Compliance Offset Supply Forecast

For California's Cap-and-Trade Program (2013-2020)

September 2012

American Carbon Registry
Contributing Authors

Sam Stevenson
Belinda Morris
Nick Martin
Mary Grady

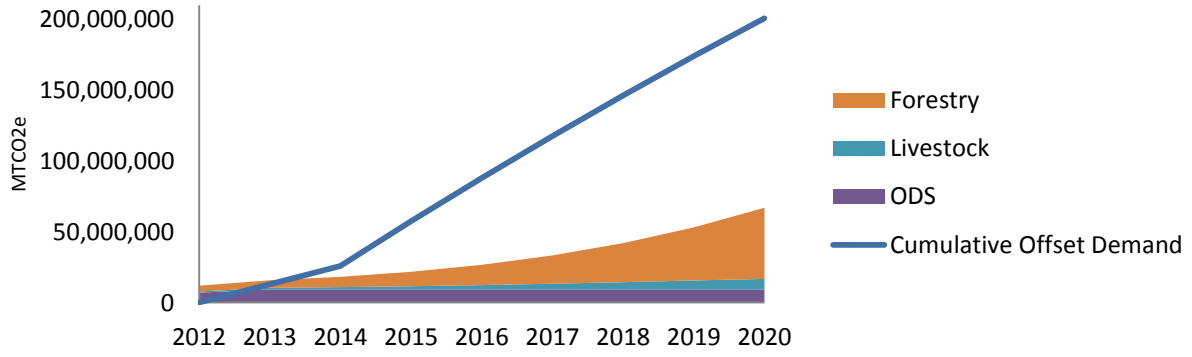
Executive Summary

California's Global Warming Solutions Act (Assembly Bill 32 or AB32) limits California's greenhouse gas (GHG) emissions to 427 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) by 2020, the equivalent of the state's GHG emissions in 1990. A GHG cap-and-trade program is a central strategy for achieving the goals of the AB32 regulation. The regulation includes a declining GHG cap. Allowances, or tradable permits, equal to the emissions allowed under the cap, will be distributed and auctioned prior to the start of each compliance period. Covered entities will be allowed to purchase allowances from other entities in lieu of reducing emissions. In addition, these entities can fulfill up to 8% of their compliance obligations using ARB Offset Credits developed under approved protocols. Over the three compliance periods, the total cumulative demand for GHG offsets in the compliance program could reach just over 200 $MMTCO_2e$.

To better understand how supply can meet potential demand for offsets, the American Carbon Registry (ACR) conducted a rigorous analysis of offset supply potential resulting in an in-depth offset supply forecast for California's Cap-and-Trade program (2013-2020). Offsets are an important cost-containment mechanism, enabling the most cost-effective GHG reductions to be achieved first and thus reducing the overall cost of the compliance program. The offset supply forecast includes potential supply from projects developed following the existing four California Air Resources Board (ARB) Compliance Offset Protocols—***Ozone Depleting Substances (ODS), U.S. Forests, Urban Forests,*** and ***Livestock***—as well as from ARB-approved early action protocols. In addition, the forecast projects potential supply under four additional project types that ARB has reviewed for potential adoption—***Coal Mine Methane, Low-bleed Pneumatic Valves, Rice Management*** and ***Fertilizer Management***.

ACR's analysis forecasts a significant shortage of compliance offsets as compared to total potential demand for compliance offsets in all compliance periods if no additional protocols beyond the existing four are adopted by ARB. Results show that with the current four project types, if total expected demand is reached, there will be a 29% shortage (7.6 $MMTCO_2e$[1]) in Compliance Period 1 (CP1).[2] This does not include additional demand anticipated from banking of credits in the early years. By Compliance Period 3 (CP3), there will be a 67% (134 $MMTCO_2e$) shortage. ***U.S. Forests*** and ***ODS*** dominate supply in all compliance periods, although the real potential for Forest Projects is dependent on acceptance by forest owners of a lengthy minimum project term and other protocol requirements, as well as the liability for future invalidation of forest offset credits.

Figure 1: Forecast Cumulative ARB Offset Supply vs. Potential Offset Demand (2012-2020)

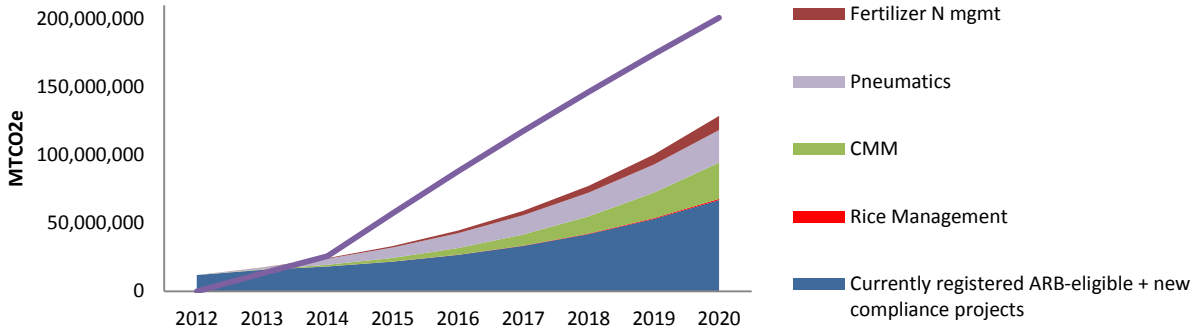


[1] $MTCO_2e$ is metric ton carbon dioxide equivalent| $MMTCO_2e$ is million metric ton CO_2e
[2] CP1 is from 2013-2014 | CP2 from 2015-2017 | CP3 from 2018-2020

The adoption of three additional project types—***Low-bleed Pneumatic Valves, Coal Mine Methane (CMM),*** and ***Rice Management***—can close the 29% shortage in CP1 if they are adopted in 2013. Most of this potential supply comes from ***Low-bleed Pneumatic Valve*** projects. With their short project development cycle, Low-bleed Pneumatic Valve projects are projected to deliver 5 $MMTCO_2e$ within CP1. ***CMM*** projects are projected to provide an additional 1.9 $MMTCO_2e$ by 2015 (though only if ARB also approves an early action ***CMM*** protocol). Offsets from ***Rice Management*** projects will add 32,000 $MTCO_2e$ by 2015. In sum, nearly seven million additional offsets could be supplied to the market within CP1 if these three protocols are adopted by ARB in 2013.

