

5-2016

# Towards a Reduction in Methane Emissions from Natural Gas in California: A Policy Brief on the Short-lived Climate Pollutant Strategy

Samantha Caputo  
sacaputo@clarku.edu

Follow this and additional works at: [http://commons.clarku.edu/idce\\_masters\\_papers](http://commons.clarku.edu/idce_masters_papers)

 Part of the [Environmental Studies Commons](#), [International and Area Studies Commons](#), and the [Urban Studies and Planning Commons](#)

---

## Recommended Citation

Caputo, Samantha, "Towards a Reduction in Methane Emissions from Natural Gas in California: A Policy Brief on the Short-lived Climate Pollutant Strategy" (2016). *International Development, Community and Environment (IDCE)*. Paper 72.

This Research Paper is brought to you for free and open access by Clark Digital Commons. It has been accepted for inclusion in International Development, Community and Environment (IDCE) by an authorized administrator of Clark Digital Commons. For more information, please contact [celwell@clarku.edu](mailto:celwell@clarku.edu).

**Towards a Reduction in Methane Emissions  
from Natural Gas in California**  
A Policy Brief on the Short-lived Climate Pollutant Strategy

Samantha Caputo

MAY 2016

A Master's Research Paper

Submitted to the faculty of Clark University, Worcester,  
Massachusetts, in partial fulfillment of the requirements for  
the degree of Master of Science in the department of IDCE

And accepted on the recommendation of

Gregory Trencher, Chief Instructor

## **Abstract**

To prevent global warming from surpassing 2°C and minimize extreme weather events, action must be taken to combat greenhouse gases (GHGs) that pose a greater short-term threat. Short-lived climate pollutants (SLCPs) have a short lifespan paired with high global warming potentials in the atmosphere. By targeting SLCPs, short-term success in combating climate change will encourage long-term investment. The California Air Resources Board (ARB) has been tasked with developing a strategy to combat SLCPs pursuant to Senate Bill 605. The overall objective of this paper is to examine the policies ARB plans to implement to tackle methane emissions in the natural gas sector. Methods include secondary research, as well as a review of stakeholder comments and analysis of the Draft Strategy released in September 2015. As a result, the paper concludes that the Draft Strategy does not sufficiently address emissions from natural gas. In order to do so, policies promoting renewable natural gas, as well as mandating an upgrade to the natural gas infrastructure are necessary.

### **Key Words:**

Methane, Draft Strategy, Natural gas, California, Renewable Natural Gas, Fugitive Emissions, Short-Lived Climate Pollutants

## Academic History

Samantha Caputo

May 2016

Baccalaureate Degree: Global Environmental Studies

Clark University

May 2015

Baccalaureate Degree: Spanish

Clark University

May 2015

Occupation and Academic Connection since date of baccalaureate degree:

National Grid

Smart Energy Solutions Ambassador

August 2015- May 2016

Harvest Power Inc.

Governmental and Regulatory Affairs Intern

Summer 2015

## Table of Contents

<b>List of Tables and Figures</b> .....	<b>v</b>
<b>1. Introduction</b> .....	<b>1</b>
<b>2. Background</b> .....	<b>5</b>
2.1 Methane.....	5
2.2 Methane from natural gas.....	7
2.3 The Natural Gas Sector in California.....	10
<b>3. Methods</b> .....	<b>13</b>
<b>4. Findings</b> .....	<b>14</b>
4.1 Necessary Actions and Strategies.....	14
4.2 Analysis of SLCP Draft Strategy and Current Policy Framework.....	18
4.3 Stakeholder Reaction.....	23
4.4. Potential Barriers .....	26
<b>5. Policy Recommendations</b> .....	<b>32</b>
5.1 Command and Control.....	32
5.2 Emissions standards.....	34
5.3 Cap-and-Trade .....	36
5.4 Market Incentives .....	40
<b>6. Conclusion</b> .....	<b>42</b>
<b>List of References</b> .....	<b>44</b>

## **List of Tables and Figures**

Table 1: Natural Gas Demand in California by End Use from 2010 to 2012.....	16
Table 2: Methane Mitigation Technology Categories .....	21
Figure 1 California Methane Mitigation Industry Compared to Locations of Methane Incidents.....	22
Figure 2 California 2013 and 2030 Methane Emission Sources.....	25
Figure 3 RNG Cost Estimates by Feedstock.....	36

## **1. Introduction**

Climate impacts and extreme weather events are increasing in frequency and magnitude with the possibility of soon reaching tipping points, which will result in catastrophic climate change. Impacts from ongoing climate change are appearing sooner and are increasingly more damaging than the most extreme scenarios depicted in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report from 2007 (Zaelke et al. 2012). Compared to long-lived climate pollutants such as carbon dioxide (CO<sub>2</sub>), short-lived climate pollutants (SLCPs) pose an immediate threat to climate change and global warming due to their relatively short lifespan paired with high global warming potentials (GWP<sub>s</sub>) in the atmosphere. Therefore, there is an urgency to tackle SLCPs to see immediate reductions in greenhouse gases (GHGs) in the atmosphere with hopes slowing climate impacts. This speed matters profoundly in order to prevent extreme climate events and warming over 2°C. Mitigating actions and policies are needed to slow the accelerating rate of global and regional warming and to strengthen GHG reduction goals for future generations. Currently, there is a lack of policy directly addressing SLCPs, particularly methane emissions. Policies that do exist are not comprehensive enough to tackle growing emissions by SLCPs. This poses a threat to the future stability of the climate and society. By implementing policy that addresses SLCPs, results will follow swiftly which will increase the drive to address CO<sub>2</sub> emissions. Success with CO<sub>2</sub> and SLCPs is necessary to have a reasonable probability of limiting global warming to 2°C through 2100 compared to pre-industrial levels (Zaelke et al. 2012). California is taking the initiative to lead the

United States down the path to address SLCPs by developing a strategy to combat these emissions within the state.

The California Air Resources Board (ARB) has been tasked with developing a strategy in 2015 that will achieve deep reductions in short-lived climate pollutant emissions (40% below 1990 levels) by 2030 to meet future greenhouse gas (GHG) emissions targets and air quality goals (CARB 2015). SLCPs include black carbon, fluorinated gases, and tropospheric ozone and its precursors such as methane (Zaelke et al. 2012). The final draft of this strategy had not been released at the time of this policy brief; therefore the analysis and recommendations made are based on the draft SLCP Reduction Strategy (Draft Strategy) released in September 2015. This draft was developed pursuant to Senate Bill 605 (Lara, Chapter 523, Statutes of 2014) that requires ARB to develop the plan. The Draft Strategy lays out current policies being used to address SLCPs and potential policies and mitigating actions that can be implemented to further reduce emissions and enable California to reach its reduction goals.

It has become widely understood that global action is the only way to immediately slow global warming through cost effective technologies, policy, and strategies with best management practices. California has particularly felt the impacts of climate change through extreme drought, historic temperatures and wildfires, and the current lifestyle is threatened by the continued rise in GHG emissions and rising sea levels (ARB 2015). The strategy developed by ARB focuses on SLCPs because cutting these emissions on a global scale will immediately slow global warming and mitigate the impacts of climate change. SLCPs are much more potent than CO<sub>2</sub>, hence, while it is important to continue to reduce



CO<sub>2</sub> emissions for future generations, to realize changes in this lifetime, SLCPs provide an answer due to their shorter lifespan in the atmosphere. For that reason, the strategy must be innovative, feasible and align with the current policy framework. Many associations and companies that commented on the Draft Strategy also support an integrated strategy. The strategy should be a model other states and countries can use for their own reduction goals of SLCPs that continue to follow California's lead.

In light of this situation, the primary purpose of this paper is to evaluate the Draft Strategy released by ARB to determine what mechanisms the agency plans on using to address methane emissions. Specifically it will seek to answer these questions:

- 1) What kinds of strategies or actions are needed to reduce climate change impacts of fugitive methane emissions from natural gas production and distribution?
- 2) To what extent does the Draft Strategy address fugitive methane emissions in the natural gas industry?
- 3) How did key stakeholders from the natural gas sector respond to the Draft Strategy?
- 4) What are the barriers to implementing policy to promote RNG and combat fugitive emissions in the natural gas sector?

Particularly, this paper will examine the policy actions ARB plans to implement targeting the natural gas sector. By looking at the Draft Strategy and comment letters sent in by various stakeholders in the natural gas sector of California, the paper will then make

various policy recommendations. These recommendations will be based on the depth in which ARB address fugitive methane emissions from natural gas, as well as the concerns of stakeholders in the industry.

## **2. Background**

### **2.1 Methane**

After carbon dioxide, methane is the second largest contributor to anthropogenic climate change. In order to prevent global warming from increasing over 2°C relative to pre-industrial temperatures in the near future, it is vital to decrease methane emissions whilst also tackling CO<sub>2</sub>. Anthropogenic sources of methane emissions result from a range of energy-related sources including leakage from oil and gas facilities or coal mines, and from incomplete combustion of biomass and fossil fuels as well as from agriculture and poor waste management (Smith, K. et al. 2009). According to the Environmental Protection Agency (EPA), natural gas and petroleum systems account for 29% of methane emissions in the United States (EPA 2015), which is the second largest anthropogenic source of GHG emissions. Atmospheric concentrations of methane have increased by nearly 152 percent since pre-industrial 1750, from about 700 ppb to 1,762 – 1,893 ppb in 2012 (Weitz, 2015). This increase is significant because methane is significantly more potent than carbon dioxide in the atmosphere. Methane has a lifespan of 12 years in the atmosphere with a global warming potential (GPW) of 28 over 100 years and 72 over a 20-year timespan (EPA 2015). Therefore, for near-term results in mitigating climate change, it is imperative to reduce emissions of methane and implement policy that directly targets this greenhouse gas. Current policy mechanisms in California, like the Cap-and-Trade program, focus on CO<sub>2</sub>e when measuring the reduction in greenhouse gases. In order to significantly reduce methane, policies are needed that measure methane alone.

