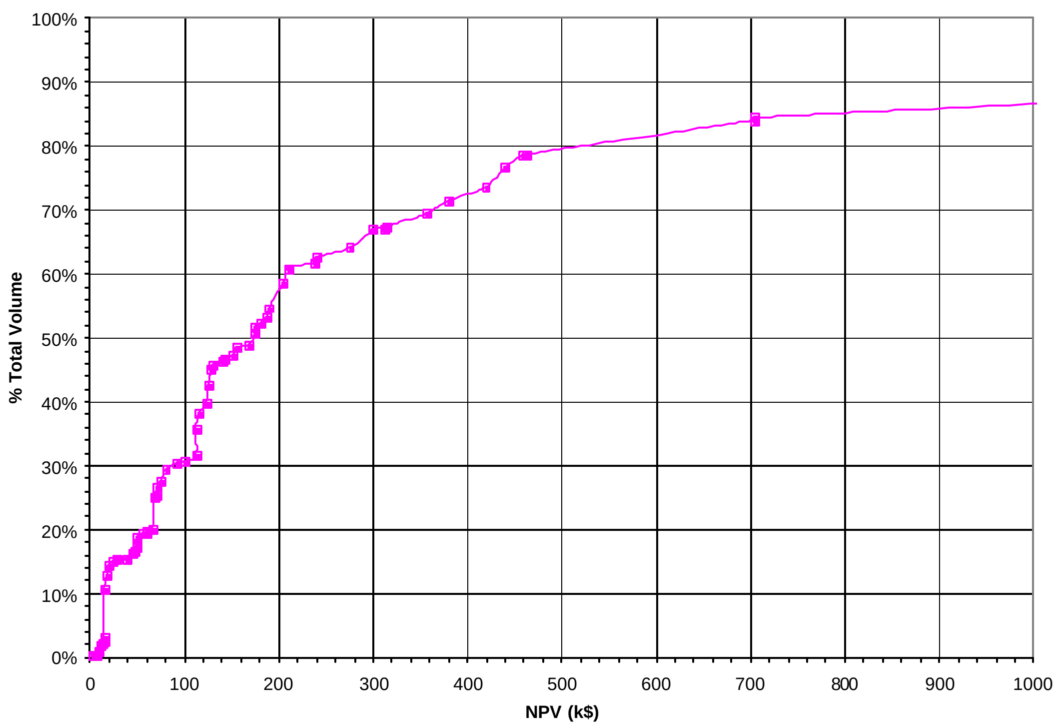

Figure 4.2 Economic Flare Projects NPV Distribution

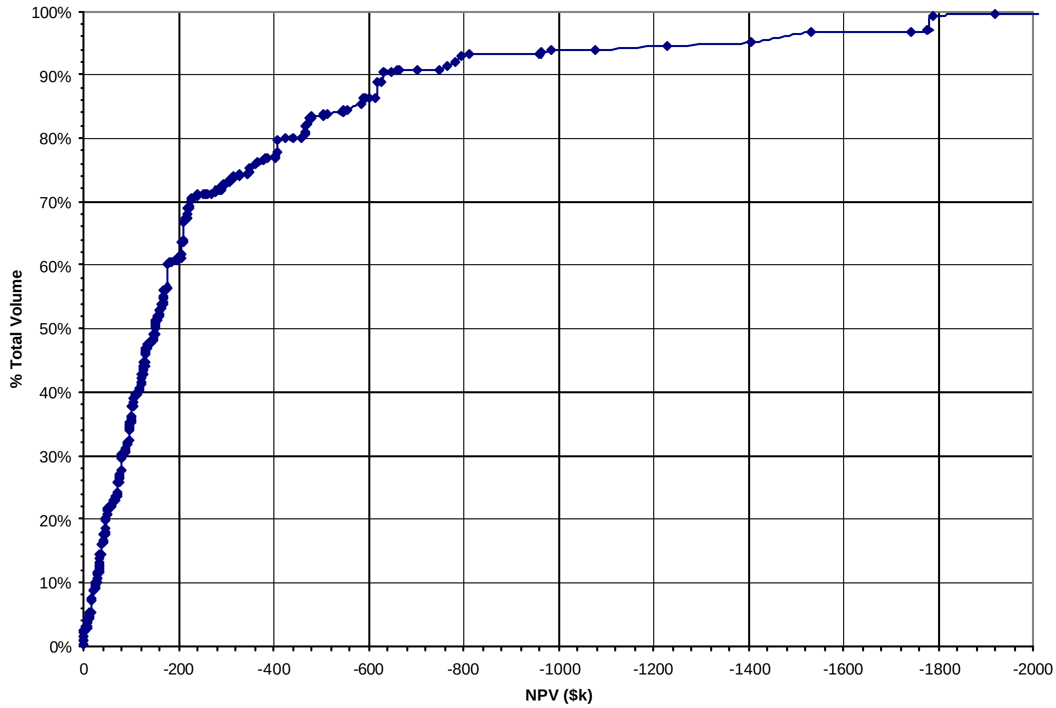

Figure 4.3 Uneconomic Flare Projects NPV Distribution

4.1.6 Pipeline Distributions

Table 4.4 and Figure 4.4 contain pipeline length distribution statistics for evaluated flare projects for which pipeline length information was available. The following conclusions may be drawn from these statistics:

1. Flares that are economic to conserve are generally closer to pipeline systems than are uneconomic projects. Economic projects have a mean distance of 0.4 km as opposed to 1.2 km for flares that are uneconomic to conserve.

2. Approximately 95% of economic sites have distances to pipelines less than 2.6km.

Table 4.4 Pipeline Length Statistics for Flared Gas Conservation Projects

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	52	331
Sample Total Volume (10^3 m^3/yr)	21,333	86,157
5^{th} Percentile (km)	0.0	0.0
1^{st} Quartile (km)	0.1	0.5
Mean (km)	0.4	1.2
3^{rd} Quartile (km)	1.3	3.2
95^{th} Percentile (km)	2.6	10.0
Maximum (km)	4.8	36.0
Minimum (km)	0.0	0.0
Average (km)	0.8	2.8

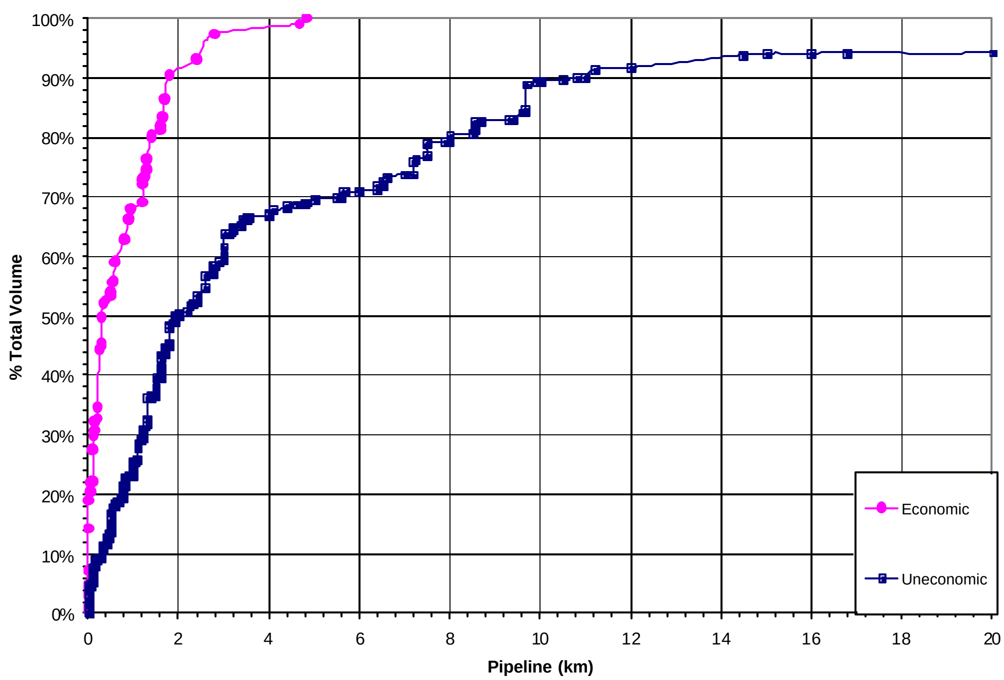

Figure 4.4 Flare Projects Pipeline Length Distribution

4.1.7 Compressor Discharge Pressure Distributions

Table 4.5 and Figure 4.5 contain compressor discharge pressures distribution statistics for evaluated flare projects for which compressor discharge pressure information was available. The following conclusions can be drawn from the statistics shown:

1. Flares that are economic to conserve generally have lower compressor discharge pressures to pipeline systems than uneconomic projects.
2. Economic projects have 50% of the values lying between 50 psig and 213 psig as opposed to 100 psig to 300 psig for uneconomic projects.
3. In general, flares with compressor discharge pressures higher than 500 psig are not economic to conserve, as represented by the 95th percentile.

Table 4.5 Flare Compressor Discharge Pressure Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	40	252
Sample Total Volume (10^3 m^3/yr)	19,477	75,124
5th Percentile (psig)	0	9
1st Quartile (psig)	50	100
Mean (psig)	100	135
3rd Quartile (psig)	213	300
95th Percentile (psig)	500	922
Maximum (psig)	700	1,440
Minimum (psig)	0	0
Average (psig)	159	258

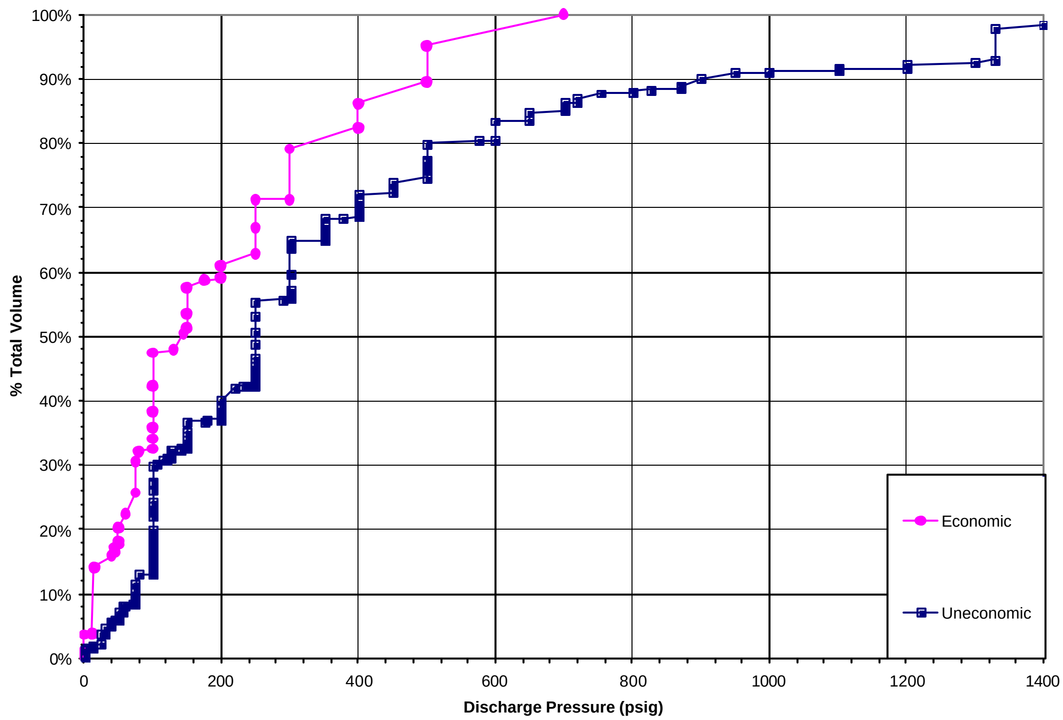

Figure 4.5 Flare Projects Compressor Discharge Pressure Distribution

4.1.8 GOR Distributions

Table 4.6 and Figure 4.6 contain GOR distribution statistics for evaluated flare projects for which GOR information was available. The following conclusions can be drawn from these statistics:

1. Flares that are economic to conserve generally have marginally higher GOR values than those that are uneconomic.
2. 50% of the GOR values lie between 34 m^3 gas/m^3 oil and 527 m^3 gas/m^3 oil for economic projects as opposed to 18m^3 gas/m^3 oil to 219 m^3 gas/m^3 oil for uneconomic projects.
3. 95% of uneconomic flares have GOR's lower than 861 m^3 gas/m^3 oil.

Table 4.6 Flare GOR Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	74	371
Sample Total Volume (10^3 m^3/yr)	38,558	99,362
5th Percentile (m^3 gas/m^3 oil)	4	1
1st Quartile (m^3 gas/m^3 oil)	34	18
Mean (m^3 gas/m^3 oil)	102	73
3rd Quartile (m^3 gas/m^3 oil)	527	219
95th Percentile (m^3 gas/m^3 oil)	1,402	861
Maximum (m^3 gas/m^3 oil)	2,805	2,443
Minimum (m^3 gas/m^3 oil)	0	0
Average (m^3 gas/m^3 oil)	413	190

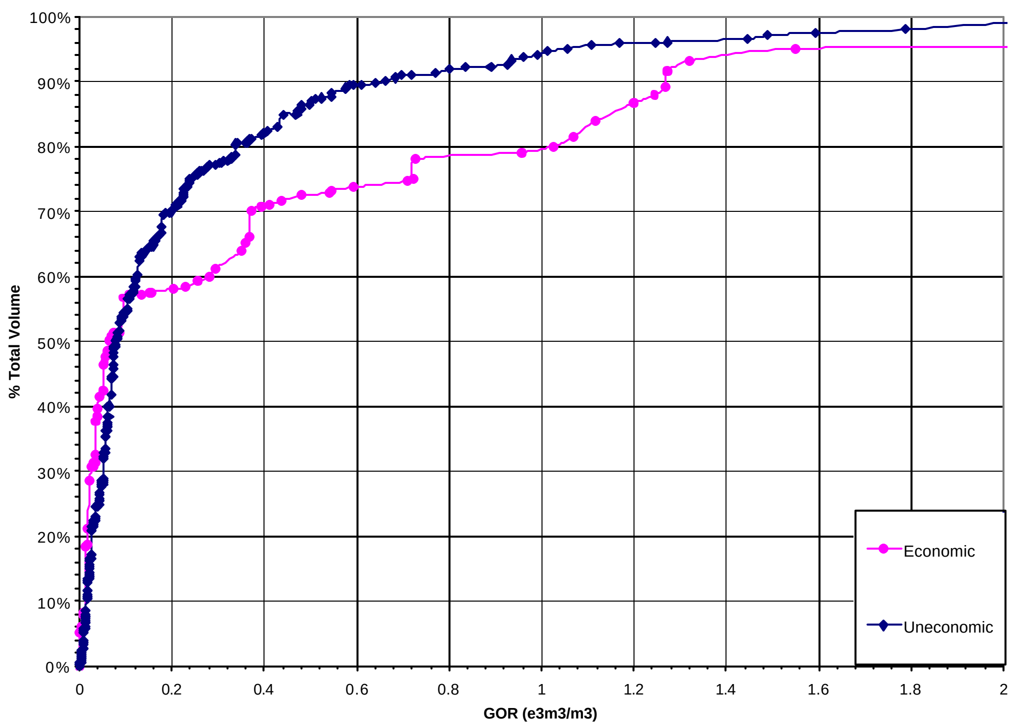

Figure 4.6 Flare Projects GOR Distribution

4.1.9 Reserve Life Distributions

Table 4.7 and Figure 4.7 show reserve life distribution statistics for evaluated flare projects for which reserve life information was available. (Reserve life is calculated by dividing submitted solution gas reserves by the solution gas production rate.) The following conclusions can be drawn from these statistics:

1. Flares that are economic to conserve typically have slightly longer reserve lives than flares that are uneconomic to conserve, although the differences are not large (mean values of 7.6 years and 6.7 years, respectively).

Table 4.7 Flare Reserve Life (Years) Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	53	287
Sample Total Volume (10^3 m^3/yr)	26,561	84,788
5th Percentile (years)	0.1	0.2
1st Quartile (years)	4.6	3.4
Mean (years)	7.6	6.7
3rd Quartile (years)	16.1	16.5
95th Percentile (years)	116.4	142.6
Maximum (years)	1,883.7	2,000.0
Minimum (years)	0.0	0.0
Average (years)	60.0	35.6

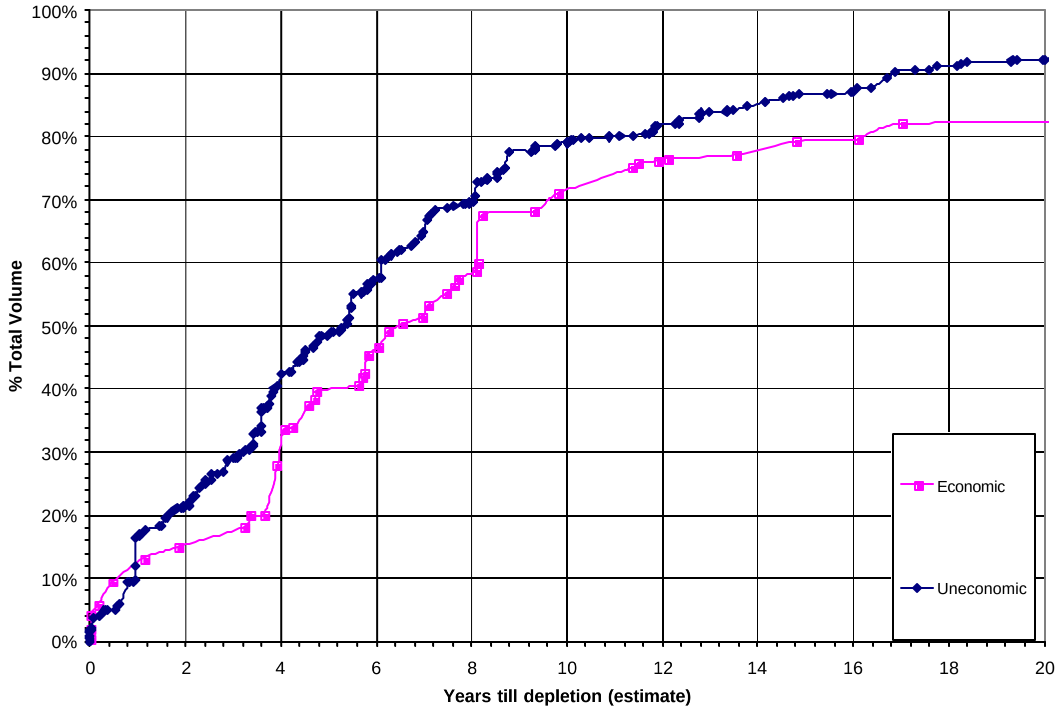

Figure 4.7 Flare Projects Reserve Life Distribution

4.2 Flare Projects by H_2S Concentration

4.2.1 Sweet Flare Volume Distribution

Table 4.8 and Figure 4.8 contain volume distribution statistics for evaluated sweet solution gas flare projects for which volume data was available. The following conclusions can be drawn from these statistics:

1. Sweet flares that are economic to conserve are generally larger in size than uneconomic ones, with mean values of 223.5 10^3 m^3/yr and 97.5 10^3 m^3/yr, respectively.

2. Most uneconomic flares, i.e. 95%, have volumes less than 681.8 10^3 m^3/yr.

Table 4.8 Sweet Flare Volume Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	48	180
Sample Total Volume (10^3 m^3/yr)	18,627	39,466
5^{th} Percentile (10^3 m^3/yr)	9.1	0.0
1^{st} Quartile (10^3 m^3/yr)	82.5	45.0
Mean (10^3 m^3/yr)	223.5	97.5
3^{rd} Quartile (10^3 m^3/yr)	426.8	273.8
95^{th} Percentile (10^3 m^3/yr)	1,453.9	681.8
Maximum (10^3 m^3/yr)	2,038.0	3,624.0
Minimum (10^3 m^3/yr)	0.0	0.0
Average (10^3 m^3/yr)	388.1	219.3

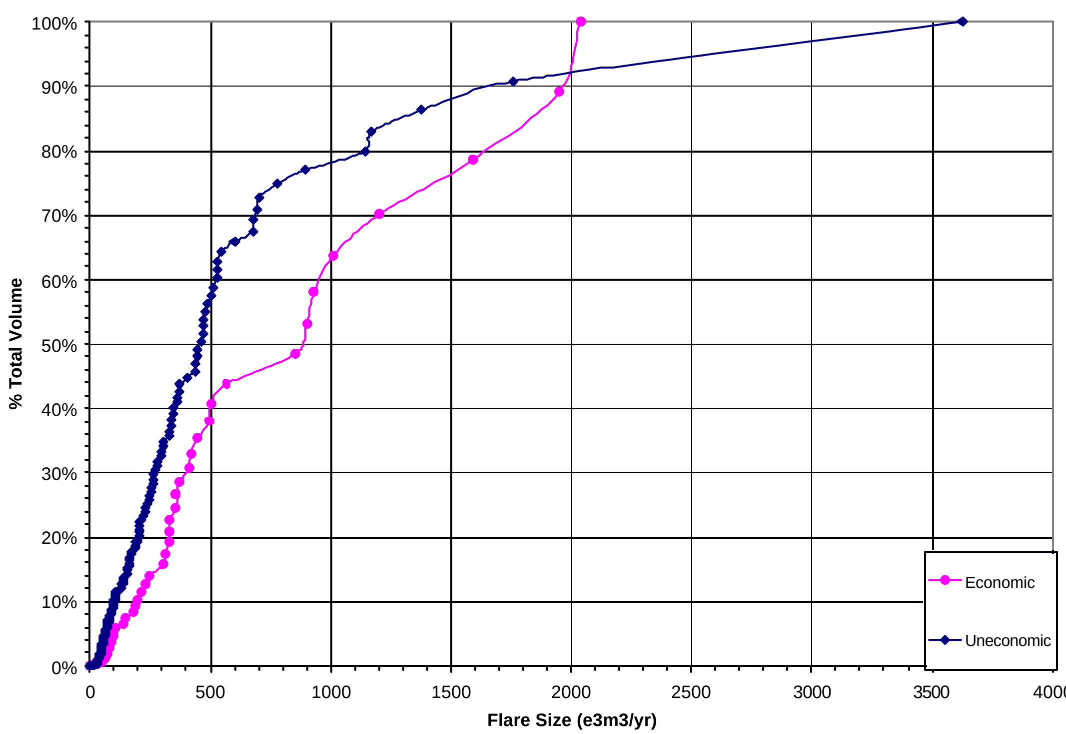

Figure 4.8 Sweet Flare Projects Volume Distribution

4.2.2 Sour Flare Volume Distribution

Table 4.9 and Figure 4.9 contain volume distribution statistics for evaluated sour solution gas flare projects for which volume data was available. The following conclusions can be drawn from these statistics:

1. Sour solution gas flares that are economic to conserve are larger in size than uneconomic ones, with mean values of 581.5 10^3 m^3/yr and 136.5 10^3 m^3/yr, respectively.
2. 95% of uneconomic sour flare sites have flare volumes less than less 1,502.4 10^3 m^3/yr.

Table 4.9 Sour Flare Volume Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	26	180
Sample Total Volume (10^3 m^3/yr)	19,931	57,761
5^{th} Percentile (10^3 m^3/yr)	41.0	3.9
1^{st} Quartile (10^3 m^3/yr)	151.5	46.0
Mean (10^3 m^3/yr)	581.5	136.5
3^{rd} Quartile (10^3 m^3/yr)	790.8	364.5
95^{th} Percentile (10^3 m^3/yr)	2,658.5	1,502.4
Maximum (10^3 m^3/yr)	3,904.0	2,992.0
Minimum (10^3 m^3/yr)	0.0	0.0
Average (10^3 m^3/yr)	766.6	320.9

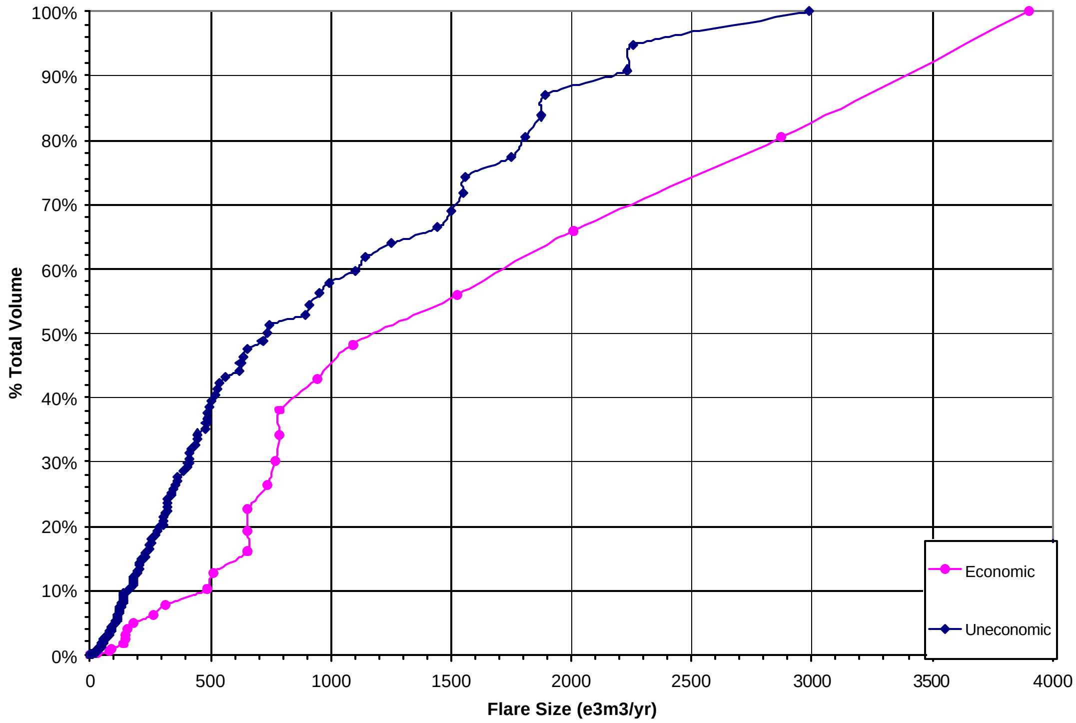

Figure 4.9 Sour Flare Projects Volume Distribution

4.2.3 H_2S Concentration Distribution

Table 4.10 and Figure 4.10 contain H_2S concentration distribution statistics for evaluated sour solution gas flare projects for which H_2S concentration data was available. From these statistics, the following conclusions can be drawn:

1. Sour solution gas flares that are economic to conserve generally have lower H_2S concentrations than uneconomic ones, with mean values of 3.7 mol/kmol and 9.1 mol/kmol, respectively.

