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FINAL REPORT

ANALYSIS OF FUTURE OPTIONS FOR CONNECTICUT'S GASOLINE DISPENSING FACILITY VAPOR CONTROL PROGRAM

June 4, 2012

Prepared for:

Connecticut Department of Energy and Environmental Protection

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1. INTRODUCTION

Under purchase order # DEPM1-0000031039, de la Torre Klausmeier Consulting, Inc. (dKC) is assisting the Connecticut Department of Energy and Environmental Protection (DEEP) in evaluating the Gasoline Dispensing Facility (GDF) Vapor Control Program. Onboard refueling vapor recovery (ORVR) systems were phased into the motor vehicle fleet beginning with the 1998 model year, and ORVR technology is now in widespread use throughout the motor vehicle fleet for purposes of controlling motor vehicle refueling emissions. EPA has determined that emission reductions from ORVR are essentially equal to and will soon surpass the emission reductions achieved by Stage II vapor recovery systems alone. Due to these findings, EPA is waiving the Stage II requirements, and as of May 16, 2012, states that are implementing mandatory Stage II programs under section 182(b)(3) of the CAA may submit revisions to their SIPS to remove this program. Connecticut is subject to the Ozone Transport Commission's (OTC) control measures, and must await EPA's issuance of guidance listing the requirements for emissions reduction comparable measures prior to submitting amendments to its State Implementation Plan (SIP).

The primary objectives of this project are listed below:

- Determine when ORVR systems in Connecticut's vehicle fleet have met a particular threshold described as widespread use (WSU).
- Estimate the cost and benefits of terminating or enhancing the Stage II vapor recovery program.
- Estimate the cost and benefits of enhancing the Stage I vapor recovery program to achieve additional volatile organic compound (VOC) reductions.
- Determine the preferred way to decommission Stage II systems.

This report presents the results of this project.

Summary of Results: Considering two known definitions of WSU and the assumed effectiveness of Stage II systems, Connecticut has passed or will soon pass the WSU threshold. Continuing the current program beyond WSU will achieve minimal emission reductions, and will in fact increase emissions after 2015. In addition, these findings suggest that, adopting the Stage II provisions of the California Enhanced Vapor Recovery program (CA EVR) would not be cost effective. Once EPA has issued its guidance on developing and submitting approvable SIP revisions, DEEP should consider regulations to phase-out the Stage II program. Connecticut, however, will still remain subject to the OTC control measures, which may allow for Stage I improvements to compensate for any backsliding due to the phasing out of the Stage II program. This study has also revealed that the Stage I systems currently in use are falling short of their assumed efficacy, resulting in a far lower reduction of emissions than that previously committed to in Connecticut's SIP. In collaboration with EPA, DEEP intends to discuss possible measures to be taken in order to address the current shortcomings of the Stage I systems. Enhancing DEEP's Stage I program may provide an opportunity to significantly reduce VOC emissions from GDFs for a reasonable cost, and bring the Stage I program up to the levels committed to in Connecticut's SIP, while offsetting any potential backsliding caused by the phasing out of Stage II systems. It may also be a cost effective risk reduction strategy that helps reduce exposure to air toxics, particularly in host communities. DEEP should evaluate the feasibility, reliability and cost effectiveness of improving its Stage I control program. At a minimum, this should involve evaluating vapor leak detection and monitoring systems, and pressure management systems.

2. SUMMARY OF GDF SURVEY

In order to collect data on the characteristics of GDFs in Connecticut, dKC contracted Eastern Research Group (ERG) to conduct a comprehensive survey. ERG designed the survey sample from GDF data obtained from the Connecticut DEEP. ERG filtered out facilities that were closed or inactive, or only handled non-gasoline materials. Two thousand and thirty-three surveys were mailed out on February 17, 2011. Of these, 23 were undeliverable.

Complete survey responses were received for a total of 851 GDFs located in Connecticut. Based on the number of delivered surveys (i.e., 2,010 surveys), the survey response rate was 43.4%. For purposes of comparison, a survey was conducted for a similar GDF sample size in Texas in 2008 and the return rate was only 27.4%.[1] The high survey response rate increases confidence that the findings of this study are applicable to GDFs across the entire state of Connecticut.

ERG designed a Microsoft Access database to house the received survey data. All survey information sent via mail, fax, or PDF format was entered into the database manually. Significant findings are shown below:

- The 96 facilities that do not have Stage II vapor control are limited to the smallest throughput classification.
- The facilities that did not identify whether or not they have Stage II vapor control are primarily limited to the smallest throughput classification (i.e., 73 out of 80 non-respondents to this question).
- Of the facilities that did identify that Stage II vapor control was present, 80% (i.e., 540 out of 675 facilities) had vacuum-assist systems, while the remaining 20% (i.e., 135 facilities) had balance systems.
- The facilities that had balance Stage II vapor control systems were concentrated primarily in the smaller throughput classifications.

The overall yearly gasoline throughput derived from the survey results was estimated to be 745,413,813 gallons, which is about half annual fuel consumption. The disaggregation of this based upon Stage II control technology is as follows:

- Vacuum-assist – 696,954,309 gallons (93.5% of total)
- Balance – 38,502,475 gallons (5.2% of total)
- Do not know – 6,966,505 gallons (0.9% of total)
- None – 2,990,523 gallons (0.4% of total)

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1 *Stage I and Stage II Gasoline Dispensing Emissions Inventory*. Prepared for the Texas Commission on Environmental Quality by Eastern Research Group, Inc. (ERG), Sacramento, CA. August 31, 2008.

Another way of interpreting the results is to note that vacuum-assist systems account for 94% of the gasoline dispensed at GDFs with Stage II systems.

The survey helps us describe the distribution of GDFs in terms of gasoline throughput. This distribution is used later in this report to evaluate the possible costs and effectiveness of enhancements to the State's Stage I and Stage II programs. We calculated two distributions of the GDFs. Results shown in Table 1 are disaggregated into five monthly facility throughput classifications that have previously been used in Stage II analyses conducted by the California Air Resources Board (CARB).[2] Results shown in Table 2 are disaggregated into 15 yearly facility throughput classifications that have previously been used in Stage I analyses conducted by the New York Department of Environmental Conservation (DEC)[3]. As shown in Tables 1 and 2, 336 out of 908 GDFs (37%) fell into the smallest gasoline throughput group, less than 300,000 gallons per year (less than 25,000 gallons per month).

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2 *Enhanced Vapor Recovery Technology Review*. Staff Report. Prepared by the California Air Resources Board, Monitoring and Laboratory Division. October 2002.

3 Stage I and Stage II Vapor Recovery Analyses. PowerPoint presentation. Prepared by the New York Department of Environmental Conservation.

Table 1 – Summary of Survey Results – CARB Facility Throughput Classifications

Group	Average Monthly Throughput by Facility (gal)	Number of Facilities	Stage II Present?			Type of Stage II System		Number of USTs					
			Yes	No	Do Not Know	Vacuum-Assist	Balanced	1	2	3	4	5	Blank
1	0-25,000	336	167	96	73	70	97	221	48	54	4	1	8
2	25,001-50,000	98	95	0	3	78	17	3	45	45	4	0	1
3	50,001-100,000	213	209	0	4	193	16	3	92	110	7	0	1
4	100,001-200,000	127	127	0	0	122	5	1	51	72	3	0	0
5	> 200,000	77	77	0	0	77	0	0	43	31	3	0	0

Table 2 – Summary of Survey Results – New York DEC Facility Throughput Classifications

Group (gal)	Yearly Throughput by Facility (gal)	Number of Facilities	Stage II Present?			Type of Stage II System		Number of USTs					
			Yes	No	Do Not Know	Vacuum-Assist	Balanced	1	2	3	4	5	Blank
A (120,000)	0-300,000	336	167	96	73	70	97	221	48	54	4	1	8
B (400,000)	300,001-500,000	71	69	0	2	55	14	3	33	30	4	0	1
C (600,000)	500,001-700,000	71	68	0	3	65	3	1	31	36	2	0	1
D (800,000)	700,001-900,000	75	75	0	0	65	10	0	33	40	2	0	0
E (1,000,000)	900,001-1,100,000	60	60	0	0	56	4	2	27	29	2	0	0
F (1,200,000)	1,100,00-1,300,000	51	49	0	2	46	3	1	21	27	2	0	0
G (1,400,000)	1,300,00 -1,500,000	31	31	0	0	29	2	0	14	16	1	0	0
H (1,600,000)	1,500,001-1,700,000	22	22	0	0	21	1	0	10	12	0	0	0
I (1,800,000)	1,700,001-1,900,000	25	25	0	0	24	1	0	9	16	0	0	0
J (2,000,000)	1,900,001-2,100,000	15	15	0	0	15	0	0	5	10	0	0	0
K (2,400,000)	2,100,001-2,700,000	36	36	0	0	36	0	0	13	22	1	0	0
L (3,000,000)	2,700,001-3,300,000	19	19	0	0	19	0	0	12	6	1	0	0
M (3,600,000)	3,300,001-3,900,000	15	15	0	0	15	0	0	11	4	0	0	0
N (4,000,000)	3,900,001-4,100,000	7	7	0	0	7	0	0	3	4	0	0	0
O (5,000,000)	>4,100,000	17	17	0	0	17	0	0	9	6	2	0	0

3. WIDESPREAD USE (WSU) ANALYSIS

WSU occurs when ORVR systems provide the same benefits as Stage II systems. dKC has determined when GDFs in Connecticut pass the WSU threshold. Appendix A presents the WSU analysis report dKC provided DEEP. Results of the WSU analysis are summarized below:

3.1 Condition of Vapor Recovery Systems

The WSU date is sensitive, and relies on the assumed effectiveness of the Stage II systems. Data from Connecticut and other states indicate that Stage II systems quickly develop leaks and other malfunctions that cause them to fail system performance tests. It's unlikely that Stage II systems have the 86% control efficiency assumed in Connecticut's State Implementation Plan (SIP). The actual Stage II control efficiency may actually be 60% or less, based on GDF inspections in Connecticut. dKC used these two estimates of Stage II effectiveness: (i.e., 86% and 60%). Corrected for rule penetration and rule effectiveness, this translates into an overall Stage II effectiveness of 82% and 57%.

- **Connecticut Test Results –** dKC reviewed two sources of information on the condition of GDFs in Connecticut: results of official certification tests and results of additional GDF tests performed by dKC.
    - Table 3 summarizes the initial results of GDF inspections that were witnessed by DEEP since December 20, 2010. Overall, 70% of the GDFs failed inspection. The most sources of failure were the tank decay test (45%), followed by air/liquid (A/L) test (14%).
    - dKC commissioned additional GDF tests to help determine when key components of the vapor control system start to deteriorate. These tests were performed approximately two months and four months after the station received its certification test. Two stations participated: one is a government station with a balance system and the other is a private station with a vacuum-assist system. Table 4 summarizes the results of these tests. None of the tests had an overall result of pass.

Table 3 – Results of Triennial GDF Inspections in Connecticut

Parameter	Number and Percent of Failures						
	Fail for Any Item	Decay	Dry Blockage	Wet Blockage	P/V Cap	A/L	6 Click
Number	111	72	5	6	10	23	13
Percent of Tests	70	45	3	4	6	14	8

Table 4 – Results of Bi-monthly GDF Testing Study in Connecticut

Station/Stage II Type	Test Date	Overall Result	Failed Items
J and A Gas/ Vacuum-Assist	6/2/11	Fail	A/L Test
	8/23/11	Fail	A/L Test
DOT Newington/ Balance	4/25/11	Fail	P/V valve
	7/14/11	Fail	Decay, P/V valve, torn hose
	11/9/11	Fail	Decay, P/V valve

- **Massachusetts Test Results –** Massachusetts DEP requires GDFs to report the initial results of their annual Stage II Certification tests. Table 5 summarizes the percent of stations that failed their initial Stage II test in Massachusetts. Facilities that fail the initial tests are required to repair and retest with passing results before submitting an annual certification form. As shown, from 2001 through 2010, 66% to 82% of the GDFs failed the initial annual certification tests. The primary test failures were pressure decay and A/L. Pressure decay tests failed mostly because of leaking hanging hardware components or leaking tank top components. The A/L tests failed mostly because of broken or improperly calibrated dispenser vacuum motors or defective nozzles.
    - Massachusetts required new GDFs with vacuum-assist Stage II systems or significantly modified GDFs with vacuum-assist systems to receive a certification test 120 days after their initial certification. Massachusetts gathered Stage II "120 day" test reports from the Stage II testing companies for the period of May 2002 through October 2003 and the results of these tests are shown on Table 6. Results indicate that over half (56%) of the recently certified GDFs failed certification tests 120 days later. The most common failure was for the pressure decay test.

Table 5 – Results of Initial Annual GDF Certification Tests in Massachusetts

Year	% Fail
2001	82
2002	78
2003	75
2004	67
2005	76
2006	78
2007	78
2008	73
2009	71
2010	66

Table 6 – Results of 120 Day GDF Certification Tests in Massachusetts

Failure Reason	Number	% Fail
Air/Liquid Ratio	17	17
Pressure Decay	45	46
P/V Cap	2	2
Any Failure	55	56

- **New Hampshire Test Results –** According to vapor release research conducted by New Hampshire, Stage II repairs last an average of 58 days. Overall, New Hampshire's research found:
    - Inspections and testing failed to fix key leaks.
    - Most leaks required the station to upgrade the hardware (i.e. hoses, nozzles, breakaways).
    - Gasoline deliveries triggered leaks.

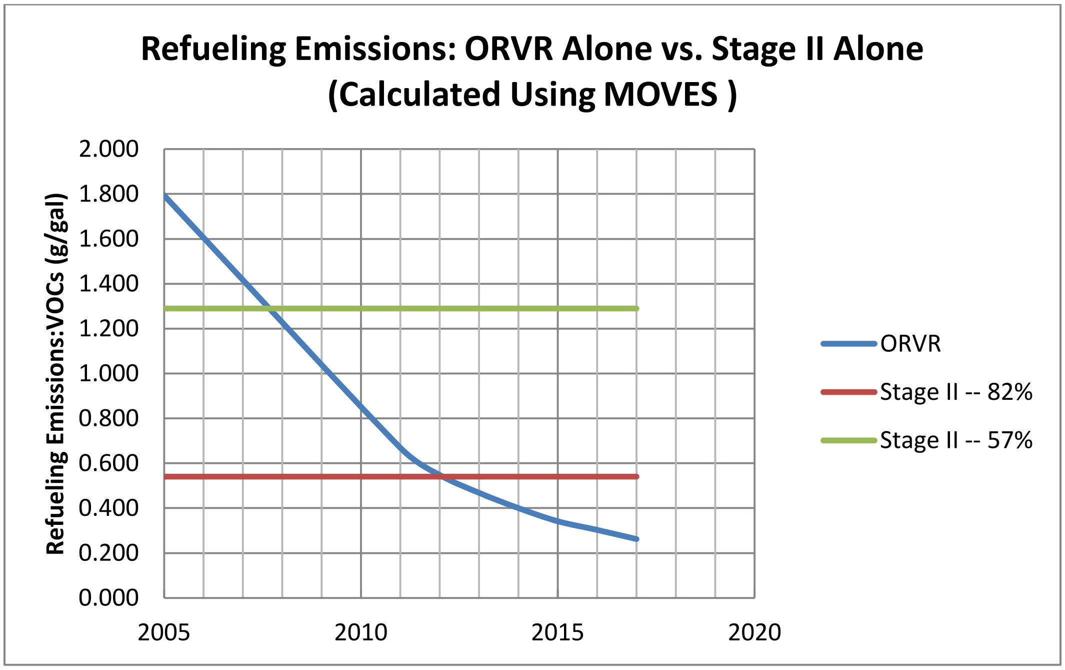
3.2 EPA's WSU Determination

Effective May 16, 2012, EPA published a Final Rule on WSU determination for ORVR systems. The rule considers that Stage II and ORVR emission control systems are redundant, and the EPA has determined that emission reductions from ORVR are essentially equal to and will soon surpass the emission reductions achieved by Stage II alone; however, since there are older vehicles that remain on the road, and the emissions generated by refueling these vehicles benefit from Stage II systems, the gap fill must be calculated and offset to prevent backsliding. In the absence of state specific analysis, EPA has set a WSU date as of the issuance of its final ruling.

dKC used EPA's current emission factor model, MOVES, to determine a state specific analysis of WSU dates for Connecticut. The following are estimates, based on MOVES, of when emissions with Stage II systems alone will equal emissions using ORVR alone:

- 82% Stage II efficiency: July 2012
- 57% Stage II efficiency: 2007-2008
- Figure 1 shows gram per gallon emission estimates for ORVR alone by model year vs. Stage II alone. WSU occurs when VOC emissions for ORVR alone drop below the Stage II lines.