Methane also contributes to ozone (O<sub>3</sub>) levels in the troposphere through photo-

oxidation of CH<sub>4</sub> and Carbon monoxide (CO), which leads to the production of O<sub>3</sub> (Dentener et al. 2005). Ozone is a powerful SLCP and contributes to poor air quality and negatively impacts human health, leading to asthma attacks, hospitalization and premature death (Dentener et al. 2005). According to ARB, about two thirds of the global rise in tropospheric background ozone can be attributed to methane emissions (ARB 2015). This is significant because ozone also affects evaporation rates, cloud formation and precipitation levels and California is experiencing extreme drought and record temperatures. Therefore, through methane emission reductions, a decrease in ozone will result and improve air quality everywhere, while also reducing global warming potential. This will provide additional climate and health benefits.

Currently, methane is responsible for about 20% of current global warming, and its emissions continue to increase in California and globally (ARB 2015). ARB recognizes that California relies on natural gas for energy supply, accounting for 54% of total energy in March 2015 (CARB 2015). Therefore, to accommodate the usage of natural gas, it is critical to increase supply of renewable natural gas and minimize fugitive emissions of methane from the natural gas infrastructure. Renewable natural gas (RNG) is a biogas, which can be captured at landfills, wastewater treatment plants, commercial food waste facilities, and agricultural operations, treated, and then used as a renewable energy source to displace fossil fuel consumption (ARB 2015). RNG reduces methane pollution from natural gas and eliminates it from organic waste, while also reducing the carbon intensity of the energy sector by subsidizing it for direct use natural gas in homes and offices. RNG is carbon neutral, but can also be a carbon-negative fuel when the feedstock is waste

organics, which offsets carbon-positive fossil fuels in addition to replacing them.

California has adopted policies that promote biogas, but lacks a mechanism that ensures the long-term growth of the market. Therefore, it is important to develop a strategy that will expand the biogas market to drive down costs and become self-sustaining. (CARB, 2015)

## **2.2 Methane from natural gas**

The burning of natural gas instead of fossil fuels such as coal offers important and immediate benefits towards climate change mitigation. These benefits include reduced air and water pollution, minimal smokestack carbon emissions, less power plant water use, greater flexibility of the power grid, and economic growth in areas of the country with large natural gas deposits (Deyette 2015). However, these benefits lose their value against the risks of fugitive emissions associated with natural gas (Brandt et al. 2014, Deyette 2015). While smokestack emissions from natural gas combustion contain significantly less CO<sub>2</sub> than coal combustion, the leakage of methane, which is 34 times stronger than CO<sub>2</sub> at trapping heat over a 100-year period, creates a new threat.

Fugitive methane emissions from the oil and gas industries are among the largest anthropogenic sources of methane in the United States. In 2013, natural gas accounted for 27.5% of energy consumption in the United States and is broadly consumed in all end-use sectors, except transportation (Weitz 2015). The U.S. Energy Information Agency (EIA) projects production levels of natural gas in the U.S to increase by 56% between 2010 and 2040, with emissions rising by 5% by 2018 (EIA 2014, ICF International 2014). Methane is the primary component to natural gas and is therefore emitted during the entire lifecycle

(Weitz 2015). Drilling and extracting natural gas from wells and transporting it in pipelines also results in the leakage of methane.

Methane emissions from the three stages of the natural gas supply chain can be broken down into three categories. “Downstream” emissions result from storage systems and transmission and distribution pipelines, while “upstream” emissions are from leaks and emissions at the well site, and “midstream” during processing the gas (Howarth et al 2012). There are two types of emissions that result from these stages. Fugitive emissions are unintended leaks throughout the system, while there is also an intentional release of methane as a matter of mechanical operation from equipment designed to emanate emissions (venting) (Stokes et al. 2014). The natural gas infrastructure is designed to channel substances that we can’t fully control. For instance, water eats away at pipes, sewage clogs and bursts them, and gas inevitably escapes. In addition, pipelines rupture, mechanical failures occur, and old pipes crack (Stokes et al. 2014).

Preliminary studies and field measurements show that fugitive methane emissions range from 1 to 9 percent of total life cycle emissions (Stokes et al. 2014). This presents an economic challenge for the natural gas industry because up to 10% of natural gas is lost to the atmosphere before reaching the end consumer, costing the industry billions of dollars each year in lost revenue (ICF International 2014). This is also a climate concern since it is better to burn methane and create CO<sub>2</sub> as a side product than it is to vent pure methane in the atmosphere. Therefore, it is essential to find ways to reduce this loss through methane mitigation projects and policies. ICF International has found that full industry adoption of methane mitigating technologies in the United States could result in an estimated 40%

reduction of methane emissions, which in turn would save the U.S economy and consumers at least \$100 million each year by preventing fugitive methane emissions (ICF International 2014). By saving the industry this much in lost costs, the net costs of reducing fugitive and vented methane emissions will be limited, if not negative, resulting in a net benefit greater than costs.

However, the US Department of Energy predicts that the major use of shale gas over the next 23 years will be needed to replace conventional reserves of natural gas as these become depleted. This poses a threat to water and air quality in communities surrounding the extraction sites by leakages in groundwater. In principle, hydraulic fracturing can create cracks thousands of feet underground, connecting shallow drinking-water aquifers to deeper layers, which provides a pathway for fracturing chemicals and formational brines to migrate upward and contaminate the water (Jackson et al, 2014). In addition to drinking water, wastewater is another concern. Oil and gas operations in the United States produce 2 billion gallons of wastewater per day and of this waste commonly is injected deep underground or sent to a facility for desalination and reuse (Jackson et al, 2014). It is vital to isolate wastewater from groundwater and surface water.

Methane emissions associated with shale gas and other unconventional gas are greater than conventional gas, which means that this will increase the methane emissions from the US from the natural gas industry in years to come (Howarth et al, 2012). Therefore, to meet emissions reductions goals, not only will the industry have to look towards methane mitigation technologies, but also renewable natural gas as an alternative to conventional

natural gas. The benefit to RNG is that it can be sourced through the same pipeline as natural gas, therefore avoiding the burden of developing a new infrastructure.

### **2.3 The Natural Gas Sector in California**

The natural gas sector in California is sizable where it is used in the residential, industrial, commercial and electric sectors, with only a fraction used as a transportation fuel. California's use in natural gas continues to grow, using more than two trillion cubic feet of natural gas per year (Levin et al. 2014). California also has around 215,000 miles of natural gas transmission and distribution pipelines, 25 compressor stations, and 25,000 metering and regulating stations (ARB 2015). Over the past decade, demand in all sectors except electric power generation remained relatively flat in large part due to energy efficiency measures, but demand for power generation rose about 30 percent between 2011 and 2012 (CEC 2015). The natural gas sector in California fluctuates depending on the season, where the demand increases in the winter for heating and in the summer to generate electricity for cooling. Therefore, as this demand increases, the need for more natural gas fired power plants increases, as well as the infrastructure to support demand. This is due to the rebound effect, meaning that while energy efficiency measures have steadied demand in the electricity sector, behavioral and systematic responses eventually offset the beneficial effects of the new technology or measures taken. The table below shows the natural gas demand in California by end use between 2010 and 2012.

**Table 1: Natural Gas Demand in California by End Use from 2010 to 2012**

Natural Gas Demand by End Use (Bcf/y)	2010	2011	2012



Residential	509	519	485
Commercial	199	201	201
Industrial	548	559	577
NG Vehicle	18	16	17
Electric Power	922	796	1032
<b>Total Natural Gas Demand</b>	<b>2,196</b>	<b>2,091</b>	<b>2,313</b>

Source: CEC 2015

This table clearly shows the increased demand for natural gas to produce electricity in 2012, while the other sectors remained relatively the same, and the overall demand only slightly increased. The fluctuation between 2010 and 2012 is due to the fact that natural gas is a dispatchable resource that can provide load when other energy resources, like hydroelectric, decrease (CEC 2015). This plateau will not last though. In early 2012 the San Onofre Nuclear Generation Station (SONGS) took two of their units offline and in June of 2013, Southern California Edison Company made the decision to permanently close SONGS (CEC 2015). In order to meet current energy demands with SONGS decommissioned, California looked to natural gas to fill the gap. In 2013, California accounted for half of all the new natural gas power generation in the United States (Levin et al. 2014). Natural gas is used to accommodate the intermittency of renewables with California's aggressive goal to reach 40% renewable energy by 2025, as well as start to replace coal-fired power plants (Kennedy et al. 2014). Natural gas also presents an opportunity in California to replace diesel fuel because it is a cleaner alternative.