2. No economic flares had H_2S concentrations above 40 mol/kmol..

Table 4.10 Flare H_2S Concentration Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	18	135
Sample Total Volume (10^3 m^3/yr)	11,588	46,804
5^{th} Percentile (mol/kmol)	0.0	0.1
1^{st} Quartile (mol/kmol)	1.3	2.2
Mean (mol/kmol)	3.7	9.1
3^{rd} Quartile (mol/kmol)	9.1	30.0
95^{th} Percentile (mol/kmol)	16.2	69.3
Maximum (mol/kmol)	40.0	230.0
Minimum (mol/kmol)	0.0	0.0
Average (mol/kmol)	6.6	21.8

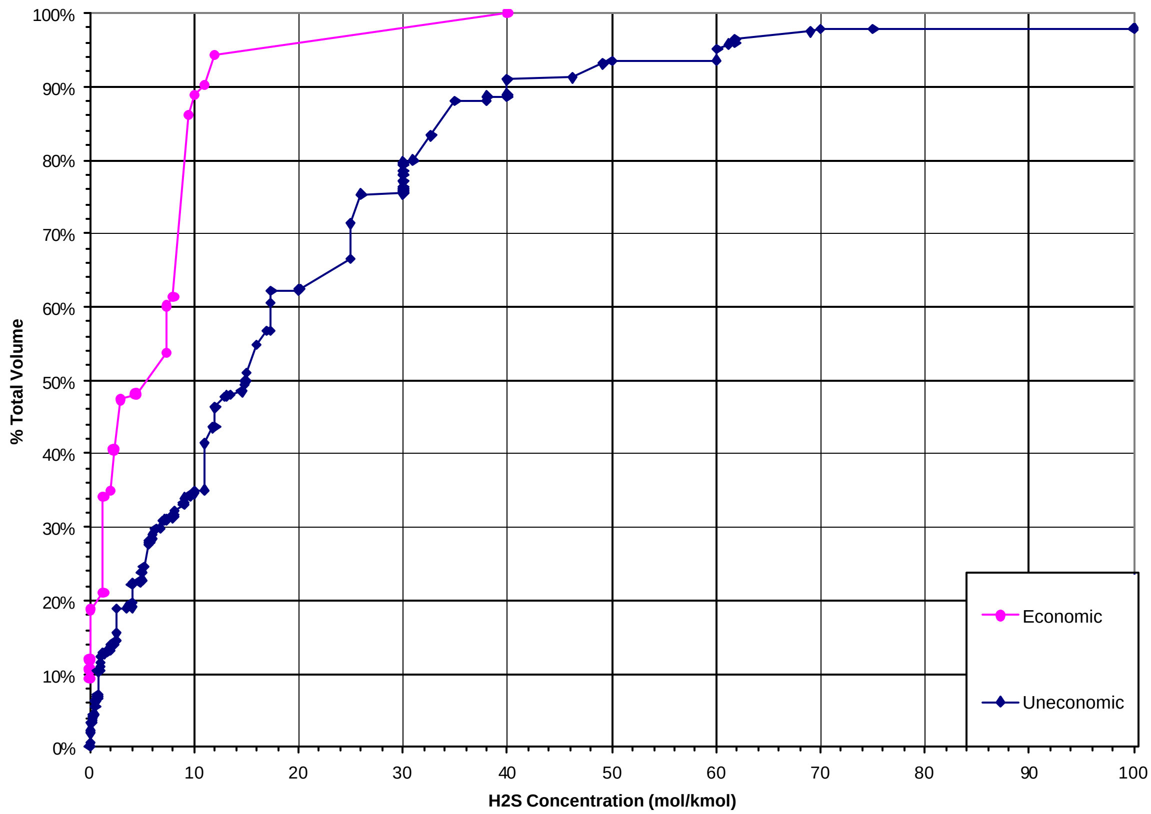

Figure 4.10 Flare Projects H_2S Concentration Distribution

4.3 Vent Projects

4.3.1 Dataset

Table 4.11 shows the number and volume of evaluations received for economic and uneconomic vent conservation projects. More data was received for economic project evaluations than uneconomic project evaluations. Note that the volumes presented in the Table 4.are less than the volumes for economic and uneconomic projects in Table 3.4 because only evaluations that were complete were used.

Table 4.11 Vent Dataset

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	132	209
Sample Total Volume (10^3 m^3/yr)	179,253	88,101

4.3.2 Volume Distributions

Table 4.12 and Figure 4.11contain volume distribution statistics for evaluated vent projects for which volume data was available. The following conclusions can be drawn from these statistics:

1. Vents that are economic to conserve are generally larger in size than those that are uneconomic, with mean values of 766 10^3 m^3/yr and 296 10^3 m^3/yr, respectively.
2. Approximately 95% of vents that are uneconomic have volumes less than 1224 10^3 m^3/yr.

It should be noted that these conclusions were drawn from an incomplete dataset, i.e as per ID 2002-02, the vast majority of the evaluations were for vents larger than 800 m^3/d.

Table 4.12 Vent Volume Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	132	209
Sample Total Volume (10^3 m^3/yr)	179,253	88,101
5^{th} Percentile (10^3 m^3/yr)	237	0
1^{st} Quartile (10^3 m^3/yr)	487	109
Mean (10^3 m^3/yr)	766	296
3^{rd} Quartile (10^3 m^3/yr)	1,512	491
95^{th} Percentile (10^3 m^3/yr)	4,334	1,224
Maximum (10^3 m^3/yr)	12,031	7,019
Minimum (10^3 m^3/yr)	56	0
Average (10^3 m^3/yr)	1,358	422

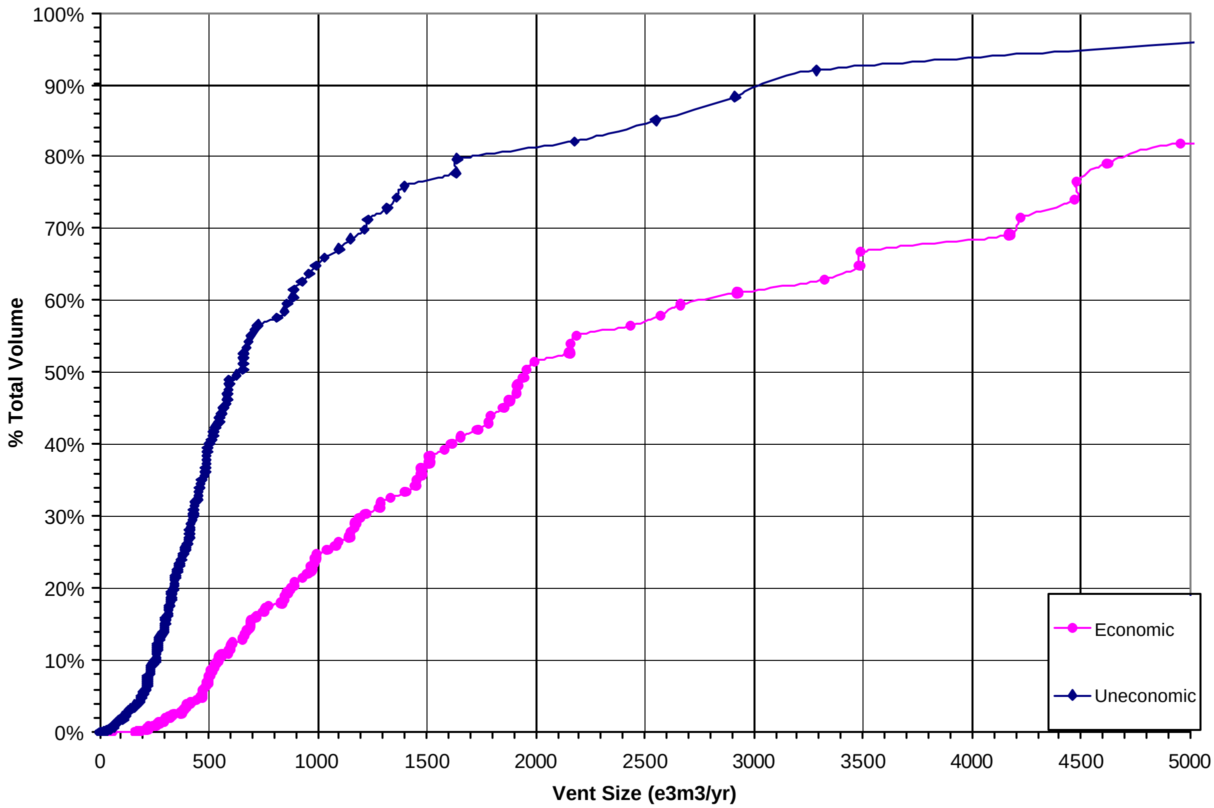

Figure 4.11 Vent Projects Volume Distribution

4.3.3 NPV Distributions

Table 4.13, Figure 4.12, and Figure 4.13 contain NPV distribution statistics for evaluated vent projects for which NPV data was available. The following conclusions can be drawn from these statistics:

1. Vents that are economic to conserve generated mean and maximum NPV's of $81,000 and $1.9 million, respectively.

2. Flares that are uneconomic to conserve have mean and minimum NPV's of -$54,900 and -$3.8 million, respectively.

Table 4.13 Vent NPV Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	73	112
Sample Total Volume (10^3 m^3/yr)	107,854	43,865
5th Percentile ($)	6,900	-8,800
1st Quartile ($)	32,000	-30,800
Mean ($)	81,000	-54,900
3rd Quartile ($)	205,900	124,800
95th Percentile ($)	501,700	-323,300
Maximum ($)	1,910,600	-465,000
Minimum ($)	2,500	Less than zero
Average ($)	165,900	-94,400

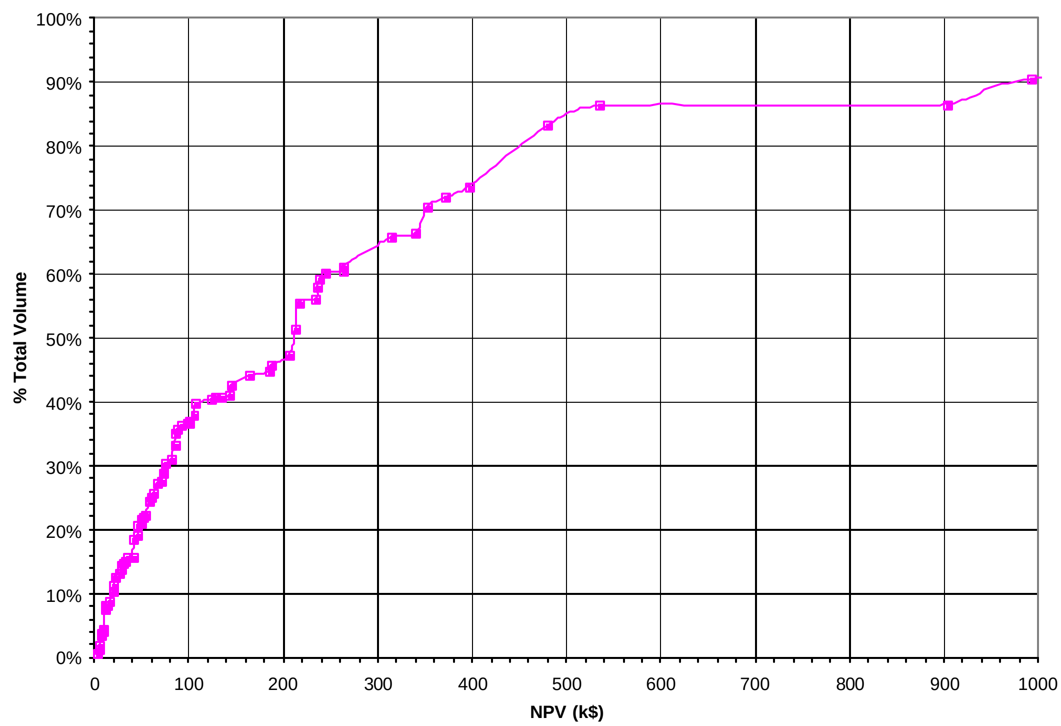

Figure 4.12 Economic Vent Projects NPV Distribution

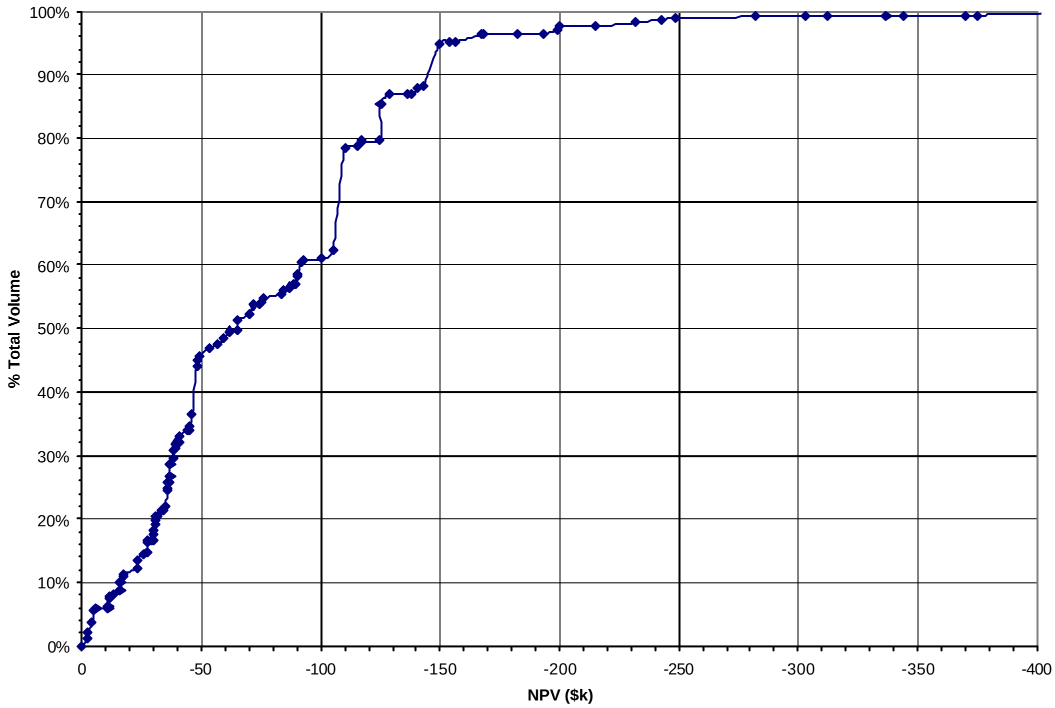

Figure 4.13 Uneconomic Vent Projects NPV Distribution

4.3.4 Pipeline Distributions

Table 4.14 and Figure 4.14 contain pipeline length distribution statistics for evaluated vent projects for which there was pipeline length data available. The following conclusions can be drawn from these statistics:

1. In general, for the data submitted, it appears that vent to pipeline tie-in distance does not seem to significantly affect conservation, as both the economic and uneconomic projects show very similar distributions.

2. A large number of venting sites reported pipeline distance of 0 km. This may imply they are fuel gas conservation projects, intending to use the vented gas on site as opposed to selling it.

Table 4.14 Vent Pipeline Length Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	130	202
Sample Total Volume (10^3 m^3/yr)	174,827	79,558
5^{th} Percentile (km)	0.0	0.0
1^{st} Quartile (km)	0.0	0.0
Mean (km)	0.1	0.1
3^{rd} Quartile (km)	1.0	0.8
95^{th} Percentile (km)	2.3	3.6
Maximum (km)	5.8	10.0
Minimum (km)	0.0	0.0
Average (km)	0.6	0.7

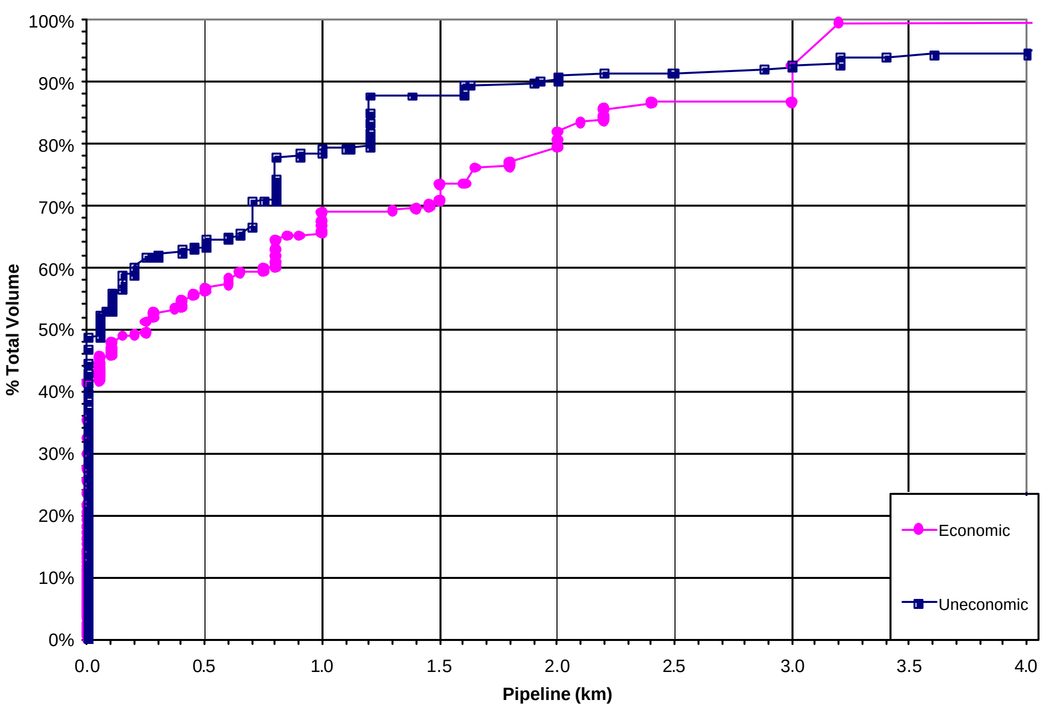

Figure 4.14 Vent Projects Pipeline Length Distribution

4.3.5 Compressor Discharge Pressure Distributions

Table 4.15 and Figure 4.15 contain compressor discharge pressure statistics for evaluated vent projects for which compressor discharge pressure information was available The following conclusions can be drawn from this data:

1. For the data submitted, the distributions of the compressor discharge pressures are similar for both the economic and uneconomic projects. This indicates that, for the data submitted, the comp ressor discharge pressure is not an important factor in determining whether or not a project is economic.

Table 4.15 Vent Compressor Discharge Pressure Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	122	191
Sample Total Volume (10^3 m^3/yr)	171,228	78,987
5th Percentile (psig)	75	50
1st Quartile (psig)	115	100
Mean (psig)	125	125
3rd Quartile (psig)	125	125
95th Percentile (psig)	219	250
Maximum (psig)	375	700
Minimum (psig)	0	0
Average (psig)	124	136

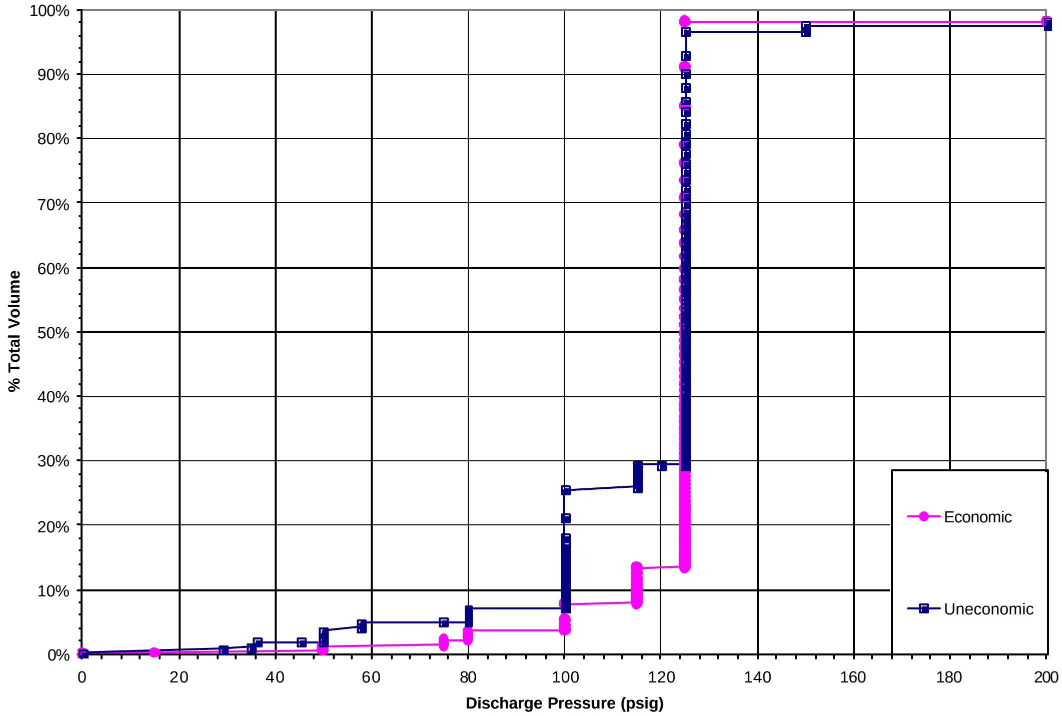

Figure 4.15 Vent Projects Compressor Discharge Pressure Distribution

4.3.6 GOR Distributions

Table 4.16 and Figure 4.16 contain GOR distribution statistics for evaluated vent projects for which GOR information was available. The following conclusions can be drawn from these statistics:

1. Vents that are economic to conserve generally have higher GOR values than uneconomic projects.
2. 50% of the GOR values for economic projects lie between 93 m^3 gas/m^3 oil and 393 m^3 gas/m^3 oil as opposed to 52 m^3 gas/m^3 oil to 203 m^3 gas/m^3 oil for uneconomic projects.
3. Approximately 95% of uneconomic sites have GORs less than 525 m^3 gas/m^3 oil.

Table 4.16 Vent GOR Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	128	192
Sample Total Volume (10^3 m^3/yr)	174,827	85,798
5th Percentile (m^3 gas/m^3 oil)	29	9
1st Quartile (m^3 gas/m^3 oil)	93	52
Mean (m^3 gas/m^3 oil)	156	105
3rd Quartile (m^3 gas/m^3 oil)	393	203
95th Percentile (m^3 gas/m^3 oil)	1,218	525
Maximum (m^3 gas/m^3 oil)	3,296	1,889
Minimum (m^3 gas/m^3 oil)	0	0
Average (m^3 gas/m^3 oil)	330	169

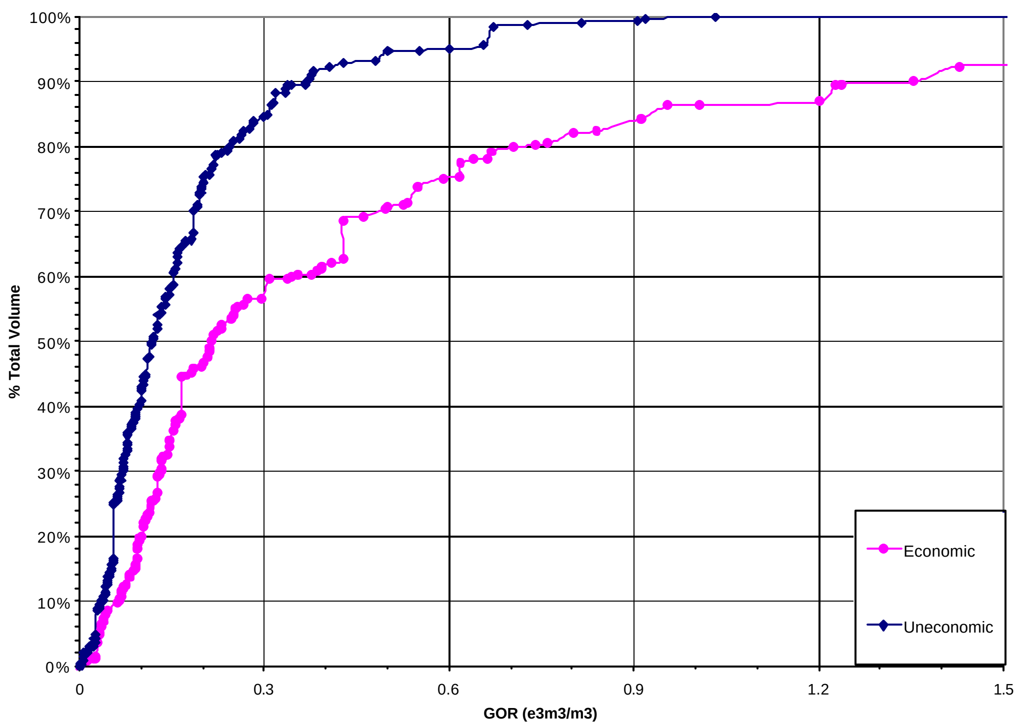

Figure 4.16 Vent Projects GOR Distribution

4.3.7 Reserve Life Distributions

Table 4.17 and Figure 4.17 contain reserve life distribution statistics for evaluated vent projects for which reserve life information was available. The following conclusions can be drawn from this information:

1. For the evaluations submitted, vent project reserve life does not appear to have significant effect on project economics, since the distributions are similar for both the economic and uneconomic projects.

