Initial Business Case:

A complete description of the VOC Monitoring system,

its users, and a cost analysis.

Sentient

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**Introduction**

The Volatile Organic Compound (VOC) Monitoring System detects VOCs that are commonly released into the atmosphere by oil refineries. Oil refineries reduce the cost of the land that surrounds them. Cheaper housing attracts families that live in poverty. Lower income adults, according the Bureau of Labor Statistics, have less education than their higher earning neighbors. Residents around oil refineries are typically aware that chemicals are released by oil refineries, they can see and smell them, but they are not informed on how dangerous those VOCs are. Oil refineries abuse this lack of knowledge and the holes in judicial law regarding VOC emissions. The idea behind the VOC Monitoring System is to protect residents by informing them when and what VOCs are being leaked. A major goal for the system is also to educate the community on what VOCs are, how to protect themselves from them, and to make them aware that they have a right to clean air; to hold oil refineries responsible for poisoning them.

The implementation of this system will start by strategically positioning VOC monitors around nearby refineries. Specific VOCs released by a company will then be interpreted and displayed in a graphical VOC(parts per million) versus time (hours), format on a web application. Residents near the oil refinery can subscribe to the web site in order to receive e-mail alerts when a VOC hits hazardous levels. Emails also contain information on VOCs and how to protect themselves. Subscribers can also opt to receive notifications for areas they have loved ones in. While this start up system is directed towards oil refineries, VOC Monitors can be specialized for a specific community’s situation.

The need for this product is great. In December of 2011, residents of Standard Heights in Baton Rouge, Louisiana awoke in the middle of the night to the sounds of their children shaking and vomiting. It would later be revealed that that night, a local Exxon Mobil oil refinery had a Naphlan Leak. At first, Exxon Mobil would claim the leak wasn’t large enough to affect the community. Months later, however, Exxon would admit the leak was greater than estimated. To this day, Standard Heights citizens have not received compensation from Exxon Mobil or an apology. It will become clear that these sequences of events following oil refinery leaks are all too familiar.

This theme will become more relevant as the US experiences a boom in at-home oil drilling. “Advances in extracting oil from shale rock drove a 39 percent jump in U.S. production since 2011, the steepest rise in history, and will boost output to a 28-year high this year (2014)” according to the Energy Information Administration.11 As time passes, the US will be creating exponentially more oil refineries as it becomes a main supplier of crude oil. The safety of residents surrounding these refineries can no longer be ignored.

The Sentient team believes this is an important product because it will give peace of mind and power to a populous that is constantly belittled by the money of large corporation. The number of oil refineries are growing; citizens need a means to defend themselves where legislation is failing them. This report will attempt to examine the types of communities that are afflicted by VOCs released by oil refineries, to compare competing systems, and an analysis of the cost of VOC Monitor Systems.

**Market Sector**

The Market Sector is divided into three sections: VOC System’s Place in Society, User Demographic, and User Motivation. VOC System’s Place in Society discusses how a VOC monitor will be used with respect to an overall society. User Demographic depicts what kind of users the system is designed and intended for. User Motivation describes what encourages a user to use a VOC monitor system.

VOC System’s Place in Society

VOCs have relatively short atmospheric lifetimes, ranging from a few hours to less than a year.Due to their short lifetimes and vastly varying sources and concentrations it is not plausible to create a global map depicting VOC sources1. With that it is not possible to state what manufacturing processes emit the largest concentration of VOCs.

The Environmental Protection Agency (EPA) has, however, found it necessary to define a set of standards by which oil refinement companies must adhere to. One of these standards requires that all those in the refinement industry must use ‘green completion’ technology during drilling, or well fracking. What ‘green completion’ means is that a company will use “mobile, trailer-mounted tanks… to capture gases before they escape into the air and route them back into pipelines for sale as natural gas and other valuable chemicals.”2

While David Doniger, of the EPA, asserts in his blog that the majority of leading companies have already begun to adhere to EPA’s standards, there have been countless reports of companies failing to contain the results of oil refinement. This is due, according to the National Oceanic Atmospheric Administration, to companies underestimating their VOC output by an order of one magnitude on average.