The downfall of the natural gas industry in California is that most of its gas is imported, which leaves California vulnerable to market manipulation. There are also public

health and environmental impacts caused by natural gas in California. While natural gas is a cleaner fuel option, it accounts for 90% of GHG emissions in the electricity sector, and roughly a quarter of all GHG emissions in California per year at about 125 million tons of carbon dioxide equivalent (Levin et al. 2014). The exploration, drilling and combustion of natural gas also contribute to negative public health and environmental impacts, which the industry is very aware of. Southern California Gas Company (SoCalGas) warned state utility regulators in 2014 of “major failures” in storage wells for natural gas, along with incapability to pay for comprehensive inspections of all 229 storage wells (Groom 2016). SoCalGas also stated that twenty-six of its wells were “high risk” and should be abandoned, even though they complied with state regulations (Groom 2016). Another state utility, Pacific Gas & Electric also pointed out that there is an absence of state regulation that account for safety standards for storage wells (Groom 2016). A storage well can comply with state regulations, but be completely unsafe and pose significant health and environmental threats if there is a rupture or leak. Therefore, while its smokestack emissions are cleaner than diesel and gasoline, it has limited benefits due to its fragile infrastructure that allows for fugitive emissions.

### **3. Methods**

The study originated from previous work conducted by the author at Harvest Power Inc., a market leader in anaerobic digestion at the intersection of waste, agriculture and energy. Work carried out during this internship included developing a proposal for California Air Resources Board after the release of their SLCP Concept Paper in May 2015. The proposal focused on methane emissions and developing recommendations for the strategy that would enable to growth of anaerobic digestion in California, therefore setting the platform for Harvest Power to grow. This study is a continuation of the proposal examining the Draft Strategy released in September 2015, after work with Harvest Power was completed for the summer. After the preliminary work was completed over the summer of 2015, the focus of this proposal shifted from anaerobic digestion and landfills to the natural gas sector.

The approach of this study is a policy brief with a focus on secondary research applicable to the Draft Strategy. Data related to methane emissions from natural gas production in California was collected from online resources, as well as comment letters sent in as a response to the Draft Strategy from different stakeholders. After the research was complete, an analysis and critique of the Draft Strategy was completed. Through this analysis, numerous policy recommendations are made for ARB to consider moving forward.

## **4. Findings**

### **4.1 Necessary Actions and Strategies**

This first section examines various strategies and actions that can be used to reduce the climate change impacts of methane emissions from natural gas. Such strategies include improving the infrastructure, using the current cap-and-trade program to develop economic incentives, using anaerobic digestion, and developing a RNG market through the use of a command and control mechanism.

An important step in mitigating methane emissions from natural gas is to improve the infrastructure. More than 38% of the pipes in SoCal Gas's territory are more than 50 years old and over 16% of their pipes are made from corrosive and leak-prone materials (EDF 2016). In order to improve the natural gas infrastructure to prevent fugitive emissions, California should take advantage of the growing methane mitigation industry in the state by outsourcing the work from utilities to the private sector. The methane mitigation industry will boost economic development and create a job demand for an industry with a median hourly wage of \$30.88, compared to \$19.60 for all U.S. jobs (Stokes et al. 2014). This industry includes eight types of methane mitigation technologies and categories, as listed in the table below. It is cost effective for oil and gas companies to outsource leak detection and repair (LDAR) services instead of spreading their resources thin. By using specialized services, companies are able to reduce methane emissions by up to 60% (ICF International 2014).

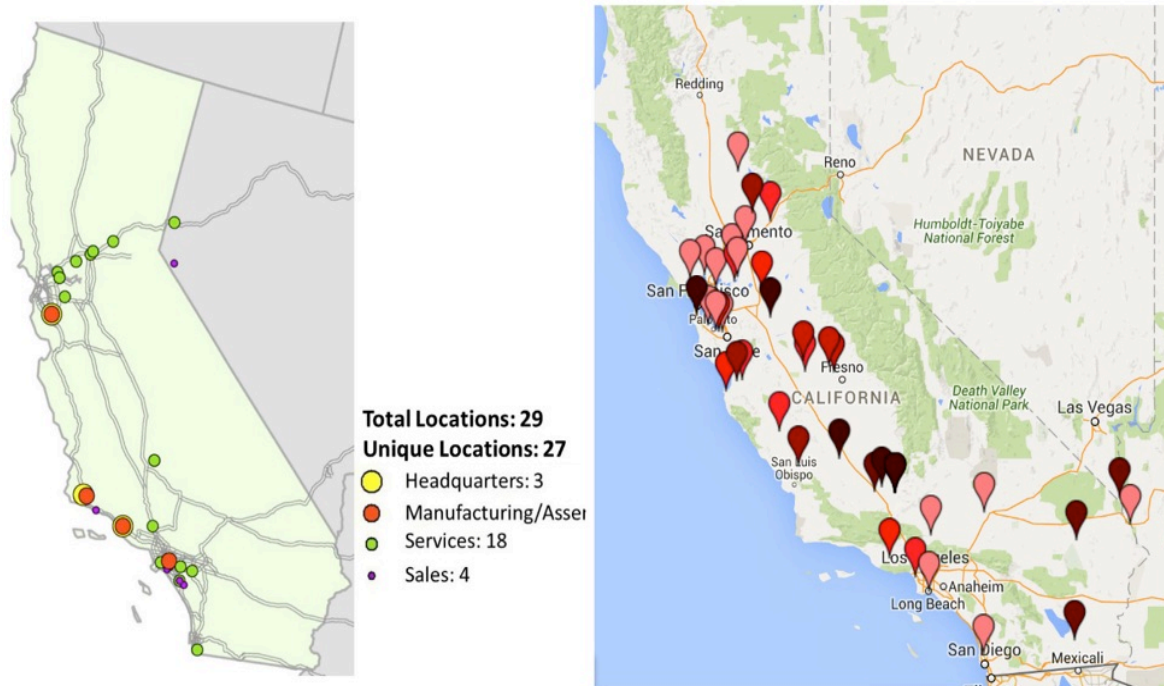
**Table 2: Methane Mitigation Technology Categories**

<b>Technology</b>	<b>Supply Chain Segment</b>	<b>Source of Emission</b>
Leak Detection	All	Leaks
Rod-Packing and Dry Seal Replacement	All	Compressors
Low-Emissions Valves	All	Valves
Low/No-Bleed Pneumatic Controllers	All	High-bleed pneumatic devices
Solar and Electric Pumps	Production & Processing	Pneumatically driven pumps
Reduced Emissions Completions	Production	Well completion
Vapor Recovery Units (VRUs)	Production & Processing	Vent lines and storage
Plunger Lifts & Velocity Tubing	Production	Liquids unloading

Source: Stokes et al. 2014

These technologies target all of the sources of fugitive methane emissions within the system. In addition, there are 29 companies working in methane mitigation in California. The map below shows where the companies are located compared to where major methane incidents have occurred since 2010. They are centrally located around San Francisco, Sacramento and Los Angeles. These industries are located in densely populated areas with access to major sections of the supply chain, and it is clear that California needs to take advantage of this connection.

Figure 1 California Methane Mitigation Industry Compared to Locations of Methane Incidents



California has a statewide Cap-and-Trade program that is an important policy mechanism for ARB to consider. The Cap-and-Trade program, adopted by ARB on October 20, 2011, will assist in developing economic strategies through the offset credits that will encourage RNG project development. The rule first applies to large emitters, like power plants and industrial plants, which emit 25,000 metric tons of CO<sub>2</sub>e per year or more. As of 2015, the rules also apply to small emitters, such as fuel distributors, including distributors of heating and transportation fuels (C2ES 2014). Natural gas is used for space and water heating; therefore these distributors will fall under the program. Therefore, ARB's could consider this market mechanism as a tool when developing a strategy to combat methane emissions.

The use of anaerobic digestion is a necessary strategy in order to increase the production of RNG and produce a steady input within the natural gas pipeline system. Anaerobic digestion can be used to produce RNG that can be directly pumped into the pipeline system in California. Biomass feedstocks such as purpose-grown fuel crops, agricultural, forestry, and municipal waste products can be converted into decarbonized RNG (E3 2014). One of the most efficient forms of anaerobic digestion is co-digestion at wastewater treatment plants (WWTPs) because they have the infrastructure already in place to process wastewater. This in-vessel processing can also take in food waste, and with the higher calorie intake more biogas will be produced in the system (CalRecycle 2013). Through the anaerobic digestion process, a bacterial digestion of biomass occurs in an environment without any oxygen, which produces a methane-rich biogas that can be injected into a pipeline line after the removal of impurities (E3 2014). Anaerobic digestion of organic waste will produce a biogas with a carbon intensity of negative 15 grams CO<sub>2</sub>e per megajoule energy and wastewater biogas has a carbon intensity of 7.89, both of which are substantially lower than natural gas at 68 (Levin et al. 2014). Therefore, anaerobic digestion of food waste to produce renewable energy will reduce GHG emissions throughout the entire cycle, from preventing methane emissions from landfills to injecting RNG into natural gas pipelines. The GHG emission reductions from these activities are due to the avoided landfill emissions, displacement of natural gas with biogas, and the reduction of synthetic fertilizer and water usage (CalRecycle 2013).

