

Wen Yan

**AIR POLLUTION IN CHINA AND THE POTENTIAL OF FINNISH
LATEST INTELLIGENT AIR PURIFYING TECHNOLOGY**

Case Lifa Air LA 500

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ABSTRACT

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| Name of thesis AIR POLLUTION IN CHINA AND THE POTENTIAL OF FINNISH LATEST INTELLIGENT AIR PURIFYING TECHNOLOGY. Case Lifa Air LA 500 | | |
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| <p>Haze problem in China led to an explosive growth on demand for air purifier. Facing a large number of air purifiers that claimed to be intelligent, how can consumer distinguish real intelligent product from others?</p> <p>This dissertation examined the latest intelligent air purifying technology from Finland through a multi-layered study on Lifa Air's LA500 air purifier. The target studied in this dissertation included the current situation of air pollution and market analysis in China.</p> <p>Two major research strategies were used: (1) a quantitative analysis of city-level data and (2) one case study - Lifa Air's LA500 air purifier. Data were mainly collected from published reports, newspaper as well as official websites. Finnish latest intelligent air purifying technology was shown to be advanced and quality. Further suggestions to Lifa Air's sales mode, marketing promotion were also given.</p> | | |

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| <p>Key words [Haze, air cleaner, China, intelligent air purifying technology, Finland, Lifa Air, PM2.5, Philips, Panasonic and marketing promotion]</p> |
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CONCEPT DEFINITIONS

| | |
|-----------------------|---|
| ACS | American Cancer Society |
| AHAM | The U.S. Association of Home Appliance Manufacturers |
| APIAC | Air Purifier Industry Alliance of China |
| AQG | Air Quality Guidelines |
| AQI | Air Quality Index |
| CADR | Clean Air Delivery Rate |
| CCM | Cumulate Clean Mass |
| CO | Carbon Monoxide |
| DC | Direct-current Dynamo |
| EPA | United States Environmental Protection Agency |
| HEPA | High Efficiency Particulate Arrestance |
| IAQ | Indoor Air Quality |
| NASA | United States National Aeronautics and Space Administration |
| NH₃ | Ammonia |
| NO | Nitrogen Oxide |
| NO₂ | Nitrogen Dioxide |
| NO_x | Oxides Of Nitrogen |
| NRDC | The U.S. National Research Development Corporation |
| O₃ | Ground-level Ozone |
| PM | Particulate Matter |
| PM 2.5 | Fine Particulate |
| PM 10 | Particulate Matter |
| SO₂ | Sulfur Dioxide |
| UF | Ultrafine Particles |
| VOC | Volatile Organic Compound |
| VOCs | Volatile Organic Chemicals |
| WHO | World Health Organization |

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1 INTRODUCTION

With the globally attention and increasing pollution levels, it is becoming necessary for the whole society of China to find a solution or viable alternative to change the current situation. There are lots of researches and papers which focus on China's current air pollution situation, and they mostly show that outdoors air pollution could not be resolved in a short term. In this case, air purifiers might be the best solution to improve surrounding air quality for ordinary citizens. In the recent years, the smart home appliance era has come with infinite development potential and huge business opportunity. However, not many researches and reports focus on China's air purifying industry can be seen inside and outside China, let alone enough specialized study on intelligent air purifier and its technology.

The aim of this project was to study the potential of Finnish advanced intelligent air purifying technology with an example, Lifa Air company's LA500 air purifier, which is already on China's consumption market.

The report mainly presents LA500's intelligence technology, its components, the product specifications and functional parameter, and shows its advantages and disadvantages when compared to other popular intelligent air purifiers on China's market.

2 AIR POLLUTION IN CHINA

Over the last few decades, rapid industrialization of China successfully drove economic development, but in the meanwhile, in order to meet increasing energy demands, China is facing a series of troubles and challenges from environmental pollution. In this sector, we are going to examine the current situation, sources, air pollutants and effects about outdoor air pollution as well as indoor air pollution in China.

2.1 Current situation

In December 2015, Beijing's authorities declared a first ever pollution "red alert" due to severe haze. It was the first red alert proclaimed by China under the four-tier alert system and it was the highest possible warning level so far. As a result, schools were closed, and outdoor construction halted. Citizen's normal life was seriously effected by this haze. Last higher warning level took place in 2013, in which the impact was not as worse as in 2015 (BBCNEWS 2015). The U.S. Embassy in Beijing presented an air quality monitor report that the concentration of PM 2.5 reached at 291 micrograms per cubic metre in Chaoyang district when the "red alert" came into effect (The U.S. Embassy 2015), which exceeded 10 times of 25 micrograms per cubic metre recommends as the maximum safe level by the World Health Organization (WHO 2005, 10-14).