Figure 1



3.3 Implications of EPA's WSU Rule

EPA's WSU rule has implications for this analysis and future strategies for controlling emissions at GDFs in Connecticut:

- **Stage II Effectiveness:** EPA lists the effectiveness of Stage II as follows:
    - **Semi-annual inspections:** 92%
    - **Annual inspections:** 86%
    - **Minimal or less frequent inspections:** 62%

  EPA assumes that 90% of gasoline is dispensed at GDFs with Stage II systems. ERG's GDF survey determined that, in Connecticut, 99% of gasoline is dispensed at GDFs with Stage II systems. Based on GDF tests in Connecticut, Massachusetts, and New Hampshire, Stage II effectiveness is likely to be lower than EPA's estimates.

- **ORVR/Stage II Incompatibility:** The EPA rule acknowledges the incompatibility between ORVR and vacuum-assist Stage II systems, noting that it reduces the effectiveness of Stage II by 1-10%. Incompatibility was not considered in the WSU determination, but EPA did mention that states should require Stage II system upgrades for ORVR compatibility if they opt to continue the Stage II program. Emissions resulting from the incompatibility between ORVR and vacuum-assist Stage II systems are termed incompatibility excess emissions (IEE). Published IEE rates vary from a low of 0.42 lbs/1000 gal to a high of 1.5 lbs/1000 gal. dKC used 0.86 lbs (California's estimate) in its IEE calculations.

- **Backsliding:** The EPA rule says that ozone non-attainment areas must make up for any emission reductions that are lost due to terminating Stage II programs. The rule does not specifically state how IEE can be factored into calculations of lost emissions reductions. If IEE is considered, continuing the current Stage II program without ORVR compatibility provides minimal benefits and, in fact, may increase emissions in the future. Accounting for IEE, Connecticut must make up 0.48 tons per day VOCs in 2013. By 2015, emissions increase if Stage II is continued due to IEE. Without considering IEE, Connecticut must make up 1.8 tons per day in 2013 and 1.3 tons per day in 2015. IEE is discussed in greater detail below.
- **Stage I Improvements:** EPA has stated that states can make up for the shortfall by improving Stage I systems, even if these improvements only bring the system up to assumed SIP effectiveness.

4. POSSIBLE STAGE II ENHANCEMENTS

If DEEP decides to continue the Stage II program it should consider the following enhancements:

4.1 End ORVR Incompatibility

Currently, vacuum-assist Stage II systems in Connecticut are not compatible with ORVR. When a vehicle with ORVR is refueled at a GDF with a vacuum-assist system, ambient air from the vicinity of the GDF nozzle will be drawn back into the GDF storage tank. This air dilutes the concentration of gasoline vapors in the headspace of the storage tank, causing some of the liquid gasoline in the storage tank to evaporate, which increases the storage tank pressure. If the tank pressure increases above the positive setting of the P/V valve, the storage tank will vent to the atmosphere. As mentioned earlier, the increased emissions that occur due to dilution of the storage tank with air from ORVR vehicles is termed incompatibility excess emissions (IEE). IEE is limited to vacuum-assist systems. Balance systems are generally compatible with ORVR systems. Almost all (94%) of the gasoline dispensed in Connecticut is dispensed at GDFs with vacuum-assist systems.

IEE can be mitigated or eliminated by the following measures:

a. Install nozzles that sense ORVR vehicles,

b. Add devices called processors to capture or incinerate vapors at the vent, or

c. Convert to balance type systems.

4.2 Other Possible Stage II Enhancements

In addition to addressing IEE with vacuum-assist systems, other enhancements could be made to Stage II systems. These enhancements have been included in California's Enhanced Vapor Recovery (CA EVR) program, and are listed below:

- CA EVR Module 2 – General Stage II improvements and tightened performance standards. The Stage II improvements outlined in Module 2 aim to reduce fugitive emissions by establishing GDF tank pressure limits. The tightened performance standards require including fugitive emissions in system efficiency calculations.

- CA EVR Module 6 – In-Station Diagnostics (ISD): ISD require GDFs to install systems that monitor tank pressure and A/L, and set alarms when there are problems that could lead to excessive emissions. ISD is similar in concept to onboard diagnostic (OBD) systems that have been on vehicles since 1998. A lot of concerns have been raised by industry over the reliability of ISD with regard to monitoring A/L. Monitoring GDFs for the presence of vapor leaks appears to be reliable. Data from Veeder-Root, which installs ISD systems in California, indicate that A/L alarms occur much more frequently than alarms for GDF vapor leaks. The effectiveness of alarms for vapor leaks (and A/L) has not been conclusively demonstrated in areas with winter weather similar to Connecticut's.

4.3 Gasoline Dispensing Improvements

The CA EVR program includes two modules that are theoretically applicable to GDFs with and without Stage II systems:

- CA EVR Module 4 – Liquid Retention and Spitting: This module aims to reduce emissions associated with liquid retention and spitting. Liquid detention occurs when liquid gasoline contained in the hanging hardware (nozzles, hoses, etc.) on the dispenser is allowed to evaporate into the atmosphere between vehicle refuelings, while the nozzle is hung on the dispenser. Nozzle spitting is defined as the release of liquid when the nozzle trigger is depressed with the dispenser not actuated.
- CA EVR Module 5 – Dripless Nozzles: This module aims to reduce dripping from the nozzle after it dispenses fuel.

Based on discussions with CARB, manufacturers expect to have systems that meet requirements for Modules 4 and 5 this year.

Appendix B summarizes the CA EVR program.

5. POSSIBLE STAGE I ENHANCEMENTS

DEEP's Stage I control program may be improved by implementing measures that go beyond current Stage I requirements:

5.1 Add Vapor Leak Monitoring System

Continuous monitoring of GDF tank pressure and other parameters that indicate the presence of vapor leaks has the potential for significant emissions reductions. Based on GDF inspections, actual Stage I control efficiencies are much lower than the 96% control efficiency assumed in the SIP. In addition, the control efficiencies for breathing losses assumed for Pressure Vacuum (P/V) valves are likely to be lower than the 90% control efficiency assumed in the SIP. This measure could reduce State oversight costs if it were coupled with self-certification of compliance. Requiring these systems also will help assure the State that any leaks resulting from removing or capping Stage II systems will be promptly identified and repaired, should the State decide to terminate the Stage II program.

These systems have not been used on GDFs outside of California, so there is some uncertainty about how well they will work on GDFs in Connecticut's harsher climate.

5.2 Add Pressure Management System (Emissions Processors)

Managing the pressure with a vapor processor reduces breathing losses and maintains the tank pressure close to ambient to avoid fugitive and vent cap emissions. Several vendors offer tank pressure control systems that minimize venting losses.

5.3 Additional Enhancements

In addition to the above options, the CA EVR program outlines additional Stage I improvements in Module 1. GDFs in Connecticut have most of these improvements. The following are additional enhancements included in CA EVR Module 1 that could be made to Connecticut's Stage I program:

- **Spill Containment Boxes –** California requires spill containment boxes to meet leak rate limits and prohibit standing fuel. Vendors have developed double-wall spill containers that meet CA EVR requirements.
- **Drop Tube with Overfill Protection Specification –** California requires drop tubes to be equipped with devices that shut off liquid flow when the underground storage tank is being filled. These drop tubes also must meet leak rate specifications.

6. POTENTIAL EMISSION REDUCTIONS FOR STAGE I AND STAGE II SYSTEM IMPROVEMENTS

6.1 Gasoline Consumption

- Emissions and emission reductions are proportional to gasoline consumption
- Statewide consumption is based on Department of Revenue reports.

Table 7 – Statewide Gasoline Consumption (2010)

MONTH	GALLONS CONSUMED
JAN	119,417,253
FEB	109,313,343
MAR	124,366,769
APR	124,549,371
MAY	132,812,176
JUN	129,606,224
JUL	134,879,449
AUG	130,328,001
SEP	125,097,789
OCT	130,473,564
NOV	124,071,272
DEC	129,706,355
TOTAL	**1,514,621,566**

6.2 Current Stage II program

- dKC estimated emissions reductions for:
  - Continuing the current Stage II program
  - Decommissioning the current Stage II program, with ORVR solely providing vapor recovery.
- Note on Figure 2 that continuing Stage II (without ORVR compatible nozzles) increases emissions after 2015 due to IEE.

Figure 2

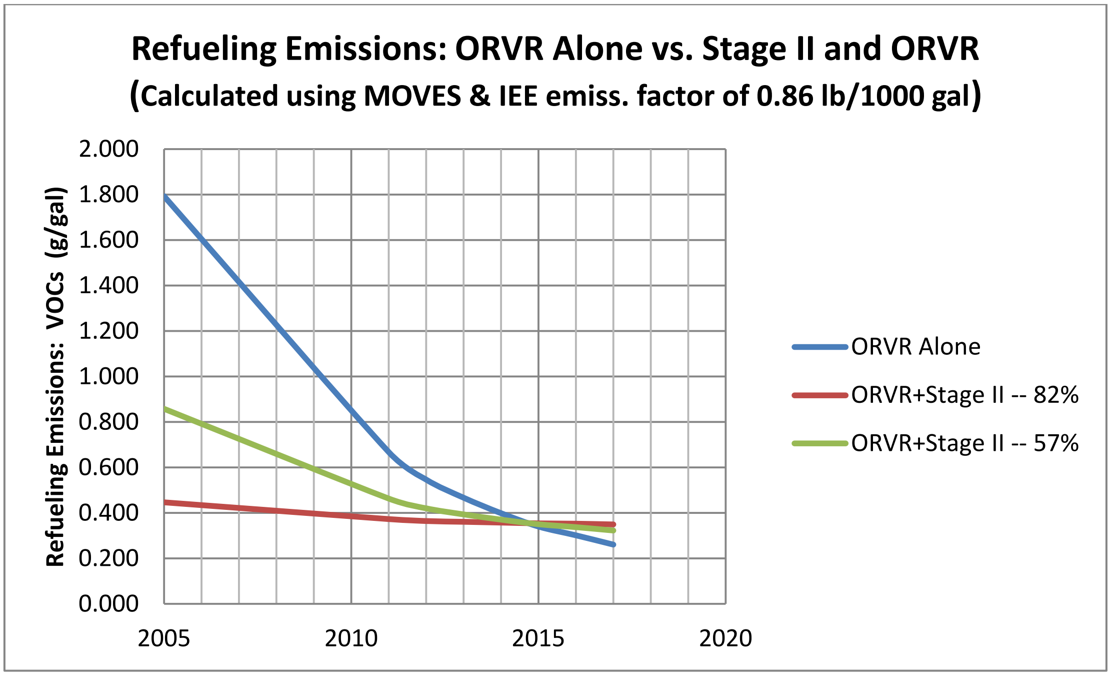


Table 8 – VOC Emission Reductions (tons/day) for Continuing Current Stage II Controls (Negative values mean that keeping current systems increases emissions due to IEE[4])

Year	ORVR only	Additional Reductions with Stage II	
		82% Control Efficiency	57% Control Efficiency
2012	11.194	0.833	0.579
2013	11.558	0.485	0.337
2014	11.869	0.189	0.131
2015	12.137	-0.063	-0.044
2016	12.313	-0.233	-0.162
2017	12.500	-0.405	-0.281

[4] IEE: Incompatibility Excess Emissions (California's estimated value of 0.86 lb/1000 gal)

6.3 Making All Stage II Systems in CT ORVR Compatible

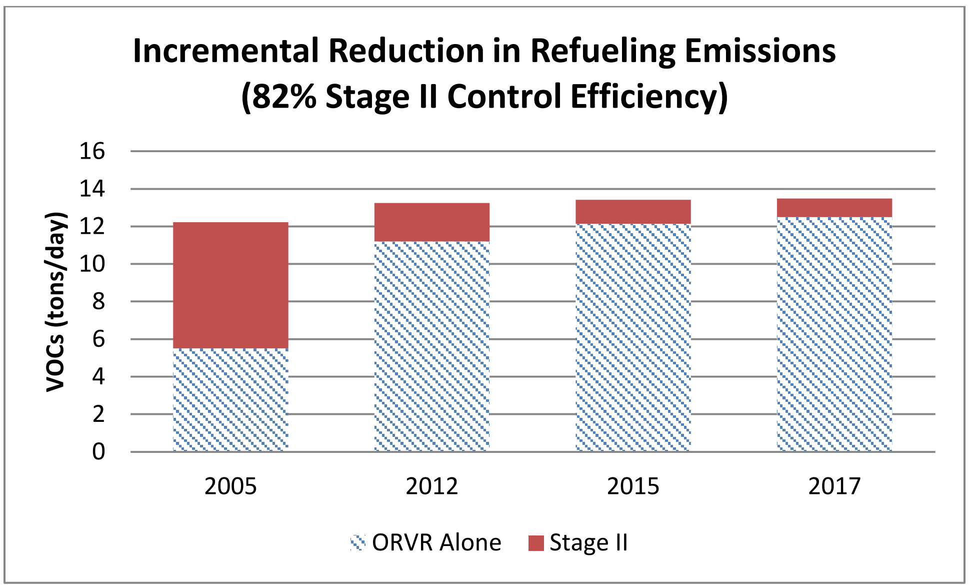
Two Stage II control scenarios were evaluated:

- **Upgrading nozzles in the current program to be ORVR compatible.** With this option, the current program will remain with the additional requirement that stations must upgrade to ORVR compatible nozzles.
  - This option eliminates IEE.
  - Control efficiencies are based on current program data.
  - Two efficiencies were modeled: 82% and 57%.

Emission estimates were calculated by multiplying gram per gallon estimates without Stage II (derived from MOVES) times annual gasoline consumption times estimated control efficiency.

- By 2015, ORVR compatible Stage II systems have minimal benefits, as shown in Figure 3.