Developing a renewable natural gas market is another strategy that will help shift the State's priorities towards the natural gas sector. The Renewable Portfolio Standard

(RPS) includes biogas for electricity, but the RPS does not focus on renewable natural gas. In order to create a focus on RNG, California needs a command and control mechanism. A Renewable Gas Standard (RGS) would work as such a mechanism. This would require utilities to sell a certain amount of RNG, which would create a demand for RNG development projects and create a market. It is important to consider these types of strategies and actions when developing policy recommendations for the inclusions of methane mitigation from natural gas in the SLCP strategy.

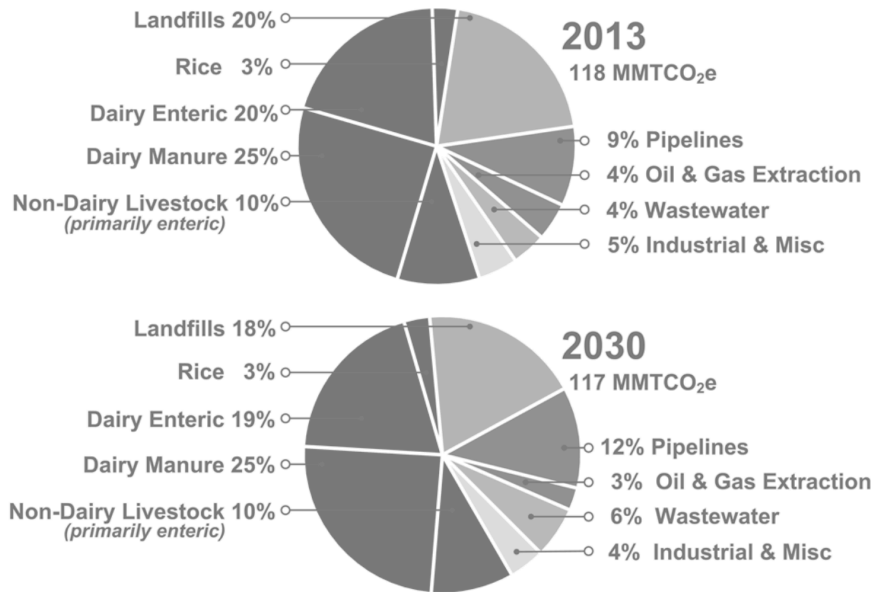
#### **4.2 Analysis of SLCP Draft Strategy and Current Policy Framework**

This section considers the extent that the Draft Strategy and current policies address methane from natural gas. California's approach to reducing SLCP emissions includes prioritizing actions with diverse benefits. The Draft Strategy tackles black carbon, F-gases, and methane by identifying practical solutions to overcome barriers, particularly financial ones. Additionally, it works on advancing the science of SLCP sources and emissions to better combat them, as well as developing programs that are centered on SLCPs, unlike the current Cap-and-Trade program. The goal for reducing methane emissions is 40% by 2030, and one of the main approaches in mitigating methane emissions includes putting organic waste to beneficial uses (ARB 2015). It is understood that in California, agriculture represents the largest source of methane emissions, with landfills accounting for the second largest source, followed by pipeline leaks, oil and gas extraction, wastewater and other industrial sources. The figure below from the Draft Strategy shows the breakdown of emissions from 2013 compared to projected sources of methane emissions in 2030. This is significant because it shows pipelines increasing their



share of emissions, while overall emissions are only projected to go down by 1MMT $\text{CO}_2\text{e}$ .

Figure 2 California 2013 and 2030 Methane Emission Sources (ARB 2015)



While methane from natural gas in California is not a major contributor, it is still important to reduce these emissions and provide California with the opportunity to produce RNG instead of importing natural gas. The fact that California imports almost all of its natural gas is the reason this sector contributes so little to the methane emission sources, but with increased demand on the pipeline system and without regulations that repair leaks, it is inevitable that emissions from this sector will increase. This is especially true as ARB is looking towards natural gas to replace diesel fuel for trucks and heavy-duty vehicles. The Draft Strategy notes that while California increases its input of RNG, hydrogen, and other cleaner fuel options, ARB must take the steps to ensure there are minimal methane leaks from these new facilities (ARB 2015). To do so, ARB plans to fund research to determine high-risk emitters of methane in the oil and gas sectors, but once these sources

are identified, it is important for ARB is have either a market incentive or a command and control policy in place to ensure these emitters take the required action to reduce their emissions.

California has taken numerous steps to reduce methane emissions from agriculture and organic waste streams that are sent to landfills, but more needs to be done to capture methane so it can be sourced as RNG for power plants, buildings, vehicles and industrial operations to use. The Draft Strategy outlines numerous recent legislative and regulatory actions that will further the reduction of methane from these sectors. These actions prioritize diverting organic waste from landfills and incentivizing the use of biogas for transportation fuel, pipeline injection and electricity generation (ARB 2015).

The current policy framework does not sufficiently target the natural gas sector to realize any significant reduction in methane. While there is current legislation requiring the use of biogas in the electric sector of energy use, there is not a single piece of legislation focusing solely on emissions from natural gas. Senate Bill 1122 (Rubio, Chapter 612, Statutes 2012) ordered the California Public Utility Commission (CPUC) to require investor owned utilities (IOUs) to develop a 10 to 20 year market price contract to secure an additional 250 megawatts of electricity generation from biogas (ARB 2015). This is a part of the California Renewables Portfolio Standard (RPS), which, under executive order S-12-08, has set the goal for California to reach 33% renewable energy sources to 2020 (CEC 2015). This legislation, while bringing biogas into the RPS, will not ensure the continued growth of the market due to the availability of other renewable energy resources and the set numerical target.

The Low Carbon Fuel Standard (LCFS) was developed pursuant to Assembly Bill AB 32 and the Governor's Executive Order S-01-07, and will help promote RNG for the transportation sector (LCFS 2007). The LCFS require the transportation sector to provide clean fuels to reduce the carbon intensity of California's Fuel mix (LCFS 2007). Biogas will also qualify for Renewable Identification Number (RIN) credits under the U.S. EPA Renewable Fuel Standard 2 (ARB 2015). This provides two incentives to develop RNG for the transportation sector. In addition, ARB has identified RNG from the anaerobic digestion of organic waste as the lowest carbon intensity pathway for California to pursue. ARB is also considering dairy-derived biogas as another LCFS pathway option (ARB 2015). Currently, RNG is not being considered as a low carbon intensity fuel to replace traditional gasoline; therefore, if the LCFS identifies RNG as an acceptable pathway, it will encourage the growth of RNG for transportation.

Assembly Bill 1257 (Bocanegra, Chapter 749, Statutes of 2013) will prove useful for the future of RNG in California as it directs CEC to assemble a report, starting this past November 2015, every four years to identify ways to maximize the benefits of natural gas (ARB 2015). This is beneficial for RNG because the report is required to examine low emission resources such as biogas and biomethane, as well as infrastructure and storage needs and pipeline and system reliability (AB 2015). Therefore, as policies are implemented that promotes the growth of RNG or the infrastructure and pipeline concerns, this report will be able to examine and report on its success or failures. The 2015 report has a very short section on biogas and biomethane in California that explains where it comes from, as well as in what ways it can replace natural gas (Brathwaite et al. 2015). In order to

see an outlook section on this in the next report due in 2019, policies must be developed that will make RNG a feasible option for California.

In the United States, California has the most stringent standards for limiting methane emissions from landfills. Currently, under ARB's Methane Control Measure, all landfills in California are required to have gas collection and control systems to reduce methane emissions from municipal solid waste landfills (ARB 2015). This measure still allows for organic waste to be disposed of in landfills, but the Legislature has taken additional steps under AB 341 (Chesbro, Chapter 476, Statutes of 2011) that sets a target to reduce solid waste sent to landfills by 75% by 2020 via practices such as recycling, composting, and source reduction practices (ARB 2015). The Draft Strategy calls for banning the disposal of organic waste from landfills and diverting them to beneficial uses (ARB 2015). Aiding in this initiative is AB 1826 (Chesbro, Chapter 727, Statutes of 2014) that requires businesses generating a certain amount of organic waste to divert those wastes from landfills beginning in 2016 (AB 2015). These initiatives serve as the first step needed to create a substantial source of RNG, but California still needs policy that will encourage the anaerobic digestion of waste to create RNG instead of composting, or other less costly options.

The current measures California is taking to reduce methane will not be enough to meet the State's goal of reducing GHG by 40% below 1990 levels by 2030. In order to meet this goal further action needs to be taken to reduce methane, which means overcoming economic and institutional barriers, particularly in the natural gas sector with upgrades needed to prevent leaks and create interconnection for RNG. The Draft Strategy

identifies a mixed approach including incentives, public and private investment, and regulation to meet state goals. The Strategy then divides its future initiatives by sector. In the oil and gas sector the Draft Strategy includes adopting and implementing regulation on oil and gas production, processing and storage, improving leak detection and successfully implementing SB 1371 (Leno Chapter 525, Statutes of 2014)(ARB 2015). SB 1371 mandates the CPUC to adopt rules and procedures to minimize gas leaks from CPUC-regulated intrastate transmission, and distribution gas pipelines and facilities (ARB 2015). This Bill also requires CPUC to identify the most technologically feasible and cost-effective way to avoid, reduce and repair leaks from the system (ARB 2015). These initiatives particular to natural gas within the Draft Strategy target reducing fugitive methane emissions, but none of them include RNG as an alternative to natural gas, nor promote the development of this renewable resource. The Draft Strategy focuses on diverting organics from landfills and putting those wastes to beneficial uses, but ARB is missing the potential connection between organic waste and RNG. ARB is aware that organic waste is the essential component to develop RNG; therefore policy and regulation should be developed to encourage this link.