In the WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide (Global update 2005 Summary of risk assessment), WHO updated the latest information of Air Quality Guidelines (AQG) related to four common air pollutants and indicated that PM 2.5 was more representative than PM 10 as particulate matter for research (WHO 2005, 11), because PM 2.5, this "fine" particulate is considered to pose the largest health risks among other particulate matters as it can directly get into the lungs and even the bloodstream (EPA). Thus, take the intensity of PM 2.5 as monitoring object is instructive to category air pollution's performance. About introduction related to various types of air pollutants, we will continue to study in depth in Sector 3 in this Chapter.

Different area in China may perform various level of air pollution as air is flowed by wind, and the source of different area may vary as well. In order to maintain the comparability of reference substance, we are going to take Beijing City as research area for air pollution in China in the following

paper. In figure 1 and figure 2, big difference between clean air and dirty air can be seen with naked eye on 1 December and on the next day in Beijing.



FIGURE 1. Clean air in Beijing on 1 December 2015 (shot by BBCNEWS near the East 4th Ring Road, facing west towards Beijing on 1 Dec 2015)

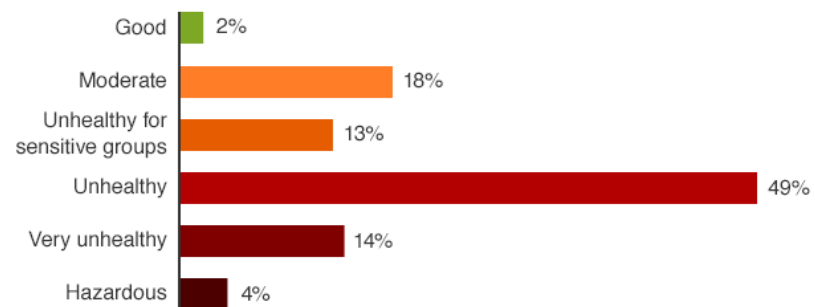


FIGURE 2. Polluted air at the same location a day later (2 Dec 2015)

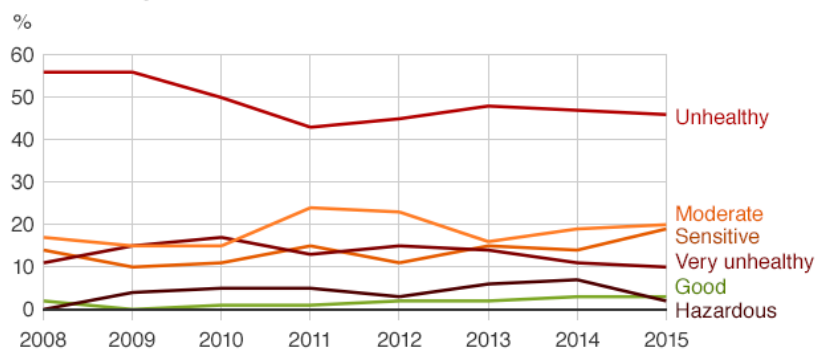
This haze event in Beijing hit the headlines of large number of media in the world at about the same time. Some scholars even indicated that haze problem in China has become the fourth worldwide largest environmental disaster after the great London fog, Japan's industrial pollution and the light pollution in Los Angeles (TechQQ). However, it was not the first time that caused worldwide public concern in the recent years. Analysis on datas including daily average as well as annual averages of air quality index (AQI) which based on PM_{2.5} from 2008 to 2015 has been shown by the U.S. Embassy in Beijing as figure 3, and it reflected the severity of haze problem in Beijing.

Beijing air quality 2008-2015

Daily average air quality index (AQI*) at US embassy, based on PM2.5 concentration readings



Annual averages



Daily average compiled from valid hourly readings Apr 2008-Jun 2015.

*AQI categories as set by the US Environmental Protection Agency

Source: US embassy, Beijing

BBC

FIGURE 3. Daily average and annual averages of air quality index (AQI) based on PM 2.5 from 2008 to 2015. (The U.S. Embassy 2015)

In previous eight years, combined both graphs, we found out that almost half of this period in Beijing was defined as “Unhealthy” air quality while only 20% looks nice, and 18% was categorized as “Very unhealthy” including 4% was “hazardous”.