Table 4.17 Vent Reserve Life (Years) Distribution

Statistic	Economic Projects	Uneconomic Projects
Sample Size (Number sites)	127	197
Sample Total Volume (10^3 m^3/yr)	175,700	88,101
5th Percentile (years)	1.0	0.3
1st Quartile (years)	1.8	1.3
Mean (years)	2.4	2.2
3rd Quartile (years)	3.7	4.2
95th Percentile (years)	21.4	56.8
Maximum (years)	97.7	Undefined
Minimum (years)	0.7	0.0
Average (years)	5.6	Undefined

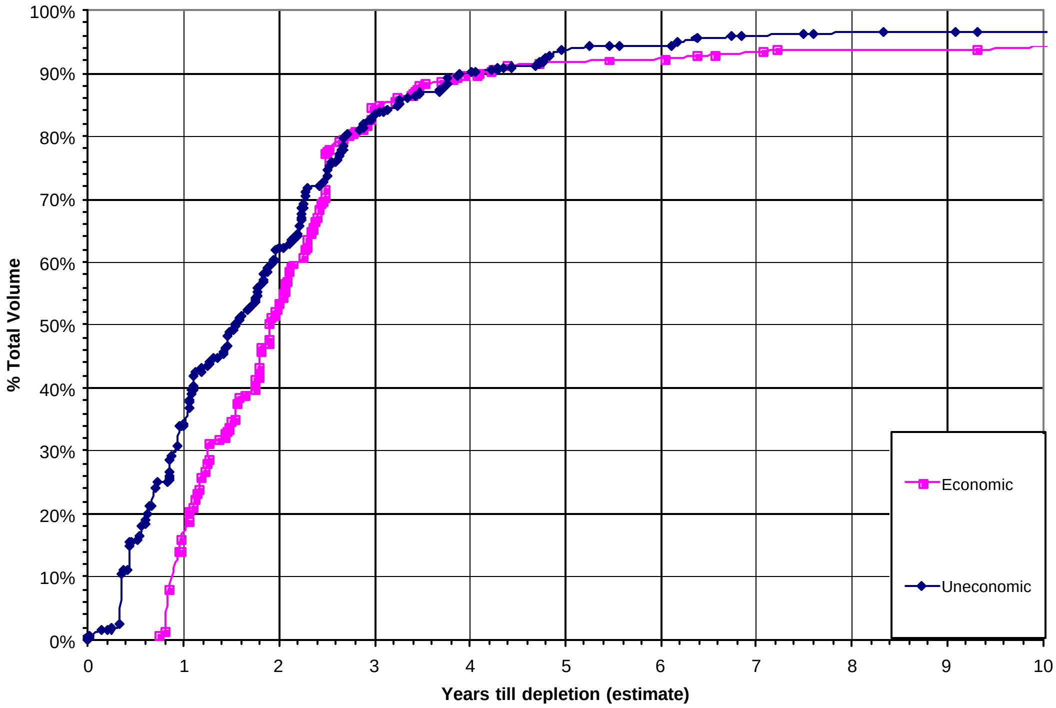

Figure 4.17 Vent Projects Reserve Life Distribution

5 Costs to Conserve Pre-2003 Solution Gas Projects

5.1 Projects Analyzed

As part of this study, the costs were estimated to conserve solution gas from pre-2003 projects that were uneconomic to conserve on a standalone basis. For these calculations, only uneconomic projects with complete submissions were analysed and the projects analyzed include only sales gas or fuel gas projects, i.e. no electrical generation projects. However, gas volumes shown in Table 5.1 do include volumes from power generation projects and thus are higher than those used in Section 4.

No distinction was made between oil solution gas and bitumen solution gas in this section.

Table 5.1 Uneconomic Projects Evaluated

	2001/2 Volume (10^6 m^3/yr)	2003 Volume Evaluated (10^6 m^3/yr)
Flare	112	99
Vent	101	62

5.2 Second NPV Estimates

To ensure the quality of project evaluations, a second estimate of the conservation costs was done using the project characteristics submitted, so that the results could be compared to the first estimates. The re-estimation was based on the G60 economic model and the latest economic outlook for natural gas. Capital costs were also modelled using a standard cost estimating model, to investigate whether there would be any major change. The methodology and assumptions for this exercise are outlined below, and the results are presented in the following sections.

5.2.1 Price Forecast

Most submitted projects used the Chenery Dobson Hydrocarbon Price Forecast for July 2002 for their economic model. The January 2003 price forecast was used in recalculating the NPV. The long term forecast for gas prices is largely unchanged, but the January 2003 forecast reflects more accurately the current higher natural gas prices.

5.2.2 Discount Rate

While having only the most minor effects on NPV, the discount rate linked to the ATB prime lending rate was updated to reflect an increase in the interest rate of 0.25%. The new rate is now 8.00%[16], up from the 7.75% that most submitted evaluations were done with.

5.2.3 Capital cost model

Due to the number of sites involved, and the range of capital costs that were submitted for various equipment, there was interest in determining if the equipment cost estimates submitted were generally reasonable, or if there was a possibility that inaccurate capital cost estimates might have skewed the overall results. To assess the impact of the capital cost estimates on the overall results, modelled capital costs were substituted for submitted capital costs in cases where the modelled costs were less than the submitted costs (this substitution was done under the underlying assumption that the submitted costs could be too high, making some conservation projects uneconomic when they should, in fact, be economic). Capital cost models were derived from New Paradigm Engineering's Heavy Oil Casing Gas Utilization Option Sheet[17] and cost estimates from several industry sources. Equation 5.1 shows the pipeline costs model as a function of the length of the pipeline, based on uniform land characteristics. This pipeline cost model would cover most small diameter plastic pipelines and up to 3 inch steel pipelines. Equation 5.2 shows the compressor cost model as a function of volume capacity and the number of stages of compression required. This model also takes into account whether the compression equipment needs to be designed to handle sour gas. It assumes that the minimum cost for any compression equipment is $50,000.

$$Pipeline\ Cost = Distance(km) * \$70{,}000$$

Equation 5.1 Pipeline Cost Model

$$Compressor\ Cost = \$20{,}000 + \left[Volume\ (10^3 m^3/d) \times Number\ of\ Stages \times (\$15{,}000\ if\ sweet\ or\ \$20{,}000\ if\ sour)\right]$$
$$(Caveat: minimum\ cost\ is\ \$50{,}000)$$

Equation 5.2 Compressor Cost Model

[16] Based on an Alberta Treasury Bank Prime Lending Rate of 5.0% in July 2003

[17] "Heavy Oil Casing Gas Utilization Option Sheet", New Paradigm Engineering Ltd.: March 2002

5.3 Available CO_2E offset credits

5.3.1 CO_2E Estimation

Basic calculations of the reduction in greenhouse emissions (in tonnes of carbon dioxide equivalent or CO_2E) attributable to the reductions in flared and vented solution gas were performed for the submitted and calculated reduction scenarios using the greenhouse gas emission reduction equivalency factors listed in Table 5.2. The greenhouse gas emissions were assumed to be creditable at various values, and the value of the resultant credits was added in to the cash flow sustaining the project. Since higher CO2E credit prices would help to sustain the economic life of any given project, more gas could be conserved and higher levels of greenhouse gas emissions reductions could be achieved.

Table 5.2 Flare and Vent CO_2E Factors

Solution Gas Disposal Type	Factor (Tonnes CO_2E per 10^3 m^3 solution gas)
Flare	2.57
Vent	14.25

5.3.2 Flare CO_2E Available

Figure 5.1 shows the amount of greenhouse gas emission reductions that could be achieved from otherwise non-economic flare conservation projects if the emission reductions were given monetary value. For example, at a value of $5 per tonne of CO_2E, 0.28 to 0.32 million tonnes of CO_2E emission reductions should be achievable. At $15 per CO_2E tonne, 0.48 to 0.65 million tonnes should be available. There are no significant breakpoints in the graph.

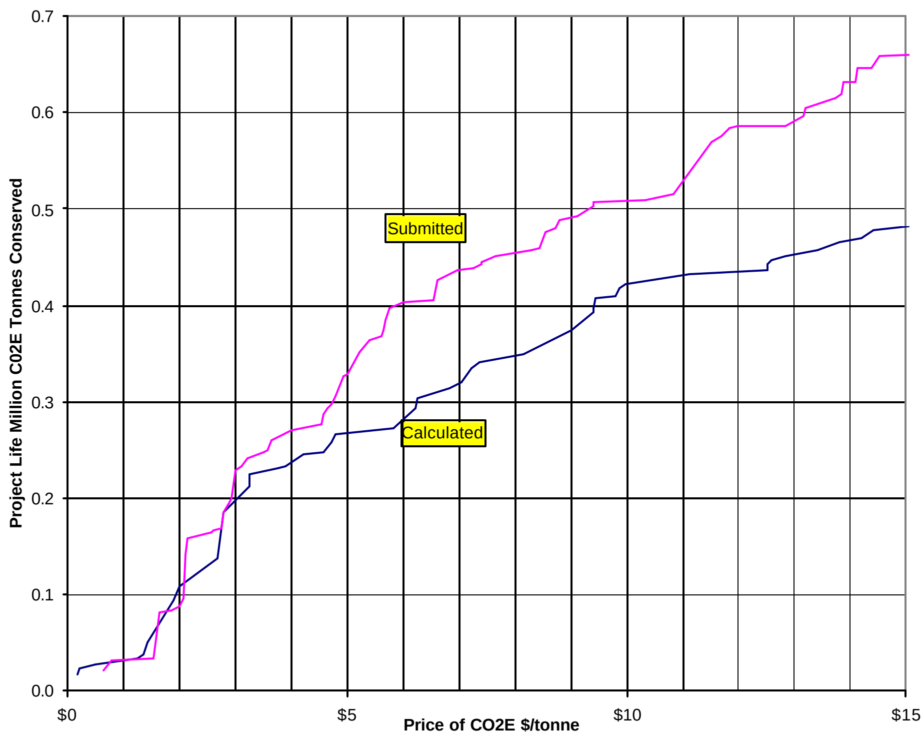

Figure 5.1 Flare CO_2E Available from Uneconomic Projects

5.3.3 Vent CO_2E Available

Figure 5.12 shows the amount of greenhouse gas emission reductions that could be achieved from otherwise non-economic vent conservation projects if the emission reductions were given monetary value. At $5 per tonne of CO_2E, 0.5 to 1.05 million tonnes of CO_2E should be available. At $15 per CO_2E tonne, 0.85 to 1.4 million tonnes should be available. There is a breakpoint in the graph at approximately $8 per tonne CO_2E, where 0.7 to 1.3 million tonnes should be available.

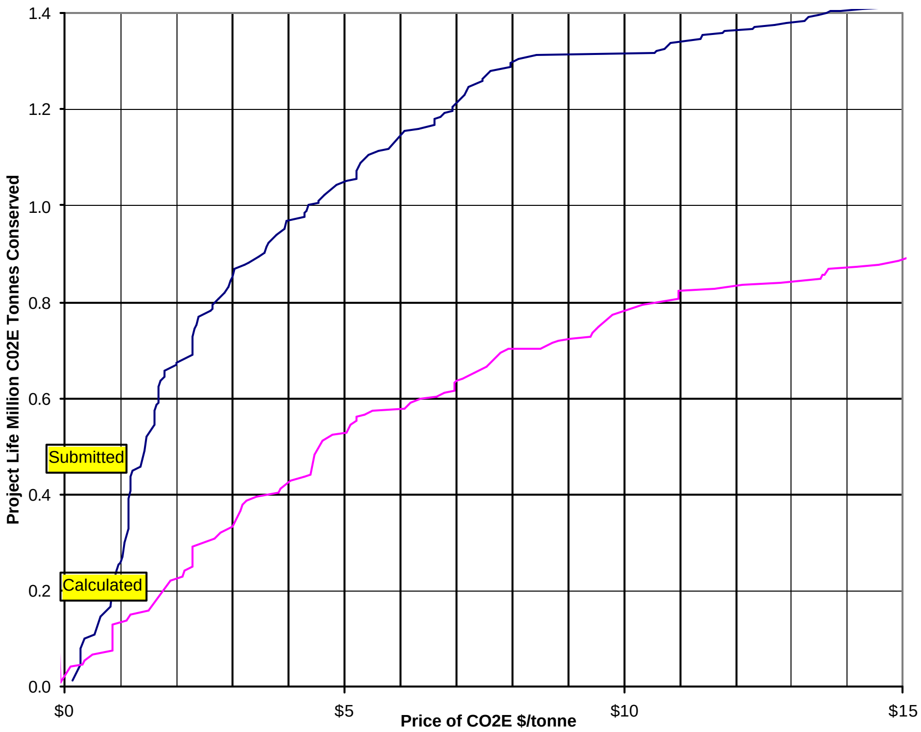

Figure 5.2 Vent CO_2E Available from Uneconomic Projects

5.4 Conservation Costs

5.4.1 Cost Estimation Method

As previously described, as part of this study conservation costs were estimated for flaring and venting with two sets of data. To estimate the costs to conserve the solution gas, NPV values were first used from the submitted evaluations, and next NPV values were calculated separately from the submissions, based on the method outlined in Section 5.2 . When the NPV's were recalculated, some sites that were deemed to be uneconomic based on the submitted data were found to be economic under the revised assumptions. The volumes of uneconomic solution gas estimated to be economic from the calculations, as opposed to the submitted data, are shown as the start point on the calculated NPV lines. Finding a project to be economic to conserve when it was submitted as uneconomic does not necessarily imply that the operators were in error in their submissions. A variety of factors are involved in the recalculated values, as explained above, including updates in the price forecast for natural gas, and the exchange rates. It does imply that, due to a changed outlook for natural gas and exchange rates and the possibility that capital costs were overestimated, the project might be found to be economic, if re-examined..

5.4.2 Flare Conservation Costs

Figure 5.3 shows the cost to conserve uneconomic solution gas flares, including sour flares but excluding those that did not submit (or were not required to submit) economics as per ID 2002-02, indicates that solution gas flares existing prior to 2003 can be conserved at a cost of approximately $90 million. Both estimates, i.e submitted and recalculated, suggest this number. No significant breakpoints exist on the graph. Approximately 18,000 10^3 m^3/yr of uneconomic solution gas flares was found to be economic to conserve when recalculated. However, the line for Calculated NPV does cross over the Submitted NPV, and this suggests that some operators may have underestimated the cost to conserve some of their solution gas.

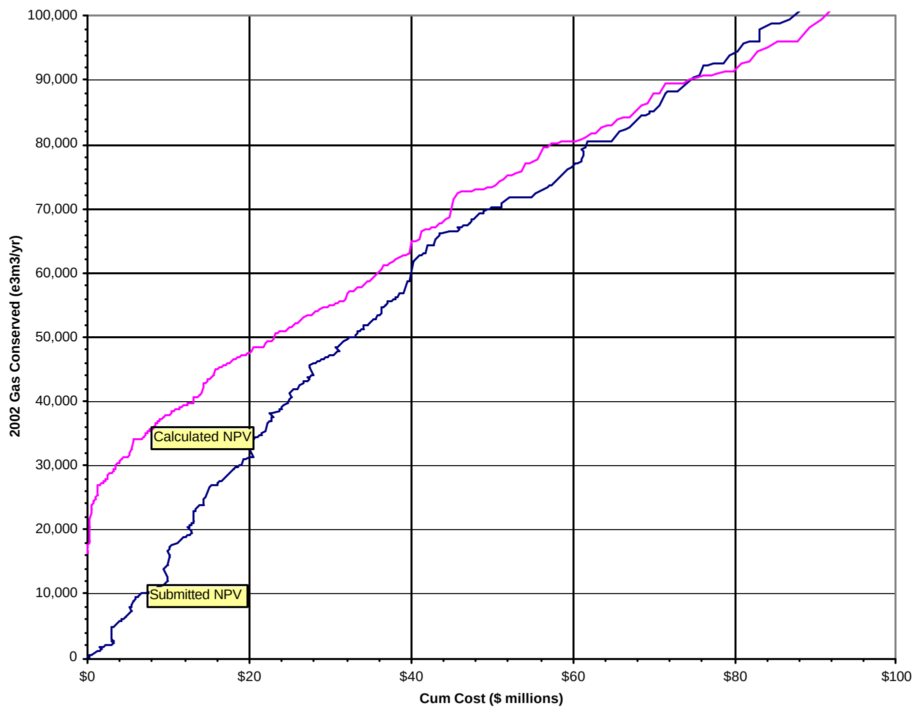

Figure 5.3 Solution Gas Flare Conservation Costs

5.4.3 Sour Flare Conservation Costs

Figure 5.4 shows the cost to conserve sour solution gas flares and indicates that sour solution gas flares existing prior to 2003 can be conserved at a cost of approximately $60 million. Both estimates suggest this number. No significant breakpoints exist on the graph. Approximately 12,000 10^3 m^3/yr of uneconomic solution gas flares was found to be economic to conserve. However, the line for Calculated NPV does cross over the Submitted NPV and this suggests that some operators may have underestimated the cost to conserve some of their solution gas

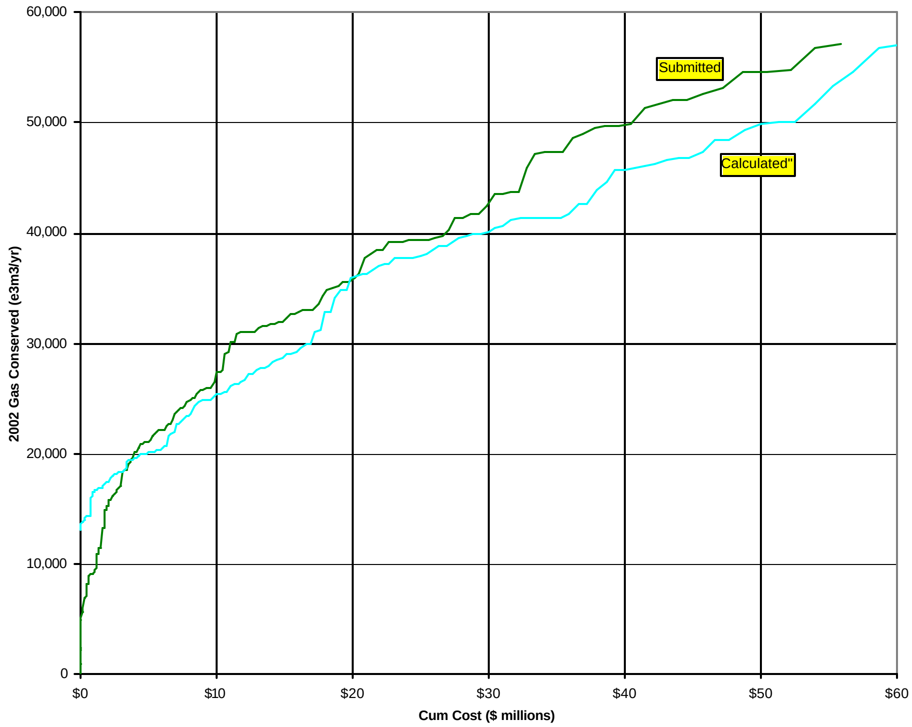

Figure 5.4 Sour Solution Gas Flare Conservation Costs

5.4.4 Vent Conservation Costs

Figure 5.4 shows the cost to conserve solution gas vents and indicates that uneconomic solution gas vents greater than 800 m^3/day existing prior to 2003 that submitted an evaluation

can be conserved at a cost of approximately $20 million. Both estimates suggest this number. A significant breakpoints exists at $10 million, where 48,000 to 55,000 10^3 m^3/yr of solution gas vents can be conserved. Approximately 14,000 10^3 m^3/yr of uneconomic solution gas flares was found to be economic to conserve. However, the line for Calculated NPV does cross over the Submitted NPV and this suggests that some operators may have underestimated the cost to conserve some of their solution gas.

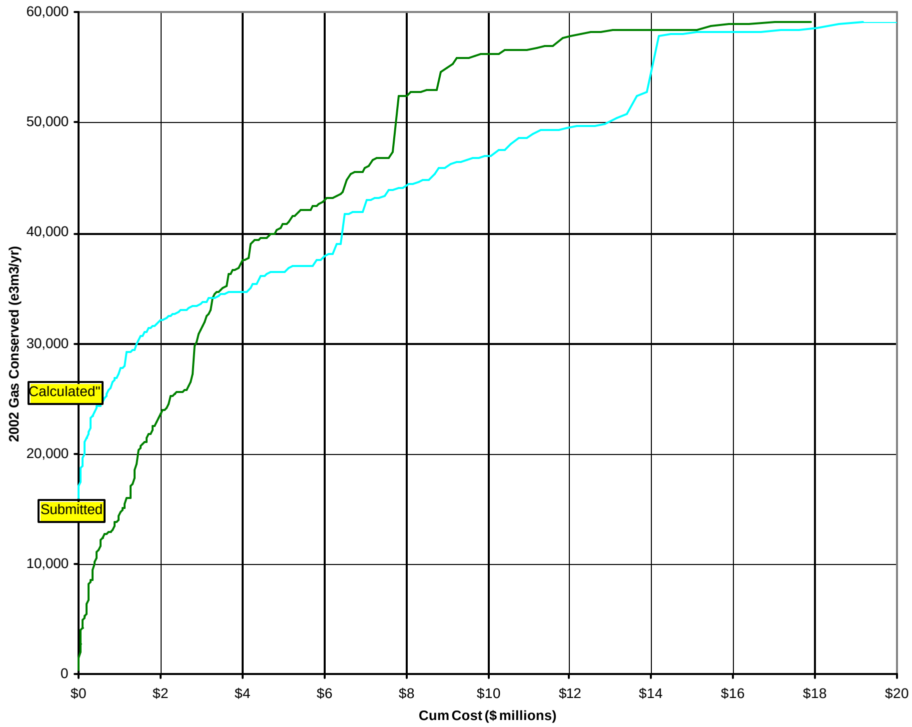

Figure 5.5 Solution Gas Vent Conservation Costs

6 Estimating Future Solution Gas Volumes

6.1 Methodology

Forecasts for crude oil and in-situ bitumen production from the EUB were used as the basis for estimating future conventional oil solution gas and in-situ bitumen solution gas volumes. Oil solution gas production was forecasted by linking it to crude oil production. In-situ bitumen solution gas production was forecast by linking it to in-situ crude bitumen production. Detailed historic production data was available from 1998 from the EUB, but distinguishing flares from vents was only possible, with reasonable accuracy, from the year 2000 onwards. This is because changes in flare reporting were not completed until the end of 1999. These changes lead to reclassifying some flare volumes as vent volumes. Historic GOR trends were used to estimate total oil and bitumen solution gas produced for the period 2003-2010 by multiplying it by the crude oil and in-situ crude bitumen production, respectively. Projected gas volumes were separated into solution gas existing pre-2003 and solution gas on-stream

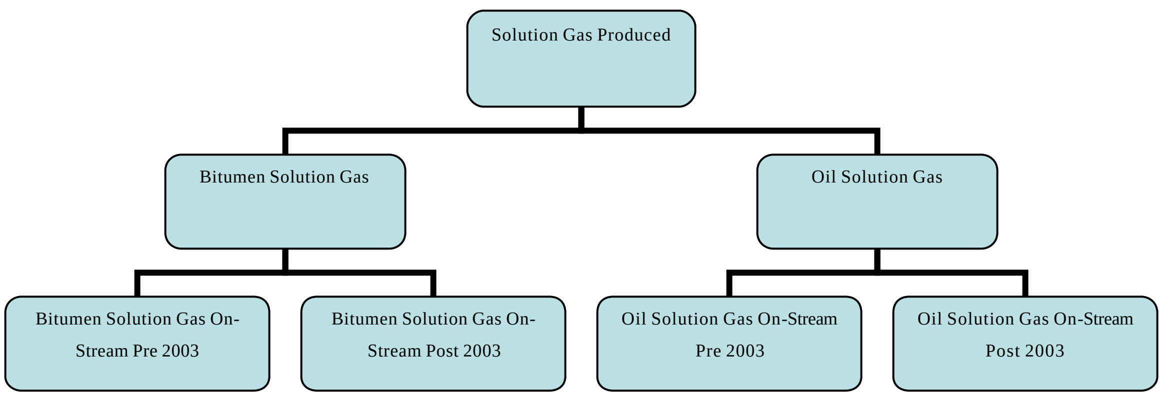

Figure 6.1 Future Solution Gas Sources

Post-2002 categories (see Figure 6.1). This was due to the assumption that existing gas would decline at a fixed rate, and new gas would come on-stream to make up some of the difference. These categories were further divided into solution gas conserved due to the produced solution gas conservation percentage in 2002, incremental solution gas conserved due to G60, flared solution gas and vented solution gas (see Figure 6.2). The anticipated incremental solution gas conserved due to G60 (Although G60 has been in place since 1999, for the purposes of this discussion "solution gas conserved due to G60" refers to incremental conservation beyond 2001/2 conservation rates. This was estimated by estimating the proportion of solution gas that was flared in 2001/2 that upon examination was determined to be economic to conserve when evaluating it with the G60 flare/vent decision tree.) and solution gas decline rates were estimated by analyzing data collected as a result of ID 2002-02. Historic trends of the ratio of solution gas flared to solution gas vented were used to estimate flare and vent volumes from non-conserved solution gas produced. Figure 6.3 contains a schematic overview of the methodology.