Even with the three additional protocols, there will be a 35% shortfall (70 $MMTCO_2e$) by 2020 if full demand for offsets is reached, indicating that more protocols, such as ***Fertilizer Management*** and others, need to be adopted. If a ***Fertilizer Management*** Project protocol were adopted in 2014, it could add a cumulative supply of 10.4 million tons by 2020 from corn alone, and more if the protocol applies to other crops. Sector-based credits from Reduced Emissions from Deforestation and Forest Degradation (REDD) are listed in the cap-and-trade regulation as eligible, although ARB has not yet initiated a rulemaking for REDD, awaiting the release of recommendations by the REDD Offset Working Group. REDD was not included in our analysis, but modeling by Environmental Defense Fund (EDF) indicates that REDD projects could generate significant supply and possibly fill the compliance gap after 2014 if accepted.

Figure 2: Forecast Offset Supply: Current compliance protocols + Rice, CMM, Pneumatics, Fertilizer



Linkage with Quebec can provide a small volume of additional offset supply. Three protocols have been accepted by Quebec: methane destruction from manure storage facilities (projects located in Quebec only), methane destruction from small landfills (projects located in Quebec only), and ODS destruction in Canada or in the U.S. from appliance foam only. The opportunity for manure storage (10,000 to 50,000 $MTCO_2e$/year) and small landfills (100,000 $MTCO_2e$/year) in Quebec is limited. The Quebec ODS protocol only allows ODS destruction from appliance foam (CFC-11, CFC-12, HCFC-22 and HCFC-141b). It is estimated that approximately 30 $MMTCO_2e$ is theoretically available from foam in the United States and Canada. However, despite the large potential from foam, these projects will require a much higher carbon price as it is more costly to access and more geographically dispersed than refrigerant ODS sources. Quebec estimates the potential for ODS at around 100,000 $MTCO_2e$/year for Quebec and 500,000 $MTCO_2e$/year for Canada.[3] Hence, linking with Quebec will provide additional supply, but not close to the amount needed to close the offset shortage projected for CP3.

[3] See http://www.climateactionreserve.org/wp-content/uploads/2009/05/Quebec-Offsets-Webinar-June-2012.pdf

Model Approach

Offset Demand

Offset demand is set at the 8% limit on individual entities' annual and triennial compliance obligations, as set in the Cap and Trade Regulation. The 8% limit in effect determines the theoretical maximum offset demand. This results in demand for 25 $MMTCO_2e$ of offset credits in CP1 and just over 200 $MMTCO_2e$ cumulative demand by the end of 2020.

We recognize that actual offset demand may be less. Actual demand will be a function of each individual regulated entity analyzing its emissions, its free allowances, its short position, how much of that short position it is allowed to cover with offsets, and the relative prices and risks of compliance offsets vs. purchasing allowances. The larger and more sophisticated entities will seek to acquire the maximum offsets they are allowed to use. Other regulated entities, particularly the smaller ones, may be less sophisticated in their compliance strategy and/or reluctant to use offsets because of perceived greater risks. This will tend to decrease offset demand.

On the other hand, the offset market will be open not only to regulated entities but also to a large number of intermediaries purchasing compliance offsets for resale, who are likely to quickly buy and bank any available compliance offsets to sell to regulated entities when prices are higher. This will tend to increase offset demand, potentially to the theoretical maximum. Banking is not incorporated into this forecast; however, it should be noted that banking is expected to increase demand in CP1, further exacerbating an offset supply shortage.

Offset demand also may not move in a smooth projection from year to year, due to the requirement that regulated entities surrender compliance instruments for at least 30% of prior-year emissions in years that do not conclude a compliance period, in addition to a triennial “true up” in which entities are required to cover all their remaining emissions from the compliance period (Regulation at §95855 and 95856). However, we expect these potential spikes in demand will be smoothed to some extent by regulated entities who elect to cover their full emissions each year rather than deferring to the true-up, and by financial intermediaries who purchase offsets in the intervening years for resale to entities who defer.

Considering these difficulties in predicting actual demand, we have used the theoretical maximum, understanding that actual demand may be less. Nonetheless, the supply shortage is significant enough that a shortfall seems likely even if actual demand is lower.

Offset Supply

The forecast uses industry expertise, publicly available data, and the Bass Diffusion Model to project offset supply. The Bass Diffusion Model provides estimated adoption rates of new technologies and products parameterized against hundreds of technologies and sectors. The widely studied model is the most popular method used in the marketing industry to predict adoption rates regardless of technology or product. It is a predictive model that forecasts future product adoption, even when no data exists for the specific product, by using a database of products that have similar characteristics. Assumptions and parameters are backed by a wide array of diffusion research across time.

For CP1, the model incorporates direct input through extensive interviews with project developers, offset buyers, and policy experts to estimate short-term offset supply. Projections for supply in CP2 and CP3 are shaped by projecting out from CP1 using extensively studied adoption rates of similar technologies and sectors. This blended approach provides projections for CP1 that are based on the current reality and specific to the carbon market, combined with estimated adoption rates for similar products parameterized by the Bass Diffusion Model to develop a medium term forecast.

The scope of this analysis includes the four ARB protocols, the four early action protocols, and four additional project types that have been discussed by the ARB (Coal Mine Methane, Low-bleed Pneumatic Valves, Rice Management and Fertilizer Management). REDD is not incorporated into the model. However, based on analysis completed by EDF (see EPRI, 2012), we conclude that emission reductions / offsets from REDD projects would close the supply shortfall by CP3 if REDD is brought into the compliance program.