2.2 Air pollutants

Haze differ from mist, fog, smog and vog, even all of them cause reduced visibility. Debra Kelly indicated that mist and fog are caused by the water droplets in the air, though their only difference is distance of visibility; haze is the reflection of sunlight off air pollution and it happens when the particles in the air are pollutants; smog emerges in pollution causes low-lying ozone; and vog only happens when there is a volcano which is releasing sulfur dioxide. (Debra Kelly 2014)

Beijing municipal environmental monitoring center gave a definition to hazy weather. Haze is an atmospheric phenomenon where a large number of dust, smoke and other dry particles get together and obscure the clarity of the sky excluding other phenomena like raining, sand storm, raise dust, smokescreen, snowstorm and so on. In China, people call it “haze” or “dust-haze”. Average visibility of haze is around 10 kilometers whereas relative humidity is less than 80%. Generally, the complex chemical reactions in haze would be enhanced under the sunlight, high relative humidity as well as stagnant air flow. (Beijing municipal environmental monitoring center 2012)

Wang yuesi, a researcher in institute of atmospheric physics, Chinese academy of sciences indicated that haze is consist of complex chemical components including various pollutants such as CO、SO₂、NO_x、NH₃、VOCs、PM (Wang yuesi 2013). In addition, according to the Clean Air Act of America, there are six common air pollutants. (also known as “criteria pollutants”) They are PM (particulate matter), photochemical oxidants and ground-level ozone, CO (carbon monoxide), SO_x (sulfur oxides), NO_x (nitrogen oxides), and lead (EPA).

The WHO offered new information included in the latest update of the Air quality guidelines (global update 2005) to four common air pollutants including particulate matter, ozone, nitrogen dioxide and sulfur dioxide. We will study the air pollution from chemical components, national standard compared to international standard, to effects as well as sources surrounding these four common air pollutants (PM, SO₂, NO₂, O₃) in the following contents.

“Particulate matter”, also known as particle pollution or PM, refers to a complex mixture of fine particles combined with liquid droplets. It is made up of lots of components like organic chemicals, metals, acids, soil or dust particles. The size of particles would directly influence on human health. EPA groups particle pollution into two classes: “inhalable coarse particles” (PM₁₀) and “fine particles” (PM_{2.5}). “Inhalable coarse particles” are particles larger than 2.5 micrometers and smaller than 10 micrometers in diameter. They are mainly from roadways and dusty industries. “Fine particles” are major component of smoke and haze, which are 2.5 micrometers in diameter and below (EPA). Both the United States Environmental Protection Agency and the European Commission have revised their air quality standards for PM more than ten years ago. The WHO also highlighted the air quality standards for PM in the guide book (WHO 2005, 9). However, China released its new ambient air quality standard in 2012, GB 3095-2012, which sets limits on PM_{2.5} for the first time.

Sulfur dioxide (SO₂) is known as “oxides of sulfur”, which is one of a category of highly reactive gasses. SO₂ emissions are mainly from fossil fuel combustion and industrial facilities. Besides, SO₂ emissions also come from industrial processes such as extracting metal from ore, and burning of high sulfur containing fuels by non-road equipment, locomotives as well as large ships. SO₂ is directly associated with lots of adverse influence on human’s respiratory system. (EPA)

Nitrogen dioxide (NO₂) is one of a group of highly reactive gasses, also know as “oxides of nitrogen” or “nitrogen oxides (NO_x)”. Two of the most toxicologically significant compounds are nitrogen oxide (NO) and nitrogen dioxide (NO₂) (Australian Government Department of the Environment). Nitrogen dioxide is a product of combustion processes, which is closely associated with other primary pollutants such as ultrafine (UF) particles. Nitrogen dioxide is itself toxic, and it is also a precursor of ozone. In addition, it coexists along with other photochemically generated oxidants. Further more, its concentrations are usually seriously correlated with those of other toxic pollutants, and easy to measure. Therefore, it has practical significance to achieve guideline concentrations for NO₂ (EPA).