### **4.3 Stakeholder Reaction**

In this section stakeholder reactions to the Draft Strategy are examined for industry perspective on how the Strategy addresses methane from natural gas. After the Draft Strategy was published in September 2015 there was an open comment period for the public to express their support or concern with the SCLP Strategy. During this time, 147 letters were submitted, and among them were letters of support sent in to encourage the

growth of RNG in California. Many stakeholders involved in the natural gas sector in California commented on its support for reducing fugitive emissions, but many also encouraged ARB to develop a RNG market in California as well. For instance, The Coalition for Renewable Natural Gas (RNG Coalition), which represents and provides public policy advocacy and education on behalf of the renewable natural gas industry (RNG, biomethane or upgraded biogas), sent a letter to Richard Corey, the Executive Officer of ARB in support of the draft strategy. The RNG Coalition expressed its support in developing policy, regulatory incentives and funding program opportunities that encourage the growth of RNG projects (Escudero 2015). Such projects expressed in the letter included capturing fugitive methane emissions at the largest feedstock sources in California including agricultural waste, landfills, wastewater treatment facilities, etc. (Escudero 2015). Capturing emissions from these sources will enable the growth of RNG in California and reduce California's dependence on importing natural gas. Currently, California imports 91% of their natural gas, which costs the state more than \$9 billion per year (Levin et al. 2014). While natural gas is a cleaner and cheaper fuel than petroleum, it still comes with economic and environmental drawbacks. California weakens its economy by importing natural gas, and consequently losing jobs, economic development and tax revenue. RNG provides an opportunity for California to develop a job market within the state and strengthen its clean air and renewable energy goals.

A letter from the Western States Petroleum Association (WSPA) expresses their interest in seeing ARB prioritize market-based approaches over command and control policies when addressing methane emissions (Reheis-Boyd 2015). WSPA has been

engaged with ARB in a rulemaking process that would implement six control measures for oil and natural gas field operations. This would help reduce fugitive emissions from the natural gas lifecycle (Reheis-Boyd 2015). WSPA states in the letter that the proposed control measures that will cover operations and equipment including storage tanks, compressors, well completions, pneumatic devices, gas well liquid unloading, and leak detection and repair (Reheis-Boyd 2015). This letter from WSPA and the comments from the RNG Coalition represent the two major factors in the natural gas sector that need to be addressed in order to substantially reduce methane emissions; upgrading the infrastructure and operations management to prevent fugitive emissions, as well as adopting policy that will encourage the growth of the RNG market in California.

WSPA also notes that another opportunity for cost-effective reduction of methane is to expand the offset credit projects beyond the current scope of livestock methane reduction offset projects under the Cap-and-Trade program (Reheis-Boyd 2015). The current program limits the ability to combat methane emissions by neglecting the rest of California's methane emissions from natural gas and landfills. By neglecting these sectors in the offset credit project eligibility, ARB disincentives project development within the natural gas sector because there is no benefit in it towards the Cap-and-Trade program.

The Southern California Gas Company ("SoCalGas") and San Diego Gas & Electric (SDG&E) also submitted a joint letter aimed at enhancing the SLCP Strategy by encouraging the role RNG can play in achieving the economic and environmental goals ARB has for California. SoCalGas and SDG&E support the development of RNG from the organic waste stream and reducing fugitive emissions from natural gas (López Mendoza

2015). By putting organic waste towards a beneficial use, economic value will be created for RNG and enable significant mitigation of methane emissions, while also providing a reliable renewable energy source in California (López Mendoza 2015). RNG from organic sources can be used to support or replace traditional sources of natural gas for same end uses, such as electricity, space and water heating, or transportation fuel (López Mendoza 2015). SoCalGas and SDG&E support ARB's inclusion of RNG as a transportation fuel as a part of the Draft Strategy since the Low Carbon Fuel Standard (LCFS) identifies RNG from organic sources as the lowest carbon intensity standard pathway available (López Mendoza 2015). RNG is currently offered by the Clean Energy Fuels Corporation at their compressed natural gas and liquefied natural gas stations, and the percent of RNG used as a transportation fuel as grown from 10% to 40-60% in the last year (López Mendoza 2015). This shows the exponential growth possible in the RNG sector that will allow it to replace traditional sources of natural gas, especially because it can be injected into the current pipeline system.

The above reactions outlined by key stakeholders show the industry's understanding of the importance to support current policies in place, as well as develop new policies that will promote RNG growth and mandate updates to the infrastructure to limit fugitive emissions.

#### **4.4. Potential Barriers**

Potential barriers in implementing policy in the natural gas sector are examined in this section, particularly focusing on economic barriers. There are various potential barriers that California may face when implementing a policy in the natural gas sector to aid in



meeting the methane reduction goal. Current funding programs exist to help support new bioenergy, but not enough to create a self-efficient market or a demand for RNG. Existing funding is helping the industry to grow, but it is not enough to increase the rate of bioenergy needed to meet the state's low carbon fuel, waster diversion and methane reduction goals.

The recent catastrophic methane leak in the greater Los Angeles area poses a major threat towards reducing methane emissions. 96,150 metric tons of methane is estimated to have escaped from Aliso Canyon since October 23, 2015, which is the same as 8,076,640 metric tons of CO<sub>2</sub> released (Ferner, M. & O'Connor, L. 2016). This number is continuing to rise and SoCalGas does not anticipate being able to contain the leak until March of 2016, this is a major set back for California's plant to reduce methane emissions by 40% from 1990 levels by 2030 since it will be incorporated into the GHG inventory for California (Ferner, M. & O'Connor, L. 2016). The regulations governing that GHG inventory program require operators and owners of natural gas systems to report emissions from all industry sectors, including leaks (Duff, 2016). This leak is a major set back for California and the rest of the country in meeting methane reduction goals. It is vital to update the aging infrastructure to prevent another historic event. This leak is California's largest single contribution to climate change, presenting a major barrier to progress. It also exposes economic barriers, due to the lack of funding utility companies have to repair and prevent leaks.

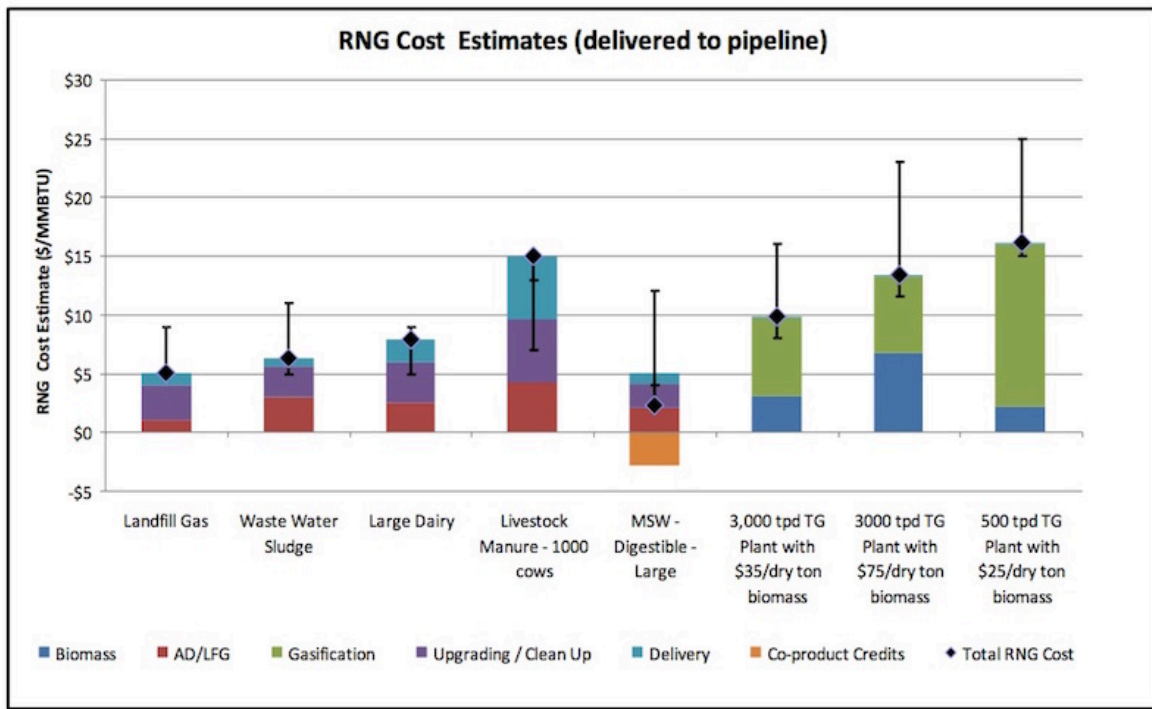
Another economic issue is cost-effectively identifying and repairing methane leaks in natural gas mining, processing, and distribution. Utility companies are required by law

to inspect their lines for safety, and fix safety problems within a specified time, particularly if they are near homes, schools or major road ways (EDF 2016). Yet, these rules do not require the repair of all leaks. In addition, even if utilities wanted to repair more leaks, many do not have the economic resources to do so. CPUC regulates the rate utilities can charge consumers for natural gas, and utilities need permission to raise rates in order to pay for repairs or upgrades. Therefore, CPUC makes it hard to invest in the major pipeline upgrades needed to prevent leaks by denying rate increases (EDF 2016). This is an economic and regulatory barrier that needs to be addressed, since the regulatory framework prevents utilities from getting the revenue needed in order to make the repairs. In addition to a poor regulatory framework, policy initiatives in California focus on the LCFS and the RPS. In order to substantially reduce methane emissions from natural gas, ARB would need to see a shift in the state's priorities, or at least a balance. The state does not have a comprehensive decarbonized gas strategy. While natural gas accounts for a substantial amount of California's energy use, ARB would require a significant amount of research, development and demonstration of a renewable gas strategy in order to strictly address its use.