Offset Forecast by Project Type

Approved ARB Protocols

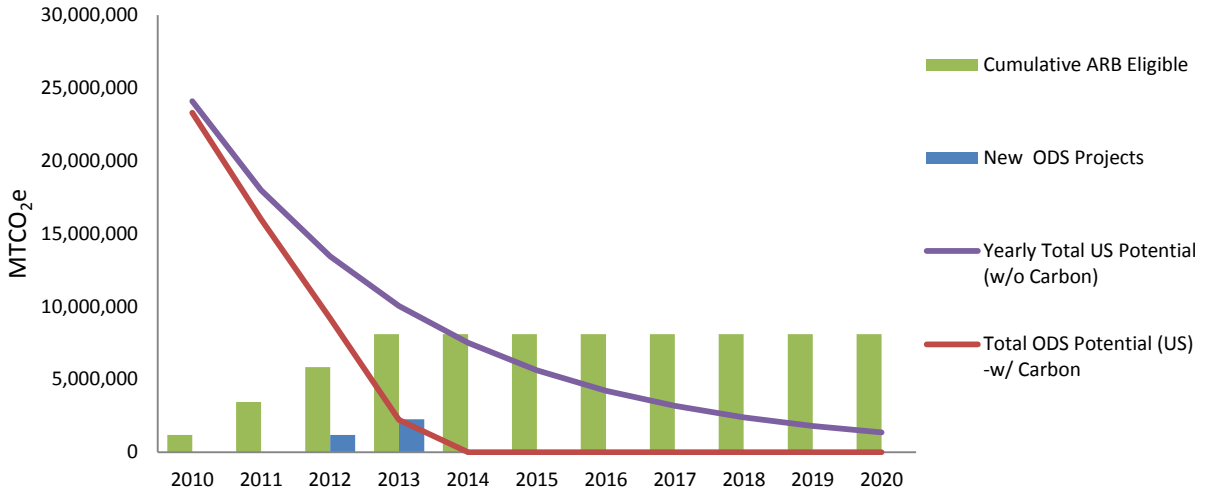
ODS

ODS gases provide a large GHG reduction opportunity because of their high global warming potential, ranging from 4,750 to 10,900. Prior to the 1989 adoption of the Montreal Protocol, ODS gases were used in products such as refrigerators, air conditioners, and foam insulation. The Montreal Protocol phased out the production and use of CFCs over a 20-year period. However, many products still contain ODS gases, which are often reused at the end of product life. The ARB compliance protocol for U.S. ODS projects includes the following ODS gases sourced and destroyed in the U.S.: CFC-11, CFC-12, CFC-13, CFC-113, CFC-114 and CFC-115 from refrigerants, as well as CFC-11, CFC-12, HCFC-22 and HCFC-141b from foam blowing agents.

The latest inventory data for these gases in the United States was completed in 2004. Despite reuse, significant GHG emissions result from the leakage of ODS gases from the equipment. The U.S. Environmental Protection Agency (EPA) and ICF Consulting developed industry-wide weighted average leak rates for different consumer goods (refrigerators, cars, foam insulation). According to the EPA, leakage rates are 15% to 25% per year (EPA, 2004). This indicates that the total potential of GHG reductions from ODS in refrigerants decreases at a rate of approximately 20% per year, meaning the window for ODS destruction is quickly closing. In 2004, the EPA estimated approximately 104 $MMTCO_2e$ in ODS available for destruction in the U.S. At the cited leakage rates, it is estimated that there will only be 13 $MMTCO_2e$ available for destruction by 2013. Under the baseline scenario (without ODS GHG projects), we estimate that by 2020, only 1.3 $MMTCO_2e$ will remain in appliances.

Of the four compliance protocols, ODS has generated the largest supply of eligible early action credits (4.6 $MMTCO_2e$ as of the date of this analysis with over 300,000 $MMTCO_2e$ retired). ODS refrigerant projects are relatively low cost and have the shortest project cycle (3-6 months) and therefore are likely to contribute significantly to offset supply in CP1. In 2011, 2.2 $MMTCO_2e$ of ODS gases were destroyed. Given these rates, it is expected that ODS can reasonably provide 32% (8 $MMTCO_2e$) of anticipated demand in CP1. The model forecasts that by CP2 the majority of ODS gases will either be emitted into the atmosphere or destroyed through carbon projects.

Figure 3: ODS Compliance Offset Credit Forecast



Livestock

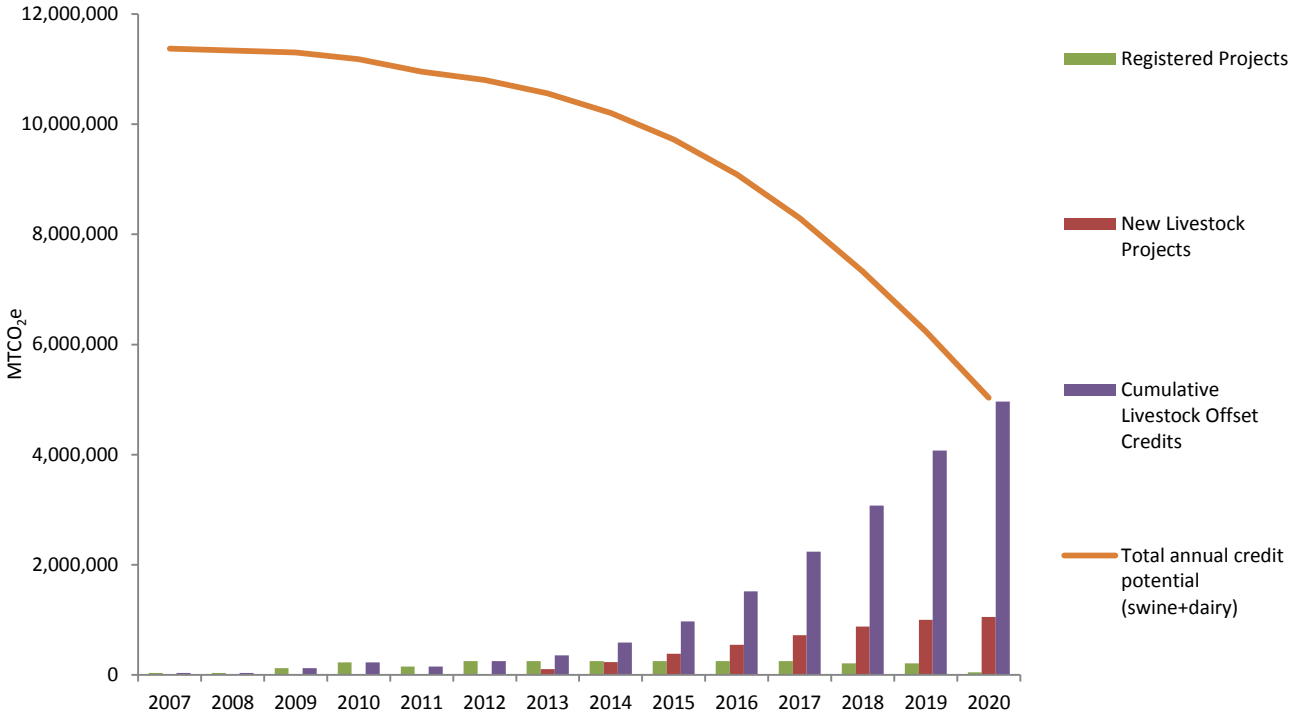
Livestock methane emissions are a significant source of U.S. emissions amounting to 37 $MMTCO_2e$ per year. The ARB compliance offset protocol is applicable to dairy and swine operations in the U.S. Despite large technical potential (11 $MMTCO_2e$/year), significant barriers exist in large-scale adoption of livestock manure digesters. Lenders have historically been wary of making loans for manure digesters for three reasons.