Ground level ozone refers to ozone of the surface layer up to 1-2 kilometers beneath the Earth’s surface. It is not directly emitted into the air, instead, created by chemical reactions between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) under the sunlight. Emissions of NO_x and VOC are primarily from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapors, and chemical solvents. Breathing ozone can trigger various health problems especially for sensitive groups. (EPA)

The following table 1 based on GB 3095-2012 and GB 3095-1996 shows the differences between Chinese ambient air quality standards and other country’s or area’s air quality standards for those common air pollutants mentioned above. (GB3095-2012, 2012, 3) (Amending China’s Air Pollution Prevention And Control Law: Recommendations From The International Experience 2009, 20)

TABLE 1. Air pollution health standards comparison for particulate matter

| Pollutant | Averaging Time | China | | USA | WHO | EU | Unit |
|-------------------|----------------|---------|----------|-----|-----|----|-------------------|
| | | Level I | Level II | | | | |
| PM _{2.5} | Day | 35 | 75 | 35 | 25 | - | μg/m ³ |
| | Year | 15 | 35 | 15 | 10 | 25 | |
| PM ₁₀ | Day | 50 | 150 | 150 | 50 | 50 | |
| | Year | 40 | 70 | - | 20 | 40 | |

(Continues)

TABLE 1. Air pollution health standards comparison for particulate matter (Continues)

| | | | | | | | |
|-----------------|--------|-----|-----|-----|-----|-----|-------------------|
| SO ₂ | Hour | 150 | 500 | - | 500 | 350 | μg/m ³ |
| | Day | 50 | 150 | 364 | 20 | 125 | |
| | Year | 20 | 60 | 78 | - | - | |
| NO ₂ | Hour | 200 | 200 | - | 200 | 200 | μg/m ³ |
| | Day | 80 | 80 | - | - | - | |
| | Year | 40 | 40 | 100 | 40 | 40 | |
| O ₃ | 1-hour | 160 | 200 | 220 | - | - | μg/m ³ |
| | 8-hour | 100 | 160 | 147 | 100 | 120 | |

These standards are phased-in beginning in 2012 for some cities, then for every city in China by 2016. At present, China's ambient air quality standard consists of two levels. Level I standards apply to special regions like national parks. Level II standards apply to all areas including urban areas and industrial areas. The WHO also encourages countries to consider adopting an increasingly strict set of standards in order to decline concentrations of PM. Based on American Cancer Society's (ACS) study, the WHO chose an annual average concentration of 10 μg/m³ as the long-term guideline value for PM_{2.5} and an annual average concentration of 20 μg/m³ as the long-term guideline value for PM₁₀ (WHO 2005, 10).

2.3 Effects

There is one website <http://aqicn.org/city/beijing/> where we can check real-time air quality index (AQI) for each city in the world. The AQI is an index for reporting daily air quality. Through AQI we can know how clean or polluted the air is in a certain city and relative information on health effects. AQI is calculated by the U.S. Environmental Protection Agency (EPA) for five major air pollutants which refer to O₃(ground-level ozone), PM (particulate matter), CO (carbon monoxide), SO₂ (sulfur dioxide), and NO₂ (nitrogen dioxide). The AirNow system, which developed by EPA, National Oceanic and Atmospheric Administration, National Park Service, tribal, state, as well as local agencies, shows how AQI work. An air quality index (AQI) value is converted from a pollutant's reading by a formula developed by the U.S. EPA. As figure 4 shows below, the AQI runs from value 0 to 500. The higher value means the greater level of air pollution and the greater influence on health as well. (Airnow system)

| Air Quality Index (AQI) Values | Levels of Health Concern | Colors |
|---------------------------------------|--------------------------------------|--|
| <i>When the AQI is in this range:</i> | <i>..air quality conditions are:</i> | <i>...as symbolized by this color:</i> |
| 0 to 50 | Good | Green |
| 51 to 100 | Moderate | Yellow |
| 101 to 150 | Unhealthy for Sensitive Groups | Orange |
| 151 to 200 | Unhealthy | Red |
| 201 to 300 | Very Unhealthy | Purple |
| 301 to 500 | Hazardous | Maroon |

FIGURE 4. Six categories divided from AQI value (Airnow system)

| Air Quality Index Levels of Health Concern | Numerical Value | Meaning |
|--|-----------------|--|
| Good | 0 to 50 | Air quality is considered satisfactory, and air pollution poses little or no risk. |
| Moderate | 51 to 100 | Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution. |
| Unhealthy for Sensitive Groups | 101 to 150 | Members of sensitive groups may experience health effects. The general public is not likely to be affected. |
| Unhealthy | 151 to 200 | Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects. |
| Very Unhealthy | 201 to 300 | Health warnings of emergency conditions. The entire population is more likely to be affected. |
| Hazardous | 301 to 500 | Health alert: everyone may experience more serious health effects. |

FIGURE 5. Air quality index levels of health concern (adapted form Airnow system)

As figure 5 presents, generally speaking, an AQI value of 100 considered as the U.S national air quality standard for the air pollutant. AQI values below 100 are good for health while AQI values above 100 are viewed as unhealthy-at first for some sensitive people, then for everyone when the value get higher.