Figure 3



- **Add CA EVR elements that pertain to Stage II, including ORVR compatibility and in-station diagnostics (ISD).**
  - This option eliminates IEE.
  - Control efficiency based on CA EVR corrected for rule effectiveness.
  - 90% control efficiency was modeled.
  - This option gets slightly greater emission reductions than adding ORVR compatibility to the current Stage II program, as shown on Table 9 below.

Table 9 – Emission Reductions from Enhancing Stage II Systems to Add ORVR Compatibility and Other Enhancements (tons/day)

Year	ORVR Alone	Stage II Efficiency (increase over ORVR alone)		
		90% (CA EVR)	82%	57%
2012	11.194	2.252	2.052	1.426
2013	11.558	1.924	1.753	1.219
2014	11.869	1.644	1.498	1.041
2015	12.137	1.403	1.279	0.889
2016	12.313	1.245	1.134	0.788
2017	12.500	1.077	0.981	0.682

6.4 Stage I Improvements

- **Continuous monitoring for GDF vapor leaks** – The emission reductions from real-time monitoring for vapor leaks were estimated as follows:
  - **Reduction in Tank Filling Losses –** To estimate the reduction in tank filling losses, the estimated improvement in Stage I efficiency was applied to emission estimates for GDF tank filling losses. Assumptions are shown in Table 10. No data has been identified on the improvement in Stage I efficiency from eliminating leaks; 10% is assumed. As previously mentioned, GDF tanks quickly develop leaks that impact vapor containment, and increase filling losses.

Table 10 – Assumptions for Determining Reductions in Tank Filling Losses for Continuous Monitoring for Vapor Leaks

Parameter	Value
Uncontrolled Tank Filling losses (g/gal)	3.314
Stage I Efficiency Improvement (%)	10

  - **Reduction in Breathing Losses –** The reduction in breathing losses from continuously monitoring GDF tanks for vapor leaks was estimated by adjusting the benefit for P/V valves that is assumed in Connecticut's SIP by the fraction of GDFs that are expected to have uncontrolled breathing losses because they have tank vapor leaks. Based on guidance from EPA[5] in 2008, uncontrolled breathing losses are 1lb/1000 gal of gasoline dispensed. Connecticut's SIP assumes that P/V valves reduce breathing losses by 90%. The fraction of GDFs that are expected to have uncontrolled breathing losses because they have tank vapor leaks is assumed to equal the fraction that failed their periodic certification test for pressure decay and/or P/V valve. Based upon the inspections of GDFs in Connecticut that are witnessed by DEEP, 45% of the GDFs fail the pressure decay test and an additional 6% fail the P/V valve test. Assuming that continuous vapor leak monitoring systems prevent these leaks, they are expected to reduce

[5] AP42 -- Transportation And Marketing Of Petroleum Liquids – USEPA, 6/2008

breathing losses by 0.46 lbs/1000 gal. Assumptions are summarized in Table 11. Calculated benefits are shown in Table 12.

Table 11 – Assumptions for Determining Reductions in Breathing Losses for Real Time Monitoring of Tank Pressure

Parameter	Value
Breathing losses –EPA emission factor	1.0 lbs VOCs/1000 gal
P/V Effectiveness	90%
Fraction of GDFs with vapor leaks	51%
Benefit for continuous vapor leak monitoring systems	0.46 lbs VOCs/1000 gal

Table 12 – Breathing Loss Reductions for Continuous Monitoring for Vapor Leaks (EPA Emission Factor of 1.0 lbs VOCs/1000 gal)

Yearly Throughput Intervals	Number of gas stations	Gasoline Dispensed (gal/yr)	Estimated Benefit (tons/yr)
<300,000	803	42,046,727	9.65
300,000-500,000	170	57,352,380	13.16
500,000-700,000	170	88,851,668	20.39
700,000-900,000	179	122,804,840	28.18
900,000-1,100,000	143	122,319,593	28.07
1,100,000-1,300,000	122	122,447,946	28.10
1,300,000-1,500,000	74	87,092,836	19.99
1,500,000-1,700,000	53	72,108,116	16.55
1,700,000-1,900,000	60	90,859,668	20.85
1,900,000-2,100,000	36	61,102,131	14.02
2,100,000-2,700,000	86	174,333,304	40.01
2,700,000-3,300,000	45	114,832,693	26.35
3,300,000-3,900,000	36	108,866,784	24.98
3,900,000-4,100,000	17	56,848,291	13.05
>4,100,000	41	192,754,588	44.24
TOTAL	**2,033**	**1,514,621,566**	**348**

About 40% of the GDFs dispense less than 300,000 gallons per year. As shown in Table 13, exempting the GDFs from these requirements reduces estimated benefits by about 3%.

Table 13 – Statewide Emission Reductions for Continuous Monitoring for Vapor Leaks (tons/day)

Pollution Source	All GDFs	GDFs with >300,000 gal/yr
Filling losses	1.51	1.47
Tank Breathing	0.95	0.93
Total	2.47	2.40

- **Alternative estimates of the reduction in breathing losses from continuous vapor leak monitoring systems** – Veeder-Root, a vendor of continuous vapor leak monitoring systems, and representatives of the oil industry have provided alternative estimates of the reduction in breathing losses from continuous vapor leak monitoring systems.
    - **Veeder-Root** – Table 14 presents Veeder-Root's estimates of the impact of continuous vapor leak monitoring systems on breathing losses. Using emission factors provided by Veeder-Root, the benefits are calculated to be 441 tons per year vs. 348 tons per year when the estimate is based on EPA's emission factors and the percentage of GDFs with vapor leaks. Veeder-Root predicts greater reductions in breathing losses for the smaller stations in terms of lbs/1000 gal.

Table 14 – Veeder-Root Estimates of Breathing Loss Reductions for Continuous Monitoring for Vapor Leaks

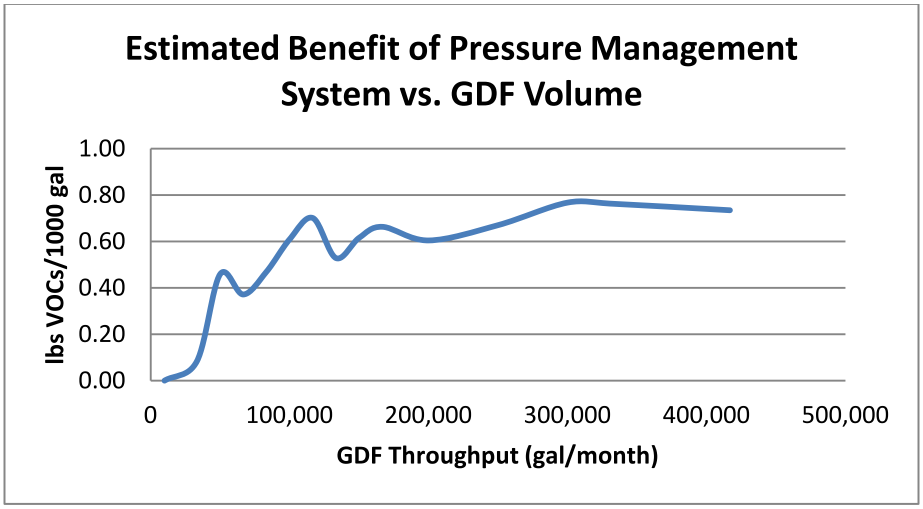
Yearly Throughput Intervals	Number of gas stations	Emissions (lbs/1000 gal)	Gasoline Dispensed (gal/yr)	Estimated Benefit (tons/yr)
<300,000	803	2.22	42,046,727	46.7
300,000-500,000	170	1.06	57,352,380	30.5
500,000-700,000	170	0.65	88,851,668	29.0
700,000-900,000	179	0.76	122,804,840	46.7
900,000-1,100,000	143	0.67	122,319,593	40.8
1,100,000-1,300,000	122	0.55	122,447,946	33.6
1,300,000-1,500,000	74	0.45	87,092,836	19.7
1,500,000-1,700,000	53	0.60	72,108,116	21.7
1,700,000-1,900,000	60	0.53	90,859,668	24.1
1,900,000-2,100,000	36	0.47	61,102,131	14.5
2,100,000-2,700,000	86	0.54	174,333,304	47.4
2,700,000-3,300,000	45	0.48	114,832,693	27.5
3,300,000-3,900,000	36	0.38	108,866,784	20.8
3,900,000-4,100,000	17	0.38	56,848,291	10.8
>4,100,000	41	0.29	192,754,588	27.7
TOTAL	**2,033**	**0.58**	**1,514,621,566**	**441**

-
    - **Connecticut Petroleum Council (CPC)** – The CPC suggested that the emissions factor for uncontrolled breathing losses be

reduced to 0.76 lbs/1000 gal to reflect reduced gasoline volatility during the summer months. EPA's recommended emission factor of 1.0 lb/1000 gal is based on tests performed in the 1960s, when the RVP[6] was higher than now. CPC also suggested that a lower emission factor be used for high volume GDFs, since the high volume limits vapor growth. CPC did not offer revised estimates of the emission benefits of continuous vapor leak monitoring systems. The cost-effectiveness calculations for continuous vapor leak monitoring systems use two breathing loss emission factors: 0.76 and 1.0 lb/1000 gal.

- **Require pressure management system (emissions processors) –** EPA has not prepared estimates of the benefits for requiring pressure management systems, so dKC based benefit estimates on information provided by vendors of these systems. Two vendors provided estimates: Veeder-Root and ARID Technologies.
    - **Veeder-Root –** Based on information from Veeder-Root, GDFs will have breathing losses corresponding to the amount of air ingested in the tank and the evaporation rate.
        - Based on in-house tests, estimated benefits from requiring pressure management systems are greatest in stations that dispense a lot of gasoline, where benefits are around 0.7 lbs/1000 gal (see Figure 4 and Table 15).
        - Exempting stations that dispense less than 1,100,000 gallons per year will reduce benefits from 1.2 to 1.0 tons per day (See Table 16).

Figure 4



[6] Fuel volatility and accordingly the potential to emit is based on Reid Vapor Pressure (RVP).

Table 15 – Veeder-Root Estimates of the Emission Benefits for Pressure Management Systems

Yearly Throughput Intervals (gal)	Number of Gas Stations	VOC Emissions (lbs /1000 gal)	Gasoline Dispensed (gal/yr)	Estimated Benefit (tons/yr)
<300,000	803	0.00	42,046,727	0
300,000-500,000	170	0.08	57,352,380	2
500,000-700,000	170	0.46	88,851,668	20
700,000-900,000	179	0.37	122,804,840	23
900,000-1,100,000	143	0.47	122,319,593	29
1,100,000-1,300,000	122	0.61	122,447,946	37
1,300,000-1,500,000	74	0.70	87,092,836	31
1,500,000-1,700,000	53	0.53	72,108,116	19
1,700,000-1,900,000	60	0.62	90,859,668	28
1,900,000-2,100,000	36	0.66	61,102,131	20
2,100,000-2,700,000	86	0.60	174,333,304	53
2,700,000-3,300,000	45	0.67	114,832,693	39
3,300,000-3,900,000	36	0.77	108,866,784	42
3,900,000-4,100,000	17	0.76	56,848,291	22
>4,100,000	41	0.73	192,754,588	71
TOTAL	**2,033**	0.57	**1,514,621,566**	435

Table 16 – Breathing Loss Reductions for Pressure Management Controls Based on Data from Veeder-Root

Scenario	tons/day
All GDFs	1.2
GDFs with throughput >1,100,000 gal/yr	1.0

- **ARID Technologies –** ARID Technologies (ARID) provided estimates of the benefits of its Permeator system on GDFs with and without Stage II systems. ARID did not break-out breathing loss reductions (fugitive losses) from reductions in venting emissions through the tank vent. In addition, ARID assumed that GDFs without Stage II have the same breathing and venting losses as stations with Stage II. Also, ARID assumed that GDFs did not have P/V valves. ARID projects a benefit between 3.3 and 3.6 lbs/1000 gal.
- dKC believes that additional research must be performed to better evaluate pressure management control systems options.

- **Other Stage I Enhancements –** Data was not available on the emission reductions from CA EVR requirements for spill containment boxes and specifications to reduce leaks in drop tubes with overfill protection devices installed. These measures are likely to reduce tank leaks that would be identified by continuous vapor leak monitoring systems, so they are unlikely to result in significant additional benefits over vapor leak monitoring systems. This does not mean these measures do not have merit. GDFs could install

CA EVR approved drop tubes and spill containment devices to reduce incidents of vapor leak monitoring alarms.

6.5 Impact on Air Toxics

The primary air toxic of concern with GDF operations is benzene. dKC used MOVES to estimate benzene emissions in vehicle refueling vapors. According to MOVES, benzene is 0.54% (mass percent) of refueling vapor. Reducing or increasing gasoline vapor emissions will have a proportional impact on benzene emissions.

7. IMPLEMENTATION AND OPERATING COSTS FOR CONTROL ALTERNATIVES

7.1 Current Costs

- **Costs to Continue Stage II Systems**
  - Annual cost for continuing Stage II are based on the following sources:
    - New York State: $2,000 per GDF
    - API: $4,410 per GDF
    - EPA: $3,277 per GDF

Table 17 -- Annual Costs to GDFs for Continuing Current Stage II Program

	Low: New York State[7]	High: API[8]	EPA[9]
Annual Stage II Cost/Station	$2,000	$4,410	$3,277
Total Annual Stage II Cost	$3,559,728	$7,849,343	$5,832,614

7.2 Cost to Make All Stage II Systems in Connecticut ORVR Compatible

Costs to make Stage II systems compatible with ORVR systems are based on EPA's estimate to continue Stage II plus OPW's (equipment vendor) estimates to upgrade the nozzles in stations with vacuum-assist systems. Costs are detailed below:

- OPW's cost quotes were used as the basis of the costs for upgrading equipment to be compatible with ORVR systems. Upgrade costs are estimated to be $2,000 to $14,000 per GDF[10]. Annualized costs assume three years of life for the nozzles and 10% interest.
- Costs to continue the program with ORVR compatibility are based on EPA's cost estimate for continuing the current program plus the cost for ORVR upgrades based on OPW's cost quotes.

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[7] **Part 230 -- Gasoline Dispensing Sites and Transport Vehicles, Stakeholder Meeting;** New York Department of Environmental Protection, December 7, 2010.

[8] **REFUELING EMISSION CONTROLS AT RETAIL GASOLINE DISPENSING STATIONS AND COST-BENEFIT ANALYSIS OF STAGE II IN CONNECTICUT;** Tech Environmental, Inc., September 24, 2007

[9] **Widespread Use for Onboard Refueling Vapor Recovery and Stage II Waiver;** USEPA, July 8, 2011.

[10] **Personal Communication between Rob Klausmeier, dKC and Jeff Steel, OPW,** August 8, 2011

Table 18 – Annual Costs for ORVR Compatible Stage II Systems

Cost Component	Annual Cost
Cost for Continuing Current Program (EPA estimate; not including DEEP oversight)	$5,832,614
ORVR Upgrade (source OPW)	$3,797,338
Total	$9,629,951

7.3 Costs for Enhanced Stage II Systems: ORVR Compatibility plus CA EVR Enhancements

The CA EVR spreadsheet[11] was used as the basis for the costs of a higher efficiency program that includes all the CA EVR Stage II upgrades. Costs were calculated as follows:

- CA EVR costs per GDF were summed for the modules that affected Stage II (i.e., Modules 2, 3, and 6).
- Balance 1 and Assist 1 costs applied to Balance and Assist Stage II systems in Connecticut.
- California's costs per GDF in different monthly throughput categories were multiplied times the projected number of GDFs in Connecticut in these categories to estimate total costs.
- Costs were increased by 33% to account for inflation since 2001, when the CA EVR spreadsheet was last updated.