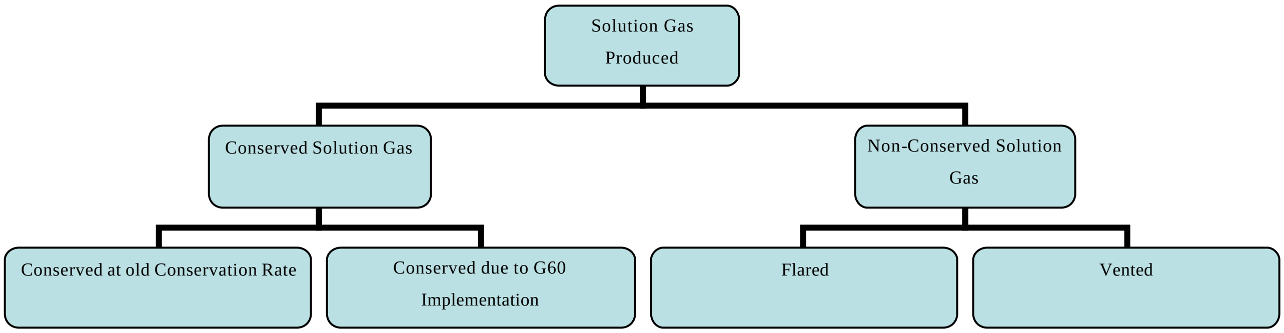

Figure 6.2 Solution Gas Classification: Utilization

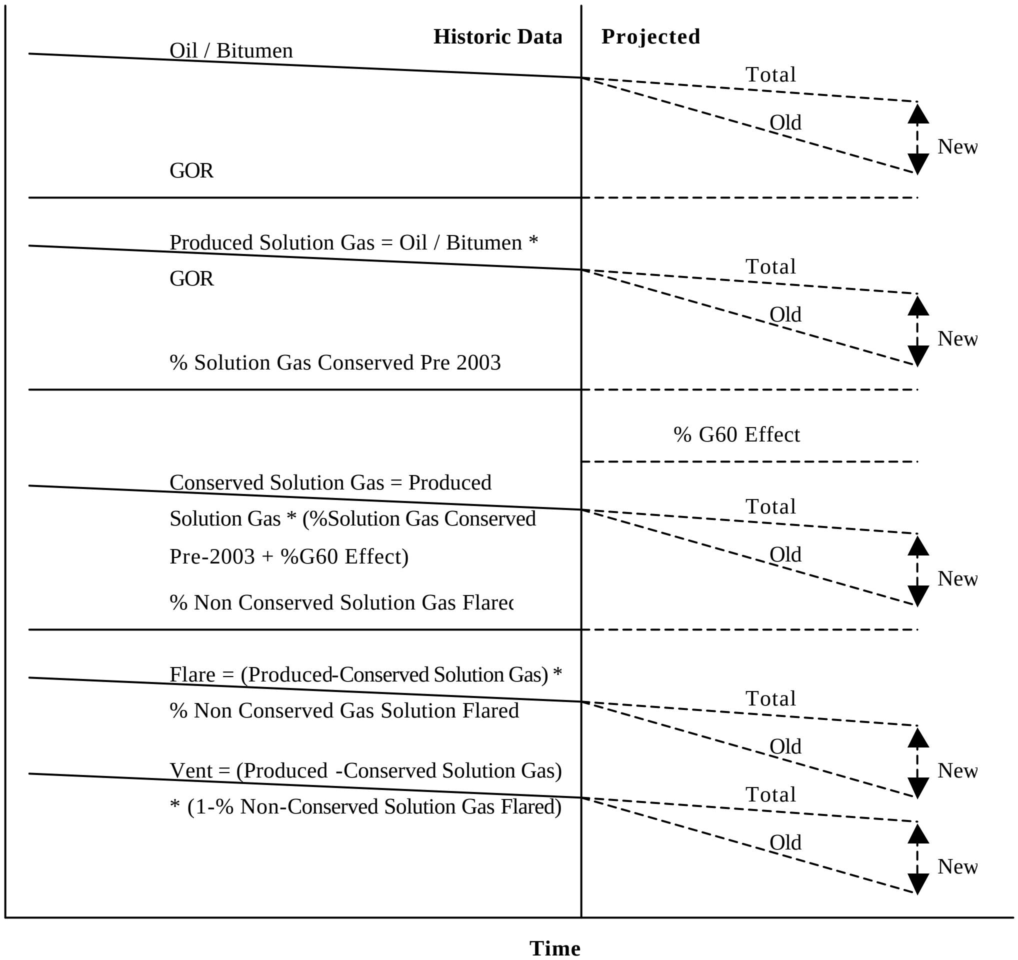

Figure 6.3 Overview of Gas Forecasting

6.2 Historical Production Data

6.2.1 Crude Oil Historical

Table 6.1 shows historic crude oil and oil solution gas production data. Crude oil production is decreasing, and the solution gas production closely follows it. Crude oil production consists of both the light-to-medium oil and heavy oil classes. In general, most of the vented volumes are linked to heavy crude oil production. However, it is not possible to distinguish volumes vented from heavy oil from volumes vented from light to medium oil in the EUB data. Solution gas vented changed significantly in the year 2000 due improvements in reporting. Following the year 2000, solution gas venting volumes stabilized. Thus, this report does not use historical data before the year 2000 for forecasting purposes. The percentage of non-conserved solution gas flared also changed as vent volumes were more accurately reported. A value of 74% non-conserved solution gas flared was used in the forecast. The GOR throughout 3 of the 5 years lies near 475 $10^3 m^3$ gas/m^3oil and this value was used in the forecast. Percent solution gas conserved was steadily improving in the data.

Table 6.1 Crude Oil Historical Production Data

Year	Oil Prod ($10^3 m^3$	Oil Solution Gas Prod ($10^6 m^3$)	Oil Solution Gas Flared ($10^6 m^3$)	Oil Solution Gas Vented ($10^6 m^3$)	% Solution Gas Conserved	GOR (m^3 gas/m^3oil)	% Non-Conserved Gas Flared
1998	48,317	22,845	1,194	80	94.4%	473	94%
1999	42,776	22,686	886	70	95.8%	530	93%
2000	41,735	20,773	755	150	95.6%	498	83%
2001	40,306	19,241	558	164	96.2%	477	77%
2002	37,582	17,840	444	157	96.6%	475	74%

6.2.2 Crude Bitumen Historical

Table 6.2, shows historic in-situ crude bitumen production and bitumen solution gas production. Crude bitumen production is increasing, and the bitumen solution gas production closely follows it. Crude bitumen production is a combination of thermal projects and cold production projects. In general, most of the vented volumes can be attributed to cold bitumen production. However, it is not possible to distinguish vent volumes coming from cold bitumen production from vent volumes coming from thermal bitumen production in the EUB data. Bitumen solution gas vented volumes changed significantly in the year 2000 due to improvements in reporting. Following the year 2000, bitumen solution gas venting volumes stabilized. The percent of non-conserved bitumen solution gas flared also changed as vent volumes were more accurately reported. 17 percent non-conserved bitumen solution gas flared was used for the forecast, based on 2002 data. The GOR throughout 3 of the 5 years lies near 82 m^3 gas/m^3 bitumen and this value was used in the forecast. Percent bitumen solution gas conserved was steadily improving in the data.

Table 6.2 In-Situ Crude Bitumen Historical Production Data

Year	Crude Bitumen Production (10^3m^3)	Bitumen Solution Gas Prod (10^6m^3)	Bitumen Solution Gas Flared (10^6m^3)	Bitumen Solution Gas Vented (10^6m^3)	% Bitumen Solution Gas Conserved	GOR (m^3 gas/m^3oil)	% Non-Conserved Gas Flared
1998	15,771	740	242	69	58%	47	78%
1999	15,883	1,021	156	285	57%	64	35%
2000	17,756	1,330	76	554	53%	75	12%
2001	18,884	1,529	66	436	67%	81	13%
2002	18,090	1,486	73	344	72%	82	17%

6.2.3 Historical Summary

In the past, the distinction between oil solution gas and bitumen solution gas production was generally not made. Reports usually classified both sources of solution gas together. This is probably the cause of most differences between the presentation of this data and other reports on flaring and venting, such as the ST60B Flaring and Venting Annual Report. However, total solution gas volumes are derived from the same data as previous EUB reports and should not differ significantly. Oil solution gas production volumes are following a decreasing trend, while bitumen solution gas production is following an increasing trend. The GOR for oil solution gas (475 10^3m^3 gas/m^3) is much higher than the GOR for bitumen solution gas (82 10^3m^3 gas/m^3). The percentage of produced solution gas conserved is much lower for bitumen solution gas (72%) than oil solution gas (96%). However, the percentage conserved is increasing faster for bitumen solution gas than for oil solution gas, where the value may be approaching a plateau.

6.3 Production Forecast

6.3.1 Oil Solution Gas Forecast

The solution gas forecast was estimated by linking gas produced to the EUB's ST 2003-98 crude oil production forecast, using the appropriate GOR value. Future oil production, and therefore future solution gas production was assumed to decline at 10 percent per annum. This value is supported by analysis of ID 2002-02 data. The effect of G60 regulation was modelled assuming 13 percent of new flares and 19 percent of new vents, above pre 2003 conservation levels, are deemed to be conservable gas. This was based on ID 2002-02 data showing that these percentages of flared gas were economic to conserve in 2001/2. The proportion of new non-conserved solution gas that is flared or vented was based on a historical value of 74 percent non-conserved gas being flared. Table 6.3

shows the forecast of total oil solution gas volumes. Oil solution gas production, flaring, and venting are all following a decreasing trend. Table 6.4 shows the oil solution gas existing prior to 2003. Most of these solution gas sources have reported conservation data through ID 2002-02 and are projected to decline. The projected volumes assume all submitted conservation projects are implemented by December 31, 2003. Figure 6.4 shows the oil solution gas on-stream pre-2003. Forecasts for these volumes should be accurate from 2004 onward, as project implementation dates will be scattered throughout 2003. Table 6.5 and Figure 6.5 show the forecast of oil solution gas from wells beginning production in 2003 and onwards. Post-2002 oil solution gas production is steadily increasing as new wells are drilled, and added to the cumulative production.

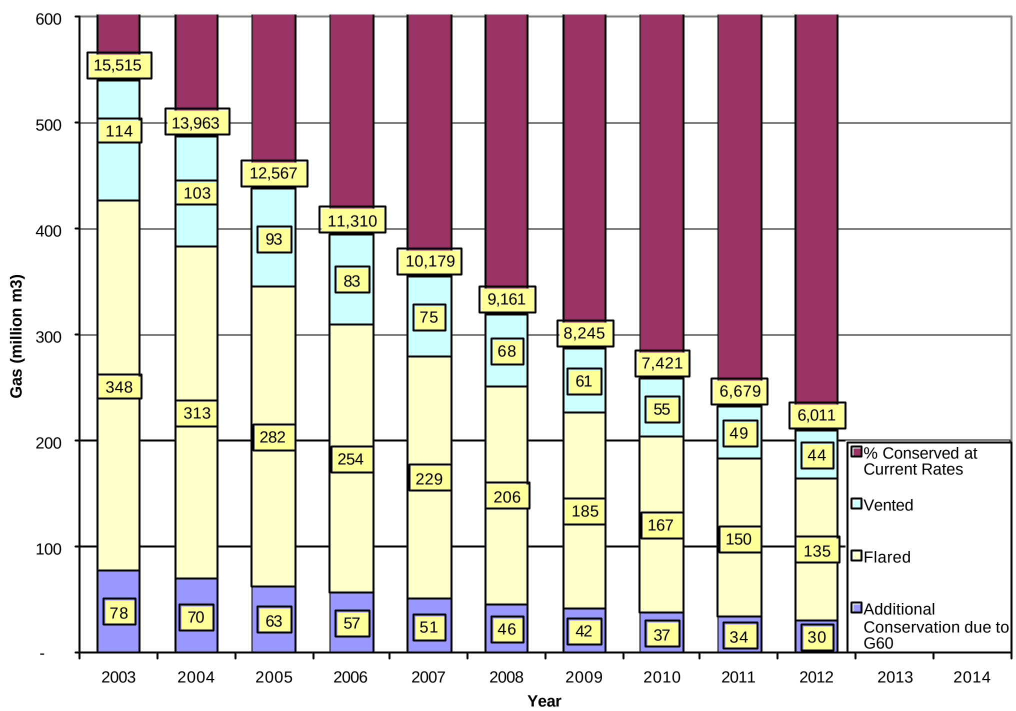

Figure 6.4 Oil Solution Gas Forecast: On-Stream Pre-2003

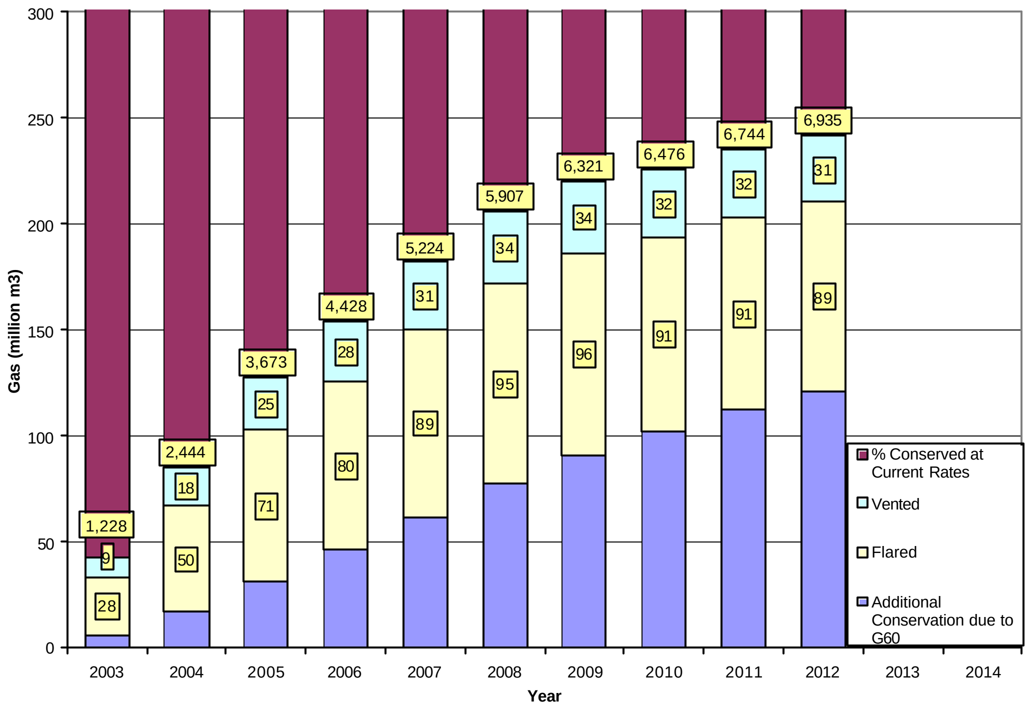

Figure 6.5 Oil Solution Gas Forecast: On-Stream Post-2002

Table 6.3 Oil Solution Gas Forecast: Total Volumes

Year	Crude Oil (10^6 m^3)	Oil Solution Gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	Conserved due to G60 (10^6 m^3)	Gas Flared (10^6 m^3)	Gas Vented (10^6 m^3)
2003	36,500	17,327	16,743	108	376	123
2004	35,770	16,980	16,408	127	364	121
2005	35,405	16,806	16,240	145	353	117
2006	34,310	16,287	15,738	152	334	112
2007	33,580	15,940	15,403	160	317	106
2008	32,850	15,594	15,068	166	301	101
2009	31,755	15,074	14,566	166	281	95
2010	30,295	14,381	13,897	161	258	87
2011	29,200	13,890	13,422	160	241	81
2012	28,105	13,398	12,946	157	224	76

Table 6.4 Oil Solution Gas Forecast: On-Stream Pre 2003

Year	Old Oil Solution Gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	G60 Flare conserved (10^6 m^3)	G60 Vent conserved (10^6 m^3)	Flare (10^6 m^3)	Vent (10^6 m^3)
2003	16,056	15,515	52	27	348	114
2004	14,450	13,963	46	24	313	103
2005	13,005	12,567	42	22	282	93
2006	11,705	11,310	38	20	254	83
2007	10,534	10,179	34	18	229	75
2008	9,481	9,161	30	16	206	68
2009	8,533	8,245	27	14	185	61
2010	7,680	7,421	25	13	167	55
2011	6,912	6,679	22	12	150	49
2012	6,220	6,011	20	10	135	44

Table 6.5 Oil Solution Gas Forecast: On-Stream Post-2002

Year	New Oil Solution Gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	G60 Flare conserved (10^6 m^3)	G60 Vent conserved (10^6 m^3)	Flare (10^6 m^3)	Vent (10^6 m^3)
2003	1,271	1,228	4	2	28	9
2004	2,530	2,444	11	6	50	18
2005	3,801	3,673	21	11	71	25
2006	4,582	4,428	31	15	80	28
2007	5,406	5,224	42	20	89	31
2008	6,113	5,907	52	25	95	34
2009	6,541	6,321	62	29	96	34
2010	6,701	6,476	70	32	91	32
2011	6,979	6,744	77	35	91	32
2012	7,177	6,935	84	38	89	31

6.3.2 Bitumen Solution Gas Forecast

The bitumen solution gas forecast was estimated by linking gas produced to the EUB's ST 2003-98 in-situ crude bitumen production forecast, using the appropriate GOR value. Crude bitumen production and, therefore bitumen solution gas production, was assumed to decline at 20 percent per annum. This value is supported by analysis of ID 2002-02 data. The effect of G60 regulation was modelled assuming 5 percent of new flares and 31 percent of new vents, above pre 2003 conservation levels, are deemed to be conservable gas. This was based on ID 2002-02 data showing these percentages of solution gas were economic to conserve in 2001/2. The proportion of new non-conserved solution gas that is flared or vented was based on a historical value indicating 17 percent of non-conserved gas is flared, and the remaining gas is vented. Table 6.6 shows the forecast of total bitumen solution gas produced. Production of bitumen solution gas is increasing, but improving conservation practices keep bitumen solution gas flaring and venting increases proportionately lower than production increases. The column showing "Conserved at pre-2003 %" is gas that would be conserved assuming the solution gas conservation percentage from 2002. This shows gas volumes that would be conserved in the future using industry's past conservation practices, which probably includes some effect of G60 regulations. The column "Conserved due to G60" shows the effect of further implementing G60. Table 6.7 and Figure 6.6 show the forecast of bitumen solution gas existing prior to 2003. Pre-2003 bitumen solution gas production and associated venting is decreasing. The effect of G60 will be spread out throughout 2003 until the deadline on December 31, 2003 and the forecast should be accurate from 2004 onward. Table 6.8 and Figure 6.7 show the forecast of bitumen solution gas from wells beginning production 2003 or later. Bitumen solution gas production is increasing as new wells are drilled. However, improving conservation practices prevent bitumen solution gas flaring and venting from increasing proportionately.

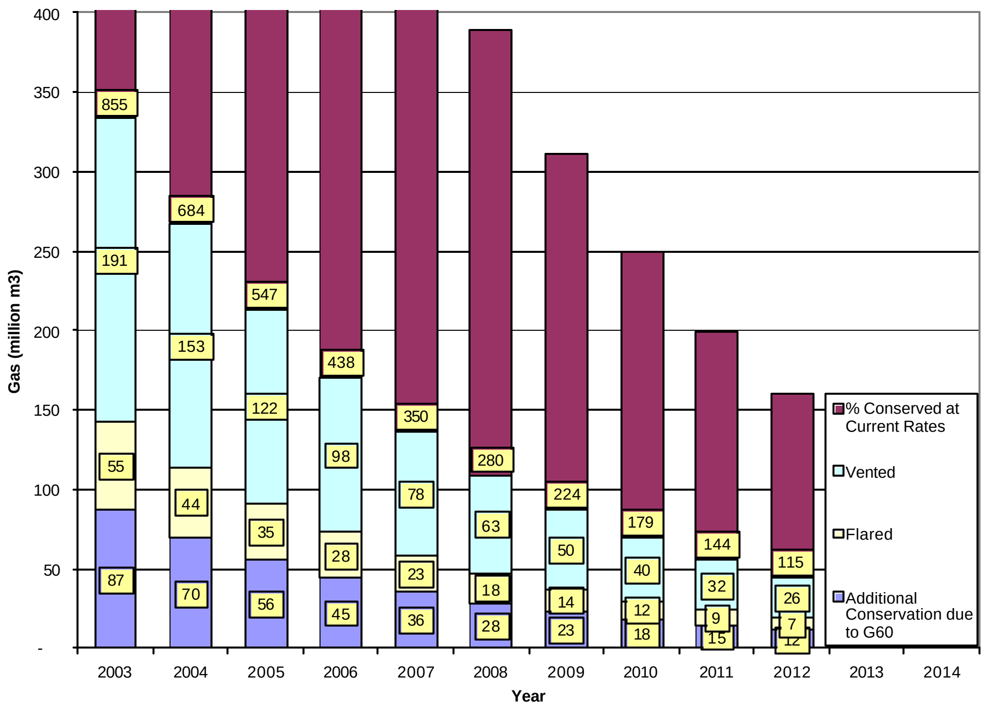

Figure 6.6 Bitumen Solution Gas Forecast: On-Stream Pre-2003

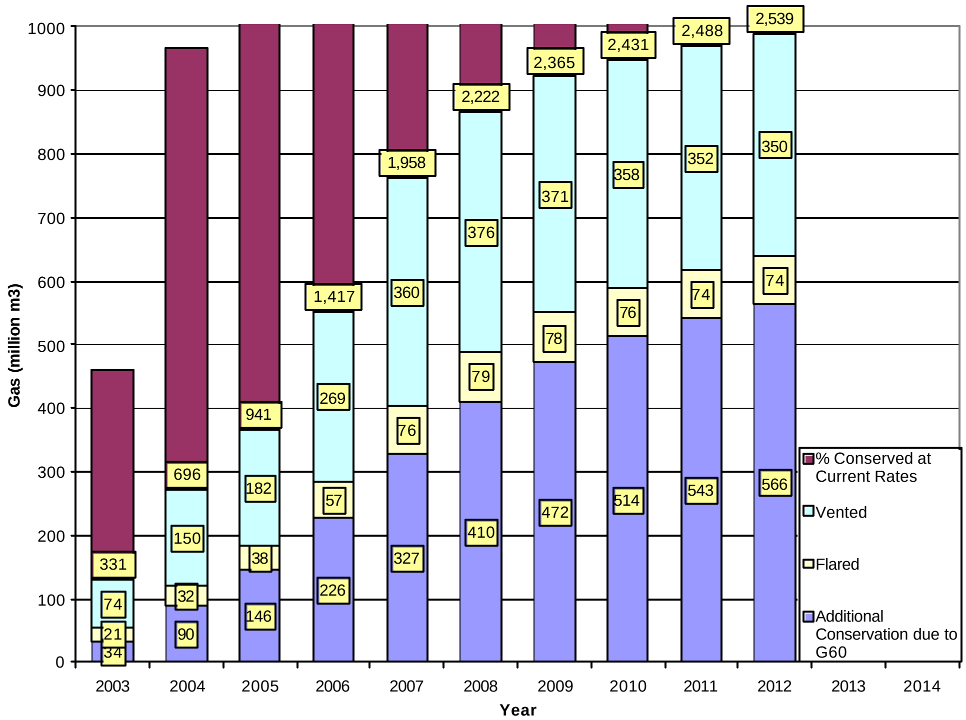

Figure 6.7 Bitumen Solution Gas Forecast: On-Stream Post-2002

Table 6.6 Bitumen Solution Gas Forecast: Total Volumes

Year	In-Situ Crude Bitumen (10^3 m^3)	Bitumen solution gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	Conserved due to G60 (10^6 m^3)	Flared (10^6 m^3)	Vented (10^6 m^3)
2003	20,075	1,649	1,187	141	77	265
2004	23,360	1,919	1,381	188	76	303
2005	25,185	2,068	1,489	235	74	304
2006	31,390	2,578	1,855	319	85	367
2007	39,055	3,208	2,308	425	99	438
2008	42,340	3,477	2,502	500	98	439
2009	43,800	3,597	2,589	552	93	421
2010	44,165	3,627	2,610	583	87	398
2011	44,530	3,657	2,632	605	84	384
2012	44,895	3,687	2,653	622	81	375

Table 6.7 Bitumen Solution Gas Forecast: On-Stream Pre 2003

Year	Old Bitumen solution gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	G60 Flare conserved (10^6 m^3)	G60 Vent conserved (10^6 m^3)	Flare (10^6 m^3)	Vent (10^6 m^3)
2003	1,189	855	3	84	55	191
2004	951	684	2	67	44	153
2005	761	547	2	54	35	122
2006	609	438	1	43	28	98
2007	487	350	1	34	23	78
2008	389	280	1	28	18	63
2009	312	224	1	22	14	50
2010	249	179	1	18	12	40
2011	199	144	0	14	9	32
2012	160	115	0	11	7	26

Table 6.8 Bitumen Solution Gas Forecast: On-Stream Post-2002

Year	New bitumen solution gas (10^6 m^3)	Conserved at pre 2003 % (10^6 m^3)	G60 Flare conserved (10^6 m^3)	G60 Vent conserved (10^6 m^3)	Flare (10^6 m^3)	Vent (10^6 m^3)
2003	460	331	1	33	21	74
2004	968	696	3	87	32	150
2005	1,308	941	6	141	38	182
2006	1,970	1,417	9	217	57	269
2007	2,721	1,958	14	313	76	360
2008	3,088	2,222	18	392	79	376
2009	3,286	2,365	22	450	78	371
2010	3,378	2,431	25	489	76	358
2011	3,458	2,488	27	516	74	352
2012	3,528	2,539	29	536	74	350

6.4 Flare Forecast

The flare forecast was obtained by combining the forecasts for the respective flare sources, i.e. oil and bitumen. The forecast shows that flaring from oil solution gas will continue to decline. However, flaring from bitumen solution gas will increase until 2008, and then begin to decline, thereafter. The percent of total flaring coming from bitumen solution gas will increase from 9 percent in 2000 to 27 percent in 2012. In total, flaring from these sources will continue to decrease in the province.

Table 6.9 Flare Forecast

Year	Oil Solution Gas Flare ($10^6 m^3$)	Bitumen Solution Gas Flare ($10^6 m^3$)	Total Flare ($10^6 m^3$)
2003	376	77	453
2004	364	76	440
2005	353	74	427
2006	334	85	419
2007	317	99	416
2008	301	98	398
2009	281	93	373
2010	258	87	345
2011	240	84	324
2012	224	81	305

6.5 Vent Forecast

The vent forecast for solution gas vents and in-situ crude bitumen solution gas vents was obtained by combining the forecasts for the respective vent sources. The forecast shows that venting from oil solution gas will continue to decline. However, venting from bitumen solution gas will increase until 2007 whereupon it will begin to decrease. The percent of total venting coming from bitumen solution gas will increase form 68 percent in 2003 to 83 percent in 2012. In total, venting from these sources will stay relatively constant in the province.

Table 6.10 Vent Forecast

Year	Oil Solution Gas Vent ($10^6 m^3$)	Bitumen Solution Gas Vent ($10^6 m^3$)	Total Vents ($10^6 m^3$)
2003	123	265	388
2004	121	303	423
2005	118	304	422
2006	112	367	478
2007	106	438	545
2008	101	439	540
2009	95	421	516
2010	87	398	485
2011	81	384	465
2012	76	375	451

6.6 Possible Sources of Error

The forecasts presented are intended to show the general trends for solution gas flaring and venting. Several critical assumptions affecting the forecast are outlined below:

1. The GOR for solution gas to oil or bitumen produced was assumed to stay constant. For oil solution gas GOR, major changes are unlikely. However, for bitumen solution gas, improvements in GOR measurement techniques may increase or decrease the GOR, and significantly change the reported bitumen solution gas production.
2. Existing solution gas production was assumed to decline at 10% per annum, which may or may not be accurate. This assumption affects the proportion of the future solution gas production attributable to wells that are currently producing, versus wells that will come on production in the future.
3. The amount of gas deemed to be economic under G60 is based on the interpretation of the ID 2002-02 data. The main sources of discrepancies in this data are discussed in Section 3. Of particular note, is that some vents smaller than 800 m^3/d may have the potential to be economic to conserve. If, in fact, there are numerous vents smaller than 800 m^3/day that are economic to conserve, then the forecasts shown will likely have overestimated future venting rates.

4. The main source of oil solution gas vents is heavy crude oil production. Heavy crude oil production as a proportion of total conventional crude oil production is increasing by 4% by 2012[18] from 2002. Light to medium crude oil, the main source for flaring, is decreasing as a proportion of total conventional crude oil production. Due to the inability to tie oil solution gas venting directly to heavy crude oil production, oil solution gas venting was linked to conventional crude oil production as a whole. This may cause the oil solution gas venting forecast to be slightly lower and oil solution gas flaring forecast to be somewhat higher.