Another economic barrier is the low cost of conventional natural gas. The cost of natural gas is variable, but with its current low rate it makes it difficult for RNG to compete on the market with its relatively higher cost. This economic variable is also dependent on the interconnection to pipelines since the injection of RNG into the natural gas grid can be expensive for small facilities or where the facility is far from the pipeline. Conversely, for some facilities, the local use of biogas and RNG or other means of

distribution may be more affordable. Some RNG feedstocks such as landfill gas, livestock manure, and municipal waste are already collected, therefore, when considering the types of RNG production projects ARB wants to encourage, the associated costs should be considered (Hamberg et al. 2012). Figure 3 below shows RNG cost estimates for the fuel delivered to the natural gas pipeline system by feedstock. The cost of RNG from municipal solid waste (MSW) is much cheaper than others feedstocks because of the co-product credits. The orange represents the revenue a MSW facility generates from tipping fees, while the error bar shows how much more expensive this feedstock would be without tipping fees. RNG from gasification is much more expensive than anaerobic digestion because of the cost per ton of biomass delivered and the size of the conversion plant, which correlates with how much biomass is accepted per day. Landfill gas is also very inexpensive because California requires landfills to have landfill gas capturing systems, therefore there is a substantial supply, but with the goal to reduce organic waste to landfills by 75%, the amount of landfill gas available will eventually decrease (ARB 2015, Hamberg et al. 2012).

**Figure 3 RNG Cost Estimates by Feedstock**



Source: Hamberg, K. et al. (2012)

As can be seen in Figure 3, costs can vary vastly between sources. For example, a California Energy Commission study (2009) did a detailed economic analysis of RNG from dairies injected into the pipeline using current technology and costs. The study concluded that the cost of pipeline injection could be significant, especially for dairy farms miles from an interconnection to the natural gas grid. For example, the cost of pipeline injected RNG would be \$12/MMBTU for Hilarides Dairy (Lindsay, California) compared to \$42/MMBTU for the Castelanelli Dairy (Lodi, California), which would require 5 miles of capital costs, including the costs to pipeline interconnect (Cheremisinoff et al. 2009). On the other hand, the California Energy Commission estimated the costs of producing pipeline quality RNG from landfill gas to be \$1.7 – \$2.2/MMBTU. Since RNG can be

produced from a variety of feedstocks, the costs greatly depend on the sector that it came from.

Another barrier is the cost of anaerobic digestion as a process to produce RNG. According to the NPC, the cost of producing RNG via anaerobic digestion is \$2-25 per \$/MMBTU/d input (Hamberg et al. 2012). The type and size of the digester used will have a large impact on cost since some digesters are more costly to construct and operate. The use of biogas will also have an effect on the net-cost of an anaerobic digester. While anaerobic digestion is not a new technology, the installation, siting, and the operation of digesters remain costly.

## **5. Policy Recommendations**

In order to substantially reduce methane emissions, California needs to implement policies and regulations that will address the aged natural gas infrastructure to reduce fugitive emissions, as well as promote production of renewable natural gas. RNG policy needs to be supported by regulatory action that oversees the operation and management of the production system to limit methane leaks from the infrastructure. In addition, policy makers need to develop regulation that will make up for industry negligence, and the State's scant regulation on the natural gas infrastructure. Targeting the natural gas sector through the development of a RNG market and methane mitigation technology, California could potentially surpass the current goal set by ARB. The state should aim to match the goal set by the Obama Administration to reduce methane emissions from the natural gas sector by 40-45% from 2012 levels by 2025 (Utech 2015) There are different types of policy and regulatory options for ARB decision makers to consider such as command and control, Cap-and-Trade, emissions standards or financial incentives. Each of these is unpacked in the following sections, together with relevant policy recommendations.

### **5.1 Command and Control**

#### **Recommendation 1**

- **Strengthen regulations for fugitive methane emissions**

Appendix A of the Draft Strategy projects emissions from pipeline leaks to increase from 9% in 2013 to 12% in 2030 due to the aging infrastructure and expansion of the natural gas pipeline system (ARB 2015). This is an increase from 10.62 MMCO<sub>2</sub>e in 2013 to 14.04 MMCO<sub>2</sub>e in 2030 (ARB 2015). Therefore it is important to upgrade the equipment used to

produce, store and transport natural gas, and since RNG can be injected into the same pipelines used for natural gas it is extremely important to prevent leaks so this resource is not lost. In the Draft Strategy, ARB states that they plan to develop regulations around reducing fugitive emissions throughout the lifecycle by the end of 2016 in addition to the sizeable methane mitigation industry already developing around the natural gas infrastructure (ARB 2015). Since state regulatory utility commissions have oversight of issues related to the siting, construction, and expansion of local distribution systems (Natgas, 2013), California should develop a regulation under CPUC surrounding the operation and management of these systems to ensure it adheres to the highest standards available. This type of regulation would establish technology-based methane emissions limits throughout the oil and gas supply chain, including both new and existing sources. Strong state laws are needed to create a comprehensive framework for monitoring, evaluating, and mitigating the potential public health and safety risks associated with hydraulic fracturing an the entire supply chain of natural gas (Deyette, 2015). This type of regulation is particularly necessary to prevent future gas leaks such as the one at the Aliso Canyon storage facility. SoCalGas knew about the risk at the Aliso Canyon storage facility since they were aware that the safety valve had stopped working in 1979, but since California law currently only requires safety valves on wells that are 100 feet off a road or a park, or within 300 feet of a home, SoCalGas opted not to replace it (Ferner, M. & O'Connor, L. 2016).

This type of regulation will aid in the resiliency of the natural gas infrastructure to withstand any future shock events from climate change. The natural gas industry is the

largest source of industrial methane emissions; therefore it is imperative to reduce emissions from the drilling, extraction, and processing and distribution systems. One way to do this would include requiring CPUC to approve utility plans to expand the system with a new pipeline, but with the condition that the applicant makes a commitment to repair an older portion of the system with known leaks. California should create a condition on permits for new pipelines or interconnection for RNG that requires the company to repair grade 1 and grade 2 leaks within their system. When meter readings show a decrease from initial amount of NG injected into the system to the customer, it is apparent that there is a leak. It is the most efficient way to get the private company to make the repairs because they want the profits from expanding their pipeline distribution.

## **5.2 Emissions standards**

### **Recommendation 2**

- **Develop a Renewable Gas Standard for energy utilities**

Another approach would be to establish a policy similar to a Renewable Portfolio Standard, alternatively called a Renewable Gas Standard, for energy utilities. This would be set up so large purchasers of natural gas, such as utilities that own and sell, are required to supply an increasing share of the natural gas from renewable sources. Utilities could then pass costs through to consumers. This RGS should apply under the jurisdiction of CPUC, which covers 82 percent of all gas consumed in California (Levin et al. 2014). A renewable gas standard (RGS) would require California to diversify the gas sector, aid in reducing GHGs, and reduce California's reliance on importing natural gas. According to Levin et al., a RGS could cut California's GHG emissions by more than 10 MMT of CO<sub>2</sub>e



per year (2014). California has numerous policies and funding programs to promote biogas development, but there is no framework that will encourage an increase in RNG production and distribution. Therefore, a Renewable Gas Standard will create the market mechanism needed to create a demand for RNG in California and help alleviate the cost of RNG by slowly phasing the program in.

To initiate the phase in process, the first goal would be to reach 1% RNG by 2020, 5% by 2025, and 10% by 2030. This would be 10% of two trillion cubic feet of natural gas per year coming from renewable sources. Initially implementing the framework under CPUC will allow it to reach most of the natural gas in California, and then in 2025, it should be extended to publically owned utilities.

RNG from organic waste is produced through anaerobic digestion. If all the organic waste available in California were converted to RNG, it would be the equivalent to 2.5 billion gasoline gallon equivalents (gge) of transportation fuel, or around 7,000 megawatts of renewable power (Levin et al. 2014). According to the RNGCA, employing a RGS will help generate more jobs and improve the economy in California, for example developing 200 RNG projects throughout the state at landfills, wastewater treatment facilities and agricultural sites would create more than 20,000 direct and indirect jobs throughout the state (López Mendoza, 2015). RGS will help to significantly reduce GHG emissions, improve public health, increase fuel diversity, reduce the reliance on fossil fuels, divert organic waste from landfills, and improve environmental quality throughout the state.