An excellent example of such a case was explained at the beginning of this report. To recap, in Baton Rouge, Louisiana there is an oil refinery owned by Exxon Mobil, a multinational oil and gas corporation. The US Government has sets limits on the amount of air pollution, in pounds, that gas companies can pump into the atmosphere. Through a number of leaks and accidents between 2008 and 2011 Exxon Mobil has dumped over four million pounds of VOCs without government approval, as stated by the Louisiana Department of Environmental Quality. 3

While Exxon Mobil claims that it is safe to live in Standard Heights, the community in which it resides, the locals have reported that the smell of chemicals has been so strong at times that they are forced to leave their homes. Tonga Nolan, Standard Heights resident, reported taking her daughter to the hospital for vomiting profusely the day Exxon discovered a Naphtha leak. Naphtha is a chemical that turns to toxic vapor as it touches the atmosphere.

Exxon Mobil at first claimed that the leak was too small to have effect on residents. Months following, the company admitted that the leak was much larger than they originally thought but residents never received an official statement, apology, or compensation for the incident. 3

While the EPA and the Government has set rules and regulations for companies whom produce and manufacture VOC’s it is not enough to keep communities safe. The oil and gas industry has not taken on the responsibility of setting up alert systems in case of accidents. Methods that companies use to measure VOCs have been proven to be invalid as companies fail to report millions of pounds of VOC leakage10. Gasoline is a multibillion dollar industry that small communities cannot stand up against in court due to insufficient evidence and funds.

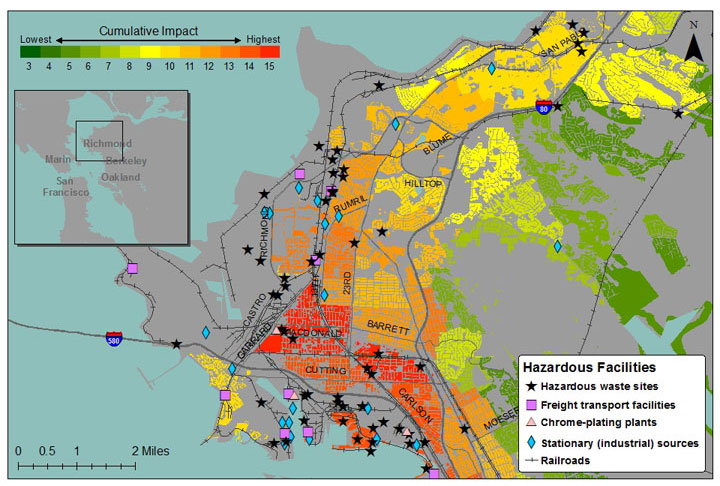
The VOC Monitoring System by Sentient is a cheap means for residents to have peace of mind due to its alert system. All VOC levels are recorded along with a time and location stamp. If a leak did occur, the monitor’s data could be used in a court setting in order to prove that VOCs traveled far enough and in a high enough concentration to effect surrounding populations.

The VOC monitor’s place in society is with the general population as a means to protect and defend themselves from both accidents and the negligence of VOC manufacturing companies.

User Demographic

During the Naphtha leak by Exxon Mobil, two EPA representatives were visiting the plant. The EPA was in Standard Heights to interview residents that live close to Exxon Mobil. The effort was part of a study being conducted by the EPA to uncover an unfair fact: “people who live near big pollution plants tend to have lower incomes.”3

Environmental Health Sciences (EHS) takes the claim home with the following image of North Richmond, California. The imagine uses a key guide to show where the five oil refineries, three chemical plants, and eight Superfund sites are located. The color index takes into consideration the distance from these sites, income, and race of residents in Richmond.

Figure 1. Map courtesy of Rachel Morello-Frosch (University of California, Berkeley), James Sadd (Occidental College), Manuel Pastor and   
Justin Scoggins (University of Southern California)

It is clear that the value of land is drastically reduced by the nearby presence of VOC emitters. Henry Clark, a longtime resident of North Richmond, recalled being a child in his home town and the air being so foul at times that he’d have to plug his nose and wait inside until the emissions cleared up. He jokes that the cheapest housing shared a fence with the Chevron oil refinery.

Residents think they are saving money with cheap rent, when they are actually trading their health for it. There is a surplus of evidence that those who are most in danger of VOC exposure are low income families. The Department of Education has also released reports stating that low income often correlates to less education and health awareness.4 Low income communities are also less able to defend themselves against multibillion dollar companies like Chevron.