Table 19 – Fixed Costs per GDF for Enhanced Stage II Systems

(Source: CA EVR Spreadsheet)

Group	Average Monthly Throughput by Facility (gal)	Vacuum-Assist	Balance
1	0-25,000	$22,678	$23,360
2	25,001-50,000	$24,056	$25,086
3	50,001-100,000	$29,305	$31,365
4	100,001-200,000	$34,549	$37,638
5	> 200,000	$39,549	$41,783

[11] **EVR Cost Analysis Spreadsheet;** California Air Resources Board, October 16, 2002. Results adjusted for inflation using Marshall and Swift Equipment Cost Index.

Table 20 – Total Annual Costs to CT GDFs for Enhanced Stage II Systems (Source: CA EVR Spreadsheet)

Group	Average Monthly Throughput by Facility (gal)	Total Annual Cost
1	0-25,000	$2,844,983
2	25,001-50,000	$1,723,774
3	50,001-100,000	$5,028,657
4	100,001-200,000	$3,820,741
5	> 200,000	$2,885,281
	TOTAL	**$16,303,440**

7.4 Costs for Improving DEEP's Stage I Control Program by Implementing Measures that go Beyond Current Stage I Requirements

- **Requiring continuous monitoring for GDF vapor leaks**

  Three sources were used to define the costs for real-time monitoring for GDF vapor leaks:

  - Veeder-Root: Supporting data provided for proposed New York Part 230 Regulation[12].
  - Franklin Fueling Systems: Cost estimates for the vapor leak monitoring portion of its California In-station Diagnostic (ISD) system[13].
  - CA EVR spreadsheet: Costs for the vapor leak monitoring portion of the CA EVR program.

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Table 21 -- Fixed Costs for Continuous Monitoring for Vapor Leaks

Source	Fixed Cost
Veeder-Root	$6,000 (includes $1000 for installation)
Franklin Fuel Systems	$5,000 (includes $1000 for installation)
CA EVR Spreadsheet	$6,105 (includes installation)

dKC used the Veeder-Root costs as the basis for the cost-effectiveness analysis. Annual costs are shown in Table 22. As discussed above, exempting GDFs that dispense less than 300,000 gallons per year reduces emission reductions of this measure by 3%. Exempting these GDFs reduces costs for this measure by 39%.

[12] **Personal Communication between Rob Klausmeier, dKC and Kristine Anderson, Veeder Root, Vapor Emissions Workbook,** November 8, 2011

[13] **Personal Communication between Rob Klausmeier, dKC and Dan Marston, Franklin Fuel Systems,** February 29, 2011

Table 22 – Annual Costs for Continuous Monitoring for Vapor Leaks

Parameter	Annualized Equip Costs	Fuel Savings	Net Cost
Annual cost per GDF (Based on Veeder-Root)[14]	$1,476		
Costs for installing at all GDFs	$3,001,668	$1,186,745	$1,814,923
Costs for installing at GDFs with throughput >300,000 gal/yr	$1,816,521	$1,153,800	$662,721

- **Requiring GDF Tank Pressure Control Systems**

  Costs for requiring GDFs to be equipped with tank pressure control systems are based on estimates prepared by Veeder-Root for New York State DEC. Total costs are reduced 72% by exempting stations that dispense less than 1,100,000 gallons per year. This exemption reduces emission benefits by 16%.

Table 23 -- Fixed Costs for GDF Tank Pressure Control Systems

Parameter	Costs
Fixed cost per GDF	$12,250
Costs for installing at all GDFs	$24,904,250
Costs for installing at GDFs with throughput >1,100,000 gal/yr	$6,964,996

Table 24 – Annual Costs for GDF Tank Pressure Control Systems

Parameter	Annualized Equip Costs	Fuel Savings	Net Cost
Annual cost per GDF (based on Veeder-Root)[15]	$3,219		
Costs for installing at all GDFs	$6,543,477	$573,374	$5,970,103
Costs for installing at GDFs with throughput >1,100,000 gal/yr	$1,830,021	$475,408	$1,354,613

8. COST PER TON OF POLLUTANT REDUCTIONS FOR CONTROL ALTERNATIVES

8.1 Making Current Stage II Systems in Connecticut ORVR Compatible

Table 25 shows the calculation of the emission reductions from improving Stage II systems to make them ORVR compatible. Emission estimates were calculated by multiplying gram per gallon estimates without Stage II (derived from MOVES) times annual gasoline consumption times estimated control efficiency. Two Stage II control efficiencies were modeled: 82% and 57%. Regardless of the assumed control

[14] $6,000 times 0.1627 (capital recovery factor assuming 10% interest and 10 year life) plus 10% (annual maintenance factor) times $5,000.

[15] $12,250 times 0.1627 (capital recovery factor assuming 10% interest and 10 year life) plus 10% (annual maintenance factor) times $12,250.

efficiency, by 2015 this option is expensive and results in relatively few emission reductions.

Table 25 – Cost Effectiveness of Improving Stage II Systems to Make Them Compatible with ORVR Systems

Year	g/gal without Stage II (MOVES)	Annual Cost (2011$) (includes DEEP oversight)	Reduction (tons/yr)		Fuel Savings ($/yr)		$/ton	
			82%	57%	82%	57%	82%	57%
2011	0.669	$10,448,781	914	636	$1,205,203	$837,763	$10,108	$15,120
2012	0.547	$10,448,781	749	521	$986,968	$686,063	$12,635	$18,755
2013	0.468	$10,448,781	640	445	$843,418	$586,278	$15,010	$22,171
2014	0.400	$10,448,781	547	380	$720,661	$500,948	$17,791	$26,172
2015	0.341	$10,448,781	467	324	$615,095	$427,566	$21,071	$30,890
2016	0.303	$10,448,781	414	288	$545,486	$379,179	$23,928	$35,000
2017	0.262	$10,448,781	358	249	$471,845	$327,990	$27,868	$40,668

8.2 Enhanced Stage II Systems: ORVR Compatibility plus CA EVR

dKC assumes that Stage II, with all the CA EVR enhancements, has a 90% control efficiency. This option results in slightly greater emission reductions than those gained by only making Stage II systems compatible with ORVR systems, and is more costly in terms of dollars per ton.

Table 26 – Cost Effectiveness of Implementing CA EVR Enhancements Including ORVR Compatibility – 90% Overall Control Efficiency

Year	g/gal	Annual Cost (2011$) (includes DEEP oversight)	Reduction (tons/yr)	Fuel Savings ($/yr)	$/ton
2011	0.669	$17,122,269	1,004	$1,322,784	$15,742
2012	0.547	$17,122,269	822	$1,083,258	$19,514
2013	0.468	$17,122,269	702	$925,702	$23,060
2014	0.400	$17,122,269	600	$790,970	$27,212
2015	0.341	$17,122,269	512	$675,104	$32,109
2016	0.303	$17,122,269	454	$598,704	$36,374
2017	0.262	$17,122,269	393	$517,879	$42,257

8.3 Enhance Stage I: Requiring Real-time Monitoring of GDFs for Vapor Leaks

The calculation of the cost-effectiveness of real-time monitoring for vapor leaks is shown in Table 27. Cost effectiveness and emission reductions are shown graphically in Figure 5. Exempting GDFs that dispense less than 300,000 gallons per year reduces cost per ton from $2,016 to $757.

As mentioned above, dKC did not have access to data on the reduction in filling losses from real-time monitoring for vapor leaks. Emission reductions assume a 10% reduction in filling losses. In addition, the petroleum industry has raised concerns that EPA's recommended emission factor of 1.0 lb/1000 gal does not reflect current fuel volatility, and that the emission factor should be 0.76 lbs/1000 gal. Table 28 presents the cost-effectiveness of this measure when the only benefit is reduction in breathing losses. Cost-effectiveness is calculated for two breathing loss emission factors: 0.76 and 1.0 lb/1000 gal. This measure still appears to be cost-effective for GDFs that dispense greater than 300,000 gallons per year with costs ranging between $4,000 and $5,700 per ton of VOCs reduced.

Table 27 – Cost per Ton Estimates for Vapor Leak Monitoring Systems

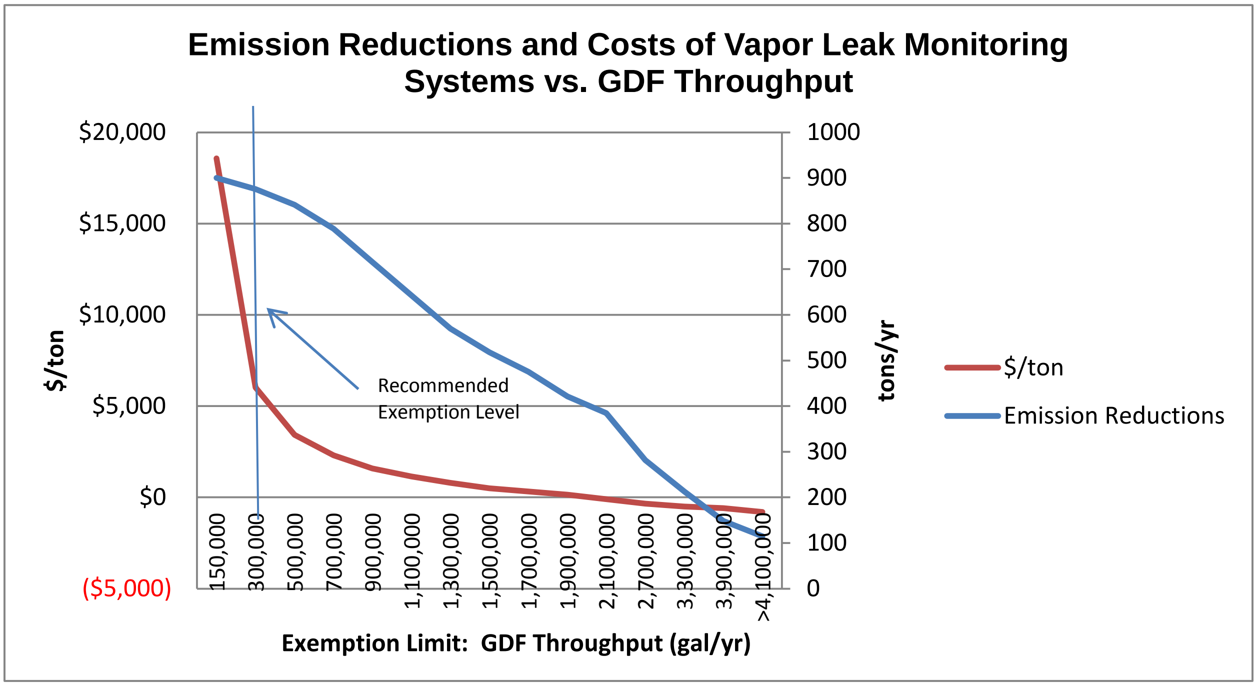
Yearly Throughput Intervals (gal)	Number of gas stations	$/yr Pressure Monitoring	Cumul. $/yr (%)	Filling Loss Reduction from Pressure Monitoring (tons VOCs/yr)	Breathing Loss Reduction from Pressure Monitoring (tons VOCs/yr)	Total Emissions Reduction from Pressure Monitoring (tons VOCs/yr)	Cumulative Reductions from Pressure Monitoring (%)	Fuel Savings from Pressure Monitoring	$/ton Pressure Monitoring
<300,000	803	$1,185,148	39	15	10	25	3	$32,945	$18,565
300,000-500,000	170	$250,433	48	21	13	34	7	$44,937	$6,027
500,000-700,000	170	$250,433	56	32	20	53	12	$69,618	$3,423
700,000-900,000	179	$264,542	65	45	28	73	21	$96,221	$2,306
900,000-1,100,000	143	$211,633	72	45	28	73	29	$95,841	$1,592
1,100,000-1,300,000	122	$179,888	78	45	28	73	37	$95,941	$1,153
1,300,000-1,500,000	74	$109,344	82	32	20	52	42	$68,239	$794
1,500,000-1,700,000	53	$77,599	84	26	17	43	47	$56,499	$492
1,700,000-1,900,000	60	$88,181	87	33	21	54	53	$71,191	$315
1,900,000-2,100,000	36	$52,908	89	22	14	36	57	$47,875	$139
2,100,000-2,700,000	86	$126,980	93	64	40	104	69	$136,595	-$93
2,700,000-3,300,000	45	$67,017	95	42	26	68	76	$89,974	-$336
3,300,000-3,900,000	36	$52,908	97	40	25	65	84	$85,300	-$500
3,900,000-4,100,000	17	$24,691	98	21	13	34	87	$44,542	-$587
>4,100,000	41	$59,963	100	70	44	115	100	$151,028	-$795
Total All	2,033	$3,001,668		553	348	900		$1,186,745	$2,016
Total > 300,000	1,230	$1,816,521		537	338	**875**		$1,153,800	$757

Table 28 – Cost/Ton Estimates for Vapor Leak Monitoring Systems Assuming Only Benefit is Reduction in Breathing Losses

Yearly Throughput Intervals	Number of gas stations in CT	$/yr Pressure Monitoring	Breathing Loss Reduction from Pressure Monitoring (tons/yr[16])		Fuel Savings from Pressure Monitoring		$/ton Pressure Monitoring	
			0.76 lb/1000 gal	1.0 lb /1000 gal	0.76 lb/1000 gal	1.0 lb /1000 gal	0.76 lb/1000 gal	1.0 lb /1000 gal
<300,000	803	$1,185,148	7	10	$9,666	$12,718	$25,162	$25,097
300,000-500,000	170	$250,433	10	13	$13,184	$17,347	$23,717	$17,708
500,000-700,000	170	$250,433	15	20	$20,425	$26,875	$14,842	$10,963
700,000-900,000	179	$264,542	21	28	$28,230	$37,145	$11,032	$8,068
900,000-1,100,000	143	$211,633	21	28	$28,119	$36,998	$8,602	$6,221
1,100,000-1,300,000	122	$179,888	21	28	$28,148	$37,037	$7,105	$5,083
1,300,000-1,500,000	74	$109,344	15	20	$20,021	$26,343	$5,880	$4,153
1,500,000-1,700,000	53	$77,599	13	17	$16,576	$21,811	$4,852	$3,371
1,700,000-1,900,000	60	$88,181	16	21	$20,887	$27,482	$4,246	$2,911
1,900,000-2,100,000	36	$52,908	11	14	$14,046	$18,482	$3,646	$2,455
2,100,000-2,700,000	86	$126,980	30	40	$40,075	$52,731	$2,858	$1,856
2,700,000-3,300,000	45	$67,017	20	26	$26,398	$34,734	$2,028	$1,225
3,300,000-3,900,000	36	$52,908	19	25	$25,026	$32,929	$1,468	$800
3,900,000-4,100,000	17	$24,691	10	13	$13,068	$17,195	$1,172	$575
>4,100,000	41	$59,963	34	44	$44,310	$58,303	$466	$38
Total All	**2,033**	**$3,001,668**	**264**	**348**	**$348,178**	**$458,129**	**$10,044**	**$7,317**
Total 300,000+	**1,230**	**$1,816,521**	**257**	**338**	**$338,513**	**$445,411**	**$5,754**	**$4,057**

[16] Two breathing loss emission factors are used: 0.76 and 1.0 lb/1000 gal. Total benefit equals breathing loss emission factor times the fraction of GDFs that are estimated to have vapor leaks times gasoline throughput.