5. The main source of bitumen solution gas vents is cold production of in-situ crude bitumen. The main source of bitumen solution gas flares is thermal production of in-situ crude bitumen. No information is available as to the proportion of in-situ crude bitumen production from thermal or cold production. Changes in the proportion of in-situ crude bitumen production from these production types may affect the proportions of bitumen solution gas flared or vented. Changes in production methods could also affect GOR and total bitumen solution gas produced.

6.7 Summary

6.7.1 Flare Summary

The history and forecast for flared solution gas are shown in the following graph, Figure 6.8. Flaring is decreasing, and improving conservation practices should reduce flaring to a level close to the past CASA Flare/Vent team's lower recommended reduction target of 60 to 70 percent by 2006-7. Figure 6.10 shows that Provincial flared gas conservation is stabilizing around 97 percent, and it is unlikely any major improvements will be seen with the current regulatory and economic environment.

[18] EUB ST 2003-98 Alberta Reserves 2002 and Supply/Demand Outlook 2003-2012

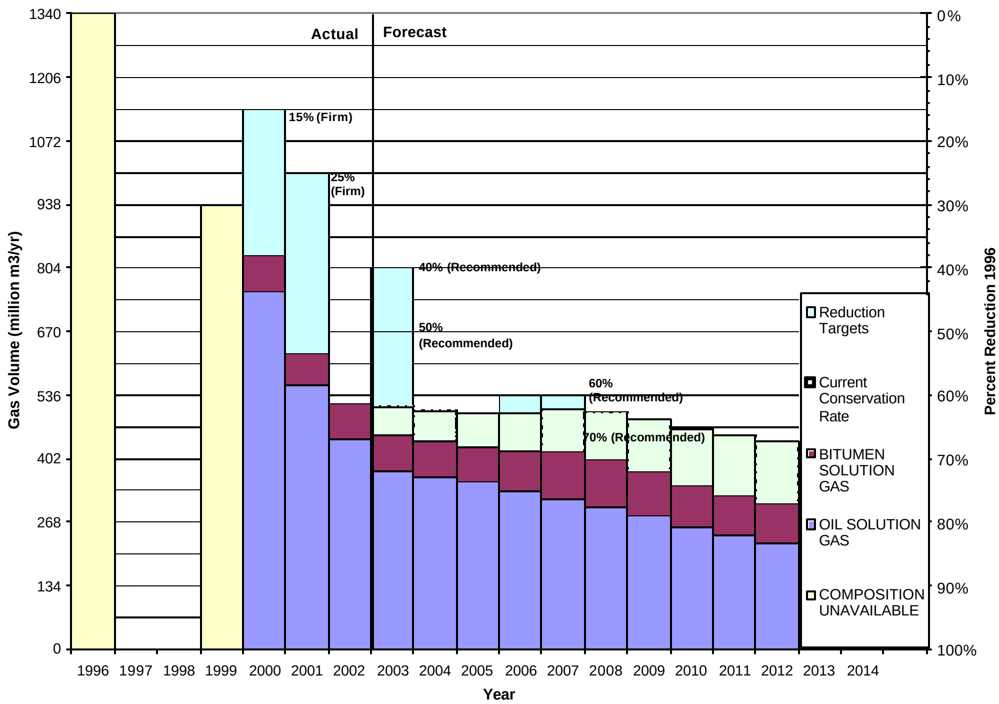

Figure 6.8 Solution Gas Flaring: Historical and Forecast

6.7.2 Vent Summary

The history and forecast for vented solution gas is summarized in the following graph, Figure 6.9. Bitumen production is expected to be relatively stable during 2002-2003, allowing implementation of G60 regulations to cause a reduction in venting. Venting should increase from 2003 to 2007, as bitumen production is increasing rapidly during this period. From 2008 onwards, improving conservation practices, coupled with slower bitumen production increases, will cause venting to decrease. Figure 6.10 shows that venting conservation percentage has a lot of room to improve. There is a good deal of uncertainty with respect to the estimates for gas conserved due to G60 since there is little data available for the economics of conserving vents between 500 m^3/day and 800 m^3/day not being required to submit. If significant portions of these vents are indeed economic, this forecast may be overestimating venting rates. However, deviations and delays in implementing G60 for venting can have major implications for vent volumes. The potential for venting to exceed 50 percent of 2000 volumes in 2012 exists, unlike flaring where volumes should decline, even without further improvements in conservation practices.

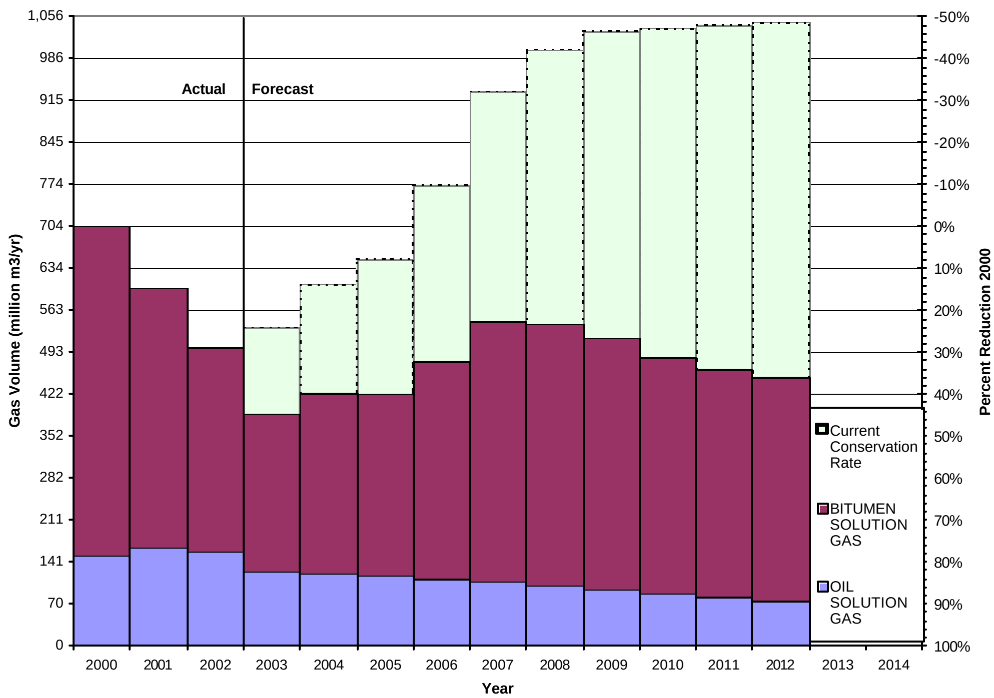

Figure 6.9 Solution Gas Venting: Historical and Forecast

6.7.3 Gas Conservation Percentage Summary

Figure 6.10 shows the percent of produced solution gas that is conserved. For oil solution gas, the percent conserved starts at 94 percent in 2000 and will continue to increase. Most solution gas is conserved, and while the percentage is increasing, no significant change is predicted. For bitumen solution gas, the percent conserved is increasing rapidly from 53 percent in 2000 to an estimated 88 percent in 2012. It should be noted that the percent conserved includes solution gas whose volume is reported based on GOR values. Improvements in measurements of vented solution gas production have the potential to change total reported solution gas production significantly. Table 6.2 shows GOR values for the main source of solution gas venting, i.e. bitumen solution gas, as increasing, possibly as a result of improving measurement techniques. If this trend continues, the actual conservation of bitumen solution gas may be lower than that forecasted in Figure 6.10.

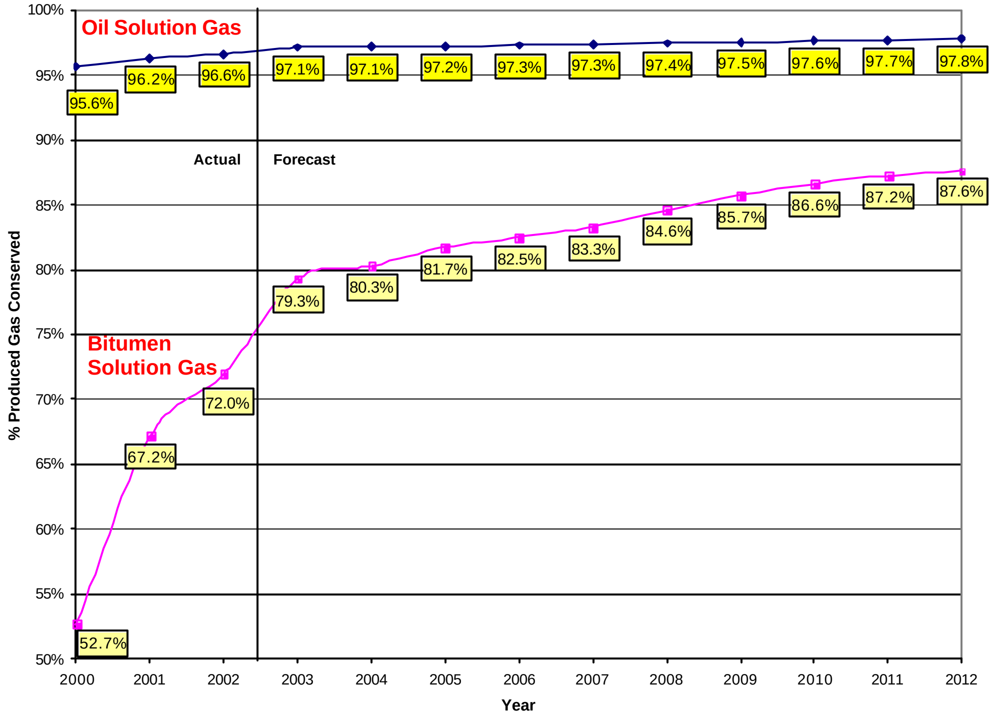

Figure 6.10 Percent Produced Gas Conserved

7 Cost to Conserve New Solution Gas Flares/Vents

7.1 Cost Estimation Methodology

7.1.1 Recoverable Solution Gas

New solution gas (post 2002) will either be utilized at conserving facilities or be flared or vented at non-conserving facilities. However, conserving facilities are sometimes unable to utilize all solution gas produced at the site and may have incidences of upset or non-routine flaring or venting. This solution gas generally cannot be readily be conserved through capital expenditure, but may be reduced in volume by changing production practices. The costs to conserve non-routine and upset solution gas flaring have not be examined in this study. Figure 7.1 shows new solution gas flares conservation options and Figure 7.2 shows new solution gas vent conservation options. The categories of “Conserved at past conservation rates”, “Additional Conservation due to G60” and “Non-Routine/Upset Flaring at Conserving Facilities” were assumed to be from conserving facilities. Conservation of solution gas from non-conserving facilities will either divert some oil/bitumen cash-flow to conserve the solution gas or shut the facility in, as the cost to implement solution gas conservation exceeds the oil/bitumen cash flow. Oil/Bitumen cash-flow does not take into account royalties and is calculated as oil revenue minus operating costs.

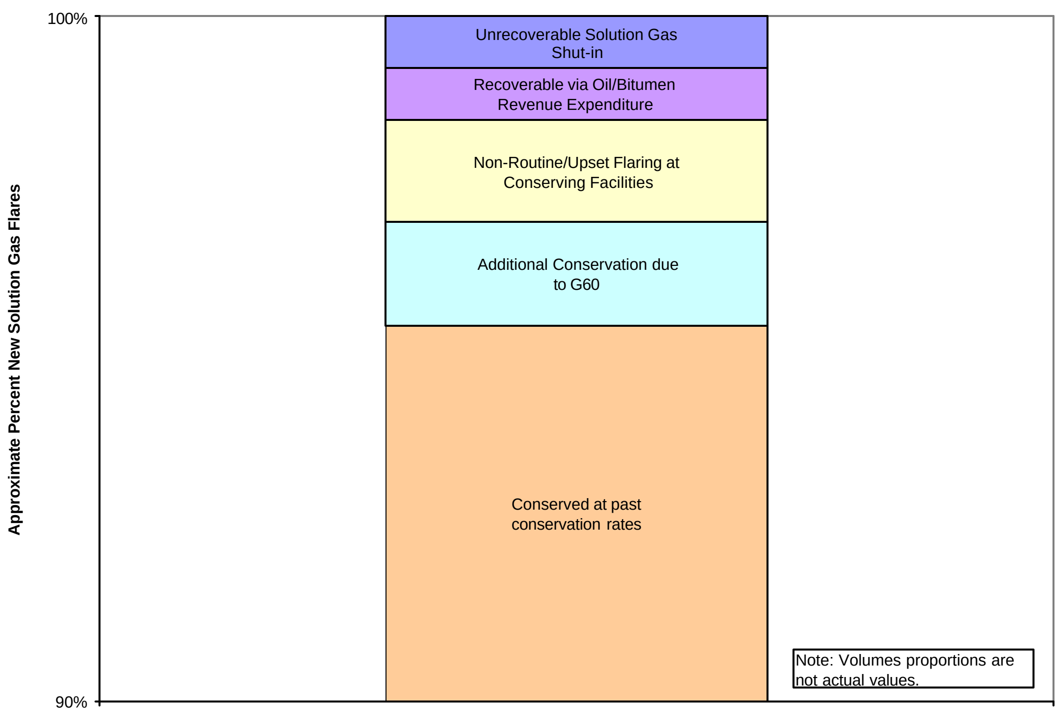

Figure 7.1 New Solution Gas Flare Conservation Types

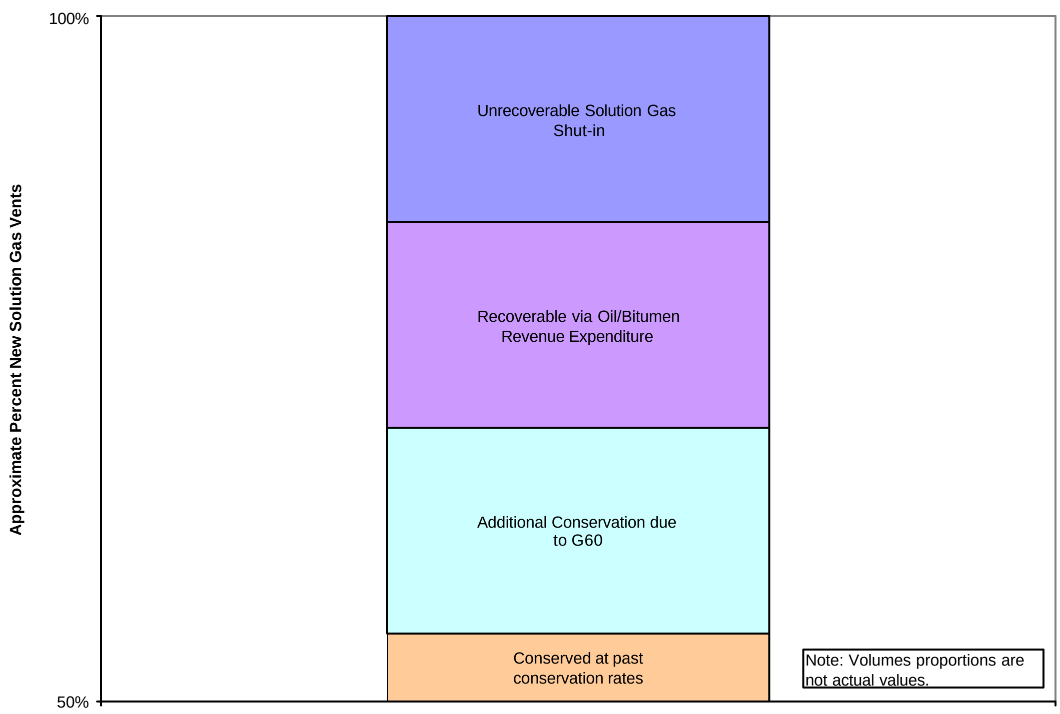

Figure 7.2 New Solution Gas Vent Conservation Types

7.1.2 Cost Model

Estimations of the costs to conserve new solution gas flares and vents were done using a Monte Carlo risk analysis technique. This method utilizes the probability distributions of several variables to estimate a probability distribution for the desired variable. The following assumptions and datasets were used in the cost model, based on ID 2002-02 data, EUB production data and the G60 economic model.

- Solution gas conservation project economics are determined by the volume, distance to pipeline, compressor discharge pressure, reserve life and H_2S content of the gas. These variables were assumed to be independent random variables.
- Crude oil production was estimated using the GOR distribution from ID 2002-02 data for uneconomic flare sites that are not conserving 95% of produced solution gas. The GOR distribution was assumed to be an independent random variable. Crude bitumen production was estimated using the GOR distribution from ID 2002-02 data for uneconomic vent sites. The GOR distribution was assumed as an independent random variable.
- The volume distributions for future solution gas flares and future solution gas vents greater than 800 m3/day were based on data from ID 2002-02 for uneconomic sites that are not conserving 95% of produced

solution gas. Vents less than 800 m^3/day follow were assumed to follow a volume distribution based on the petroleum registry data and EUB production data.

- The distributions for flare and vent pipeline lengths, compressor discharge pressure, and H2S content were based on data from uneconomic ID 2002-02 flare sites.
- The distributions for flare and vent reserve life were based on ID 2002-02 data, but increased by two years, because the distribution data was from sites that were already producing for some period of time.
- The cost to society of conserving solution gas were assumed as either the loss in revenue from maintaining a solution gas sales/fuel project or lost oil/bitumen production cash flow (oil/bitumen revenue minus operating costs) if the project cannot sustain conservation costs on a standalone basis. A project cannot sustain conservation costs if combined cash flow from the oil and solution gas cannot support the capital and operating costs of the solution gas conservation project.
- Oil and bitumen operating costs[19] were assumed to be $6 per barrel for crude oil production and $7 per barrel for crude bitumen production. Distinguishing between operating costs for oil solution gas flares and vents and bitumen solution gas flares and vents was not attempted.
- Economic criteria and assumptions stated in Section 5.2 were used.
- A sales/fuel gas project proceeds if the oil/bitumen cash flow after costs to conserve is positive. If oil/bitumen cash flow is negative, the well is shut-in and oil/bitumen production is lost.
- The cost to conserve forecast for lost oil/bitumen production and the cost to society assumed that drilling continues normally. The lost oil/bitumen forecast in no way accounts for lost production due to operators adjusting to a new regulatory environment.
- The forecast did not take into account improving natural gas pipeline infrastructure or improvements in conservation technology.
- The economic model did not include revenue from natural gas liquids that may be conserved along with the solution gas.
- Sites that are both flaring and venting were are dealt with as two separate projects.

[19] John Parr, Flare/Vent Econ-Sub Group Meeting # 10, June 17, 2003

7.1.3 Conservation Cost Units

The cost to conserve solution gas is presented in terms of total cost to either implement a conservation project or the lost oil/bitumen cash-flow from shutting the facility in. This is referred to as the cost to society. The conservation cost is presented for solution gas flares/vents starting in 2003 and ending in 2012. The cost is discounted at 8% per annum, the current discount rate for G60 economic analyses, to give values in 2003 dollars. The total oil/bitumen lost is not discounted, and is the total shut-in oil/bitumen throughout the life of the solution gas flare/vent conservation projects from 2003 to 2012. The cumulative probability value indicates the probability that the actual value is less than or equal to the value shown. Solution gas that is "not flared/vented" is the solution gas that, through sales/fuel projects and/or facility shut-in, is not released to the atmosphere, and is summed for the entire life of the project. The CO_2E available values were estimated using the previously discussed CO_2E factors.

7.2 Flare Conservation Costs

7.2.1 New Crude Oil Solution Gas Flares Greater than 800 m^3/day

Figure 7.9 shows the distribution curve for the estimated cost to conserve new crude oil solution gas flares greater than 800 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude oil solution gas flares would be less than $13.4 million and lost crude oil production would be less than 106,000 m^3. Table 7.1 shows the volumes of crude oil solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 136,000 10^3 m^3 of crude oil solution gas can be conserved during the period 2003 to 2012, resulting in 0.35 million tonnes of CO_2E not being emitted.

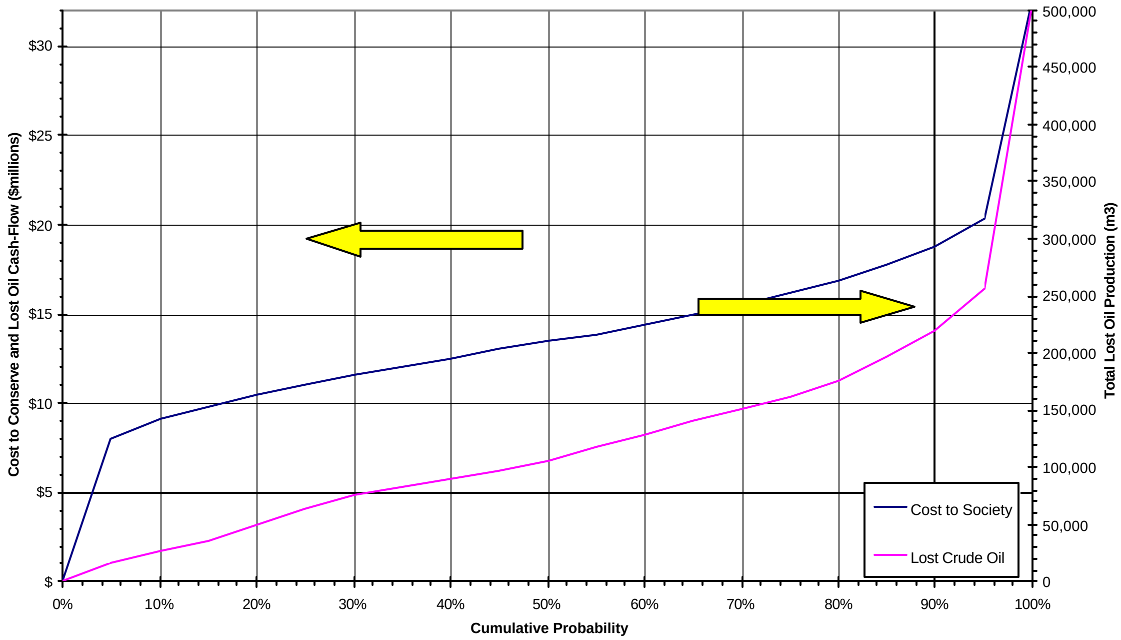

Figure 7.3 Post-2002 Crude Oil Solution Gas Flare Greater than 800 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.1 Post-2002 Crude Oil Solution Gas Greater than 800 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	4,824	0.01
2004	8,816	0.02
2005	12,479	0.03
2006	13,949	0.04
2007	15,539	0.04
2008	16,639	0.04
2009	16,716	0.04
2010	15,940	0.04
2011	15,841	0.04
2012	15,576	0.04
Total[20]	136,318	0.35

7.2.2 New Crude Bitumen Solution Gas Flares Greater than 800 m^3/day

Figure 7.10 shows the distribution curve for the estimated cost to conserve new crude bitumen solution gas flares greater than 800 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude bitumen solution gas flares would be less than $6.6 million and lost crude bitumen production would be less than 14,000 m^3. Table 7.2 shows the volumes of crude bitumen solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 106,000 10^3 m^3 of crude bitumen solution gas can be conserved during the period 2003 to 2012, resulting in 0.3 million tonnes of CO_2E not being emitted.

[20] May not sum exactly due to rounding.

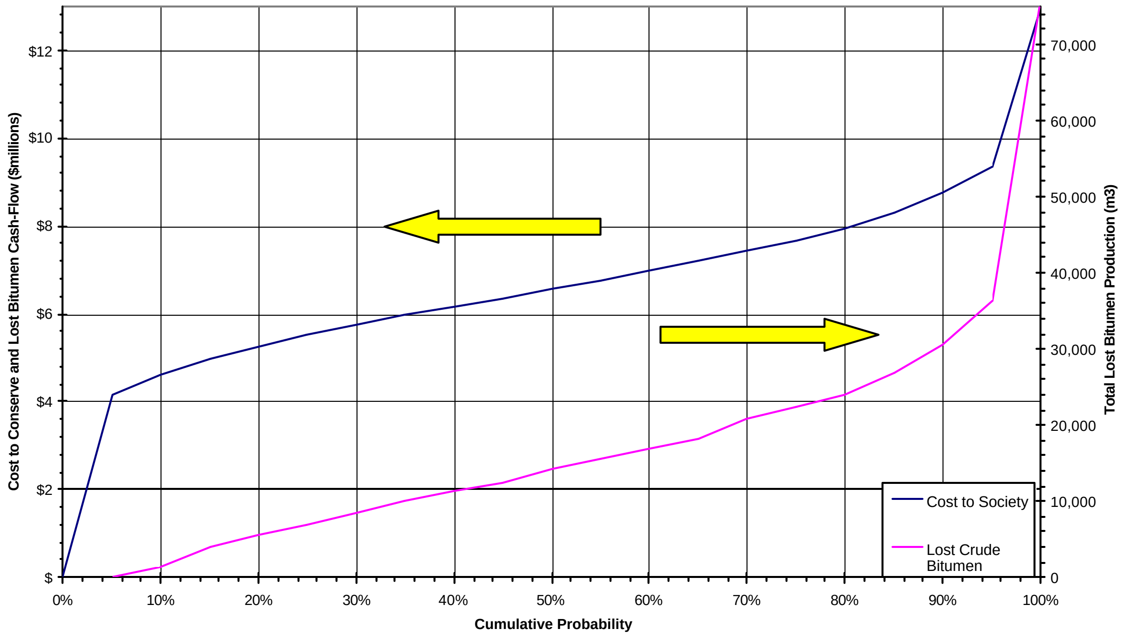

Figure 7.4 Post-2002 Crude Bitumen Solution Gas Flare Greater than 800 m^3/day Conservation Costs and Lost Bitumen Production

Table 7.2 Post-2002 Crude Bitumen Solution Gas Greater than 800 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	3,743	0.01
2004	5,543	0.01
2005	6,730	0.02
2006	9,944	0.03
2007	13,313	0.03
2008	13,907	0.04
2009	13,716	0.04
2010	13,230	0.03
2011	13,007	0.03
2012	12,930	0.03
Total[21]	106,063	0.27

7.2.3 All New Solution Gas Flares Greater than 800 m^3/day

Figure 7.11 shows the distribution curve for the estimated cost to conserve all new solution gas flares greater than 800 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than $20 million, lost crude oil production would be less than 106,000 m^3 and lost crude bitumen production would be less than 14,000 m^3. Table 7.3 shows the volumes of solution gas not flared due to conservation and CO_2E available as a result of not flaring this gas. Approximately 242,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 0.6 million tonnes of CO_2E not being emitted.

[21] May not sum exactly due to rounding.