For these reasons the user demographic of our system consists of low income, limited education communities that border VOC manufacturers. The nature of the VOC Monitor, however, allows for use in wealthier communities that have a lower risk of VOC exposure. While the user demographic can be expanded, this system’s design focuses on low income communities.

User Motivation

During his excerpt with the EHS, Clark summed up his experience to “nobody came to check on the health in North Richmond.” 3 His quote directly addresses the user motivation behind the system. In North Richmond it is up to the community itself to address the issue of VOC pollution. In fact, even when the correlation between air quality and property value is not cut and paste as is in Richmond, low income communities are still left to fend for themselves.

Even with residents simultaneously complaining of strong chemical smells and vomiting, Exxon Mobil ignored and downplayed the extent of a VOC leak. Even after Exxon Mobil admitted that the spill was much grander than they originally believed, they still did not offer compensation or issue an apology for the incident. Even after countless leaks and accidents from 2008 to 2011, Exxon has not implemented a warning system in Standard Heights.3

The EPA has already set tight standards for VOC emitters. The Government has already set limits on the number of pounds companies can release into the atmosphere.2 If the community does not come together to put in their own VOC Monitoring system, then they will not have sufficient evidence of VOC emissions and nothing will change. The motivation behind the users of the Sentient VOC Monitoring System is that it is affordable, easy to implement, and their answer to a very serious issue.

**Competing Survey System**

The Competing Survey System is divided into 4 sections: Competing Systems Explained, Feature Comparison, Cost Comparison, and Improvements. Competing Systems Explained will present three competing technologies for the VOC Monitoring Market. Features Comparison will compare the features of these systems with the features of the Sentient product, Cost Comparison will compare the cost of these systems with the cost of the Sentient product. Lastly, Improvements will depict what about our system is an improvement over the competition.

Competing Systems Explained

The big name in VOC monitoring systems is RAE Systems. Founded in 1991 RAE Systems has a firm handle on the VOC monitoring market with a large selection of handheld and fixed location devices. RAE devices are designed and marketed for industrial purposes and consequently come at an industrial price. RAE devices range in price anywhere from $2,500 to $30,000. The three RAE systems most comparable to the system Sentient is offering are the FMC 2000 Controller, the MeshGuard Sensor, and the ProRAE Guardian application.

Feature Comparison

The FMC 2000 wireless multi-channel controller is an all in one MeshGuard command-and-control system.6 The FMC 2000 receives and processes data from the MeshGuard sensors via a built in wireless modem. The Sentient VOC monitoring system communicates via a laptop-XBEE set up to allow users to communicate between their computer and the Arduino VOC monitor.

The Meshguard Sensor detects Dihydrogen sulfide, Carbon Monoxide, Dioxygen, Ammonia, Chlorine gas, and Sulfur dioxide. The specification ranges for these compounds range from 0 to 10 ppm to 0 to 2,000 ppm.7 The Sentient VOC monitoring system will detect the VOCs that a community is specifically concern over. For a populous surrounding an oil refinery the monitor could have a sensor for Tulene or Formaldehyde. The specification range for the VOC Monitor falls between 50 – 5,000 ppm.

The ProRAE Guardian application is designed for technicians and provides extensive information. 8 Similar to the Sentient product, it provide graphical and text displays. The Sentient equivalent is the Sentient VOCMS website, which allows users to sort through processed data and see visual representation of VOC levels, as well as sign up for VOC email alerts.

Cost Comparison

Unfortunately for small communities, it is difficult to purchase a single VOC detector at reasonable price. A MeshGuard Gas Detection System consisting of a FMC 2000 unit, six Meshguard Sensors and the ProRAE Guardian software costs around $29,000. 9 Sentient seeks to offer an affordable alternative for small communities. A Sentient VOC Mesh system consisting of five VOC units is estimated to cost $1,000 with customers having a $200 down payment and a monthly maintenance fee of $100.

Improvement

The Sentient VOC system is engineered with small, low-income communities in mind. The largest improvement the Sentient team makes over its competitors in not in VOC ranges or precision but by providing an inexpensive and effective tool. The minimalistic hardware design is centered on reliability and ease of maintenance. The Sentient VOC unit is aims to give small communities peace of mind they can afford.

**Cost Analysis**

A key factor for the VOC Monitoring System is that is must be affordable. The markets this product is targeted towards are low income communities. This section will consider the hardware, man hours, and maintenance cost for each monitor and complete system. Following a base line cost analysis this section will describe possible purchasing plans for users.