Figure 5



8.4 Enhance Stage I: Requiring GDF Tank Pressure Control Systems

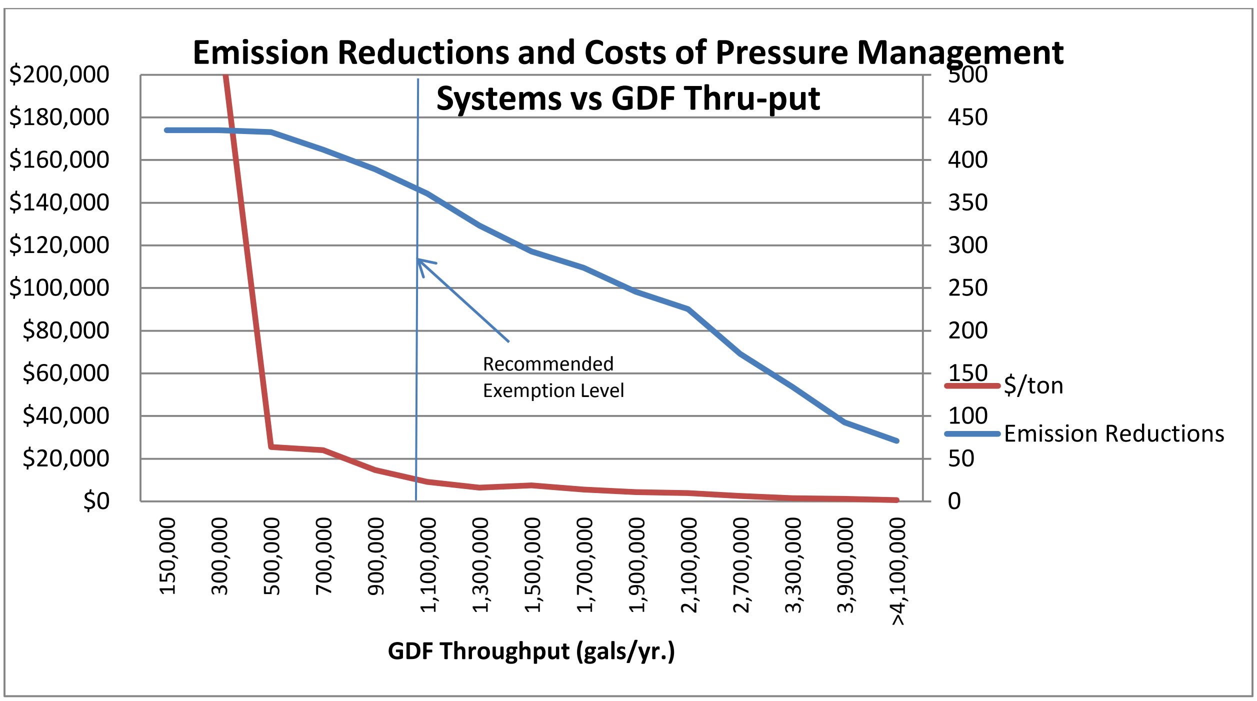
The calculation of the cost-effectiveness of tank pressure control systems is shown in Table 29. Cost effectiveness and emission reductions are shown graphically in Figure 6. Exempting GDFs that dispense less than 1,100,000 gallons per year reduces costs by about 72% while emission reductions are reduced by only 16%, so cost per ton is reduced from $14,000 to $3,800.

As mentioned previously, dKC believes that additional data must be collected from GDFs in Connecticut to better define the benefits and cost-effectiveness for tank pressure control systems.

Table 29 -- Cost per Ton Estimates for Tank Pressure Control Systems (Data Source: Veeder-Root)

Yearly Throughput Intervals	Number of gas stations	Additional from PMC (tons/yr)	Cumulative Reductions from PMC (%)	$/yr PMC	Cumul. $/yr (%)	Fuel Savings ($/yr)	$/ton PMC
<300,000	803	0	0%	$2,583,558	39%	$0	NM
300,000-500,000	170	2	1%	$545,931	48%	$3,172	$225,517
500,000-700,000	170	20	5%	$545,931	56%	$26,876	$25,454
700,000-900,000	179	23	10%	$576,687	65%	$30,065	$23,962
900,000-1,100,000	143	29	17%	$461,350	72%	$37,853	$14,745
1,100,000-1,300,000	122	37	26%	$392,147	78%	$49,202	$9,186
1,300,000-1,500,000	74	31	33%	$238,364	82%	$40,257	$6,486
1,500,000-1,700,000	53	19	37%	$169,162	84%	$25,118	$7,558
1,700,000-1,900,000	60	28	44%	$192,229	87%	$36,889	$5,550
1,900,000-2,100,000	36	20	48%	$115,337	89%	$26,715	$4,372
2,100,000-2,700,000	86	53	60%	$276,810	93%	$69,462	$3,934
2,700,000-3,300,000	45	39	69%	$146,094	95%	$50,758	$2,475
3,300,000-3,900,000	36	42	79%	$115,337	97%	$55,096	$1,441
3,900,000-4,100,000	17	22	84%	$53,824	98%	$28,568	$1,165
>4,100,000	41	71	100%	$130,716	100%	$93,344	$528
Total All	2,033	435	-	$6,543,477	-	$573,374	$13,723
Total 1,100,000+	**569**	**361**	-	**$1,830,021**	**-**	**$475,408**	**$3,755**

Figure 6



9. RECOMMENDED PROCEDURES FOR DECOMMISSIONING STAGE II SYSTEMS

The following is a summary of how to decommission the major components of Stage II vapor recovery systems:

- Vapor recovery piping
- Hanging hardware for dispenser
- Dispenser decals for instructions and proper use
- Vacuum pump (only for vacuum-assist systems)
- Liquid drop-out tank (if necessary)

The vacuum pump is a component unique to vacuum-assist systems. Aside from the disabling of these pumps, the steps to decommission both vacuum-assist and balance systems are congruent.

Drawn from implemented procedures in Vermont and New York, as well as standard protocols from the Petroleum Equipment Institute's (PEI) *Recommend Practices for Installation and Testing of Vapor-Recovery Systems at Vehicle-Fueling Sites* PEI RP 300-09, the steps to decommission each component of Stage II vapor recovery systems are summarized below.

a. **Vapor recovery piping**

   1. Disconnect piping from dispenser(s). Purge any liquid from piping. Seal with vapor-tight cap or plug.
   2. If accessible without excavation, disconnect piping from tank and seal. Check for liquids and, if necessary, discard properly. Remove piping.
   3. If tank is not accessible, leave piping in place (i.e., connected to tank) until next excavation.

b. **Liquid drop-out tank**

   1. Some GDFs, where the slope between the dispensers and tanks is not sufficient, require a drop-out tank to collect any liquid accumulated in the Stage II vapor recovery piping.
   2. Either remove or decommission the tank (i.e., remove any liquid, disconnect the line, and seal).

c. **Vacuum pump**

   1. For systems with pumps for each dispenser:
      i. Disconnect all electronic wiring for pump.
      ii. Reprogram dispenser electronics to deactivate Stage II vapor recovery.

iii. Drain any liquids from pump. If no gasoline remains in the pump, it can be left in place. Otherwise, remove pump.

2. For systems with a central pump:

    i. Remove the vacuum pump.

    ii. Seal vapor piping previously attached to pump.

d. **Hanging hardware**

    1. Drain liquid from hardware.

    2. Replace Stage II hanging hardware with conventional hardware and adjust adaptors.

e. **Dispenser decals --** Remove Stage II operating instructions from dispenser.

f. **Final checks and tests**

    1. Confirm overfill protection device is fully functional. If the Stage II vapor piping is still connected to the tank and the protection device is not operating correctly, gasoline may be released. If the device is found faulty, it must be reinstalled.

    2. Complete pressure decay and P/V valve test to ensure all components are vapor-tight.

    3. Once passed, complete a tie-tank test per CARB procedure TP-201.3C to confirm all vents are functional.

g. **Checklist and documentation**

    1. Complete form with GDF information and checklist.

    2. Submit to necessary authorities.

The above procedures should only be administered by trained technicians. Though represented in the summary, we recommend Connecticut refer to PEI RP 300 for detailed steps on decommissioning Stage II systems.

Next Steps – dKC recommends that the following steps be taken if the State adopts regulations to remove the requirement for Stage II:

1. Immediately exempt new or significantly modified GDFs from Stage II requirements.
2. Give priority to decommissioning Stage II in stations with vacuum-assist systems. Decommission Stage II in GDFs with balance systems after vacuum-assist systems are decommissioned.

10. CONCLUSIONS/RECOMMENDATIONS

Table 30 summarizes estimates of the emission reductions and cost effectiveness of Stage I and Stage II options for calendar year 2015.

Table 30 – Estimates of Emission Reductions and Cost Effectiveness of Stage I and Stage II Options (2015)

Control Measure	Emission Reductions (tons/day)	Cost/Ton
Decommission Stage II Program	0.04 to 0.06	Cost Savings
Make Current Stage II ORVR Compatible	0.9 to 1.3	$21,000 to $31,000
Upgrade Stage II to CA EVR Requirements	1.4	$32,000
Enhance Stage I: GDF Vapor Leak Monitoring System (exempt GDFs <300,000gal/yr)	0.7 to 2.4	$760 to $5,700
Enhance Stage I: GDF Tank Pressure Control System	To be determined	To be determined

Conclusions

The following are the primary conclusions of this project:

- Widespread use (WSU) in Connecticut will take place, at the latest, by summer 2012. The State could argue that WSU has already occurred. There are minimal benefits and, in fact, after 2014 there will be increases in emissions if GDFs must keep current Stage II systems beyond the WSU date.
- If Connecticut chooses to phase-out current Stage II requirements, the State has several options to continue the reduction of VOCs from GDFs.
- Enhancing Stage II systems to make them compatible with ORVR systems is estimated to result in 0.9 to 1.3 tons per day emission reductions in 2014. This measure, however, is expensive at a cost of $21,000 to $31,000 per ton. Adopting Stage II improvements included in the CA EVR program increases benefits by 0.1 to 0.5 tons per day at a cost of $32,000 per ton.
- Enhancing Stage I systems to require continuous monitoring of GDFs for vapor leaks appears to be effective and relatively inexpensive. This measure is estimated to result in 0.7 to 2.4 tons per day emission reductions in 2015 at a cost of $760 to $5,700 per ton. Exempting GDFs that dispense less than 300,000 gallons per year would significantly improves the cost-effectiveness of this measure, while decreasing emissions reductions by only 3%. In addition, requiring these systems will help assure the State that any leaks that result from the removal or capping of Stage II systems will be promptly identified and repaired, should the State decide to phase-out the Stage II program. Continuous vapor leak monitoring systems however, have not been used on GDFs outside of California. Due to Connecticut's colder climate, there is some uncertainty about how well these systems will work on Connecticut's GDF's during the winter months.

- The addition of GDF tank pressure control systems may also be cost effective, but additional data is needed to determine the costs and effectiveness of this measure. Currently, there is only limited data regarding the impact of these systems on GDFs without Stage II systems.

Recommendations

dKC recommends that DEEP pursue the following actions:

1. Connecticut should submit a revision to their SIP in order to remove Stage II vapor recovery systems once EPA issues its guidance on developing and submitting approvable SIP revisions, because these systems will soon become less effective in providing continued emissions reduction.
2. DEEP should continue with its plans to waive requirements for the installation of Stage II vapor recovery systems at newly constructed gasoline stations.
3. DEEP should work with stakeholders to design a plan for Stage II vapor control system phase-out at existing gasoline stations, starting with GDFs that currently have vacuum-assist Stage II systems.
4. DEEP should initiate a pilot study of continuous vapor leak monitoring systems and tank pressure control systems. The following are suggested goals for the study:
    a. Assess the feasibility of continuous vapor leak monitoring systems and pressure control systems in Connecticut’s climate, specifically during the winter months.
    b. Assess emission reductions, reliability, action levels and cost-effectiveness of continuous vapor leak monitoring systems and pressure control systems.
    c. Develop minimum specifications for continuous vapor leak monitoring and pressure control systems.
    d. Define monitoring, inspection, repair, and reporting requirements.
    e. Determine throughput thresholds for requiring continuous vapor leak and tank pressure control systems.
    f. Define the implementation schedule for continuous vapor leak monitoring systems and pressure control systems, assuming studies indicate that they are feasible and cost-effective.

APPENDIX A: REPORT ON ANALYSIS OF WIDESPREAD USE (WSU) IN CONNECTICUT

INTRODUCTION

As part of a task to assist the Connecticut Department of Energy and Environmental Protection (DEEP) in evaluating the Gasoline Dispensing Facility (GDF) Vapor Control Program, dKC determined when onboard refueling vapor recovery (ORVR) systems in Connecticut's vehicle fleet have met a particular threshold described as widespread use (WSU). ORVR systems were phased into the motor vehicle fleet beginning with the 1998 model year. After Connecticut reaches WSU, EPA will allow the State to submit a revision to its SIP which will phase-out the Stage II portion of the Vapor Recovery program, provided the State can achieve emission reductions through other means.

Results of the WSU analysis are summarized below:

a. Vacuum assist systems are used in 80% of the GDFs with Stage II systems. From a gasoline throughput standpoint, vacuum assist systems account for 94% of the gasoline dispensed at GDFs with Stage II systems.
b. Data from Connecticut and other states indicate that Stage II systems quickly develop leaks and other malfunctions that cause them to fail system performance tests. It is unlikely that Stage II systems have the 86% control efficiency that is assumed in Connecticut's State Implementation Plan. The actual control efficiency is likely to be 60% or less.
c. Recent correspondence between EPA and other states indicates that EPA will consider that WSU has occurred when emissions with Stage II systems alone equal emissions with ORVR alone. dKC used EPA's current emission factor model, MOVES, and the NESCAUM WSU spreadsheet to determine WSU dates using this and other WSU criteria. The following are estimates of when emissions with Stage II systems alone equal emissions with ORVR alone:
    - MOVES:
        - 86% Stage II efficiency: 2012
        - 60% Stage II efficiency: 2007-2008
    - NESCAUM SPREADSHEET:
        - 86% Stage II efficiency: 2011
        - 60% Stage II efficiency: 2007

This report presents the results of the WSU analysis. First, we summarize the results of a survey of GDFs in Connecticut. The survey provides key inputs into the WSU analysis. Next, we review information on the condition of vapor recovery systems in GDFs in Connecticut and nearby states. We then use different methods to assess if or when WSU has occurred.

RESULTS OF GDF SURVEY

Eastern Research Group (ERG) conducted a comprehensive survey of GDFs located in Connecticut. ERG designed the survey sample from GDF data obtained from the Connecticut DEEP. ERG filtered out facilities that were closed or inactive, or that were only handling non-gasoline materials. Two thousand and thirty-three surveys were mailed out on February 17, 2011. Of these, 23 were undeliverable.