Clean air is a basic requirement of human health. However, the WHO mentioned that more than 2 million premature deaths each year due to air pollution including urban outdoor air pollution and indoor air pollution. Further more, more than a half of those disease caused by air pollution is borne by the citizens of many countries in the developing world (WHO 2005, 5).

A recent report showed us clearly that outdoor ambient concentrations of particulate in polluted air were 55% higher whereas life expectancy of population shorten by 5 and a half years in the north China. And the human deaths in the area were increasingly caused by cardiorespiratory diseases. (Chen, Y., et al. 2013, 110(32): p. 12936-41)

We could find out more evidences on effect of air pollution according to figure 6. In December 2012, the Lancet issued the Global Burden of Disease analyses related to average 2005 worldwide fine particle (PM_{2.5}) air pollution (Lim, S.S., et al. 2010, 380(9859): p. 2224-60). In 2013, the Health Effects Institute in Boston republished a report, which indicated that outdoor air pollution in China led to 1.2 million premature deaths as well as 25 million healthy years of life lost (AMBIENT AIR POLLUTION AMONG TOP GLOBAL HEALTH RISKS IN 2010: Risks Especially High in China and Other Developing Countries of Asia, in HEI International. 2013 Health Effects Institute: Boston, MA.). As the huge impact on health, outdoor air pollution was considered as the fourth leading cause for loss of life expectancy in China and indoor air pollution due to burning solid fuels for cooking and heating was ranked as the fifth leading risk.

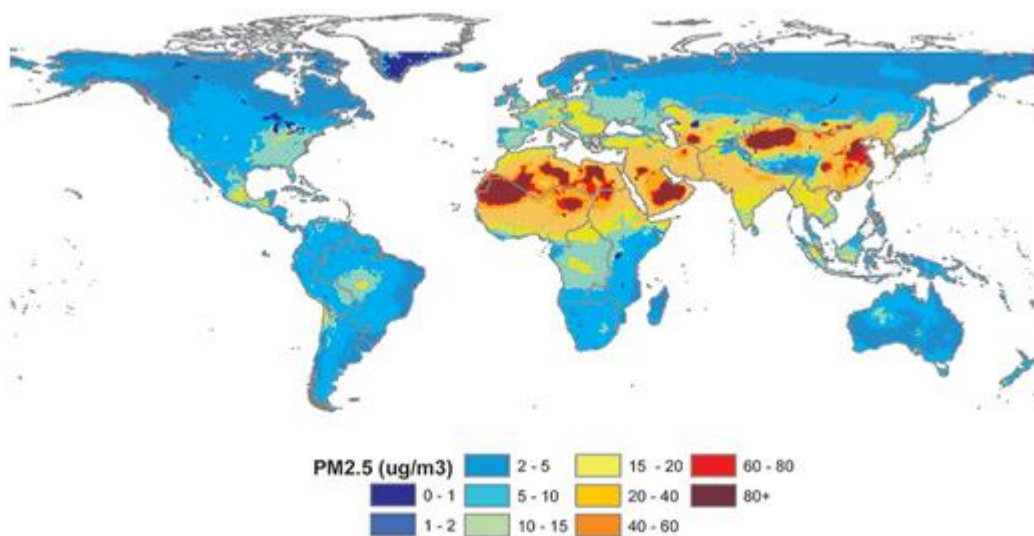


FIGURE 6. Evaluated 2005 annual average PM_{2.5} concentrations ($\mu\text{g}/\text{m}^3$) (Brauer, M., et al., Exposure assessment for estimation of the global burden of disease attributable to outdoor air pollution. Environ Sci Technol 2012. 46(2): p. 652-60)

Many studies have proved that PM 2.5 in air pollution is harmful to human's respiratory system, cardiovascular system, blood system, and reproductive system as well.