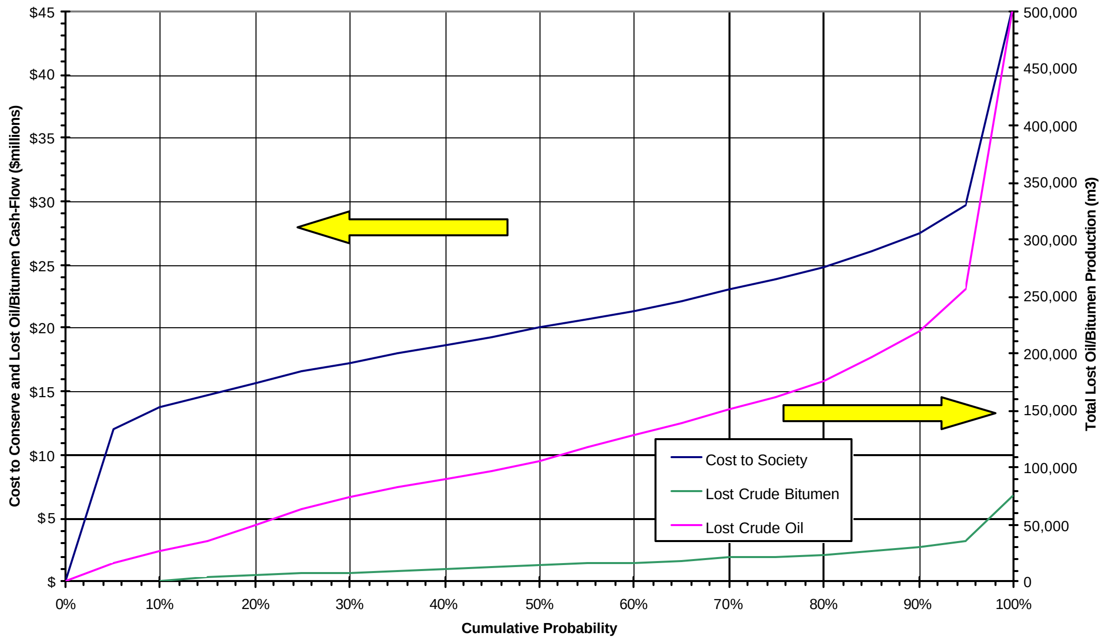

Figure 7.5 Post-2002 Solution Gas Flare Greater than 800 m^3/day Conservation Costs and Lost Oil/Bitumen Production

Table 7.3 Post-2002 Solution Gas Greater than 800 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	8,566	0.0
2004	14,359	0.0
2005	19,209	0.0
2006	23,893	0.1
2007	28,852	0.1
2008	30,547	0.1
2009	30,433	0.1
2010	29,170	0.1
2011	28,848	0.1
2012	28,506	0.1
Total[22]	242,382	0.6

[22] May not sum exactly due to rounding.

7.2.4 New Crude Oil Solution Gas Flares Greater than 300 m^3/day

Figure 7.9 shows the distribution curve for the estimated cost to conserve new crude oil solution gas flares greater than 300 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude oil solution gas flares would be less than $33.4 million and lost crude oil production would be less than 320,000 m^3. Table 7.1 shows the volumes of crude oil solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 253,000 10^3 m^3 of crude oil solution gas can be conserved during the period 2003 to 2012, resulting in 0.7 million tonnes of CO_2E not being emitted.

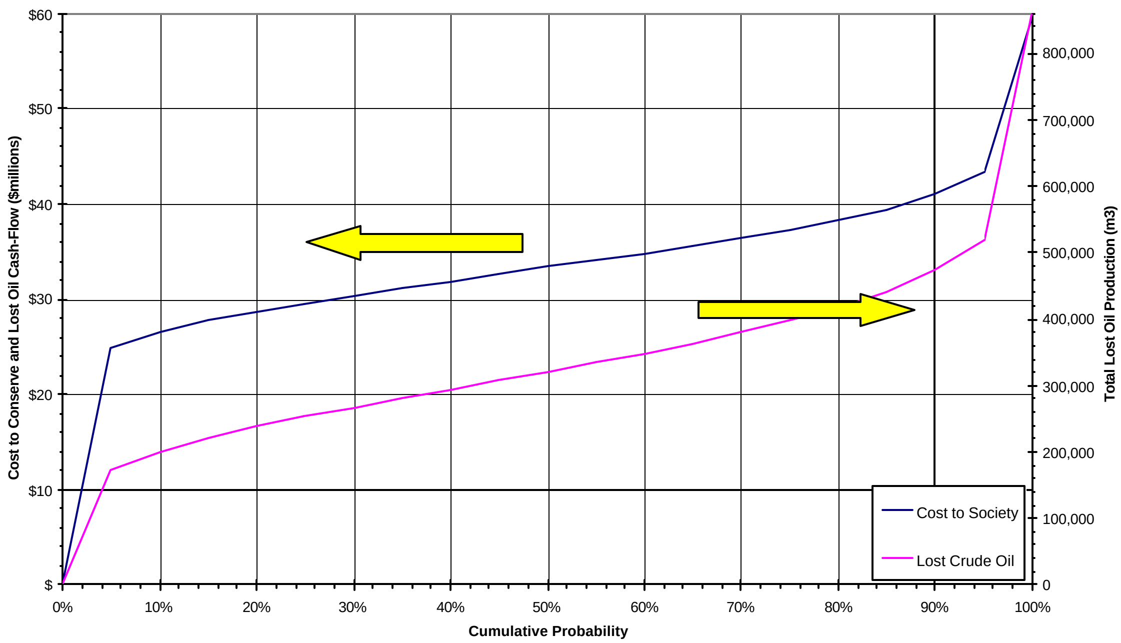

Figure 7.6 Post-2002 Crude Oil Solution Gas Flare Greater than 300 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.1 Post-2002 Crude Oil Solution Gas Greater than 300 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	8,958	0.0
2004	16,372	0.0
2005	23,174	0.1
2006	25,905	0.1
2007	28,857	0.1
2008	30,901	0.1
2009	31,045	0.1
2010	29,603	0.1
2011	29,420	0.1
2012	28,927	0.1
Total[23]	253,163	0.7

7.2.5 New Crude Bitumen Solution Gas Flares Greater than 300 m^3/day

Figure 7.10 shows the distribution curve for the estimated cost to conserve new crude bitumen solution gas flares greater than 300 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude bitumen solution gas flares would be less than $17.1 million and lost crude bitumen production would be less than 94,000 m^3. Table 7.2 shows the volumes of crude bitumen solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 197,000 10^3 m^3 of crude bitumen solution gas can be conserved during the period 2003 to 2012, resulting in 0.5 million tonnes of CO_2E not being emitted.

[23] May not sum exactly due to rounding.

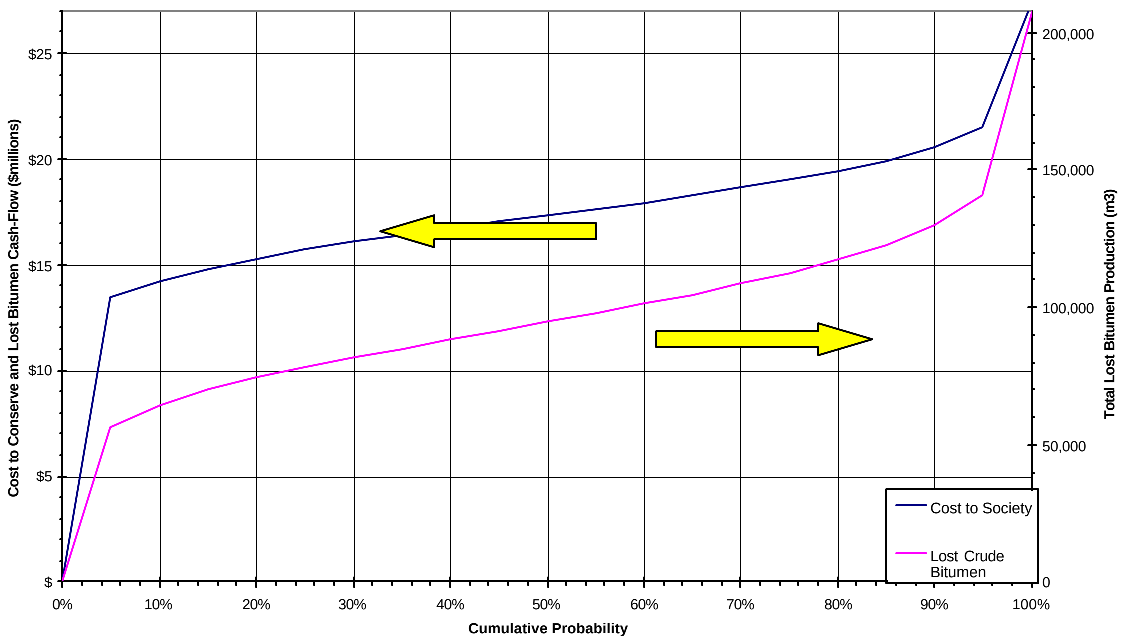

Figure 7.7 Post-2002 Crude Bitumen Solution Gas Flare Greater than 300 m^3/day Conservation Costs and Lost Bitumen Production

Table 7.2 Post-2002 Crude Bitumen Solution Gas Greater than 300 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	6,951	0.0
2004	10,295	0.0
2005	12,499	0.0
2006	18,467	0.0
2007	24,724	0.1
2008	25,828	0.1
2009	25,473	0.1
2010	24,570	0.1
2011	24,156	0.1
2012	24,012	0.1
Total[24]	196,975	0.5

7.2.6 All New Solution Gas Flares Greater than 300 m^3/day

Figure 7.11 shows the distribution curve for the estimated cost to conserve all new solution gas flares greater than 300 m^3/day. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than $50.7 million, lost crude oil production would be less than 320,000 m^3 and lost crude bitumen production would be less than 94,000 m^3. Table 7.3 shows the volumes of solution gas not flared due to conservation and CO_2E available as a result of not flaring this gas. Approximately 450,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 1.2 million tonnes of CO_2E not being emitted.

[24] May not sum exactly due to rounding.

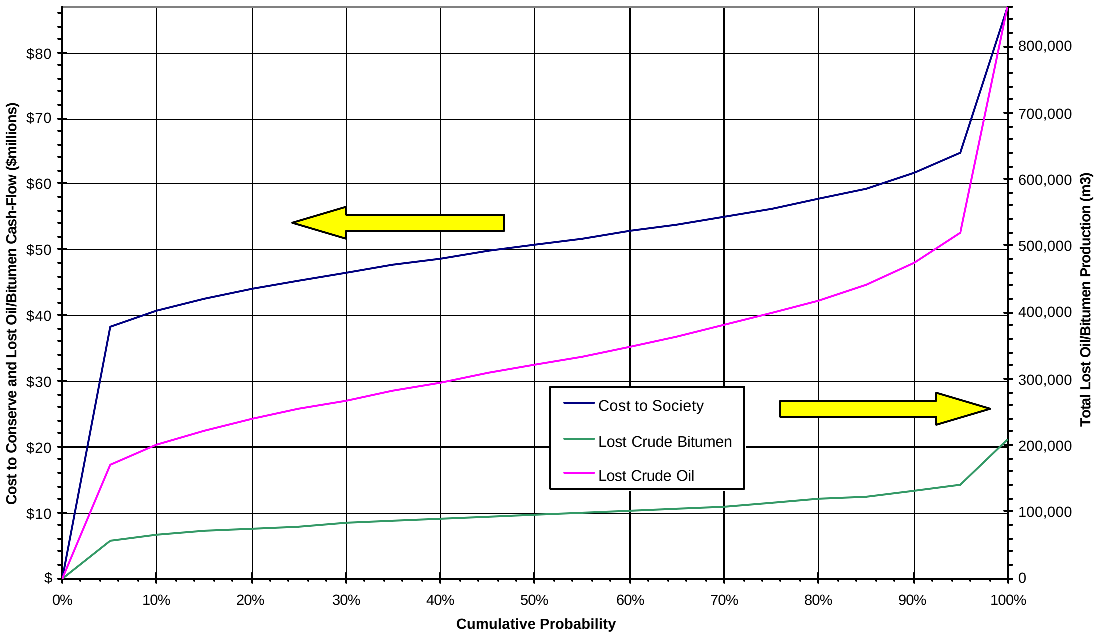

Figure 7.8 Post-2002 Solution Gas Flare Greater than 300 m^3/day Conservation Costs and Lost Oil/Bitumen Production

Table 7.3 Post-2002 Solution Gas Greater than 300 m^3/day Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	15,909	0.0
2004	26,667	0.1
2005	35,674	0.1
2006	44,372	0.1
2007	53,582	0.1
2008	56,729	0.1
2009	56,518	0.1
2010	54,173	0.1
2011	53,576	0.1
2012	52,939	0.1
Total[25]	450,138	1.2

[25] May not sum exactly due to rounding.

7.2.7 New Crude Oil Solution Gas Flares

Figure 7.9 shows the distribution curve for the estimated cost to conserve new crude oil solution gas flares. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude oil solution gas flares would be less than $41 million and lost crude oil production would be less than 500,000 m^3. Table 7.1 shows the volumes of crude oil solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 390,000 10^3 m^3 of crude oil solution gas can be conserved during the period 2003 to 2012, resulting in 1.0 million tonnes of CO_2E not being emitted.

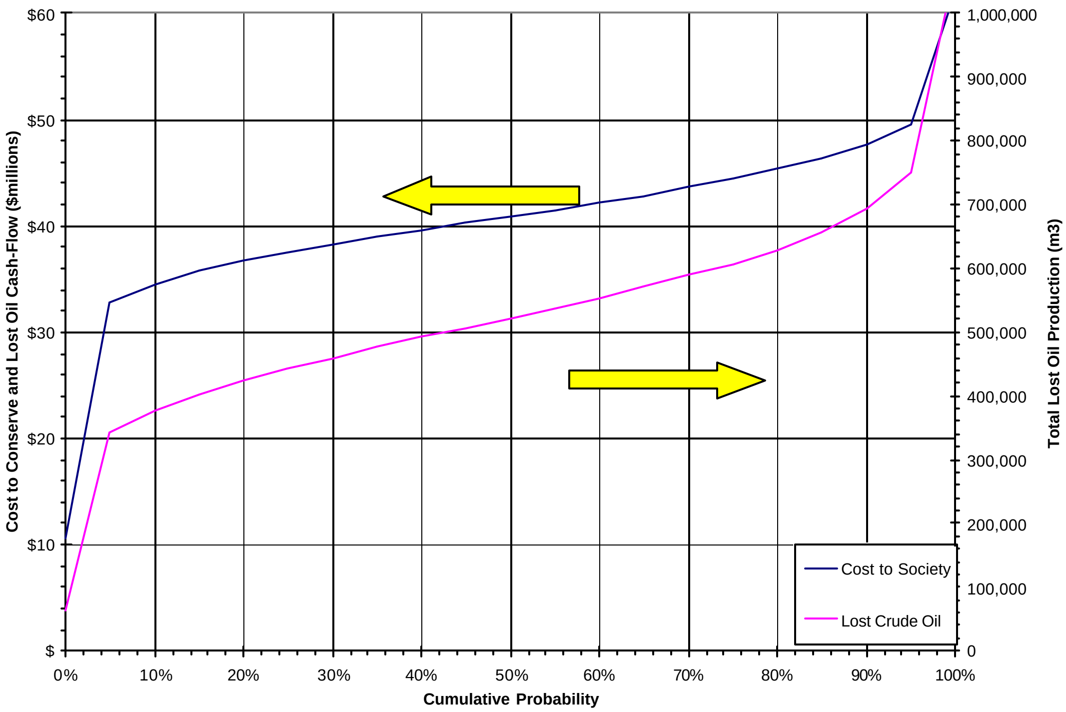

Figure 7.9 Post-2002 Crude Oil Solution Gas Flare Conservation Costs and Lost Crude Oil Production

Table 7.1 Post-2002 Crude Oil Solution Gas Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	14,000	0.0
2004	25,000	0.1
2005	36,000	0.1
2006	40,000	0.1
2007	44,000	0.1
2008	48,000	0.1
2009	48,000	0.1
2010	46,000	0.1
2011	45,000	0.1
2012	45,000	0.1
Total[26]	390,000	1.0

7.2.8 New Crude Bitumen Solution Gas Flares

Figure 7.10 shows the distribution curve for the estimated cost to conserve new crude bitumen solution gas flares. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude bitumen solution gas flares would be less than $35 million and lost crude bitumen production would be less than 200,000 m^3. Table 7.2 shows the volumes of crude bitumen solution gas not flared due to conservation and the CO_2E available as a result of not flaring this gas. Approximately 300,000 10^3 m^3 of crude bitumen solution gas can be conserved during the period 2003 to 2012, resulting in 0.8 million tonnes of CO_2E not being emitted.

[26] May not sum exactly due to rounding.

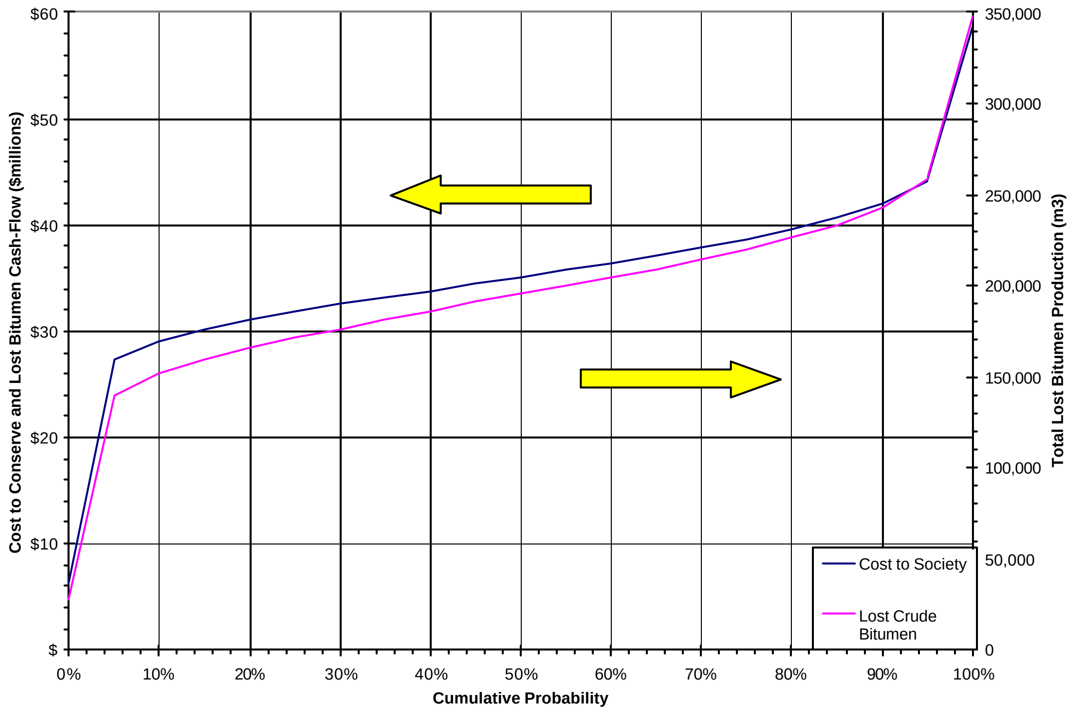

Figure 7.10 Post-2002 Crude Bitumen Solution Gas Flare Conservation Costs and Lost Bitumen Production

Table 7.2 Post-2002 Crude Bitumen Solution Gas Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	11,000	0.0
2004	16,000	0.0
2005	19,000	0.0
2006	28,000	0.1
2007	38,000	0.1
2008	40,000	0.1
2009	39,000	0.1
2010	38,000	0.1
2011	37,000	0.1
2012	37,000	0.1
Total[27]	303,000	0.8

7.2.9 All New Solution Gas Flares

Figure 7.11 shows the distribution curve for the estimated cost to conserve all new solution gas flares. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than $76 million, lost crude oil production would be less than 530,000 m^3 and lost crude bitumen production would be less than 200,000 m^3. Table 7.3 shows the volumes of solution gas not flared due to conservation and CO_2E available as a result of not flaring this gas. Approximately 690,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 1.8 million tonnes of CO_2E not being emitted.

[27] May not sum exactly due to rounding.

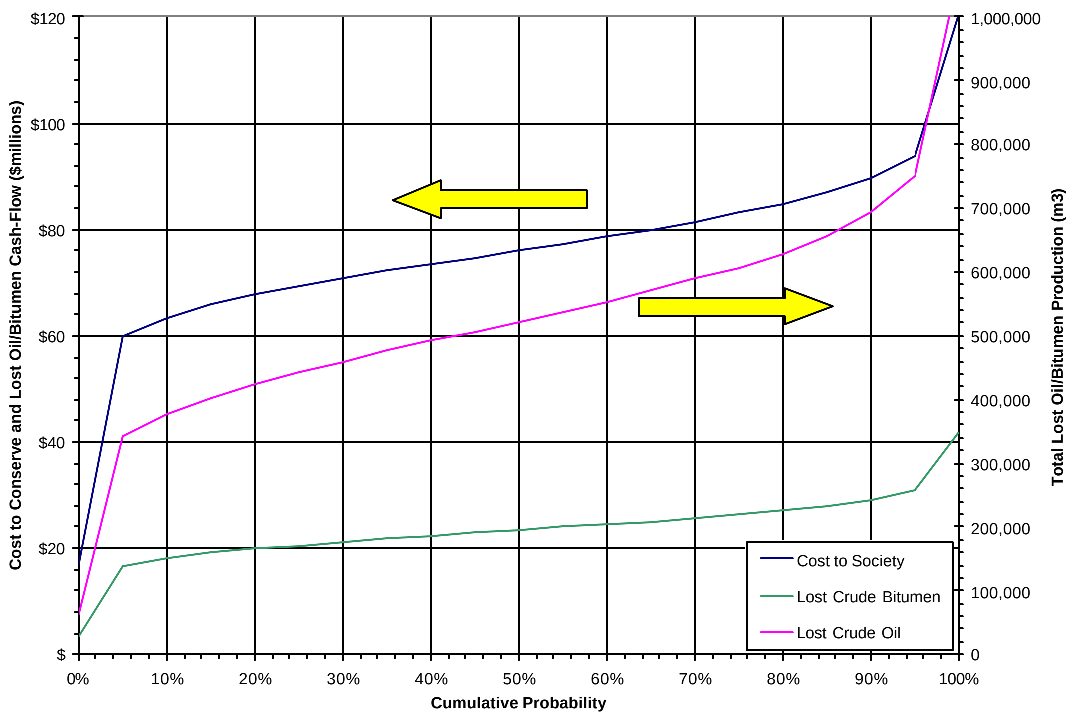

Figure 7.11 Post-2002 Solution Gas Flare Conservation Costs and Lost Oil/Bitumen Production

Table 7.3 Post-2002 Solution Gas Not Flared due to Conservation

Year	Volume Not Flared (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	24,000	0.1
2004	41,000	0.1
2005	55,000	0.1
2006	68,000	0.2
2007	82,000	0.2
2008	87,000	0.2
2009	87,000	0.2
2010	83,000	0.2
2011	82,000	0.2
2012	81,000	0.2
Total[28]	693,000	1.8

[28] May not sum exactly due to rounding.

7.3 Vent Conservation Costs

7.3.1 New Crude Oil Solution Gas Vents Greater than 1500 m^3/day

Figure 7.18 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1500 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than \$0.01 million and lost crude oil production would be 0 m^3. Table 7.10 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 18,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 0.3 million tonnes of CO_2E not being emitted.

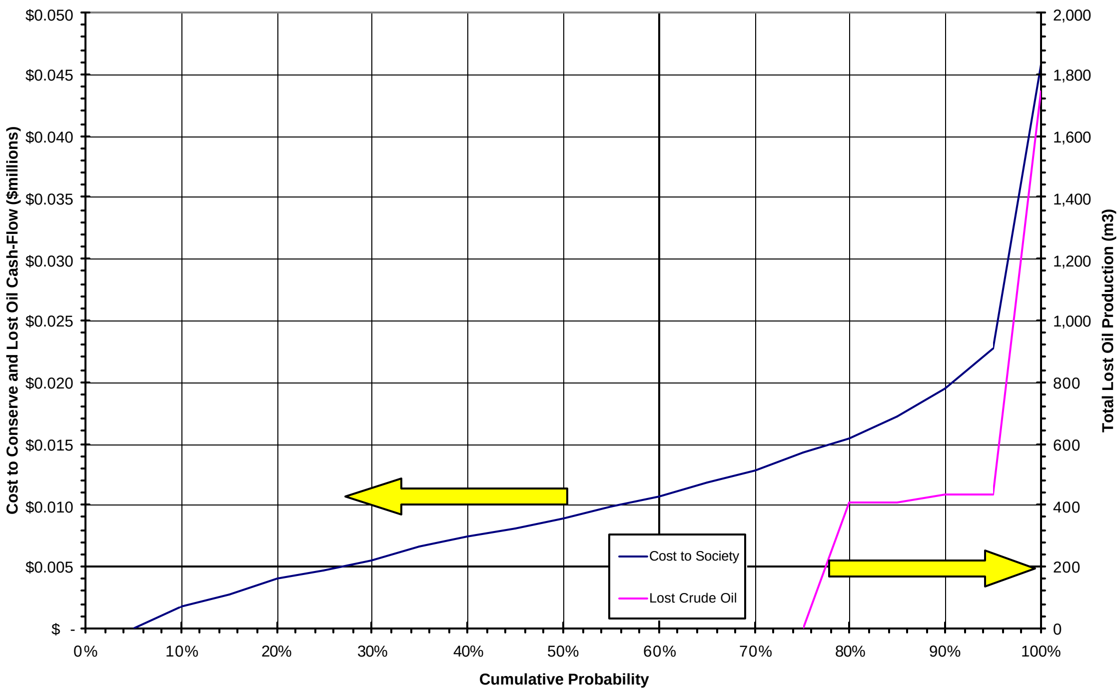

Figure 7.12 Post-2002 Crude Oil Solution Gas Vent Greater than 1500 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.4 Post-2002 Crude Oil Solution Gas Greater than 1500 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	611	0.01
2004	1,200	0.02
2005	1,699	0.02
2006	1,899	0.03
2007	2,116	0.03
2008	2,266	0.03
2009	2,276	0.03
2010	2,170	0.03
2011	2,157	0.03
2012	2,121	0.03
Total[29]	18,516	0.3

7.3.2 New Crude Bitumen Solution Gas Vents Greater than 1500 m^3/day

Figure 7.19 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1500 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than $2 million, and lost crude bitumen production would be less than 0 m^3. Table 7.11 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 402,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 5.7 million tonnes of CO_2E not being emitted.