Survey responses were received for a total of 908 GDFs located in Connecticut. Based on the number of delivered surveys (i.e., 2,010 surveys), the survey response rate was 43.4%. For purposes of comparison, a comparable survey was conducted for a similar GDF sample size in Texas in 2008 and the return rate was only 27.4%.[17] The high survey response rate increases confidence that the findings of this study are applicable to GDFs across the entire state of Connecticut.

ERG designed a Microsoft Access database to house the received survey data. All survey returns that were sent in via mail, fax, or PDF format were input into the database manually. Significant findings are shown below:

- The 96 facilities that do not have Stage II vapor control are limited to the smallest throughput classification.
- The facilities that did not identify whether or not they have Stage II vapor control are primarily limited to the smallest throughput classification (i.e., 73 out of 80 non-respondents to this question).
- Of the facilities that did identify that Stage II vapor control was present, 80% (i.e., 540 out of 675 facilities) had vacuum-assisted systems, while the remaining 20% (i.e., 135 facilities) had balance systems.
- The facilities that had balance Stage II vapor control systems were concentrated primarily in the smaller throughput classifications.

The overall yearly gasoline throughput derived from the survey results was estimated to be 745,413,813 gallons. The disaggregation of this based upon Stage II control technology is as follows:

- Vacuum-assisted – 696,954,309 gallons (93.5% of total)
- Balance – 38,502,475 gallons (5.2% of total)
- Do not know – 6,966,505 gallons (0.9% of total)
- None – 2,990,523 gallons (0.4% of total)

Another way of interpreting the results is to note that vacuum assist systems account for 94% of the gasoline dispensed at GDFs with Stage II systems.

CONDITION OF VAPOR CONTROL SYSTEMS

As part of this project, dKC is collecting information on the condition of Stage I/II vapor control systems in Connecticut. DEEP is providing dKC with the initial results of the

[17] *Stage I and Stage II Gasoline Dispensing Emissions Inventory*. Final. Prepared for the Texas Commission on Environmental Quality by Eastern Research Group, Inc. (ERG), Sacramento, CA. August 31, 2008.

triennial GDF inspections. In addition, dKC is commissioning additional GDF tests to help determine when key components of the vapor control system start to deteriorate. dKC also has compiled information from other states on vapor control system deterioration rates.

Connecticut Test Results – Table 1a summarizes the initial results of GDF inspections that were witnessed by DEEP since December 20, 2010. Overall, 79% of the GDFs failed inspection. The most common sources of failure were the tank decay test (50%), followed by A/L (25%) and P/V cap test (21%).

Table 1a – Results of Triennial GDF Inspections in Connecticut

Parameter	Number and Percent of Failures						
	System Pass/Fail	Decay	Dry Blockage	Wet Blockage	P/V Cap	A/L	6 Click
Number	111	72	5	6	10	23	13
Percent of Tests	70	45	3	4	6	14	8

dKC commissioned additional GDF tests to help determine when key components of the vapor control system start to deteriorate. These tests were performed approximately two months and four months after the station received its certification test. Two stations participated: one is a government station with a balance system; the other is a private station with a vacuum assist system. Table 1b summarizes the results of these tests. None of the tests had an overall result of pass.

Table 1b – Results of Bi-monthly GDF Inspections in Connecticut

Station/Stage II Type	Test date	Overall Result	Failed items
J and A Gas Vacuum Assist	6/2/11	Fail	A/L Test
	8/23/11	Fail	A/L Test
DOT Newington Balance	4/25/11	Fail	P/V valve
	7/14/11	Fail	Decay, P/V valve, torn hose
	11/9/11	Fail	Decay, P/V valve

Massachusetts Test Results – Other states and organizations have reported on the reliability of vapor control systems. Massachusetts DEP requires GDFs to report the initial results of their annual Stage II Certification tests. Table 2 summarizes the percent of stations that fail their initial Stage II tests in Massachusetts. As shown, from 2001 through 2010, 66% to 82% of the GDFs fail the initial annual Certification tests. The primary problem causing test failures were seal caps and fittings that needed tightening. Note that Massachusetts required GDFs with vacuum assist systems to implement by July 2004 enhancements to improve the integrity of Stage I/II systems (e.g., product and vapor swivel adaptors). It’s hard to tell if these enhancements have lowered the failure rate.

Table 2 – Results of Annual GDF Certification Tests in Massachusetts

Year	Percent Fail
2001	82
2002	78
2003	75
2004	67
2005	76
2006	78
2007	78
2008	73
2009	71
2010	66

From May 2002 through October 2003, Massachusetts required new GDFs with vacuum assist Stage II systems or significantly modified GDFs with vacuum assist systems to receive a certification test 120 days after they were initially certified. The results of these tests are shown on Table 3. Results indicate that over half (56%) of the recently certified GDFs failed Certification tests 120 days later. The most common failure was for the pressure decay test.

Table 3 – Results of 120 Day GDF Certification Tests in Massachusetts

Failure Reason	Number	Percent Fail
Air/Liquid Ratio	17	17
Pressure Decay	45	46
P/V Cap	2	2
Any Failure	55	56

New Hampshire Test Results – According to vapor release research conducted by New Hampshire, Stage II repairs last an average of 58 days. Overall, New Hampshire's research found:

1. Inspections and testing failed to fix key leaks
2. Most leaks required the station to upgrade the hardware (i.e., hoses, nozzles, breakaways)
3. Gasoline deliveries triggered leaks

Summary – Based on available data, it's unlikely that Stage II systems in Connecticut are achieving the 86% control efficiency assumed in Connecticut's State Implementation Plan (SIP). Data were not available that relate specific failure modes to a reduction in control efficiency. Assuming stations that fail GDF inspections see a 50%

drop in control efficiency, the actual control efficiency is less than 60%. The WSU analysis uses a range between 60% and 86% for control efficiency.

PREDICTIONS OF WHEN WSU OCCURS

Definition of Widespread Use

Four general definitions have been proposed to determine when WSU has occurred:

a. When “x” percent of the vehicles in service are ORVR-equipped. 75% and 85% have been proposed for “x”.
b. When “x” percent of the vehicle miles traveled (VMT) are from ORVR-equipped vehicles.
c. When total VOC emissions with ORVR-equipped vehicles are equal to total VOC emissions with Stage II VRS programs:
    1. When emissions with Stage II alone equal emissions with ORVR alone.
    2. When emissions with Stage II and ORVR combined including Incompatibility Excess Emissions (IEE) equal emissions with ORVR alone.
d. When “x” percent of gasoline sold is dispensed to ORVR-equipped vehicles.

EPA’s recent WSU analysis is based on definition c.1 (when emissions with Stage II alone equal emissions with ORVR alone). dKC calculated WSU using all of the above methods.

Incompatibility Excess Emissions (IEE) Factors -- The assumed IEE factor is a key parameter in estimating when WSU occurs using method c.2. (when emissions with Stage II and ORVR combined including IEE equal emissions with ORVR alone). IEE refers to the increase in GDF emissions from using vacuum assist systems to refuel vehicles with ORVR systems. When a vehicle with ORVR is refueled at a GDF with a vacuum assist system, ambient air from the vicinity of the GDF nozzle will be drawn back into the GDF storage tank. This air dilutes the concentration of gasoline vapors in the headspace of the storage tank, causing some of the liquid gasoline in the storage tank to evaporate, which increases the storage tank pressure. If the tank pressure increases above the positive setting of the P/V valve, the storage tank will vent to the atmosphere. Almost all (94%) of the gasoline dispensed in Connecticut is dispensed at GDFs with vacuum assist systems.

Table 4 documents different estimates of IEE. Based on their research, California Air Resources Board uses an IEE factor for vacuum assist systems of 0.86 lbs/1000 gal of fuel dispensed. The American Petroleum Institute (API) believes that the IEE factor should be lower based on their studies. Recent tests by Veeder-Root place the IEE factor between 1.5 and 2.5 lbs/1000 gal. dKC analyzed WSU using two IEE factors: 0.42 lbs/1000 gal and 0.86 lbs/1000 gal.

Table 4 – IEE Factors[18]

Data Collected by	Nozzle Type	Excess Emissions (lbs/1000 gal)
CARB	Standard (no boot)	0.86
CARB	Mini-booted	0.43
API	Standard (no boot)	0.72
API	Standard (no boot)	0.42*
API	Mini-booted	0
Veeder-Root	Not-specified	1.5-2.5 (2.0 most likely)

*Rate is for total incompatibility emissions. Total incompatibility emissions are the difference between all refueling emissions (pressure-related fugitives, P/V valve and fill pipe emissions) for an ORVR vehicle versus a non-ORVR vehicle.

Estimating When WSU Occurs

dKC took two approaches to estimate when WSU occurs:

1. Modify and run the NESCAUM WSU spreadsheet.
2. Use EPA's latest vehicle emissions model, MOVES, to determine refueling emissions with and without Stage II.

WSU Spreadsheet – The Northeast States for Coordinated Air Use Management (NESCAUM) developed a spreadsheet model for calculating when WSU occurs. NESCAUM modified a model that was initially developed by Todd Tamura who was a consultant for the American Petroleum Institute (API). The model calculates refueling emissions using algorithms from EPA's MOBILE 6 model. It also calculates IEE. The model calculates composite refueling emissions in grams per gallon and total emissions in tons per day. The spreadsheet model has been used by NESCAUM and other organizations for ORVR WSU analyses. In 2007, Ariel Garcia updated the spreadsheet with Connecticut-specific parameters. These parameters include Stage II effectiveness and vehicle registration distributions. The vehicle registration distribution was based on 2007 Connecticut vehicle registration data from the Department of Motor Vehicles (DMV).

dKC has updated the spreadsheet model using 2009 vehicle registration data and the fraction of gasoline dispensed at vacuum assist stations, based on results of the recently completed survey of GDFs in Connecticut.

MOVES – dKC also used EPA's latest emission factor model, MOVES, to estimate when WSU occurs based on definition c): *When total VOC emissions with ORVR-equipped vehicles are equal to total VOC emissions with Stage II VRS programs.* EPA is now requiring states to use MOVES to estimate vehicle emissions and the impact of controls such as Stage II and Inspection/Maintenance (I/M) programs. MOVES is much

[18] Reference: **REFUELING EMISSION CONTROLS AT RETAIL GASOLINE DISPENSING STATIONS AND COST-BENEFIT ANALYSIS OF STAGE II IN CONNECTICUT,** Tech Environmental, Inc., September 24, 2007.

different than EPA's past "MOBILE" models, and requires complex data input files. DEEP provided dKC with MOVES input files by county for years 2007, 2013, 2017, and 2020. For this analysis, dKC modified 2013 input files for Fairfield County for all the years evaluated. Using information outputted by MOVES, dKC calculated composite refueling emissions in grams per gallon.

WSU Predictions based on NESCAUM Spreadsheet

dKC used the NESCAUM spreadsheet to determine WSU dates based on the percent of vehicles with ORVR and emissions with and without Stage II.

WSU based on the Percent of Vehicles with ORVR – Table 5 presents the WSU dates (in calendar year) based on the WSU spreadsheet for definitions:

a) percent of vehicles,

b) percent of VMT, and

d) percent of gasoline consumed.

Table 6 shows the ORVR percentages by calendar year.

Table 5 – Widespread Use (WSU) Dates Based on Percent of Vehicles, VMT, and Gasoline Sales

Method	Calendar Year
a. When "x" percent of the vehicles in service are ORVR-equipped	
75%	2012-2013
85%	2015-2016
b. When "x" percent of the vehicle miles traveled (VMT) are from ORVR-equipped vehicles	
75%	2009-2010
85%	2012
d. When "x" percent of gasoline sold is dispensed to ORVR-equipped vehicles	
75%	2010-2011
85%	2012-2012

Table 6 – Fraction of Fleet with ORVR

Calendar Year	Vehicle Basis, Definition a	VMT Basis, Definition b	Fuel Usage Basis, Definition d
2001	13%	17%	14%
2002	18%	22%	19%
2003	23%	28%	25%
2004	29%	35%	31%
2005	35%	43%	39%
2006	42%	51%	47%
2007	49%	58%	55%
2008	55%	65%	62%
2009	61%	71%	69%
2010	66%	77%	74%
2011	70%	81%	79%
2012	74%	85%	83%
2013	78%	88%	87%
2014	81%	91%	89%
2015	83%	93%	92%
2016	85%	94%	93%
2017	87%	96%	95%
2018	88%	96%	96%
2019	89%	97%	96%
2020	90%	97%	97%

WSU Based on Emissions with and without Stage II – In addition to the three methods based on the percent of vehicles, VMT or gasoline consumption for ORVR equipped vehicles, a fourth method has been proposed for WSU determination. With this method, WSU is said to occur when total VOC emissions with ORVR-equipped vehicles are equal to total VOC emissions with Stage II vapor recovery programs. Two ways of doing this calculation have been proposed:

1. When emissions with Stage II alone equal emissions with ORVR alone.
2. When emissions with Stage II and ORVR including IEE equal emissions with ORVR alone.

As mentioned earlier, EPA appears to be leaning towards definition 1 for WSU determination.

The WSU spreadsheet allows users to input Stage II control efficiencies. Connecticut's State Implementation Plan (SIP) assumes that the Stage II systems have 86% control efficiency. The SIP also assumes that Rule Penetration for Stage II is 99% and that Rule Effectiveness is 96.8%. Based on information on the condition of the Stage II systems at representative GDFs, dKC believes that the Stage II effectiveness factor for Connecticut should be lower than 86%. For the WSU analysis, dKC used two control efficiency factors: 86% and 60%. When these factors are adjusted for Rule Effectiveness and Rule Penetration, the overall control efficiencies for the two scenarios are 82% and 57%.

Table 7 presents the calculated WSU dates when WSU is defined as when emissions with Stage II systems alone equal emissions with ORVR alone. This calculation is not affected by the assumed IEE factor. As shown, with 86% Stage II effectiveness, the WSU date is 2011; with 60% effectiveness the WSU date is 2007. Figure 1 shows refueling emissions in grams per gallon for ORVR alone and Stage II alone.