### **5.3 Cap-and-Trade**

California's Cap-and-Trade program is a key tool in meeting GHG emissions reduction goals. California's climate legislation, referred to in shorthand as AB 32, requires the state to lower GHG emissions to 1990 levels by 2020 (ARB 2015). Each entity covered by the Cap-and-Trade program is required to have an emissions allowance for every metric ton of CO<sub>2</sub> emitted. Emissions allowances can be allocated to a company by the government, bought at auction, traded amongst covered entities, or created through offset projects, and entities without enough allowances to cover their emissions face a fine. (Francis et al. 2015)

The GHG emission limit will decrease by 3% each year between 2015 and 2020 to bring the economy closer to the target emission level. Generally, free allowances will cover 90% of business's overall emissions, but this percentage will decline each year. Free allowances are allocated by the ARB depending on the business industry to cover a percentage of emissions, and the business then has to purchase credits to cover remaining emissions. However, the transportation sector is covered under the second compliance period and will not receive any free allowances. Fuel suppliers will be required to supply low carbon fuels or purchasing allowances to account for their emissions from natural gas, gasoline or diesel (ARB 2014). This is significant because the transportation sector will have to buy all of their compliance credits or complete offset credit projects. Therefore, projects that develop RNG are vital to this industry because they will count as offset credits, but also help the transportation sector reduce their carbon emissions by using the

fuel. In addition, distributors of natural gas are also covered under the Cap-and-Trade program as of 2015.

Affected entities can also buy allowances from the market to meet the annual compliance obligation, which for is at least 30% of its emissions from the previous year (Francis et al. 2015). The gases covered by the Cap-and-Trade program are the same as those covered by the Kyoto Protocol: Carbon Dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), Nitrous Oxide (N<sub>2</sub>O), Sulphur Hexafluoride (SF<sub>6</sub>), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Nitrogen Trifluoride and other fluorinated GHGs (Francis et al. 2015). The price started at \$10 minimum per ton in 2012, rising 5% annually over inflation. The emissions targets or allowance availability in 2015 is 394.5 MMT and in 2020 it will be 334.2 MMT, a 15% reduction. (C2ES 2014)

Under the Cap-and-Trade program there are flexibility provisions and cost containment mechanisms that include the use of offsets, compliance accounts, holding accounts, and bank and borrowing of allowances. ARB offset credits are generated by GHG emission reduction projects undertaken by a business in place of, or to aid in purchasing credits from the market. Each offset credit represents a ton of CO<sub>2</sub>e emissions diverted from the atmosphere. Approved offsets may be used by a company up to 8% of their total compliance obligation for each compliance period. According to the USDA, this quantitative limit will help maintain a balance between the need to achieve deep emissions reductions from capped sources with the need to provide low-cost reduction opportunities for emission sources within capped sectors (O'Sullivan et al. 2012).

### **Recommendation 3**

- **Expand offset credit eligibility to projects that cover methane emissions beyond livestock, including offset credits from projects such as building anaerobic digesters at wastewater treatment facilities and centralized anaerobic digestion that generate Renewable Natural Gas**

During the second period of the cap-and-trade program, offset projects will be utilized more as a way to meet compliance, as newly covered entities are required to comply. This is particularly true in regards to the transportation sector, which is not allotted any free allowances. Therefore they must buy during the auction period or invest in projects that reduce GHG emissions. By expanding the scope of offset projects there will be greater environmental and economic benefits for landowners, farmers, food distributors, wastewater treatment plants, etc., who are able to partake in the market by documenting emissions reductions and generating sellable credits. Offset projects will also provide a push in innovation in areas outside of capped sectors, provide new job opportunities and stakeholder involvement.

ARB should consider expanding the scope of offset projects because the American Carbon Registry has forecasted a “significant shortage of compliance offsets as compared to total potential demand in all compliance periods if no additional protocols beyond the existing four are adopted by ARB” (Stevenson et al. 2012). By expanding the scope of offset projects, ARB will avoid market inflation from the projected increase in prices for allowances due to increased demand (Francis et al. 2015).

#### **Recommendation 4**

- **Allocate a larger portion of the proceeds from the cap-and-trade auction that go to the Greenhouse Gas Reduction Fund (GGRF) towards biogas development projects**

The cost of building anaerobic digesters remains the primary barrier in producing RNG. To aid in the development of the necessary infrastructure for biogas development, a larger portion of the proceeds from the Cap-and-Trade auction that go into the GGRF should be allotted to the development of cogeneration anaerobic digesters in California. In the current expenditure plan for 2015-16 only 9% (US\$ 92 million) is set to go to natural resources and waste diversion (Francis et al. 2015). None of the Cap-and-Trade revenues were allocated to biogas based transportation fuels, renewable hydrogen from biogas, forest biomass facilities or biogas from wastewater treatment facilities (Levin et al. 2014). There are various organizations that commented on the Draft Strategy that recommend allocating Cap-and-Trade auction proceeds to the State Water Boards as a key source of funding for publically owned treatment works (POTWs), such as California Association of Sanitation Agencies (CASA), CA Wastewater Climate Change Group (CWCCG), South Orange County Wastewater Authority (SOCWA), and Southern California Alliance of Publically Owned Treatment Works (SCAP). By allocating more funds to the development of anaerobic digesters it will remove the market conditions that make it economical to landfill instead. “From 1990 to 2013, CH<sub>4</sub> and N<sub>2</sub>O emissions from wastewater treatment decreased by 0.6 MMT CO<sub>2</sub> Eq. (4.0 percent) and increased by 1.6 MMT CO<sub>2</sub> Eq. (46.5 percent), respectively (Weitz 2015).” Methane emissions from domestic wastewater treatment have decreased since 1999 due to decreasing percentages of wastewater being

treated in anaerobic systems, including reduced use of on-site septic systems and central anaerobic treatment systems (Weitz 2015). Wastewater treatment facilities provide a lot of promise in developing RNG when food waste is brought in, but a portion of the GGRF funds should also be allocated to the development of biogas for transportation and renewable hydrogen biogas.

There are numerous benefits to anaerobic digestion at wastewater treatment facilities, particularly where food waste is brought in from commercial sites in the surrounding area. When food waste is disposed of in landfills, it decomposes and produces potent methane emissions that are released into the atmosphere. Food waste also has three times the methane production potential than biosolids (Cattle manure= 25m<sup>3</sup> gas/ton, Biosolids= 120 m<sup>3</sup> gas/ton, and Food waste= 376 m<sup>3</sup> gas/ton), but diverting food waste from landfills to wastewater treatment facilities allows for the capture of the methane, which can be converted into biogas (EPA 2013). Wastewater treatment facilities provide existing streams of unused waste, and food waste enhances the anaerobic process because the calories in the food produce more energy. There are also economic drivers, such as cost savings from incorporating food waste into anaerobic digesters. Such savings include reduced energy costs due to production of on-site power and tipping fee for accepting the food waste, which results in a shorter payback period.

## **5.4 Market Incentives**

### **Recommendation 5**

- **Introduce production tax credits for RNG development**

In addition to allocating funds from the GGRF to RNG development, California

lawmakers and regulators should consider introducing a production tax credit to increase investment in biogas development, similar to the federal tax credit for renewables. This is important because Congress passed an Alternative Fuel Tax Credit, which supports the continued use of natural gas as an alternative to diesel and gasoline (Johnston 2015). This tax credit applies to liquefied natural gas and compressed natural gas, but not renewable natural gas. Therefore, to compete with the market prices of natural gas, California should introduce a similar bill to the federal legislation of 2009 when Senator Benjamin E. Nelson (D-Nebraska) introduced the Biogas Production Incentives Act of 2009 (López Mendoza 2015). This increased investment in RNG by providing a Federal Tax Credit of \$4.27/MMBtu for biogas produced (López Mendoza 2015). A production tax credit will help increase the production of RNG and help grow the market to a competitive level against compressed and liquefied natural gas.

## **6. Conclusion**

The Draft Strategy developed by ARB will help California meet their GHG emissions reduction goals and has presented numerous current and potential policies to address methane emissions. However, there is a gap in the Draft Strategy that does not sufficiently address methane emissions from the natural gas sector. The Strategy focuses on agriculture and waste diversion, while only anticipating regulations for utilities at a distant point in the future. This study proposes four policy approaches that Californian lawmakers could use to regulate and mitigate methane emissions from natural gas in the state. This includes introducing a command and control regulation through the California Public Utility Commission to eliminate fugitive emissions, developing a RNG market through an emissions standard, introducing market incentives such as production tax credits, and strengthening the Cap-and-Trade program by expanding offset credit eligibility and allocating more fund to RNG. It is important to address the need for RNG, as well as improve the natural gas infrastructure to limit fugitive and vented emissions during the lifecycle of natural gas. Developing RNG will reduce the need for conventional natural gas, while repairing and upgrading the infrastructure will reduce the amount of fugitive emissions released throughout the lifecycle of natural gas.

Together, this array of policy approaches could significantly reduce methane emissions from natural gas and help California reach their methane reduction goal of 40% below 1990 levels by 2030. They will also enable California to address the need for RNG and develop a market, as well as ensure utilities have the revenue and incentive to make repairs to their systems. Methane is currently California's greatest contribution to climate



change, so by addressing this short-lived climate pollutant, California will aid in slowing the accelerating rate of global and regional warming.