2.4 Sources

Despite haze is considered as a particularly acute problem in Southeast Asia since 1991, it is not a new term, but why it only become popular in recent years especially after a documentary about pollution entitled “Under the Dome” spread across the Internet within China? People didn’t neglect existing of haze, instead, they misunderstood it. Generally, it is difficult to distinguish between “fog” and “haze” by human eye in daily life. Until the severity and influence of haze problem these years far exceeds than ever before, in addition to extensive media reports as well as worldwide attention, people realized that it was “haze” not “fog”.

Is haze the product of recent years? We might get a negative answer. As figure 7 shows, Aaron van Donkelaar from Dalhousie University of U.S. presented a Global satellite-derived map of PM_{2.5} averaged between 2001 and 2006 on NASA. It provides the most comprehensive view of the health-sapping particles so far (Aaron van Donkelaar 2010).

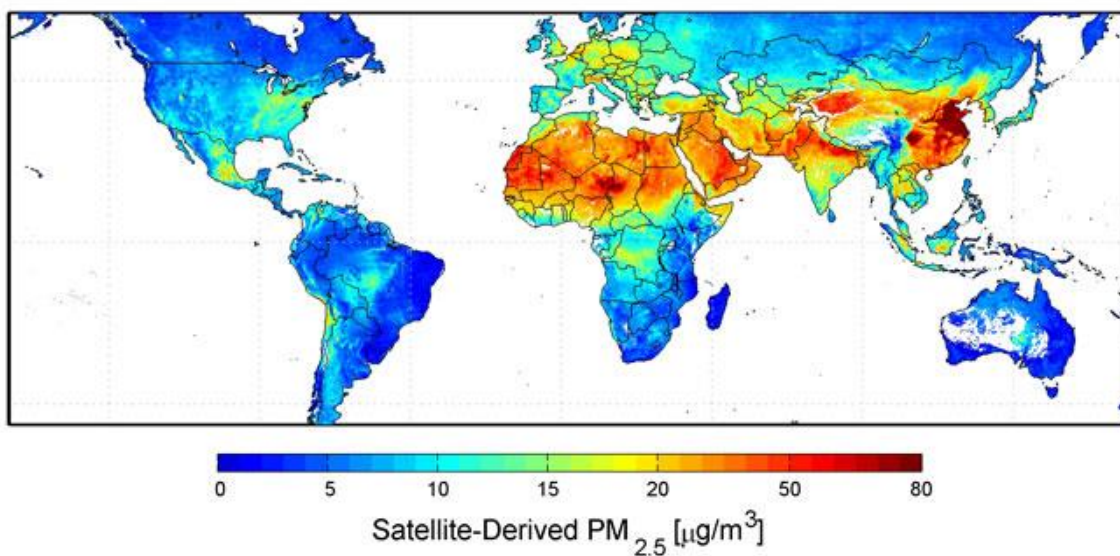


FIGURE 7. Global satellite-derived map of PM_{2.5} averaged over 2001-2006 (Aaron van Donkelaar 2010)

This map shows the average PM 2.5 results over 2001-2006. We can see in the past one and two decades, people live in large areas of China breathed polluted air that exceeds level of 30 µg per cubic meter, even reached at 80 µg per cubic meter.

Fossil fuel consumption particularly coal and oil, in addition to industrial emissions, vehicle emissions and numerous other emissions result to a large scale of air pollution problems.

The NRDC's China Climate and Energy Map figure 8, showing the areas of highest coal consumption in the north of China, we can realize that how reliant northern China is on coal and oil. Air pollutants especially sulfur dioxide and nitrogen oxide from coal combustion, which contributes 70% of China's energy and 80% of China's electricity, mainly used by power plants, heavy industry like steel, iron and cement factories, and also used for household heating in winter; emissions from vehicles especially the heavy vehicles like trucks; and dust from construction activities. (Alvin Lin 2013)