Table 7 – WSU Date When Emissions with Stage II Systems Alone Equal Emissions with ORVR Systems Alone (Definition c.1) – Spreadsheet Results

Assumed Stage II Effectiveness	WSU Date
82% (86% Adjusted for Rule Penetration and Effectiveness)	2011
57% (60% Adjusted for Rule Penetration and Effectiveness)	2007

Figure 1

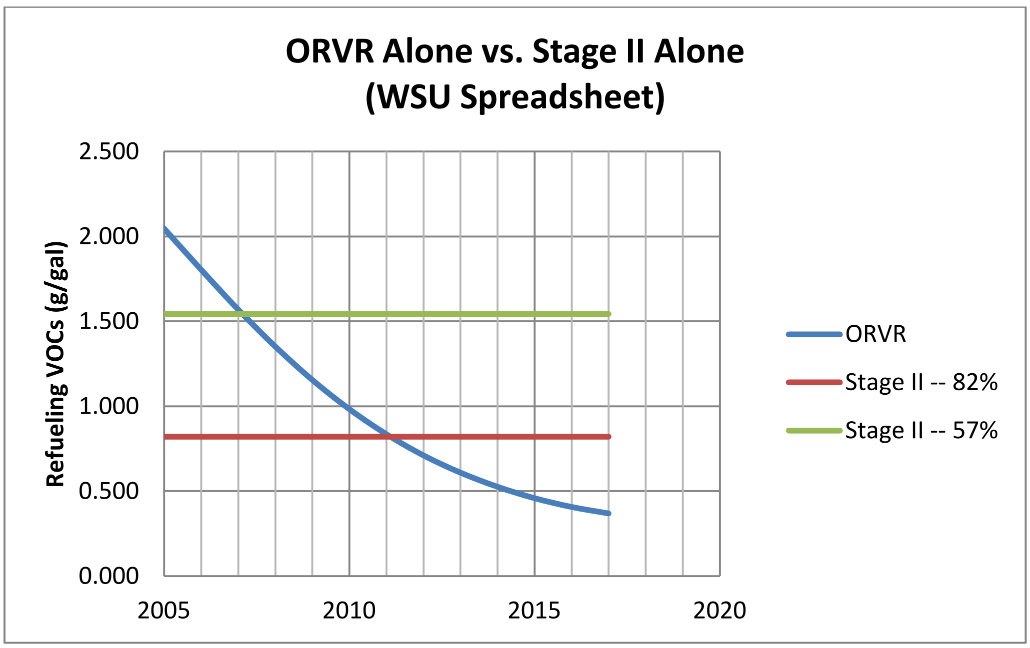


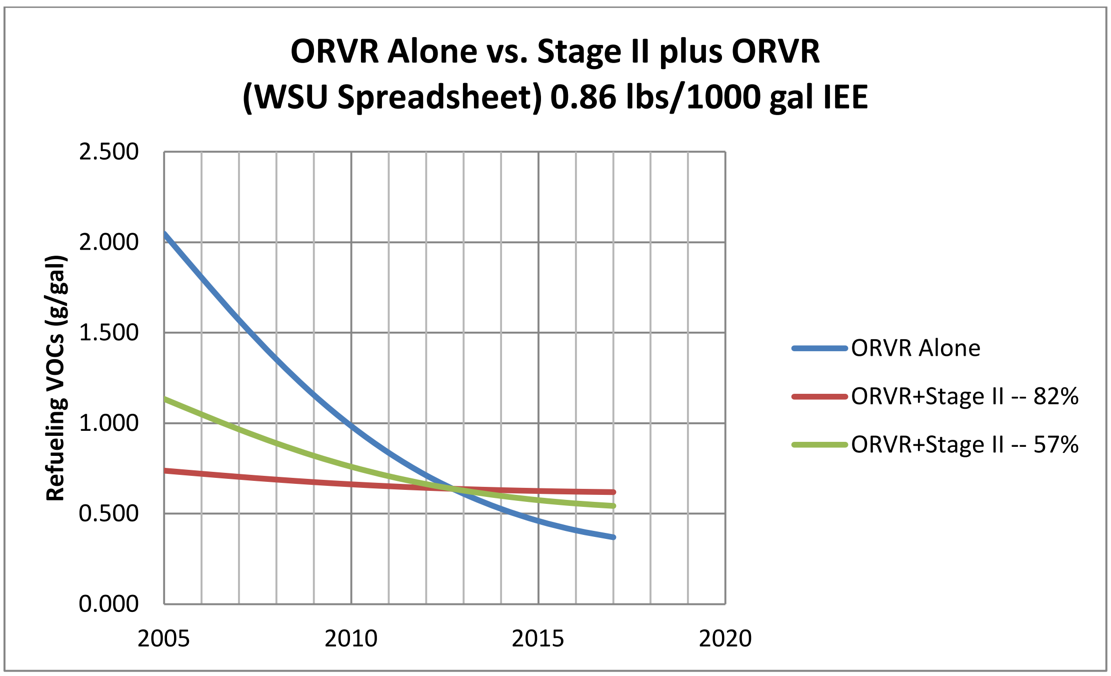
Table 8 presents the calculated WSU dates, defining WSU as the date when emissions with Stage II and ORVR combined (including IEE) equal emissions with ORVR alone. This definition determines the time when overall VOC emissions will increase due to IEE. It assumes that ORVR compatible Stage II systems are not used in Connecticut. Total IEE are sensitive to the assumed percentage of balance vs. vacuum assist systems. Based on ERG's survey of GDFs, dKC assumes that 94% of the gasoline is dispensed at stations using vacuum assist systems and 6% is dispensed at stations using balance systems. dKC analyzed WSU using two IEE factors, 0.42 lbs/1000 gal and 0.86 lbs/1000 gal, and two Stage II effectiveness factors, 82% and 57%. As shown in Table 8, the WSU date by this definition is affected by the IEE factor, but not the assumed Stage II effectiveness factor.

Figure 2 shows refueling emissions in grams per gallon for ORVR alone and Stage II plus ORVR (including IEE) when an IEE factor of 0.86 lbs/1000 gal is input into the spreadsheet. After approximately 2013, emissions for the Stage II plus ORVR scenarios are greater than for the ORVR only scenario.

Table 8 – WSU Date When Emissions with Stage II Systems plus ORVR Equal Emissions with ORVR Systems Alone (Definition c.2)

Assumed Stage II Effectiveness	Assumed Incompatibility Excess Emissions (IEE) (lbs VOCs/1000 gal)	
	0.86	0.42
82%	2013	2015
57%	2013	2015

Figure 2



WSU Predictions Based on MOVES

MOVES can be used to determine when WSU occurs according to definition c, when emissions with Stage II equal emissions with ORVR alone. To use MOVES to estimate emissions for the different WSU scenarios, dKC did the following:

1. Developed input files. DEEP provided input files for different counties and calendar years. dKC used the 2013 Fairfield County file with appropriate

calendar year modifications for all the MOVES runs. Fairfield County has the most vehicles miles traveled (VMT) in Connecticut. All runs were made for July.

2. Ran MOVES for the following scenarios:
    a. ORVR only: Compared refueling emissions estimates in grams per gallon with uncontrolled estimates.
        i. Uncontrolled estimates in grams per gallon were derived by running MOVES for calendar year 1990 without vapor controls.
        ii. Emissions with ORVR only (no Stage II) were estimated for calendar years 2005, 2011, 2012, 2013, 2014, 2015, 2016, and 2017. dKC edited the *County Year* file in the MOVES database to set the vapor control program effectiveness to 0%.
    b. Stage II plus ORVR with appropriate effectiveness inputs: dKC ran the same years using the following Stage II effectiveness factors.
        i. 57% Stage II effectiveness (60% adjusted for Rule Penetration and Effectiveness)
        ii. 82% Stage II effectiveness (86% adjusted for Rule Penetration and Effectiveness)
3. Using the following procedure based on energy consumption estimates outputted by MOVES, dKC calculated IEE:
    a. Calculate gasoline consumption (1 gallon = 115,000 MMBtu).
    b. Calculate IEE for a range of IEE factors:
        i. 0.42 lbs/1000 gal
        ii. 0.86 lbs/1000 gal
    c. Add IEE to the estimates for the Stage II plus ORVR scenario.

Predictions of when ORVR alone provides the same emission reductions as Stage II – MOVES offers a means of calculating when ORVR alone will provide the same emission reductions as Stage II alone. The user can set the effectiveness of a region's vapor control program to 0% and calculate refueling emissions. The drop in refueling emissions will be due to phase-in of vehicles with ORVR.

Table 9 shows the WSU date for this definition based on MOVES. Table 10 presents MOVES estimates for refueling emissions in grams per gallon for the non-Stage II scenarios. The percent control column can be directly compared to Stage II control efficiency. For example, in 2012, ORVR alone provides 82% control efficiency, which is equivalent to applying 82% efficient Stage II controls to a non-ORVR fleet. Results for the ORVR alone case are compared with the two Stage II effectiveness scenarios on Figure 3.

Table 9 – WSU Date When Emissions with Stage II Systems Alone Equal Emissions with ORVR Systems Alone (Definition c.1) – MOVES Results

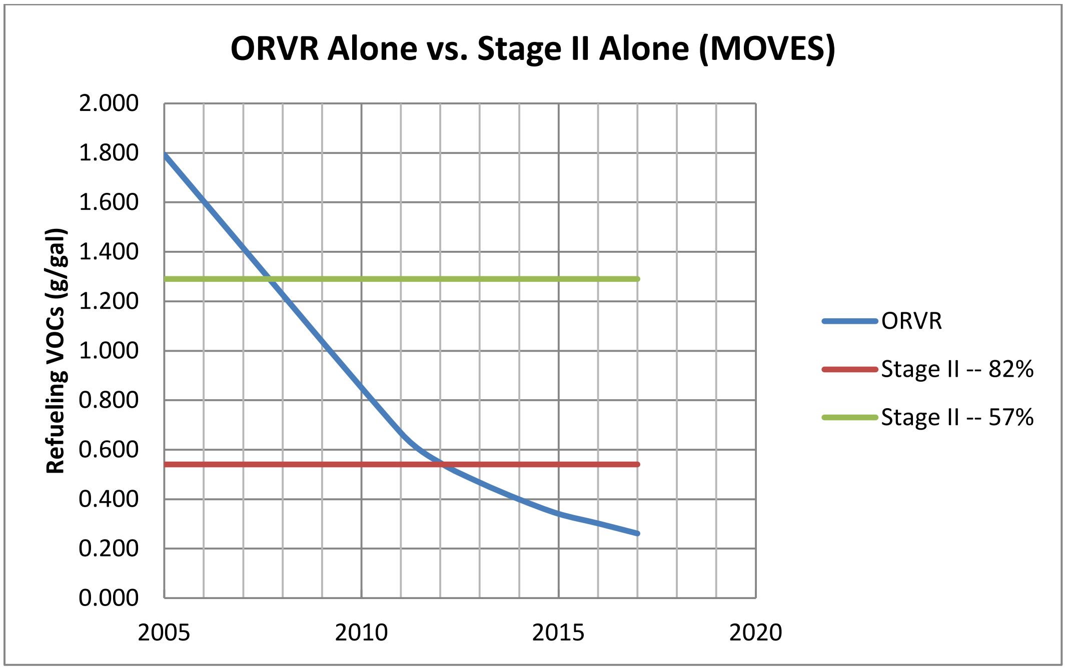
Assumed Stage II Effectiveness	WSU Date
82% (86% Adjusted for Rule Penetration and Effectiveness)	2012
57% (60% Adjusted for Rule Penetration and Effectiveness)	2007-2008

Table 10 – MOVES Refueling Emission Estimates – ORVR Alone

Year	Refueling Vapor (lbs)	Distance (mi)	g/mi	gal	MPG	g/gal	Control (%)
1990	328,677	696,461,824	0.2143	49,790,737	13.988	2.997	0
2005	158,985	695,594,368	0.1038	40,254,445	17.280	1.793	40
2011	58,217	695,284,544	0.0380	39,534,749	17.587	0.669	78
2012	46,982	695,322,688	0.0307	38,959,823	17.847	0.547	82
2013	39,571	695,322,688	0.0258	38,399,333	18.108	0.468	84
2014	33,168	695,334,432	0.0217	37,668,001	18.460	0.400	87
2015	27,780	695,346,176	0.0181	36,964,029	18.811	0.341	89
2016	24,048	695,301,600	0.0157	36,081,156	19.270	0.303	90
2017	20,316	695,257,024	0.0133	35,239,367	19.73	0.262	91

As shown in Table 9 and Figure 3, the WSU date is between 2007 and 2008 for the 57% Stage II effectiveness case, and 2012 for the 82% Stage II effectiveness case. These are about one year higher than the WSU dates derived from the WSU spreadsheet. Note that the WSU spreadsheet uses 2009 registration data, while the MOVES files provided by DEEP appear to use 2007 registration data. In December of 2010, when dKC investigated the sensitivity of the WSU dates to the registration data, we found that using 2009 data lowered WSU dates by about one year, because the 2009 data projected a younger light-truck fleet.

Figure 3



Predictions of when ORVR alone provides the same emission reductions as Stage II plus ORVR – In order to use MOVES to determine when emissions with ORVR alone are lower than emissions with Stage II plus ORVR, it is necessary to separately calculate IEE. MOVES estimates petroleum energy consumption from which we derive estimated gasoline consumption. Then, IEE factors are applied to gasoline consumption estimates to estimate total IEE. Total IEE is then added to MOVES estimates of refueling emissions with Stage II controls.

Table 11 shows WSU dates for the scenario where emissions with Stage II begin to increase over the ORVR scenario alone. Table 12 shows the calculation of total refueling emissions for the Stage II plus ORVR scenario, accounting for IEE. Results are shown graphically in Figure 4. The WSU date using an IEE factor of 0.86 lbs/1000 gal is between 2014 and 2015. The WSU date using an IEE factor of 0.42 lbs/1000 gal is estimated to be 2018. The WSU date by this definition is not sensitive to the assumed Stage II effectiveness factor.