First, there is significant upfront capital cost (around $3.5M per MW capacity). Second, besides the electric generator, which represents about one third of the capital cost, the other two-thirds (concrete and other nontransferable assets) are not sufficient to cover the collateral required by banks. Lastly, low natural gas prices in non-net metering states lower incentives for digesters and, despite favorable project financials in states with net metering, the barriers to implementation are unlikely to change significantly until higher carbon prices are available (>$25/$MTCO_2e$). Nevertheless, third-party financing and livestock-specific loans are growing and such efforts will be key for the sector's growth.

The typical project development cycle for livestock projects is 12 to 18 months. As of July 2012, 26 livestock projects have been registered and are eligible for early action offset credits. Our analysis projected dairy and swine market size through 2020. We determined the GHG reduction potential per dairy or swine operation based on current early action U.S. livestock projects. Average dairy farm size is greater than 500 cows and average swine farm size is greater than 2,000 pigs. Digesters on dairy farms are on average producing 2.08 $MTCO_2e$ per year for each dairy cow. There is currently just one digester project on a swine farm that is producing 0.09 $MTCO_2e$ per year for each head of swine. Application of the Bass Diffusion Model forecasts 20% market penetration by 2020. Our projection looked at existing projects (average credit volumes per year forecast to 2020) and new projects using the Bass Diffusion model with parameters for technological adoption within the agriculture sector.

Despite a large theoretical potential, due to the above mentioned barriers and project risks we forecast that livestock projects will produce just 2.5% (0.55 $MMTCO_2e$) of the projected offset demand through CP1 increasing to 2% (4.05 $MMTCO_2e$) by 2020.

Figure 4: Livestock Compliance Offset Credit Forecast



Forestry

U.S. Forest projects represent the largest technical potential for GHG reductions in all compliance periods, amounting to 500-750 $MMTCO_2e$ by 2020. However, this project type has the highest forecast uncertainty. The transferability of technical potential to carbon credit potential is highly uncertain without a comprehensive national level land-use study.

In order to forecast the practical potential, projections for CP1 were obtained by industry analysis and interviews with project developers. Despite progress, scaling adoption is a challenge in CP1 due to the complexity of forestry projects. Post-2014, market projections of U.S. forest projects are based on the Bass Diffusion Model against technical potential. The Bass Diffusion Model projects 20% market penetration by 2020.

There are significant barriers and uncertainties that reduce the number of expected offsets from forestry, including acceptance by forest owners of liability for invalidation, and the difficulty of continually signing up willing landowners given the 100-year legal obligation to continue project activities. In addition, for early action projects implemented under CAR Forest Protocol v2.1 and 3.0 through 3.2, there will be a decrease in the number of ARB credits issued once converted to compliance offset credits, due to required buffer pool contributions / deductions and baseline re-calculation per Regulation §95990(i)(1)(D) and §95990(k)(1)(D). These reductions will be project-specific and are difficult to generalize, so in our model are applied a simple 20% discount.

In addition, our analysis of the currently available supply from early action forestry projects dating from 2005 does not account for the fact that some portion of these credits has already been retired and will not be available for compliance. As of September 2012, over 529,000 forestry CRTs have been retired on the CAR registry, which does not include early action offsets contracted with voluntary buyers for retirement, but not yet retired. Considering retirements to date, retirements contracted, and mandated discounts when early action forestry offsets are converted to ARB Offset Credits, the compliance-eligible early action supply will be significantly less than the 4.1 $MMTCO_2e$ issued to date.

The project types eligible for ARB Offset Credit issuance **are *Reforestation, Improved Forest Management (IFM), Conservation-based Forest Management*** (used in earlier CAR protocols, now called ***IFM***), ***Avoided Conversion,*** and ***Urban Forestry***. Typical project development times are 18 to 24 months.

Reforestation and ***Urban Forestry*** projects are not expected to produce significant offset credits prior to 2020. ***Reforestation*** projects have long lead times before the trees are large enough to produce material reductions, and there are no registered early action Reforestation projects to be transferred to compliance offset credits. With long lead times and no current pipeline, ACR does not forecast significant reductions from ***Reforestation*** projects prior to 2020. ***Urban Forestry*** will not produce significant offset credits due to unfavorable economics. Carbon prices are not expected to be high enough to make Urban Forest projects financially attractive prior to 2020.