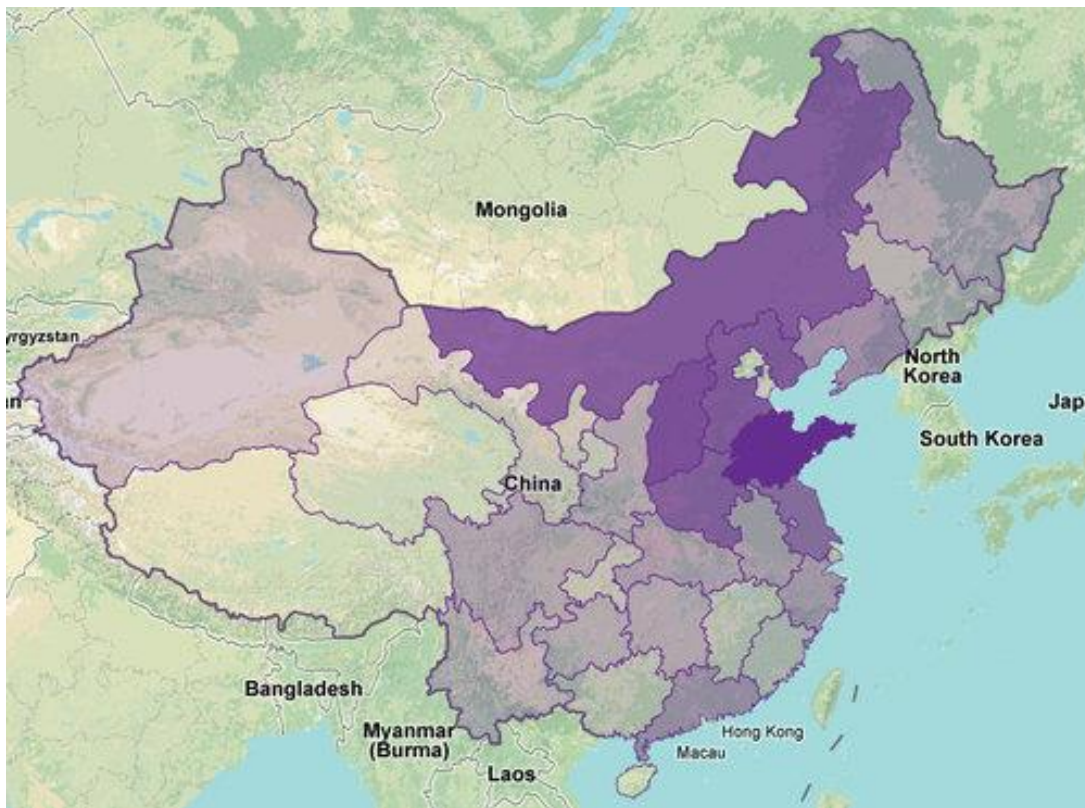


FIGURE 8. Map of coal consumption in 2010 by province in China

Although the authorities such as Beijing have developed a series of emergency response measures for both short term and long term, and taken actions to deal with air pollution problems, some scholars in China prophesied that to address the root causes of China's severe air pollution would take more than 10 years. For individuals, it seems impossible to clean up the ambient outdoor air; effects of masks in preventing individuals from breathing in ambient particles are limited; air conditioning helps on removing gaseous pollutants such as sulfur dioxide, ozone, nitrogen oxides, and other water soluble gases, but not work to small particle. Therefore, people start to place their hopes on air purifier. In the next chapter, we will discuss the air purifier industry on the China's market.

3 ANALYSIS ON AIR PURIFIER MARKET

The air purifier belongs to the new high-tech industry. In China's market, the air purifier industry still has plenty of space to grow. In this chapter, we will analyze this dramatically growing market to detail.

3.1 Demand and customer

The air purifier market is very potential in China. In recent years, the attention to PM2.5 caused the hot situation of air purifier. As China's cities experience record numbers of hazardous hazy days, sales of household air purifiers have been booming.

In February 2016, the company "Radiant Insights" from USA published a household air purifier market growth analysis report in China by 2020. This report indicated that in recent years, the sales of household air purifier on China's market increased by 27% per year. The sales in 2013 increased to 2.64 million dollars with 16% increases over 2012. In recent future, the sales is predicted to keep rising due to current situation of severe air pollution, and under conservative expectation, the market scale of household air purifier in China will averagely grow up by 9%. The sales in 2018 is even predicted to hit 4 million dollars (Radiant Insights 2016). However, up to now, the popularization rate of air purifier in China is less than 0.1% whereas the popularization rate is 27% in America, 17% in Japan, 42% in Europe and 70% in Korea (Time-weekly 2014). As one sunrise industry in China, the market room of household air purifier is enormous.