## List of References

- Air Resource Board (ARB), (September 2015), 'Draft Short-Lived Climate Pollutant Reduction Strategy', *California Environmental Protection Agency*
- Brandt, A. et al., (2014) 'Methane Leaks from North American Natural Gas Systems', *Science Magazine Policy Forum: Energy and Environment*, Vol. 343, 733-735, 10.1126/science.1247045
- Brathwaite, L. et al., (2015), '2015 Natural Gas Outlook', *California Energy Commission*, Docket Number: 15-IEPR-03
- California Air Resources Board (CARB), (May 2015) 'Short-Lived Climate Pollutant Reduction Strategy Concept Paper', *California Environmental Protection Agency*
- California Air Resources Board (CARB) (2014), 'California's Cap and Trade Program, Fuel Facts', *California Environmental Protection Agency*, Retrieved from: [http://www.arb.ca.gov/cc/capandtrade/guidance/facts\\_fuels\\_under\\_the\\_cap.pdf](http://www.arb.ca.gov/cc/capandtrade/guidance/facts_fuels_under_the_cap.pdf)
- California Energy Commission (CEC) (2015), 'Renewables Portfolio Standard', *Energy Almanac*, Docket # 11-RPS-01 and 14-RPS-01
- California Energy Commission (CEC) (2015), 'Supply and Demand of Natural Gas in California', *Energy Almanac*, Retrieved from: <http://energyalmanac.ca.gov/naturalgas/overview.html>
- CalRecycle, (2013), 'Composting and Anaerobic Digestion', *California Department of Resources Recycling and Recovery*, Retrieved from: <http://www.calrecycle.ca.gov/actions/Documents%5C77%5C20132013%5C935%5CComposting%20and%20Anaerobic%20Digestion%20FINAL.pdf>
- Cheremisinoff, N. et al. (2009), 'Economic Study of Bioenergy Production from Digesters at California Dairies', *Princeton Energy Resources International, LLC*, Prepared For: California Energy Commission: Public Interest Energy Research Program, CEC-500-2009-058
- C2ES Center for Climate and Energy Solutions, (January 2014), *California Cap-and-Trade Program Summary*, U.S. Policy
- Duffy, S., (2016), 'Lessons from Alison Canyon, Part 1: Regulation of the Oil and Gas Sector', *Legal Planet*, Berkley Law, Retrieved from: <http://legal-planet.org/2016/02/04/lessons-from-aliso-canyon-part-i/>

- Deyette, J. et al. (2015), 'The Natural Gas Gamble: A Risky Bet on America's Clean Energy Future', *Union of Concerned Scientists*, Retrieved from: [www.ucsusa.org/naturalgasgamble](http://www.ucsusa.org/naturalgasgamble)
- EIA. (2014), 'Annual Energy Outlook 2014 with Projections to 2040.', U.S. Energy Information Administration. Retrieved from: [http://www.eia.gov/forecats/aeo/pdf/0383\(2014\).pdf](http://www.eia.gov/forecats/aeo/pdf/0383(2014).pdf)
- Energy and Environmental Economics (E3), (2014), '*Decarbonizing Pipeline Gas to Help Meet California's 2050 Greenhouse Gas Reduction Goal*', San Francisco, CA, Retrieved from: [https://ethree.com/documents/E3\\_Decarbonizing\\_Pipeline\\_01-27-2015.pdf](https://ethree.com/documents/E3_Decarbonizing_Pipeline_01-27-2015.pdf)
- Environmental Defense Fund (EDF), (2016), "Why are natural gas leaks a problem?" *EDF Climate and Energy: Natural Gas*, Retrieved from: <https://www.edf.org/climate/methanemaps/leaks-problem>
- Environmental Protection Agency (EPA), (2013) Region 9, The Benefits of Anaerobic Digestion at Wastewater Treatment Facilities, Web, Retrieved from: <http://www3.epa.gov/region9/waste/features/foodtoenergy/wastewater.html>
- Environmental Protection Agency (EPA), (2015), Climate Change: Overview of Greenhouse Gases: Methane Emissions, Retrieved from: <http://www3.epa.gov/climatechange/ghgemissions/gases/ch4.html>
- Escudero, Johannes D. "The Coalition for Renewable Natural Gas." Letter to Richard Corey. 29 Oct. 2015. *Workshop Comments Log*. California Air Resources Board, 6 Nov. 2015. Web.
- Ferner, M. & O'Connor, L. (2016), 'Why Everyone Should Be Worried About The California Gas Leak Disaster', *Huffington Post*, HuffPost Politics, Retrieved from: [http://www.huffingtonpost.com/entry/porter-ranch-gas-leak-worry\\_us\\_569fdcd4e4b0fca5ba76528f](http://www.huffingtonpost.com/entry/porter-ranch-gas-leak-worry_us_569fdcd4e4b0fca5ba76528f)
- Francis et al. (April 2015) California: an Emissions Trading Case Study, *Environmental DefenseFund, CDC Climat Research, IETA*
- Groom, N. (2016) 'California gas leak spotlights shoddy regulation of aging storage wells', *Thomson Reuters*, Web, Retrieved from: <http://www.reuters.com/article/us-losangeles-gas-leak-regulation-exclus-idUSKCN0V00DM>
- Hamberg, K. et al. (2012) 'Renewable Natural Gas for Transportation: An Overview of the

- Feedstock Capacity, Economics, and GHG Emission Reduction Benefits of RNG as a Low Carbon Fuel’, *National Petroleum Council, A white paper*, Retrieved from: [http://www.npc.org/ftf\\_topic\\_papers/22-rng.pdf](http://www.npc.org/ftf_topic_papers/22-rng.pdf)
- Howarth, R. et al. (2012) ‘Methane Emissions from Natural Gas Systems, *National Climate Change Assessment*, Ref. no. 2011–0003, 2012.
- ICF International (2014), ‘Economic Analysis of Methane Emission Reduction Opportunities in the U.S. Onshore Oil and Natural Gas Industries’, Prepared for Environmental Defense Fund, Retrieved from: [https://www.edf.org/sites/default/files/methane\\_cost\\_curve\\_report.pdf](https://www.edf.org/sites/default/files/methane_cost_curve_report.pdf)
- Jackson, R. et al. (2014), ‘The Environmental Costs and Benefits of Fracking’, *The Annual Review of Environment and Resources*, Vol. 39:327–62, 10.1146/annurev-environ-031113-144051
- Johnston, J., (2015), ‘Clean Energy Welcomes Passage of Alternative Fuel Tax Credit by Congress’, *Clean Energy Fuels Corp., Business wire*, Retrieved from: <http://www.businesswire.com/news/home/20151218005729/en/>
- Kennedy, R. et al. (July 2014), ‘Final Staff Report: 2013 Natural Gas Issues, Trends and Outlooks’, *California Energy Commission*, CEC-200-2014-001-SF
- Levin, J. et al. (November 2014) ‘Decarbonizing the Gas Sector: Why California Needs A Renewable Gas Standard’, *Bioenergy Association of California*
- Low Carbon Fuel Standard, (2007) California Code of Regulations, title 17, subchapter 10, Article 4, subarticle 7 § 95480
- López Mendoza, J., “Southern California Gas and on behalf of San Diego Gas & Electric”, 30 Oct. 2015, *Workshop Comments Log*, California Air Resources Board, 30 Oct 2015, Web
- O’Sullivan et al., *California Cap-and-Trade and International Forest Carbon Offsets for Institutional Investors*, USAID, December 2012
- Naik, N. et al., (2013), ‘The Anaerobic Digestion of Organic Municipal Solid Waste in California’, *University of California, Berkley*, Professors: Mulvihill, M., et al., Chemistry C234
- Plummer, M., (2015), ‘Pacific Gas and Electric Company’s Comments on the Air Resources Board Draft Short-Lived Climate Pollutant Reduction Strategy’, Letter to Michael Tollstrup, 30 Oct. 2015, *Workshop Comments Log*, California Air Resources Board, 30 Oct. 2015, Web

Reheis-Boyd, Catherine, "Western States Petroleum Association," Letter to David Mehl, 4 Nov. 2015. *Workshop Comments Log*. California Air Resources Board, 5 Nov. 2015. Web.

Smith, K. et al., (November 2009) 'Public health benefits of strategies to reduce greenhouse-gas emissions: health implications of short-lived greenhouse Pollutants', *Lancet: Health and Climate Change Series*, 374(5): 2091–103, DOI:10.1016

Stevenson, S. et al., (2012), 'Compliance Offset Supply Forecast for California's Cap-and-Trade Program', *American Carbon Registry & Winrock International*

Stokes, S. et al. (October 2014) 'The Emerging U.S. Methane Mitigation Industry', *Datu Research LLC*, Prepared for the Environmental Defense Fund

Utech, D., (2015), 'Continuing to Drive Methane Emission Reductions', *The White House Blog*, Web, Retrieved from:  
<https://www.whitehouse.gov/blog/2015/08/18/continuing-drive-methane-emission-reductions>

Weitz, M., Hight, C. (April 2015), Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2013, *U.S. Environmental Protection Agency*, Washington DC, EPA 430-R-12-004

Zaelke, D. et al., (2012), 'Strengthening Ambition for Climate Mitigation: The Role of the Montreal Protocol in Reducing Short-lived Climate Pollutants', *Review of European Community & International Environmental Law*, 21(3), 231-242