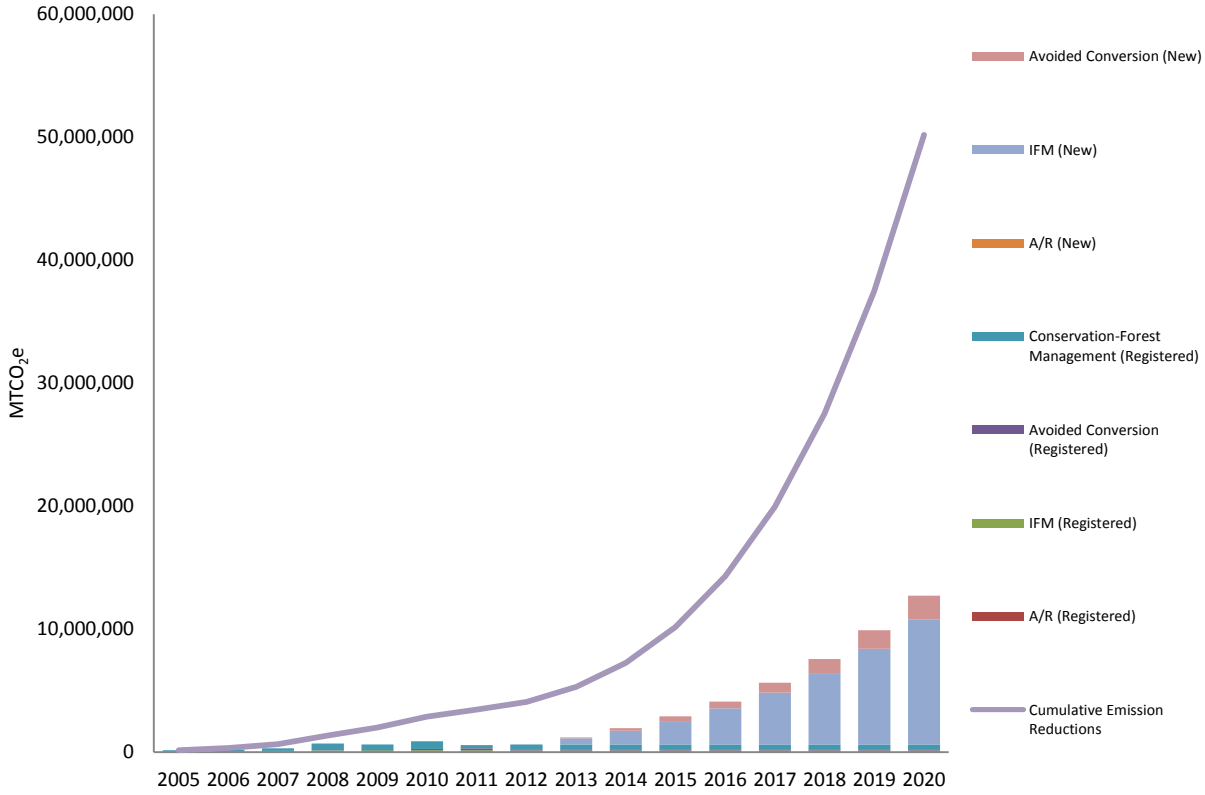
IFM is projected to produce 37% of the U.S. Forests offset credits for CP1 (2.8 $MMTCO_2e$). By 2020, ***IFM*** projects will account for 61% (36 $MMTCO_2e$) of the forest credit pipeline due to its favorable economics and relative ease of project development. Approximately 40% of the total ***IFM*** potential becomes financially viable with a $\$15/tCO_2e$ price and increases to 90% with a $\$30/tCO_2e$.

Conservation Forest Management (CFM) early action projects will account for 50% (3.8 $MMTCO_2e$) of forest credits in CP1 and 26% (15 $MMTCO_2e$) by 2020. Two large ***CFM*** projects registered on CAR are producing an average of 200,000 $MTCO_2e$ per year. However, the above-cited sections of the Regulation will require a reduction of ARB Offset Credits issued to these ***CFM*** projects, so less than the full *CFM* pipeline will be transferred to compliance credits.

Avoided Conversion (AC) projects will account for 13% (1 $MMTCO_2e$) of forestry credits in CP1 and 14% (8 $MMTCO_2e$) by 2020. On average, current ***AC*** projects are producing around 50,000 credits per year with one project that developed 160,859 credits in 2011. As with ***CFM*** projects, additional buffer pool contributions and adjustments to baseline quantification will need to be made in order for the CAR projects to be eligible for early action.

Reduced Emissions for Degradation and Deforestation (REDD) was not included in this analysis because of high uncertainties in timing and policy actions. However recent modeling by the Environmental Defense Fund (EDF) indicates that ***REDD*** projects can fill the compliance offset credit supply gap if accepted by ARB. Sector-based offset credits (including ***REDD***) from eligible developing countries are subject to sub-limit of 2% of compliance obligations for CP1 and 4% for CP2 and CP3, for a total maximum potential demand of around 100$MMTCO_2e$ between 2013-2020.