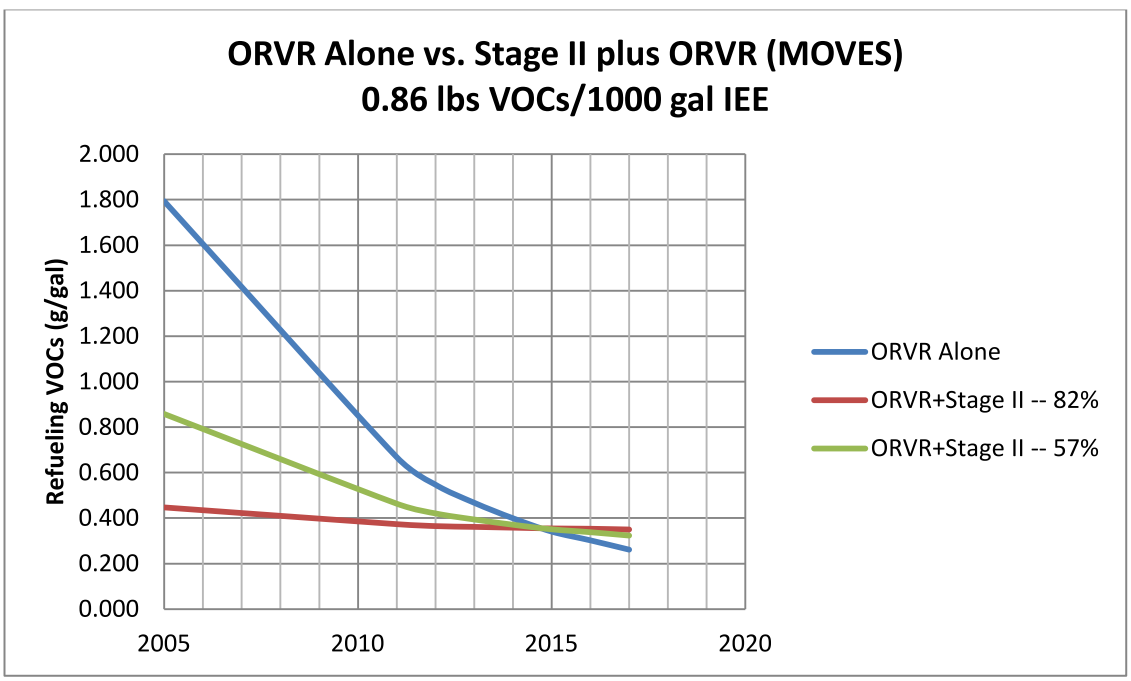
Table 11 – WSU Date Based on MOVES when Emissions with Stage II Systems plus ORVR Exceed Emissions with ORVR Systems Alone (Definition c.2)

Assumed Stage II Effectiveness	Assumed Incompatibility Excess Emissions (IEE) (lbs VOCs/1000 gal)	
	0.86	0.42
82%	2014-2015	2018
57%	2014-2015	2018

Table 12 – MOVES Refueling Emission Estimates – ORVR Alone vs. Stage II plus ORVR -- with Incompatibility Excess Emissions (IEE)

Scenario	Year	Refueling Vapor ORVR only (lbs)	Refueling Vapor ORVR only (g/gal)	Refueling Vapor Stage II. Plus ORVR (g/gal) No IEE	gal	% ORVR	IEE (g/gal)		Total Refueling Stage II with IEE (g/gal)	
							0.42	0.86	0.42	0.86
82% Control	2005	158,985	1.793	0.323	40,254,445	39	0.061	0.125	0.3837	0.4476
	2011	58,217	0.669	0.120	39,534,749	79	0.124	0.253	0.2441	0.3738
	2012	46,982	0.547	0.099	38,959,823	83	0.130	0.267	0.2288	0.3653
	2013	39,571	0.468	0.084	38,399,333	87	0.136	0.278	0.2198	0.3618
	2014	33,168	0.400	0.072	37,668,001	89	0.140	0.286	0.2119	0.3584
	2015	27,780	0.341	0.061	36,964,029	92	0.143	0.294	0.2048	0.3550
	2016	24,048	0.303	0.054	36,081,156	93	0.146	0.299	0.2006	0.3536
	2017	20,316	0.262	0.047	35,239,367	95	0.148	0.303	0.1952	0.3503
57% Control	2005	158,985	1.793	0.771	40,254,445	39	0.042	0.087	0.8134	0.8578
	2011	58,217	0.669	0.287	39,534,749	79	0.086	0.176	0.3735	0.4637
	2012	46,982	0.547	0.235	38,959,823	83	0.091	0.185	0.3260	0.4208
	2013	39,571	0.468	0.201	38,399,333	87	0.094	0.193	0.2954	0.3941
	2014	33,168	0.400	0.172	37,668,001	89	0.097	0.199	0.2691	0.3710
	2015	27,780	0.341	0.147	36,964,029	92	0.100	0.204	0.2464	0.3508
	2016	24,048	0.303	0.130	36,081,156	93	0.102	0.208	0.2317	0.3380
	2017	20,316	0.262	0.113	35,239,367	95	0.103	0.211	0.2155	0.3233

Figure 4



APPENDIX B: DESCRIPTION OF CALIFORNIA ENHANCED VAPOR RECOVERY PROGRAM (CA EVR)

Module 1: Phase I Vapor Recovery

CARB staff propose to increase efficiency requirements to gain additional emission reductions as well as require more stringent leak requirements for Phase I components to ensure these efficiencies are achievable at all installations. The proposed certification requirements for Phase I vapor recovery system certification are set forth in CP-201, "Certification Procedure for Vapor Recovery Systems for Gasoline Dispensing Facilities." Proposed changes to Phase I certification consist of an increase in the efficiency requirement from 95% to 98%, a new specification for Phase I couplers to reduce leaks, new performance specifications for drain valves in spill containment boxes and other improved Phase I equipment specifications.

A. Increase from 95% Efficiency to 98% Efficiency Standard

B. Phase I Adaptor Specifications: Phase I adaptors are the connection points for the cargo tank truck to the service station underground storage tank. The adaptors tend to become loose during the bulk drop as the cargo tank driver connects and disconnects the hoses for the fuel transfer. This is one of the commonly identified causes of leaks from vapor recovery systems, as well as a contributing factor to reduced effectiveness of the Phase I system. Staff has added a requirement for 360 degree rotatable Phase I vapor and product adaptors.

C. Drop Tube with Overfill Protection Specification: A new specification is proposed to reduce leaks in drop tubes with overfill protection devices installed. These devices are installed in the Phase I drop tube and use a valve to shut off liquid flow when the underground storage tank is being filled. The moving parts and the fasteners, which connect the flapper valve to the drop tube, can result in holes that can lead to air ingestion during the bulk drop. All drop tubes with overfill protection will be required to meet a pressure vs. flow specification of < 0.17 CFH at 2.0 inches water column.

D. Pressure/Vacuum Relief Valves (P/V Valves) on Vent Pipes: Vent pipes are required for gasoline underground storage tanks to allow venting of vapors if the underground tanks develop significant pressure. The EVR proposal requires P/V valves for all systems.

E. Spill Containment Boxes: Spill containment boxes are required by the State Water Resources Control Board (SWRCB) to contain any spills which occur during the bulk drop. CARB staff has added product containment box standards which limit the leak rate to < 0.17 CFH at 2.0 inches water column and prohibit any standing fuel in the containment box of product connectors. Drain valves would be prohibited in the spill boxes of vapor connectors under this proposal. In addition, any application for certification of a drain valve that requires unreasonable maintenance shall be deemed unacceptable.

F. Connectors and Fittings: Loose connectors and fittings can also lead to leaks in the underground tank vapor. This new specification explicitly states that connectors and fittings shall be leak-free as determined by either leak detection solution or by bagging the fittings and observing inflation of the bag.

G. Fuel Blend Compatibility: Phase I components must be demonstrated to be compatible with fuel blends approved for use and commonly used in California, including fuels meeting the recently adopted Phase III fuels requirements.

Module 2: Phase II Vapor Recovery

Field inspections conducted jointly by CARB and district staff have uncovered many deficiencies with installed Phase II systems. CARB staff are working with the districts and equipment manufacturers to resolve these problems; however, it became clear that many reliability concerns could be addressed during the certification process. Staff have proposed extending the certification tests and expanding on the tests required during certification to thoroughly address durability and reliability issues. Staff have also identified new emission points for gasoline vapor emissions and proposed new standards to control these emissions.

Fugitive leaks from the underground storage tank are a concern with existing systems. Staff have proposed pressure profiles that would limit underground storage tank pressures and assess leaks in the vapor space. Increased use of processors is expected to maintain desired underground storage tank pressures, but concerns have been raised regarding toxics in the exhaust of combustion processors. New limits for selected hazardous air pollutants are included in the proposal. Another proposal to address system deficiencies is to limit the certification to four years with renewal contingent on successfully addressing any problems that have been documented during the four-year period. Currently, certifications have no expiration date.

A. Include Pressure-Related Fugitives in Efficiency Standard Calculation

B. Replace Efficiency Requirement with Emission Limit

C. Compatible with Phase I System: Staff propose a new standard requiring that Phase II vapor recovery systems shall not cause excess emissions from Phase I systems.

D. Underground Storage Tank Pressure Limits

E. Nozzle/Dispenser Compatibility: Staff propose a new standard for nozzle/dispenser compatibility to verify that the vapor check valve and hold-open latch are closed when the nozzle is properly hung on the dispenser.

F. Unihose MPD Configuration: Gasoline dispensers may have three hoses per fueling point (one for each grade of gasoline) or just one hose for all grades, which is known as a unihose configuration. The unihose configuration reduces the number of hoses, nozzles and other hanging hardware by two-thirds. As this equipment has leak sources, such as check valves, the less hanging hardware, the less potential exists for leaks. Staff propose that all systems have unihose dispensers to reduce the potential number of leak sources.

G. Liquid Removal

H. Vapor Return Piping: Staff propose to establish the maximum allowable pipe run lengths during the certification process.

I. Liquid Condensate Traps: A new standard is proposed for liquid condensate traps (also known as knockout pots). These traps are used to keep the vapor lines clear when it is not possible to achieve the minimum slopes for the vapor recovery piping as discussed above.

J. Connections and Fittings: This new specification explicitly states that connectors and fittings shall be leak-free as determined by either leak detection solution or by bagging the fittings and observing inflation or deflation of the bag when the underground storage tank vapor space in under pressure or vacuum.

Sections K through M- Proposed new standards applicable to balance systems:

K. Balance nozzles: Staff propose that the balance nozzle check valve be located in the nozzle to reduce vapor emissions which result if the check valve is present in another location between the nozzle and the underground storage tank. A new specification is proposed to determine nozzle bellows insertion force. This will allow a check that the production nozzles are consistent with the nozzle certified as well as provide an evaluation of nozzle bellows durability.

L. Dynamic Backpressure: Staff propose to modify the existing backpressure requirements to remove the limit at 40 CFH.

M. Component Pressure Drop Limits: New standards are proposed for individual balance system components to ensure the overall dynamic backpressure requirements discussed above are met. This is necessary as certified balance system equipment is currently specified in a matrix that allows different combinations of certified balance system components. Staff has learned that some combinations of balance system components are not able to meet the dynamic backpressure limits described above. A pressure drop budget has been suggested to resolve this problem. Staff has developed component pressure drop limits with input from several vapor recovery equipment manufacturers. The proposed individual component pressure drops are listed below.

N. Assist Nozzles: Staff propose that all “bootless” assist nozzles be equipped with a vapor guard. This is a small cup or mini-boot at the base of the nozzle that assists in routing the vapor back through the nozzle. Each assist nozzle must have a vapor check valve. The purpose of the check valve is to keep vapors from exiting the underground vapor space through the vapor return line when the nozzle is not in operation.

O. Air to Liquid Ratio Limits: Staff propose a new limit on air to liquid ratio (A/L) for assist systems.

P. Assist Systems with Common Collection Device: Staff propose new specifications for assist systems utilizing a common collection device. This means that there is one vacuum source for the entire station rather than a separate vacuum pump in each dispenser.

Q. Assist Systems with Destructive Processors: New performance standards provide limits on criteria (CO, NOx) and hazardous air pollutant (HAP) emissions for destructive processors.

Module 3 – ORVR Compatibility

The goal of the ORVR compatibility standard is to eliminate the excess emissions which can occur during fueling of an ORVR vehicle with a Phase II vapor recovery system. Phase II systems must demonstrate during the certification test period that the Phase II system is compatible with ORVR vehicles. Compatibility is determined by verifying that the Phase II system can refuel ORVR vehicles and that the refueling does not cause the vapor recovery system emissions to exceed the 0.38 lbs/1000 gal standard. The statewide emission reductions (in California) for ORVR compatibility were estimated at 6.3 tons per day.

There are several certified systems that achieve ORVR compatibility. These are the balance system and the Healy system. These systems do not ingest “excess air” when fueling ORVR vehicles and thus do not cause excess emissions. No modifications are necessary for the balance system to achieve ORVR compatibility, as the passive system design only collects vapor actually displaced by fueling of the vehicle. Since the ORVR vehicles collect the vapor in the canister, the dispensing facility with a balance system will dispense fuel without replacing it with vapor, thus leading to negative pressure in the underground storage tank. Even if the balance system station has some leaks, field data shows the underground storage tank tends to maintain negative UST pressure. This was demonstrated during a CARB field test of a balance system at which 32% of the fuel was dispensed in ORVR simulation. The underground storage tank pressure was less than 0.10 inches water for 99% of the test, including the bulk delivery periods.

The Healy assist-type vapor recovery system recognizes ORVR vehicle fuelings by means of a pressure-sensing diaphragm in the nozzle that prevents the ingestion of air when fueling an ORVR vehicle. Other system manufacturers are exploring hydrocarbon sensing technology. Both of these systems illustrate how differences in the vapor return line can be monitored to detect ORVR vehicles and adjust the vapor collection of the system.

Assist systems with processors may be compatible with ORVR. For example, ARID’s Permeator system has been certified for use with vacuum assist systems.

Module 4: Liquid Retention and Spitting

Staff are proposing standards for liquid retention and “nozzle spitting”. Liquid detention occurs when liquid gasoline contained in the hanging hardware (nozzles, hoses, etc.) on the dispenser is allowed to evaporate into the atmosphere between vehicle fuelings while the nozzle is hung on the dispenser. Nozzle spitting is defined as the release of liquid when the nozzle trigger is depressed with the dispenser not actuated.

Module 5: Spillage and Dripless Nozzle

Staff propose to reduce the spillage limit from 0.42 lbs/1000 gal to 0.24 lbs/1000 gal limit. Staff also propose to limit the number of drops to two drops per fueling event.

Module 6: In-Station Diagnostics (ISD)

The goal of ISD is to provide continuous monitoring of important emission-related vapor recovery system parameters and to alert the station operator when a failure mode is detected so that corrective action can be taken. It is similar in concept to the current CARB on-board diagnostics regulations for motor vehicles, where every emission-related component or system must be regularly monitored for proper operation.

General requirements for ISD systems include:

a) Diagnostics that alert the owner/operator to potential problems

b) Provide audible and visible alarms upon detection of defect
c) Prohibit dispensing if an identified defect is not repaired within a reasonable period of time
d) Monitor critical component performance
e) Provide record of system performance

ISD designs are expected to be specific to vapor recovery system type. However, certain minimum design parameters, such as calibration of monitors, frequency of data collection, type of data storage and accessibility, criteria for determining warning and failure conditions and other parameters shall be proposed by the applicant and will be evaluated and verified during the certification process. Other criteria proposed for ISD systems are discussed below.

UST pressure monitoring will be required for all vapor recovery systems. These monitors will detect leaks in the underground storage space indicated by long periods that the tank remains at atmospheric pressure. Pressure monitors can also indicate if the gasoline delivery was conducted correctly. For example, connecting the product hose, but failing to connect the vapor return hose, would generate a large pressure spike which would lead to escape of the vapors out the vent pipe. Stations which remain at high pressures for significant periods would signal an investigation to correct system operations so that pressure-related fugitive emissions are minimized.

Additional requirements for ISD vary depending on the type of vapor recovery system. The three system categories are balance, assist, and assist with processor.

A. Balance Systems: In addition to the pressure monitor, balance systems would be required to check for liquid blockage at each dispensing point. A high pressure drop would indicate a blockage problem. Another approach is to measure the vapor to liquid ratio (V/L) (also referred to as A/L) in each dispenser with a flow meter. The flow meter installed in each dispenser, would measure the amount of vapor flow during every fueling episode without reducing the vapor recovery system's efficiency. A consistent lack of flow, or low flow, would indicate a blockage.

B. Assist Systems: Assist systems would also be required to monitor the V/L in a way that would detect a failure mode at individual dispensers. Recent inspections have discovered that vapor pumps were not operating at some dispensers although gasoline fueling was normal. Staff propose that when the monitor detects an A/L of zero, which would mean no vapor recovery, the dispenser be shut down.

C. Assist Systems with a Processor: In addition to monitoring the V/L, vapor recovery systems with processors must have additional ISD sensors to ensure the processors are operating correctly. The hydrocarbon concentration, the flow rate, and other parameters unique to each processor will need to be continuously monitored. This is already required for current systems with thermal processors. For vapor recovery systems certified to operate at a continuous vacuum, a pressure switch is used to detect insufficient vacuum. An alarm signals the station operator when the system fails to achieve the certified vacuum level after a prescribed time interval, indicating insufficient system leak integrity or a system failure.