[29] May not sum exactly due to rounding.

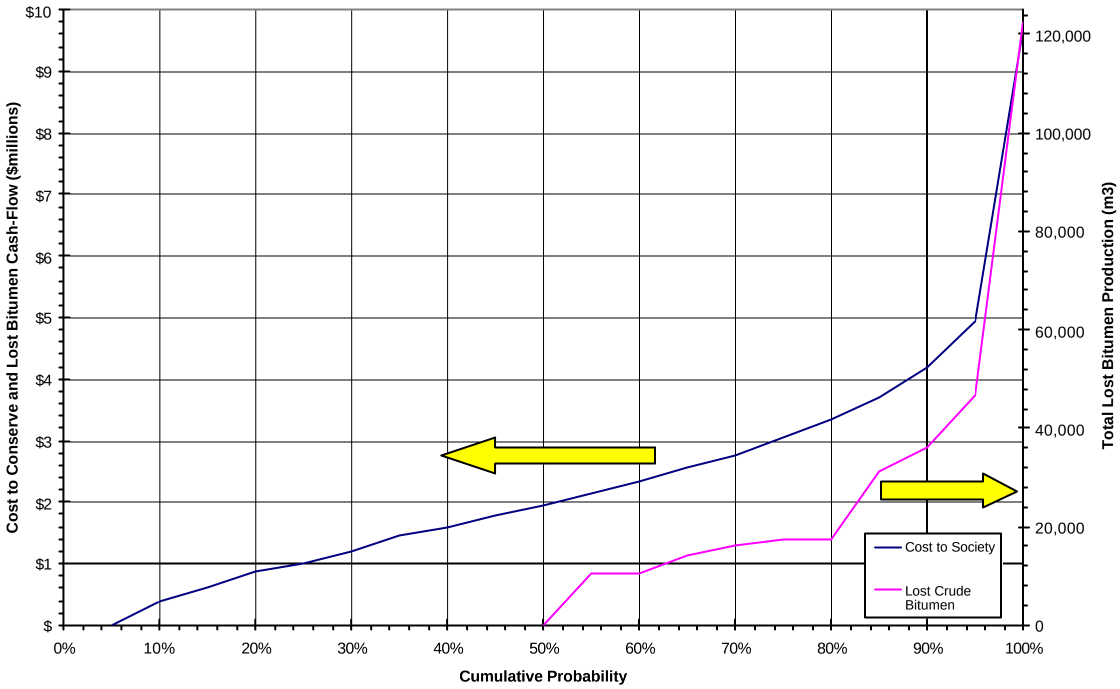

Figure 7.13 Post-2002 Crude Bitumen Solution Gas Vent Greater than 1500 m^3/day Conservation Costs and Lost Crude Bitumen Production

Table 7.5 Post-2002 Crude Bitumen Solution Gas Greater than 1500 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	10,485	0.1
2004	21,249	0.3
2005	25,801	0.4
2006	38,119	0.5
2007	51,034	0.7
2008	53,313	0.8
2009	52,580	0.7
2010	50,716	0.7
2011	49,861	0.7
2012	49,564	0.7
Total	402,723	5.7

7.3.3 All Solution Gas Vents Greater than 1500 m^3/day

Figure 7.20 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1500 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new solution gas vents greater than 1500 m^3/d would be less than $2 million, lost crude oil production would be 0 m^3 and lost crude bitumen production would 0 m^3. Table 7.12 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 420,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 6.0 million tonnes of CO_2E not being emitted.

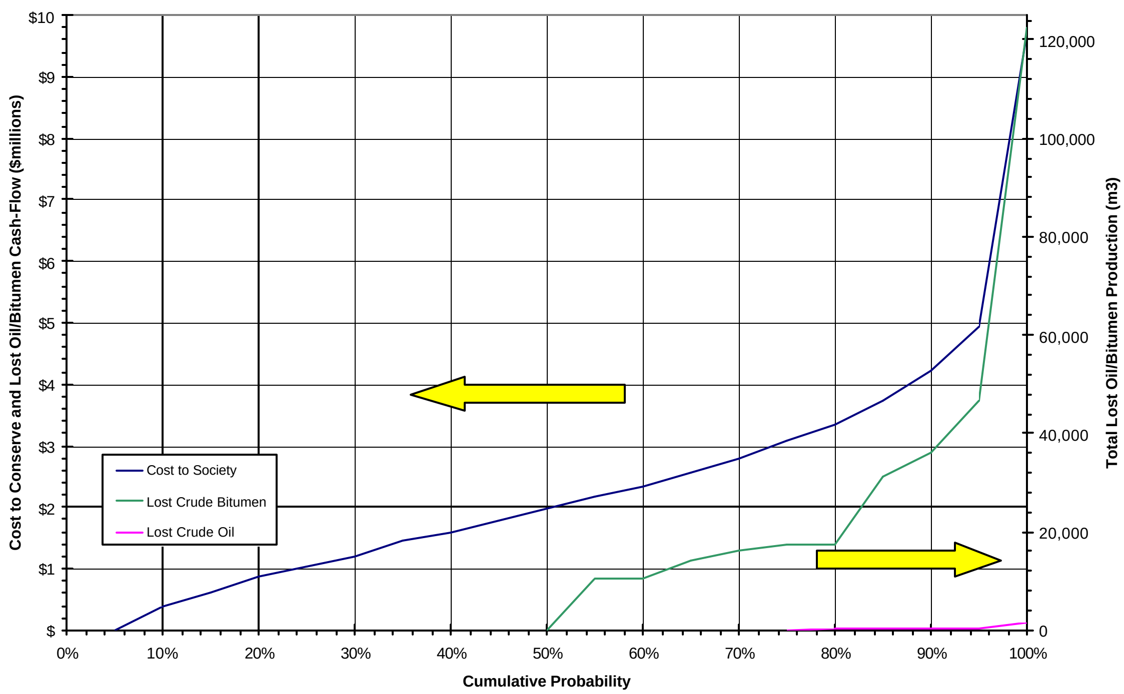

Figure 7.14 All Post-2002 Solution Gas Vent Greater than 1500 m^3/day Conservation Costs and Lost Crude Oil/Bitumen Production

Table 7.6 All Post-2002 Solution Gas Greater than 1500 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	11,096	0.2
2004	22,450	0.3
2005	27,500	0.4
2006	40,018	0.6
2007	53,150	0.8
2008	55,578	0.8
2009	54,856	0.8
2010	52,887	0.8
2011	52,018	0.7
2012	51,685	0.7
Total[30]	421,238	6.0

[30] May not sum exactly due to rounding.

7.3.4 New Crude Oil Solution Gas Vents Greater than 1000 m^3/day

Figure 7.18 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1000 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than \$0.025 million and lost crude oil production would be less than 500 m^3. Table 7.10 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 33,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 0.5 million tonnes of CO_2E not being emitted.

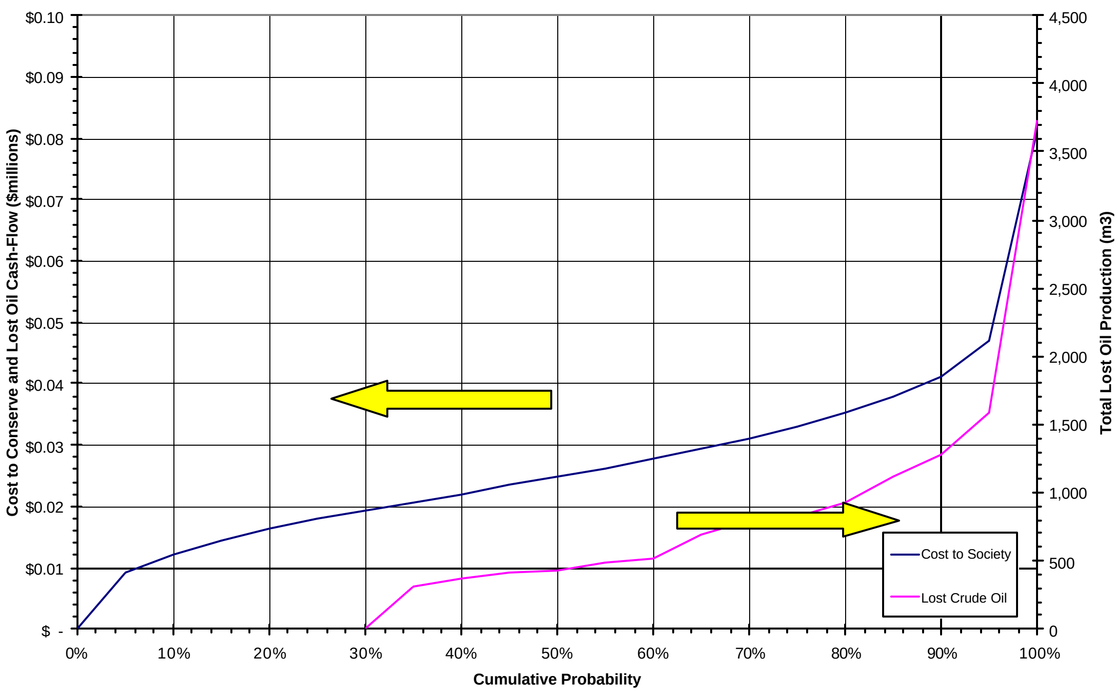

Figure 7.15 Post-2002 Crude Oil Solution Gas Vent Greater than 1000 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.7 Post-2002 Crude Oil Solution Gas Greater than 1000 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	1,086	0.0
2004	2,134	0.0
2005	3,021	0.0
2006	3,376	0.0
2007	3,761	0.1
2008	4,028	0.1
2009	4,046	0.1
2010	3,859	0.1
2011	3,835	0.1
2012	3,770	0.1
Total[31]	32,916	0.5

7.3.5 New Crude Bitumen Solution Gas Vents Greater than 1000 m^3/day

Figure 7.19 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1000 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than \$5.3 million, and lost crude bitumen production would be less than 31,000 m^3. Table 7.11 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 715,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 10.2 million tonnes of CO_2E not being emitted.

[31] May not sum exactly due to rounding.

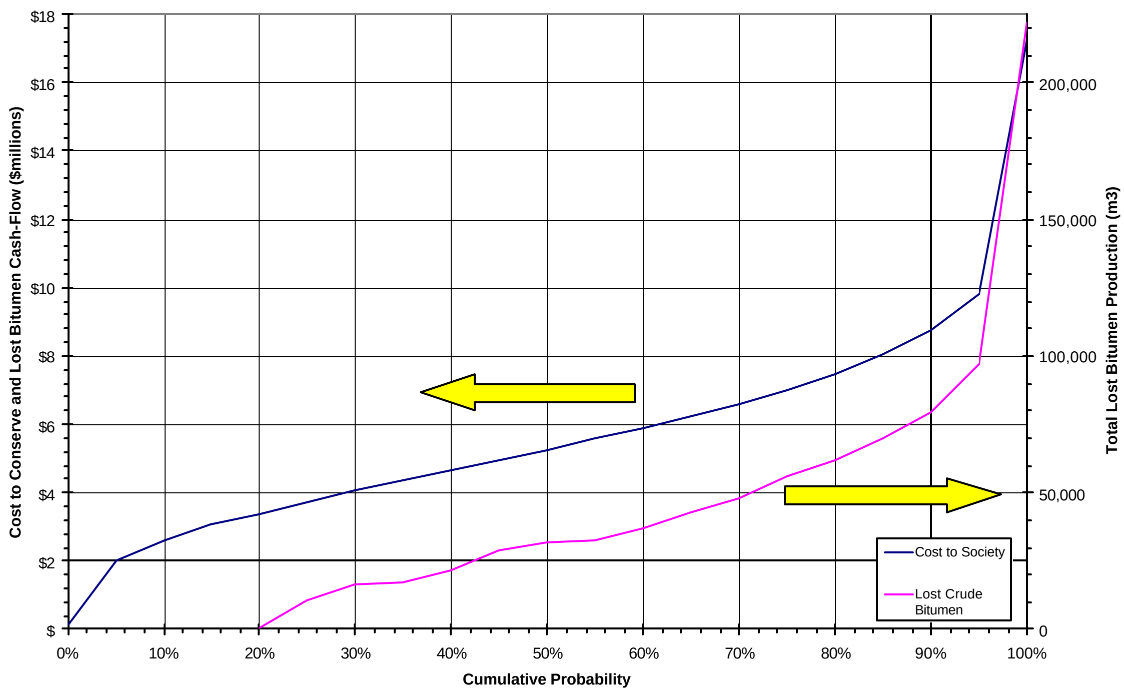

Figure 7.16 Post-2002 Crude Bitumen Solution Gas Vent Greater than 1000 m^3/day Conservation Costs and Lost Crude Bitumen Production

Table 7.8 Post-2002 Crude Bitumen Solution Gas Greater than 1000 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	18,640	0.3
2004	37,777	0.5
2005	45,868	0.7
2006	67,767	1.0
2007	90,728	1.3
2008	94,778	1.4
2009	93,476	1.3
2010	90,162	1.3
2011	88,642	1.3
2012	88,114	1.3
Total	715,951	10.2

7.3.6 All Solution Gas Vents Greater than 1000 m^3/day

Figure 7.20 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 1000 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new solution gas vents greater than 1000 m^3/d would be less than \$5.3 million, lost crude oil production would be less than 500 m^3 and lost crude bitumen production would be less than 31,000 m^3. Table 7.12 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 748,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 10.7 million tonnes of CO_2E not being emitted.

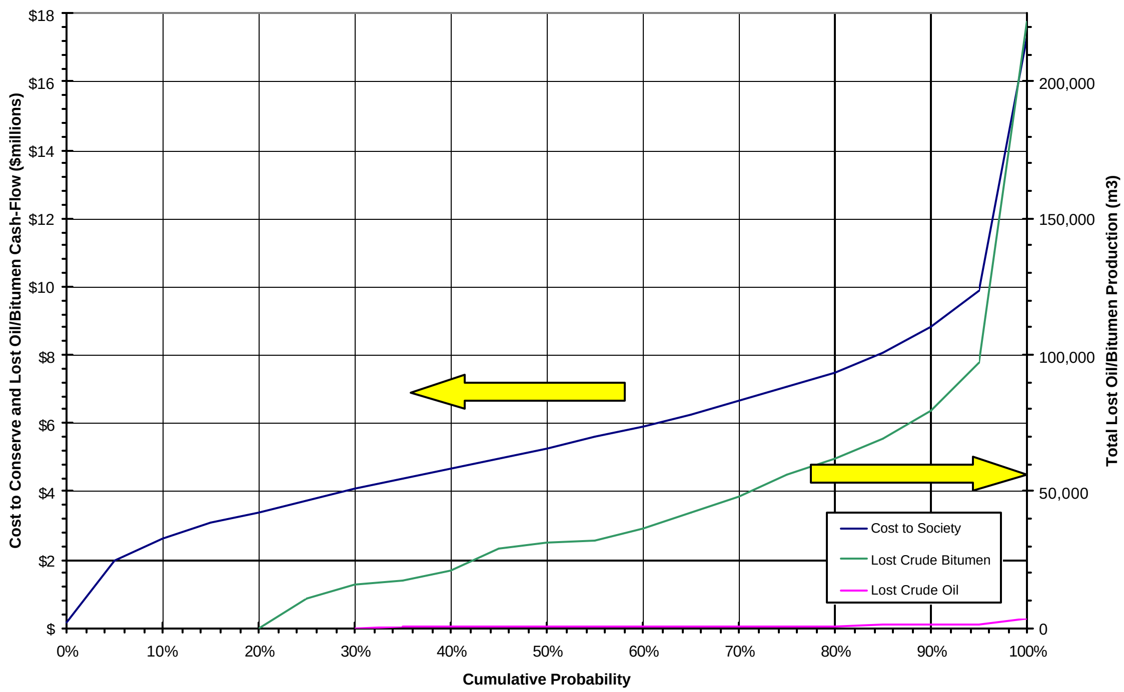

Figure 7.17 All Post-2002 Solution Gas Vent Greater than 1000 m^3/day Conservation Costs and Lost Crude Oil/Bitumen Production

Table 7.9 All Post-2002 Solution Gas Greater than 1000 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	19,726	0.3
2004	39,911	0.6
2005	48,888	0.7
2006	71,144	1.0
2007	94,489	1.3
2008	98,806	1.4
2009	97,522	1.4
2010	94,021	1.3
2011	92,476	1.3
2012	91,885	1.3
Total[32]	748,868	10.7

7.3.7 New Crude Oil Solution Gas Vents Greater than 800 m^3/day

Figure 7.18 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than $0.04 million and lost crude oil production would be less than 2,000 m^3. Table 7.10 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 41,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 0.6 million tonnes of CO_2E not being emitted.

[32] May not sum exactly due to rounding.

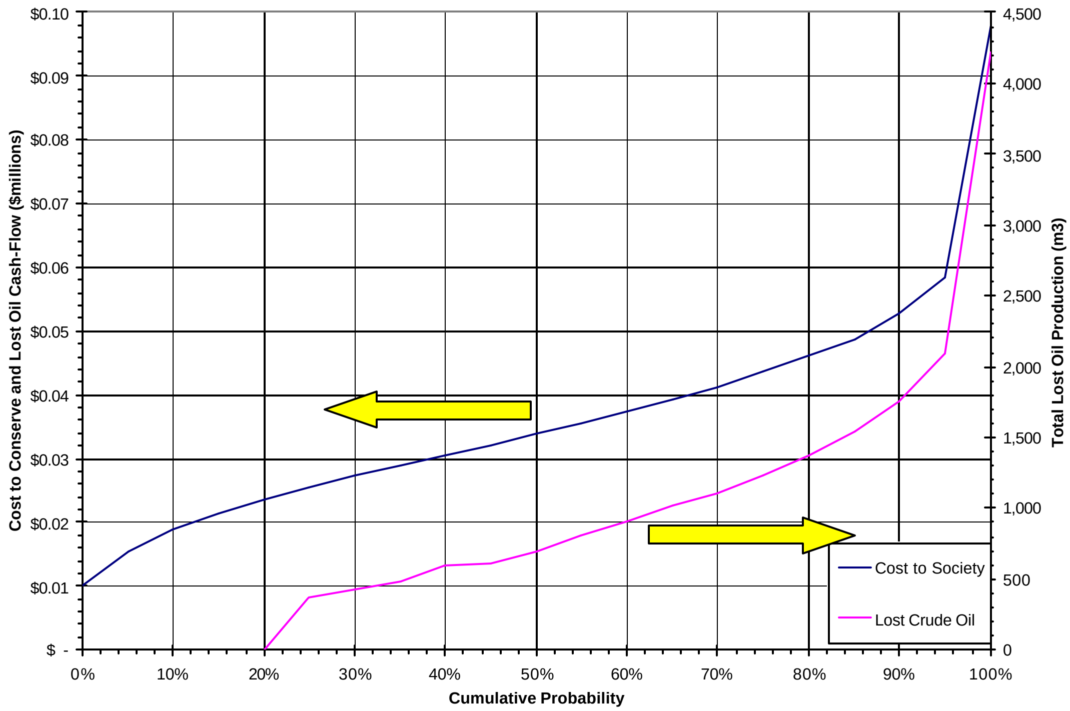

Figure 7.18 Post-2002 Crude Oil Solution Gas Vent Greater than 800 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.10 Post-2002 Crude Oil Solution Gas Greater than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	1,000	0.0
2004	3,000	0.0
2005	4,000	0.1
2006	4,000	0.1
2007	5,000	0.1
2008	5,000	0.1
2009	5,000	0.1
2010	5,000	0.1
2011	5,000	0.1
2012	5,000	0.1
Total[33]	41,000	0.6

7.3.8 New Crude Bitumen Solution Gas Vents Greater than 800 m^3/day

Figure 7.19 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society would be less than \$7 million, and lost crude bitumen production would be less than 40,000 m^3. Table 7.11 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 895,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 12.8 million tonnes of CO_2E not being emitted.

[33] May not sum exactly due to rounding.

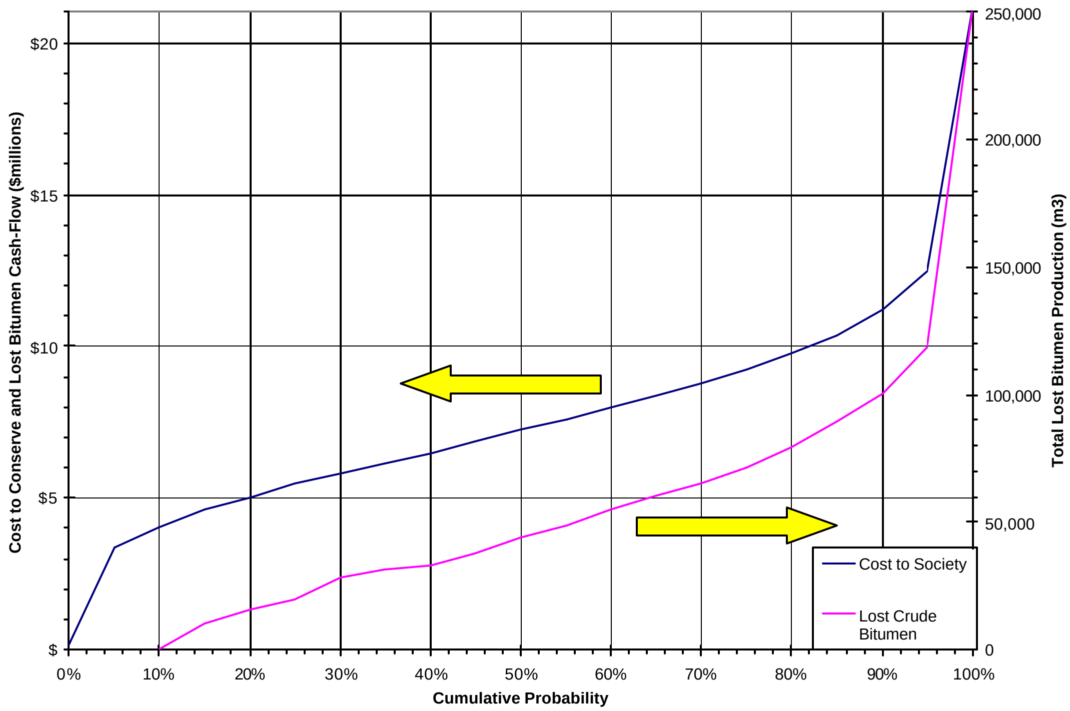

Figure 7.19 Post-2002 Crude Bitumen Solution Gas Vent Greater than 800 m^3/day Conservation Costs and Lost Crude Bitumen Production

Table 7.11 Post-2002 Crude Bitumen Solution Gas Greater than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	23,000	0.3
2004	47,000	0.7
2005	57,000	0.8
2006	85,000	1.2
2007	113,000	1.6
2008	118,000	1.7
2009	117,000	1.7
2010	113,000	1.6
2011	111,000	1.6
2012	110,000	1.6
Total	895,000	12.8

7.3.9 All Solution Gas Vents Greater than 800 m^3/day

Figure 7.20 shows the distribution curve for the estimated cost to conserve new solution gas vents greater than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new solution gas vents greater than 800 m^3/d would be less than $7 million, lost crude oil production would be less than 2,000 m^3 and lost crude bitumen production would be less than 40,000 m^3. Table 7.12 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 936,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 13.4 million tonnes of CO_2E not being emitted.

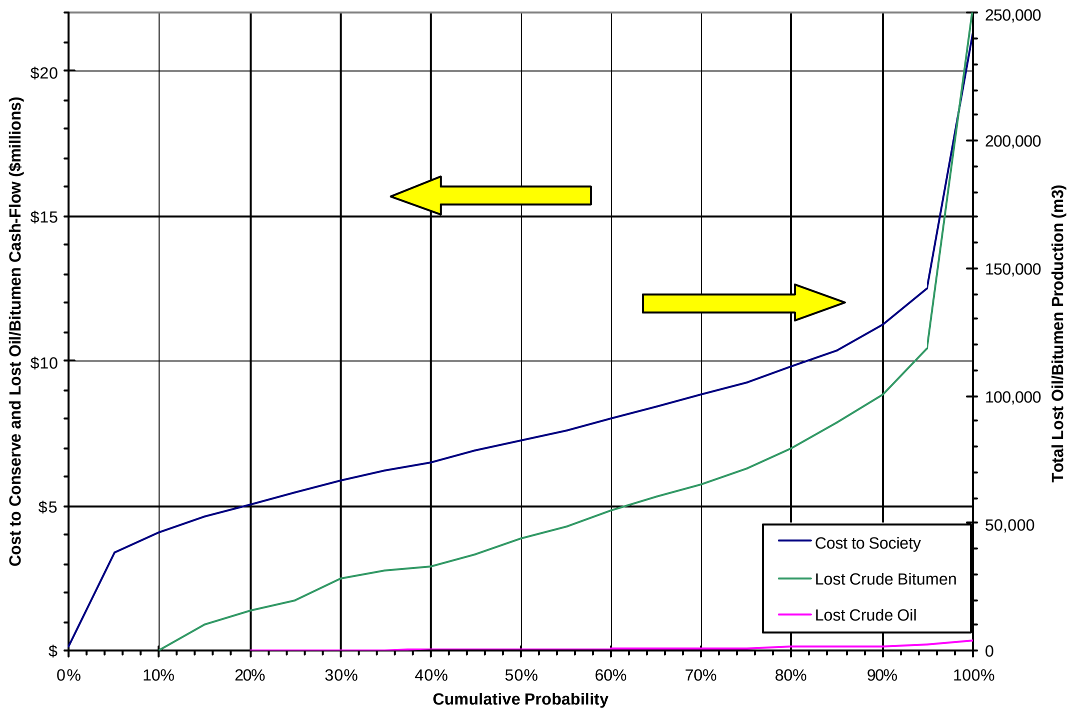

Figure 7.20 All Post-2002 Solution Gas Vent Greater than 800 m^3/day Conservation Costs and Lost Crude Oil/Bitumen Production

Table 7.12 All Post-2002 Solution Gas Greater than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	25,000	0.4
2004	50,000	0.7
2005	61,000	0.9
2006	89,000	1.3
2007	118,000	1.7
2008	124,000	1.8
2009	122,000	1.7
2010	118,000	1.7
2011	116,000	1.6
2012	115,000	1.6
Total[34]	936,000	13.3

7.3.10 New Crude Oil Solution Gas Vents Less than 800 m^3/day

Figure 7.21 shows the distribution curve for the estimated cost to conserve new solution gas vents less than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new solution gas vents less than 800 m^3/d would be less than $38 million and lost crude oil production would be less than 50,000 m^3. Table 7.13 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 96,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 1.4 million tonnes of CO_2E not being emitted.