Figure 5: U.S. Forests Compliance Offset Credit Forecast



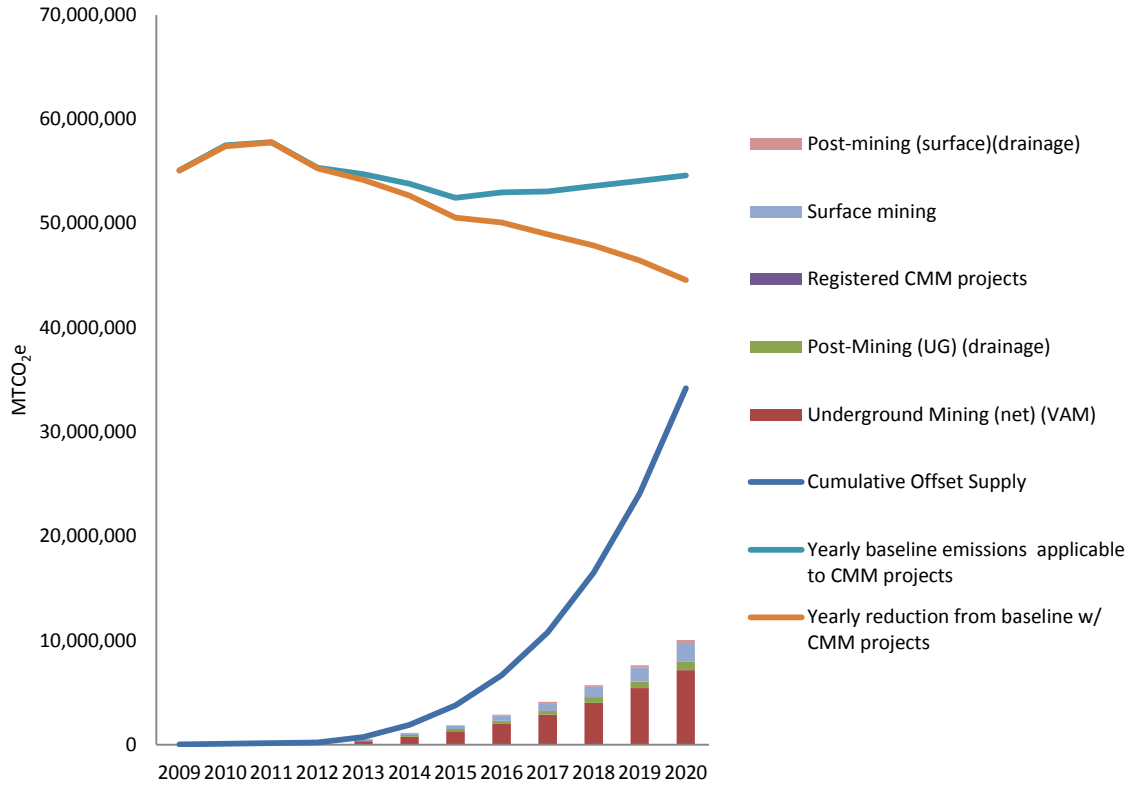
Additional Project Types

Coal Mine Methane (CMM)

CMM projects have a technical potential of around 70 $MMTCO_2e$ per year. However, several barriers will delay large-scale project development until after CP1. The eligibility of CMM project types (Abandoned, Drainage, Ventilation Air Methane -VAM, and Surface) is still unclear. Currently, the CAR protocol does not allow projects to be sourced from surface mines while the Verified Carbon Standard (VCS) protocol does. Additionally, the ownership of GHG reductions is not always clear due to complicated ownership structures for surface rights, mineral rights, etc. These issues will likely take time to resolve and it is not expected that a new ARB protocol will be accepted prior to mid-2013. Despite these issues, CMM represents an enormous opportunity. It is projected that CMM could deliver 7.6% (1.9 $MMTCO_2e$) of the anticipated demand in CP1 and increasing to 17% (34 $MMTCO_2e$) by 2020. Project development cycles average 12 to 24 months.

The forecast methodology used for CMM project supply looked at projected coal production through 2020 (EIA AEO2012), since methane emissions are directly associated with coal production. We determined eligibility of emission reduction types and projected net methane mine emissions through 2020 based on 2011 EPA data and AEO2012 projections. We assumed 70% from technical to real reductions in credits based on 95% VAM capture rate and projected project emissions. The Bass Diffusion Model was employed basing parameters on the low end of technological adoption.

Figure 7: Coal Mine Methane Offset Credit Forecast



Low-bleed Pneumatic Valves

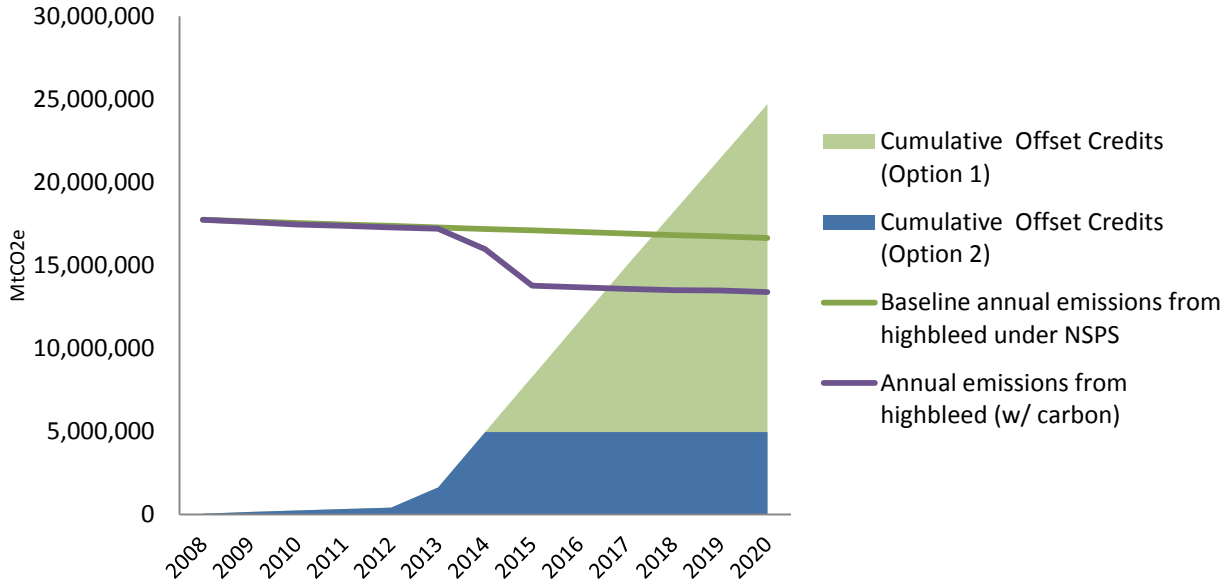
The fugitive emissions from high-bleed pneumatic valves in the U.S. oil and gas sector amount to 18 $MMTCO_2e$ per year. Each high-bleed device emits on average 56 $MTCO_2e$ compared with 3 $MTCO_2e$ per year for low-bleed devices that are readily available. The replacement of these high-bleed devices represents a significant GHG reduction opportunity in the short term at a low cost (less than $\$10/MTCO_2e$). Project development cycles are relatively short at 8 to 12 months.

Projects with a start date after 31 December 2014 would not be eligible for compliance offsets because oil and gas is included in the compliance program after CP1. However, the ease of project development ensures significant supply in CP1. Conversations with industry have confirmed that 20% market penetration by 2014 is realistic, which equates to offset supply of 5 $MMTCO_2e$ by 2015. Operational control of pneumatic devices is highly fragmented. However, an estimated 15 to 20% of the total potential is under the control of the major oil and gas companies. With a two-year project development outlook (2013-2014), it is expected that this segment of high-bleed devices can be replaced amounting to 20% (5 $MMTCO_2e$) of anticipated demand in CP1.