#### Hardware costs

The VOC Monitor consists of an UNO Arduino kit, SD Shield, Solar Power Shield, VOC sensor, potentiometer, and an XBEE module. An outlier for this analysis is the VOC sensor. While the first model is focused towards VOC released from an oil refinery, sensors will differ between monitors based on a communities need. The cost of a sensor is therefore a rough estimation. This report does not consider the possibility of buying items in bulk. The cost analysis is therefore a worst case scenario representation.

|  |  |  |
| --- | --- | --- |
| Hardware | Source | Price |
| Arduino Kit | Amazon | 33.99 |
| Sensor\* | Sparkfun | 7.25 |
| SD Shield | Amazon | 10.00 |
| Solar Power Shield | Sensor Depended | 35.00 |
| Potentiometer | Amazon | 0.60 |
| XBEE | Sparkfun | 20.95 |

Table 1: Hardware cost breakdown for a single VOC monitor

\* Sensor cost varies greatly depending upon VOC

The hardware for each VOC monitor will cost approximately $107.79 dollars.

#### Man Hours

According to GlassDoor.com5, the average wage of an intern is $19.60 an hour. Based on the Evidence Based estimations for the Sentient team, each member puts in five hours of work a week towards the VOC Monitor. There are four team members. The project will be worked on consistently for a thirty-two week period.

#### Wages: 4(members)

#### \* 5(hours)

#### \* 32(weeks)

#### \* 19.60(intern wage)

Total: $12,160

The one time, man hour cost, for VOC System is $12,160.

#### Maintenance

Maintenance is divided into two categories: hardware and software. Hardware maintenance consists of retrieving VOC data weekly and general VOC Monitor replacements. Software maintenance consists of database alterations and web application updates.

Hardware

One option for low income communities is a training session that will teach users how to retrieve VOC data. These trainings will be complimentary of the system in order to encourage communities to take charge and responsibility for the air they breathe. This will also reduce the cost of the system. General VOC Monitor maintenance check and repairs will occur monthly and is included in the packages described below.

Hardware Maintenance is highly relative but for the purposes of this report will be estimated at an hour per VOC Monitor System at an intern wage.

#### Software

Database and Web Application can be done at Sentient headquarters. This will also be included in the packages described below. Malfunctions in software on the VOC Monitor will be addressed during hardware maintenance checks.

Software Maintenance is relative but for the purposes of this report will be estimated at two hours a month at an intern wage. Total Cost: $39.00

#### Purchasing Plan

In order to reduce the cost of the overall system, the VOC Monitoring system will come in packages that have include a deposit and monthly fee. This will reduce the overall cost and also make the product more affordable over time.

|  |  |  |  |
| --- | --- | --- | --- |
| Package Type | Number of VOCs | Optional Level Retrieval | Monthly Fee |
| Small System\* | 3 | +10 | 75 |
| Large System\*\* | 5 | +10 | 100 |

\* Deposit of $100

\*\* Deposit of $200

The small system costs $100 for the monitors and $75 for monthly maintenance.

The large system cost $200 for the monitors and $100 for monthly maintenance.

In a mock example, there will be five large systems and five small system deployed. The total cost of the VOC monitors and maintenance is $8,572 a year. The total profit from the same example is $10,500 for a profit of $1,928 dollars. It will take the product six and a half years to turn an overall profit at this constant mock rate. This time decreases at the number of systems increases.

**Final Argument**

This report has covered the Sentient’s market audience: low-income neighborhoods bordering oil refineries. It delve into REA competing systems that, while a powerful products, are too costly and require users to have an in-depth knowledge of VOCs that the Sentient consumer couldn’t meet nor afford. While it would be wondrous to give this system away to neighborhoods that are in dire need of it, this report concluded by presenting a down payment and monthly plan that the Sentient team believes is possible for even poor communities to collectively afford.

The idea behind the Sentient system isn’t just the product itself. We believe that our consumers aren’t aware of how much danger they are really in, how grossly their safety is being neglected, nor that they hold the ability to do something about it. Our goal is, through training and education sessions during installment, to teach residents what a VOC is and how VOCs effect a populous, exactly how our system works, and how to run and maintain it themselves. Our project is about protecting our consumers, but it is even more important that they are empowered and educated through the VOC Monitoring System.

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