[34] May not sum exactly due to rounding.

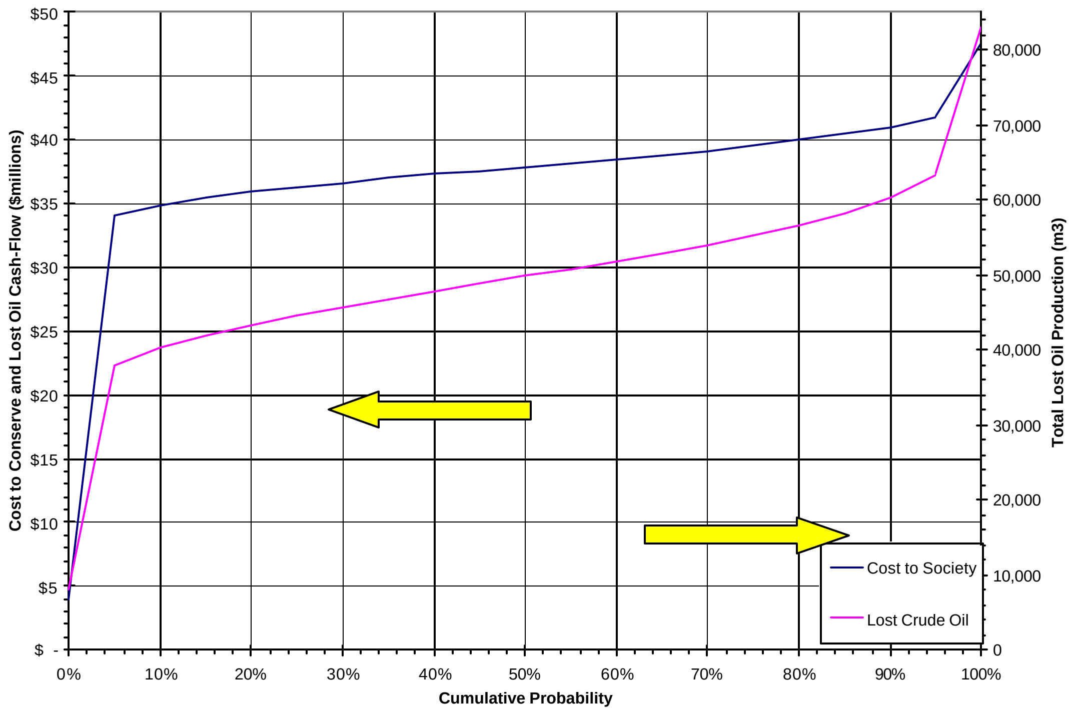

Figure 7.21 Post-2002 Crude Oil Solution Gas Vent Less than 800 m^3/day Conservation Costs and Lost Crude Oil Production

Table 7.13 Post-2002 Crude Oil Solution Gas Less than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	3,000	0.0
2004	6,000	0.1
2005	9,000	0.1
2006	10,000	0.1
2007	11,000	0.2
2008	12,000	0.2
2009	12,000	0.2
2010	11,000	0.2
2011	11,000	0.2
2012	11,000	0.2
Total[35]	96,006	1.4

[35] May not sum exactly due to rounding.

7.3.11 New Crude Bitumen Solution Gas Vents Less than 800 m^3/day

Figure 7.22 shows distribution curve for the estimated cost to conserve new crude bitumen solution gas vents less than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve new crude bitumen solution gas would be less than $59 million and lost crude bitumen production would be less than 460,000 m^3. Table 7.14 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 525,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012, resulting in 7.5 million tonnes of CO_2E not being emitted.

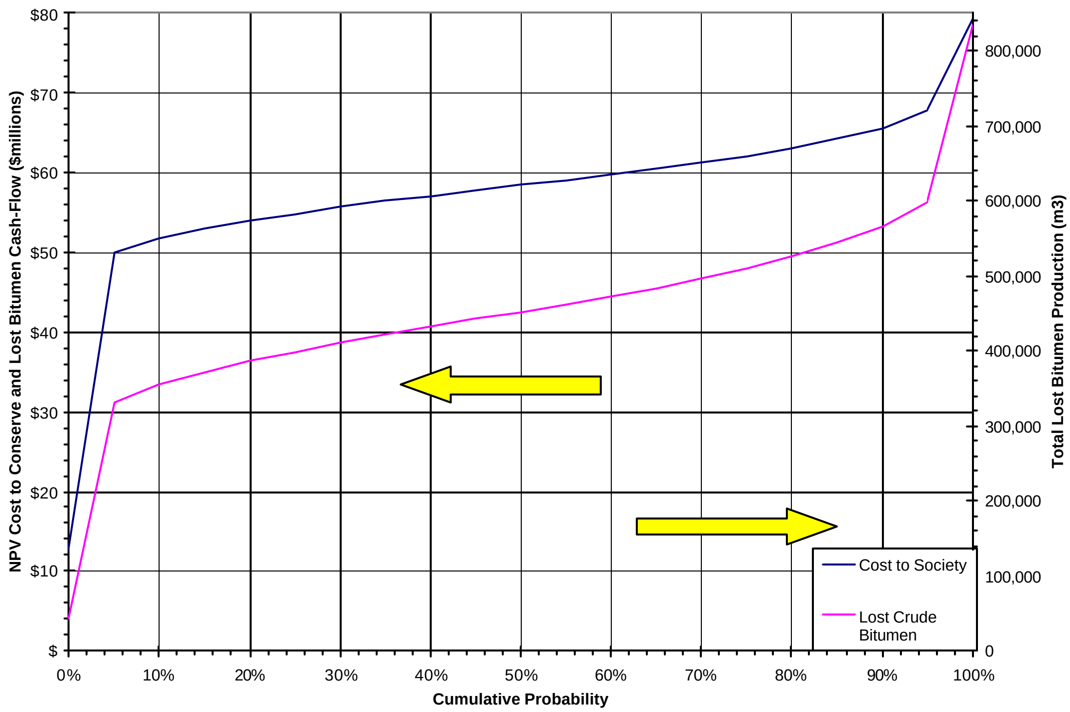

Figure 7.22 Post-2002 Crude Bitumen Solution Gas Vent Less than 800 m^3/day Conservation Costs and Lost Crude Bitumen Production

Table 7.14 Post-2002 Crude Bitumen Solution Gas Less than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	14,000	0.2
2004	28,000	0.4
2005	34,000	0.5
2006	50,000	0.7
2007	67,000	0.9
2008	70,000	1.0
2009	69,000	1.0
2010	66,000	0.9
2011	65,000	0.9
2012	65,000	0.9
Total[36]	526,000	7.5

7.3.12 All Solution Gas Vents Less than 800 m^3/day

Figure 7.23 shows the distribution curve for the estimated cost to conserve all new solution gas vents less than 800 m^3/d. The graph indicates, as an example, that there is a 50% probability that the cost to society to conserve all new solution gas vents less than 800 m^3/d would be less than $97 million, lost crude oil production would be less than 50,000 m^3 and lost crude bitumen production would be less than 460,000 m^3. Table 7.15 shows the volumes of solution gas not vented due to conservation and the CO_2E available as a result of not venting this gas. Approximately 621,000 10^3 m^3 of solution gas can be conserved during the period 2003 to 2012 resulting in 8.9 million tonnes of CO_2E not being emitted.

[36] May not sum exactly due to rounding.

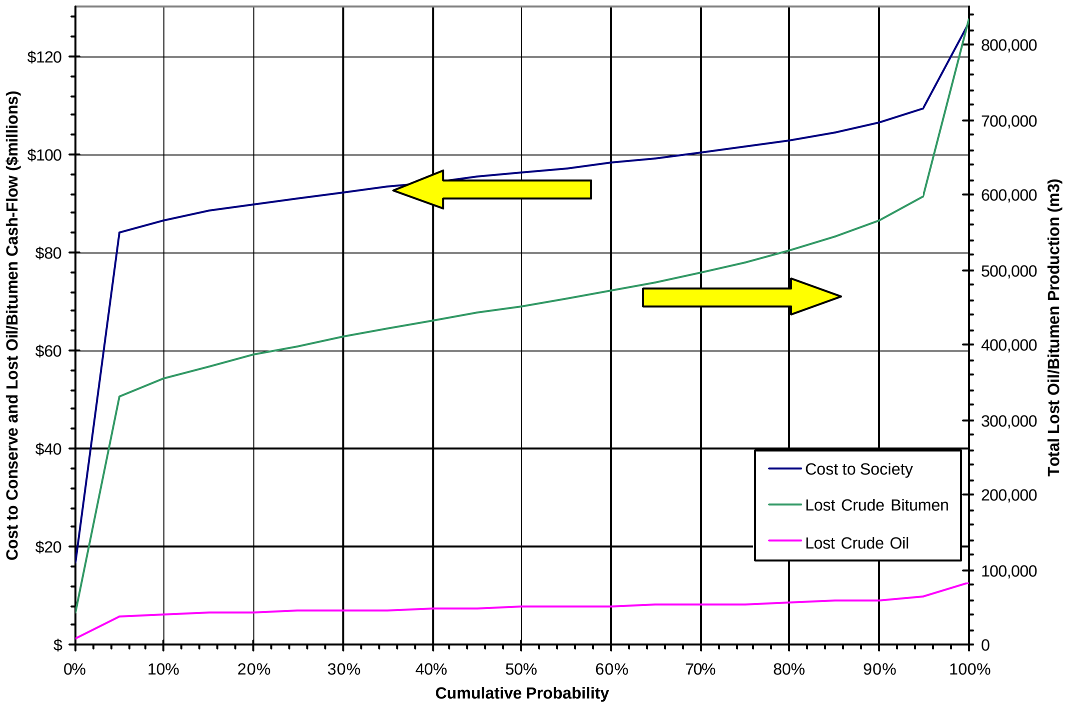

Figure 7.23 All Post-2002 Solution Gas Vent Less than 800 m^3/day Conservation Costs and Lost Crude Oil/Bitumen Production

Table 7.15 All Post-2002 Solution Gas Less than 800 m^3/day not Vented due to Conservation

Year	Volume Not Vented (10^3 m^3/yr)	CO_2E (Million Tonnes)
2003	17,000	0.2
2004	34,000	0.5
2005	42,000	0.6
2006	60,000	0.8
2007	78,000	1.1
2008	81,000	1.2
2009	80,000	1.1
2010	77,000	1.1
2011	76,000	1.1
2012	76,000	1.1
Total[37]	622,000	8.9

7.4 New Solution Gas Conservation Summary

Table 7.10 gives a summary of the costs and benefits of conserving flared and vented solution gas from the various sectors described above. The following conclusions can be drawn from this information:

1. The costs and benefits of conserving solution gas depends, in large part, on the source of the soluion gas and how it is being disposed of, i.e. whether it is being flared or vented.
2. The sector with the least economic impact to conserve (i.e. cost plus shut in production) is the otherwise vented crude oil solution gas vents greater than 800 m^3/day. Not surprisingly, the benefits from this sector conserving are also the lowest in terms of conserved solution gas and greenhouse gas emissions reductions.
3. The sector with the largest benefits to conservation (i.e. conserved solution gas plus greenhouse gas emissions reductions) is the otherwise vented crude bitumen solution gas vents greater than 800 m3/day sector.

[37] May not sum exactly due to rounding.

4. It is difficult to compare the costs and benefits between sectors because the benefits and impacts represent a mixture of variables, i.e. the benefits combine conserved solution gas with greenhouse gas emissions reductions, while the costs combine decreases in NPV with lost oil and bitumen production. A rough comparison could be done if values were assigned to crude oil, crude bitumen, and greenhouse gas emissions reductions (per tonne of CO_2E).

5. From a greenhouse gas emissions perspective alone, conserving vented gas has a much higher benefit than conserving flared gas.

Table 7.16 New Solution Gas Conservation Summary (Based on 50% Probability from Distribution Curve)

Sector	Cost	Lost Production (value included in cost column)	Solution Gas Conserved	CO_2E Available
New otherwise flared crude oil solution gas	$41 million	53,000 m^3 oil	390,000 10^3 m^3	1.0 million tonnes
New otherwise flared crude oil solution gas > 300 m3/d	$33.4 million	320,000 m^3 oil	253,000 10^3 m^3	0.7 million tonnes
New otherwise flared crude oil solution gas > 800 m3/d	$13.4 million	106,000 m^3 oil	136,000 10^3 m^3	0.3 million tonnes
New otherwise flared crude bitumen solution gas	$35 million	200,000 m^3 bitumen	300,000 10^3 m^3	0.8 million tonnes
New otherwise flared crude bitumen solution gas > 300 m3/d	$17.1 million	94,000 m^3 bitumen	197,000 10^3 m^3	0.5 million tonnes
New otherwise flared crude bitumen solution gas > 800 m3/d	$6.6 million	14,000 m^3 bitumen	106,00 10^3 m^3	0.3 million tonnes
New otherwise vented crude oil solution gas vents > 1500 m3/d	$0.001 million	0 m^3 oil	18,000 10^3 m^3	0.3 million tonnes
New otherwise vented crude oil solution gas vents > 1000 m3/d	$0.025 million	500 m^3 oil	33,000 10^3 m^3	0.5 million tonnes

Sector	Cost	Lost Production (value included in cost column)	Solution Gas Conserved	CO_2E Available
New otherwise vented crude oil solution gas vents > 800 m3/d	$0.04 million	700 m^3 oil	41,000 10^3 m^3	0.6 million tonnes
New otherwise vented crude bitumen solution gas vents > 1500 m3/d	$2 million	0 m^3 bitumen	402,000 10^3 m^3	5.7 million tonnes
New otherwise vented crude bitumen solution gas vents > 1000 m3/d	$5.3 million	31,000 m^3 bitumen	715,000 10^3 m^3	10.2 million tonnes
New otherwise vented crude bitumen solution gas vents > 800 m3/d	$7 million	40,000 m^3 bitumen	895,000 10^3 m^3	12.8 million tonnes
New otherwise vented crude oil solution gas vents < 800 m3/d	$38 million	50,000 m^3 oil	96,000 10^3 m^3	1.4 million tonnes
New otherwise vented crude bitumen solution gas vents <800 m3/d	$59 million	460,000 m^3 bitumen	525,000 10^3 m^3	7.5 million tonnes
TOTAL (to conserve all solution gas)	$180 million	552,000 m^3 oil 740,000 m^3 bitumen	2,247,000 10^3 m^3	24.1 million tonnes

8 Conclusions

8.1 ID 2002-02 Data Submissions Complete

In terms of the data received with respect to ID 2002-02, economic evaluations have been received from virtually all facilities required to do so that would have a material impact on the results of this study. There were some issues with data quality, specifically with units and missing information. However, most of these have been resolved based on cross-checking with existing data and acceptable ranges for the values. The small numbers of sites that may have not submitted information are likely due, for the most part, to facilities being shut-in or being scheduled for suspension in the near future.

8.2 Current Solution Gas Flaring and Venting Volumes Estimated

Solution gas flaring and venting has been analyzed for the years 2002 and 2001, respectively. A breakdown of the different sizes, current conservation practices and further conservation prospects was prepared. For solution gas flaring, roughly half the volume comes from sites that are conserving 95% or more of solution gas produced. For solution gas venting, significant improvements in conservation should be seen in the future, as the volume of economic sites is approximately twice that of uneconomic sites.

8.3 Characteristics of Economic and Uneconomic Projects

Conservation projects have been analyzed to gain a better understanding of the factors affecting project viability. For solution gas flares, several factors play a part in determining the viability. The most important factors are distance to pipelines, compressor discharge pressures, solution gas volumes and reserve life. Some statistics for flaring are highlighted in Table 8.1. For solution gas venting, project viability is affected by predominantly by solution gas volumes. Some statistic for venting are highlighted in Table 8.2. Most solution gas vents have pipeline infrastructure near them and thus project economics are not very dependant on the distance to pipelines or compressor discharge pressures (compressor discharge pressure is usually affected by distance to pipelines).

Table 8.1 Selected Project Statistics for Flares

Statistic	Economic Projects	Uneconomic Projects
Mean Flare Volume	309 10^3 m^3/ year	121 10^3 m^3/ year
75 Percentile of distance to pipeline	Less than 1.3 km	Less than 3.2
95 Percentile of GORs	Less than 1400 10^3 m^3 gas/ m^3 oil	Less than 861 10^3 m^3 gas/ m^3 oil

Table 8.2 Selected Project Statistics for Vents

Statistic	Economic Projects	Uneconomic Projects
Mean Vent Volume	766 10^3 m^3/ year	296 10^3 m^3/ year
75 Percentile of distance to pipeline	Less than 1.0 km	Less than 0.8 km
95 Percentile of GORs	Less than 1218 10^3 m^3 gas/ m^3 oil	Less than 525 10^3 m^3 gas/ m^3 oil

8.4 Conservation Costs for Current Solution Gas Flaring and Venting

Conservation costs have been calculated for current solution gas flaring and venting. For solution gas flaring, it should be noted that estimated conservation costs do not include costs for reducing flaring at sites conserving 95% of produced solution nor sites with low flare volumes. For approximately $60 million, current solution gas flaring could be reduced by 60,000 10^3 m^3 per year in 2003. For current solution gas venting, it should be noted that estimated conservation costs do not include costs to conserve vents less than 800 m^3/day, nor do they include costs to conserve vents evaluations deferred with the 50% rule. For approximately $10 million, current solution gas venting could be reduced by 50,000 10^3 m^3 per year in 2003. However, these cost estimates are a snap shot in time. Solution gas flaring and venting from these sites will be declining and cost estimates will change in the future.

8.5 Solution Gas Flaring and Venting Forecasted for 2003-2012

For the period of 2003 to 2012, solution gas production was forecasted. Using this production forecast, solution gas flaring and venting were forecasted, including modelling for the effect of G60 regulations. It is expected that solution gas flaring should be steadily declining over this time period. A reduction of roughly 76 percent from 1996 values may be achieved by 2012. The composition of flaring will change in this period from being primarily related to crude oil production to include a larger portion from crude bitumen production, following production trends where crude oil production is declining, whereas crude bitumen production is increasing. This increase of crude bitumen production will have major effects on solution gas venting. Solution gas venting is expected to stay at or below 2002 values until 2008, whereupon it will begin to decline. Of course, this is dependant on operators consistently implementing G60 regulation conservation practices.

8.6 Costs and Effect on Oil/Bitumen Production of Conserving Future Solution Gas Flaring and Venting Estimated

A probability-based model was devised to estimate the costs to conserve new solution gas flares and vents in the period 2003 to 2012. Flaring and venting associated with well testing, gas pipeline and distribution systems and gas plants have not been examined in this report. The report does not estimate costs to comply with current guides and regulations for the upstream petroleum industry. This model estimated the costs to conserve including lost oil/bitumen cash-flows and lost oil/bitumen production. The costs to conserve were summarized in Table 7.10 and the following conclusions were drawn from the results:

1. The costs and benefits of conserving solution gas depends, in large part, on the source of the gas and how it is being disposed of, i.e. whether it is being flared or vented.
2. The sector with the least economic impact to conserve (i.e. cost plus shut in production) is the otherwise vented crude oil solution gas vents greater than 800 m^3/day. Not surprisingly, the benefits from this sector conserving are also the lowest in terms of conserved solution gas and greenhouse gas emissions reductions.
3. The sector with the largest benefits to conservation (i.e. conserved solution gas plus greenhouse gas emissions reductions) is the otherwise vented crude bitumen solution gas vents greater than 800 m^3/day sector.
4. It is difficult to compare the costs and benefits between sectors because the benefits and impacts represent a mixture of variables, i.e. the benefits combine conserved solution gas with greenhouse gas emissions reductions, while the costs combine decreases in NPV with lost oil and bitumen production. A rough comparison could be done if values were assigned to crude oil, crude bitumen, and greenhouse gas emissions reductions (per tonne of CO_2E).
5. From a greenhouse gas emissions perspective alone, conserving vented gas has a much higher benefit than conserving flared gas.

Glossary

CAPP	Canadian Association of Petroleum Producers
CASA	Clean Air Strategic Alliance
CO_2E	Carbon Dioxide Equivalent
Crude Bitumen	A naturally occurring viscous mixture mainly of hydrocarbons that in its naturally occurring viscous state will not flow to a well. Also defined according to the geographic region where produced.
Crude Oil	A naturally occurring mixture mainly of viscous hydrocarbons that in its naturally occurring state will flow to a well. Also defined according to the geographic region where produced.
EUB	Alberta Energy and Utilities Board
Flare	Act of burning natural gas as a waste product when it is uneconomic to conserve or in emergency situations when accumulations of gas become a safety concern.
G60	EUB Guide 60: Upstream Petroleum Industry Flaring, Venting and Incinerating
GB	EUB General Bulletin
GOR	Gas to Oil Ratio, also used for Gas to Bitumen Ratio
H_2S	Hydrogen Sulphide
ID	EUB Interim Directive
ID 2002-02	EUB Interim Directive 2002-02 EUB REQUIREMENTS FOR SUBMISSION OF DATA FOR SOLUTION GAS FLARING AND VENTING EVALUATIONS
In-Situ Crude Bitumen	Bitumen produced from processes that do not involve surface mining.
Paper Batteries	Group of wells reporting to one centralized location for accounting purposes.
Solution Gas	All gas that is separated from oil or bitumen production.
Vent	Direct release of natural gas into the atmosphere.

References

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Appendix A - ID 2002-02 Data

The ID 2002-02 data collected by the EUB is available on CASA's webpage at www.casahome.org.

Appendix B - New and Old Solution Gas Production Graphs

Figure B.1 below shows solution gas flaring forecasts with old solution gas that existed prior to 2003 and new solution gas starting production after 2002.

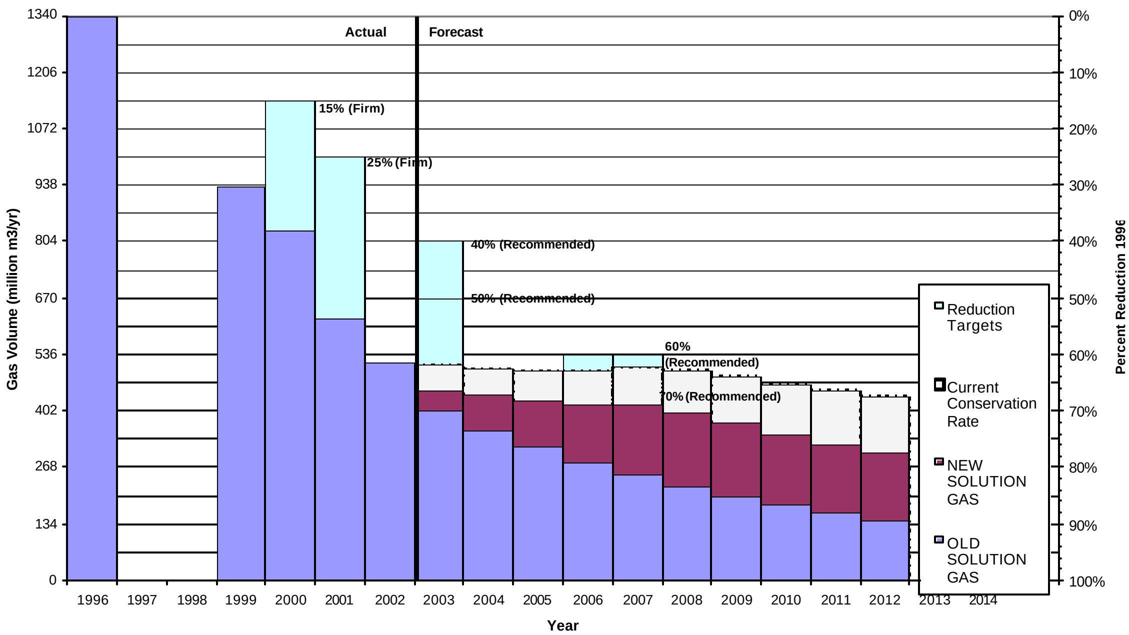

Figure B.1 Solution Gas Flaring Forecast: Old and New Solution Gas

Figure B.2 below shows solution gas venting forecasts with old solution gas that existed prior to 2003 and new solution gas starting production after 2002.

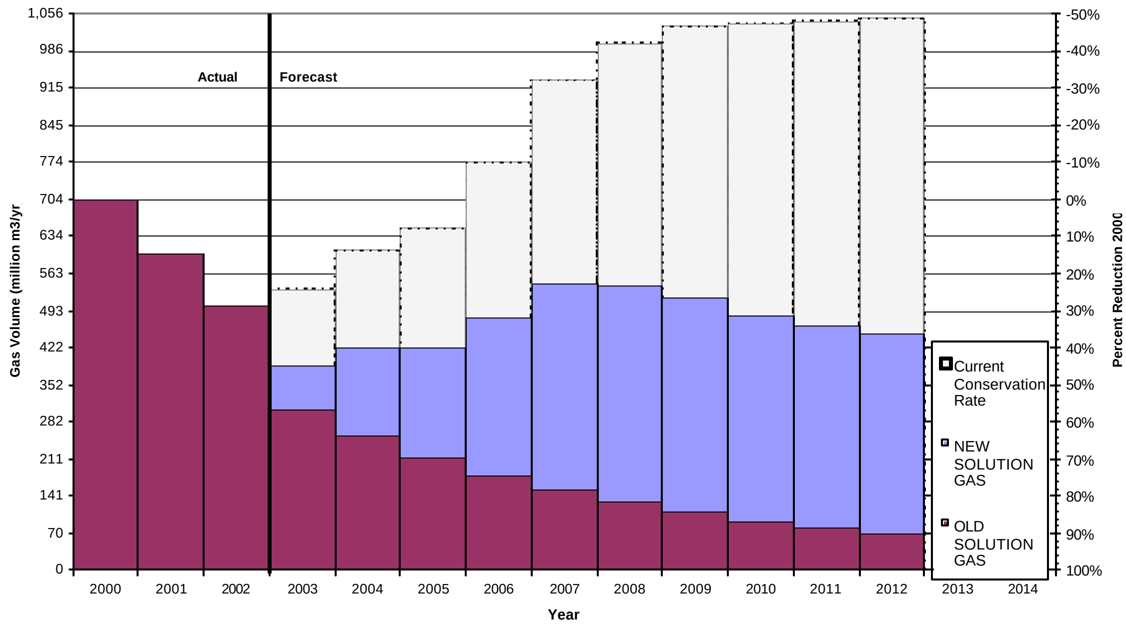

Figure B.2 Solution Gas Venting Forecast: Old and New Solution Gas