Two regulations directly affect the applicability of this project type. First, the oil & gas sector will be covered under the California Cap-and-Trade program in 2015. Therefore, new project development will not be eligible past CP1. Second, the EPA New Source Performance Standard (NSPS) requires that each pneumatic device be replaced with a low or no-bleed device. Despite NSPS requirements, pneumatic projects will continue to be additional through CP1 because the NSPS only applies to devices implemented or replaced after August 23, 2011.

This effectively leaves the entire high-bleed population of approximately 323,000 devices to continue to end of life (EOL). Additionally, with natural gas prices hovering at $2.50 to $3.00/mmbtu, operators have no financial incentive to reduce fugitive methane emissions. Thus, these high-bleed devices will continue to operate well past 2020 and will only be replaced if prematurely damaged. For these reasons, the NSPS will not change business-as-usual practices since current common practice is to replace high-bleed devices with low or no-bleed devices at EOL. Finally, because the applicability criteria of the pneumatics protocol do not allow credits from the replacements of EOL equipment, it is additional to replace high-bleed pneumatics with low- or no-bleed devices prior to EOL.

Figure 6: Low-bleed Pneumatic Valve Offset Credit Forecast

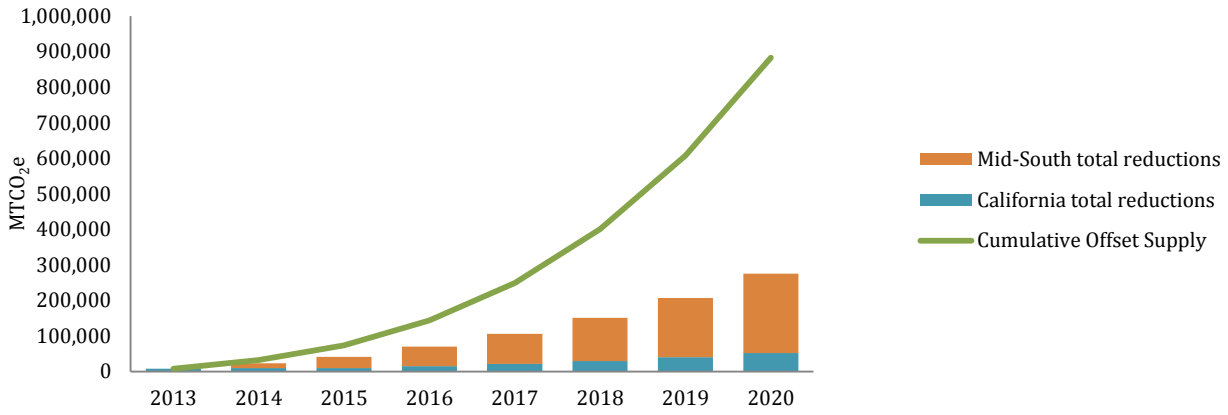


There are two potential options for crediting low-bleed pneumatic valve projects. Option one would allow new project development through 2014, granting of early action credits between 2005 and 2014, and a crediting period that extends through 2020. Under this option, the total potential offset supply would be 26 $MMTCO_2e$ by 2020. Option 2 would allow new project development through 2014, early action credits between 2005 and 2014, and a crediting period through 2014. The total potential offset supply under option 2 would be 5 $MMTCO_2e$.

Rice Management

The majority of rice in the U.S. is produced in California and the Mid-South (Arkansas, Texas, Mississippi, Missouri and Louisiana). Currently, CAR is the only registry with a published rice protocol, which is restricted to California, where the scientific measurements and modeling for GHG reductions from rice production is most advanced. A rice management protocol is also in the ACR approval process. Expected to be approved and published in early 2013, the ACR protocol is eligible in California and will expand project eligibility to the Mid-South. Pilot projects in California and Arkansas are currently under way; however we anticipate that most of the initial rice management projects will be in California. In the future, given the millions of rice acres in production in the Mid-South, we anticipate the majority of rice offset credits will come from the Mid-South region. Using the Bass Diffusion Model, we predict a gradual increase in uptake to 20% of California acres and 14% of Mid-South acres by 2020. A typical project development cycle for a rice management project is 12 months. With an average reduction of 0.5 $MTCO_2e$/acre, we project that 32,000 $MTCO_2e$ (0.1% of potential offset demand) will be generated for CP1 increasing to a total of 0.9 $MMTCO_2e$ (0.4% of demand) by 2020.

Figure 8: Rice Management Offset Credit Forecast

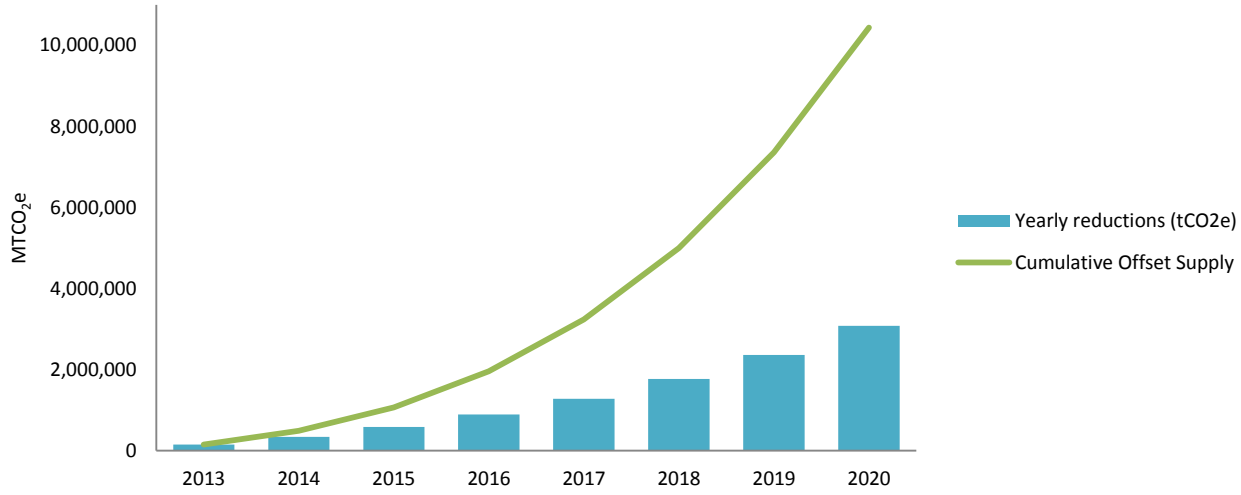


Fertilizer Management

ACR and CAR have published fertilizer methodologies. Both have methodologies that quantify changes in nitrous oxide (N_2O) emissions through changes in the rate of fertilizer application, and which are currently applicable primarily to corn in the Midwest. Another ACR published methodology quantifies changes in N_2O emissions from changes in the timing, placement and type of fertilizer.

Given the lack of data for quantifying N_2O reductions from a variety of crops, our model looked only at reductions from fertilizer management in corn production across the U.S. Using 2012 numbers we estimated 96 million acres planted U.S.-wide. Using conservative assumptions for uptake and per-acre reductions, our model forecasts 484,000 $MTCO_2e$ reductions in CP1 and 10.4 $MMTCO_2e$ cumulative reductions by 2020. A typical project development cycle for a Fertilizer Management Project is 12 months. We consider these estimates conservative because many other crops have significant potential for nitrogen use efficiency improvements, but are currently lacking sufficient calibration and validation data to model the associated N_2O reductions.

Figure 8: Fertilizer Management Offset Credit Forecast



Offset Supply from Quebec

Though California and Quebec's Cap-and-Trade programs are not linked, it is expected that this will occur within CP1. With the announcement that Quebec will accept three protocols into their Cap-and-Trade program, there will likely be additional supply to California from these projects, as the offset demand from Quebec will not match the demand generated within California.

The three project types that are eligible are ***Methane destruction from manure storage facilities*** (projects located in Quebec only)***, Methane destruction from small landfills*** (projects located in Quebec only)**,** and ***ODS destruction in Canada or in U.S. from appliance foam only***. Neither manure storage methane nor small landfills will produce a significant supply of offsets. Quebec estimates that manure methane has a total potential to produce 10 to 50,000 $MTCO_2e$ per year and small landfills can produce approximately 100,000 $MTCO_2e$ per year. Given that these are total potential estimates, even with a 50% market penetration rate, these two project types will not produce significant compliance offsets to alleviate the supply shortage expected in California for CP3.

ODS from foam on the other hand has the potential to provide a significant number of offsets. In the U.S. alone, there is a total market potential of 16 $MMTCO_2e$. Assuming that Canada has a similar amount of ODS gases trapped in foam, the total reduction opportunity is approximately 30 $MMTCO_2e$. However, foam ODS is more costly to access than refrigerant ODS sources because the ODS is trapped in the foam and the foam is geographically dispersed. In order for significant ODS destruction from foam to occur, carbon prices will need to increase significantly.

On the other hand, Quebec has announced that there will be no buyer liability for its offset credits, meaning that prices are likely to be slightly higher than for ARB Offset Credits, but potentially more appealing to buyers.

Conclusion

ACR's analysis forecasts a significant shortage of compliance offset credits in all compliance periods. This shortage assumes that entities will maximize their offset use. We do not attempt to assess actual demand for offsets or the level of offsets required for cost-containment. However, with a shortage of over two-thirds of the potential demand, we highlight the need for additional compliance offset protocols, to increase supply and as a cost-containment mechanism for the program. Without the adoption of additional protocols, we predict there will be additional cost pressure on compliance entities to meet their 2020 targets. Short supply of offsets will result in a higher overall cost of the program to California companies and residents, and could overwhelm the other cost-containment mechanisms ARB has built into the program, leading to market instabilities, price spikes, and increased public resistance. ARB could avert these shortages by moving swiftly in adopting additional protocols, including Low-bleed Pneumatic Valves, Coal Mine Methane, Rice Management, and Fertilizer Management, that can deliver real, additional, measurable, permanent, verifiable and enforceable reductions in CP1 and throughout the program.

Sources

ODS
EPA, *Analysis of Costs to Abate International Ozone-Depleting Substance Substitute Emissions,* 2004
Climate Action Reserve, *U.S. Ozone Depleting Substances Project Protocol: 2010*, 2010
ICF, *ODS Destruction in the United States of America and Abroad*, 2009

Livestock
USDA, Data + Statistics, 2012 (available: http://www.nass.usda.gov/Statistics_by_Subject/index.php)
EPA, *Market Opportunities for AgSTAR Biogas Recovery Systems at U.S. Livestock Facilities*, 2011 (available: http://www.epa.gov/agstar/documents/biogas_recovery_systems_screenres.pdf)
EPA, *Anaerobic Digestion Capital Costs for Dairy Farms*, 2010 (available: http://www.epa.gov/agstar/documents/digester_cost_fs.pdf)
Climate Action Reserve, *Project Database*, July 2012

Forestry
Brown S., et. al., *Terrestrial Carbon Sequestration in the Northeast: Quantities and Costs. 2007*
EPA, *Greenhouse Gas Mitigation Potential in U.S. Forestry and Agriculture,* 2005
EPRI, *Overview of Subnational Programs to Reduce Emissions from Deforestation and Forest Degradation (REDD) as Part of the Governor's Climate and Forest Task Force, 2012*
CBO*, The Potential for Carbon Sequestration in the United States, 2007*
Galik C., *Transaction Costs and Forest Management Carbon Offset Potential, 2009*
New Energy Finance, *Forestry Offsets – Paradox or Panacea?,* 2009.
Sohngen B., Brown S., *The influence of conversion of forest types on carbon sequestration and other ecosystem services in the South Central United States.* 2005, Ecological Economics.
Stavins R., Richards K., The Cost of U.S. Forest-based Carbon Sequestration, 2005, Pew Center on Global Climate Change
USDA, *Land Rent Values and Cash Rents,* 2009
Winrock International*, Baseline Greenhouse Gas Emissions for Forest, Range, and Agricultural lands in California, 2004*

Pneumatics
EPA, Lessons Learned from Natural Gas STAR Partners: Options for Reducing Methane Emissions from Pneumatic Devices in the Natural Gas Industry, 2006.
American Carbon Registry, *Project Database*, July 2012

Coalmine Methane
EPA*, Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 1999-2003*
EPA, Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 2002-2006
EIA, Annual Energy Outlook 2012
Verified Carbon Standard, *Project Database, July 2012*
Climate Action Reserve, *Project Database, July 2012*

Rice
Winrock International, Internal analysis, 2011