At present, household air purifier is still the biggest section compared other types of air purifier on demand. From the consumer's perspective, a report titled "consumer acceptance of air purifier in China" showed us that infant and children is one group who need air pollution protection the most; the next group is pregnant women and old people. The study also concluded that consumers with different personal background would influence consumers acceptance of air purifier, such as gender, age, monthly salary, occupation etc. Consumers educational background and marital status sometime might not effect their acceptance. Those interviewees have the high satisfaction with air purifier products. Another result is consumers whether have special protection people is not a important factor to affect consumers attitude against air purifier and consumer acceptance. (Yanxi Guo 2012, 9)

3.2 Categories of air purifier

In all segmentation, the functions of air purifiers are repeated highly, with 45% of air purifiers are able to eliminate decoration pollution, 65% of air purifiers can remove bacteria and only 33% of air purifier are traditional dedusting equipment and enter into the demand market as gifts and complimentary gifts. According to statistics, there were more than 200 brands in air purifier market in China in 2014. Foreign-funded brands still occupied mostly market shares. In 2013, the top five brands of air purifier in on-line market were Philips, Sharp, Panasonic, Ya Du (domestic brand), and Daikin. At present, there are three major camps on China's market: Euro-America brand camp with market share of over 45%, represented by Philips, Airoswiss, Austin and Whirlpool; Japan-ROK brand camp takes 35% of market shares, represented by Panasonic, Sharp, Daikin, Samsung and LG, etc; and domestic brand camp, which takes less than 20% of market shares, represented by Ya Du, Broad, Midea, Gree, Airmate and Lexy (Radiant Insights 2016). As we can see, foreign-funded brands have occupied 80% of market shares due to technical advantages. It is difficult for domestic brands to change the situation of competitive disadvantages.

If seeing from competition pattern, each brand has its own competition focuses like Philips and Panasonic absolutely dominate the activated carbon filtering system; ionic filtration system is dominated by Panasonic, Ya Du and Sharp; and Blueair dominates catalyst filtration system. If seeing from filtration layers, Philips adopts four layers of filtration or less, while Panasonic primarily adopts three-layer filtration system, and Yadu as well as Blueair use four-layer filtration system or above, and Sharp uses five-layer filtration system or above. (Radiant Insights 2016)

In addition, from the perspectives of mainstream technology categories, activated carbon filtering system takes 45.9% of household air purifier market shares, ionic filtration system takes 35.7% market shares and HEPA (High Efficiency Particulate Arrestance) filtration system takes only 9.1% market shares. (Time-weekly 2014)

Based on different purifying demand, household air purifiers also can be divided into three major categories: pure air purifier, air purifier combined with humidifier and intelligent air purifier.

3.3 Phenomenon and existing problems

At present, There are several categories of phenomenon and existing problems in air purifier market in China.

First of all, people in China are increasingly concerned about environmental issues. They attempt to protect themselves from ambient polluted air. Therefore, air purifiers in Beijing's on-line market particularly in those famous website such as Tao Bao and Jing Dong are usually out of stock due to short supply. At the same time, people are willing to spend a lot on air purifiers despite of a lack of awareness (Joseph Luk 2014). What's more, consumers find it difficult to choose a good product they actually need due to product diversity.

Second, the gross margin of air purifier is often over 50%. The great temptation have attracted about 300 manufacturers with approximately 1700 kinds of air purifiers come into China's market. However, there have been concerns raised at the lack of regulation in this lucrative market. In 2014, the China consumers association published an assessment report based on 21 kinds of household air purifiers from off-line market, in which interpret the chaos of the situation of air purifier market in China (China consumers association 2014). Some products have been proved to have bad quality. Some manufacturers are inaccurately describing the features of their products in terms of power, function, cost of after-sale, purifying capacity without professional identification, and even exaggerate features and mislead consumers through promotion and advertisement. Besides, some products are sold at high price but actually their manufacturing costs are low. Generally, AHAM (the U.S. Association of Home Appliance Manufacturers) is the most authoritative certification authority which accepted by U.S. EPA, followed by domestic certification authority such as Shanghai environmental protection and testing station of goods and services or Guangzhou Testing Center of Industrial Microbiology. The China consumers association tell us those products identified by above organizations are more reliable than other products identified by original manufacturer or even without certificate.

Third, before the issue of latest regulation, APIAC (Air Purifier Industry Alliance of China)/LM 01-2015 Indoor air cleaner's purification performance evaluation requirements, which were postponed its issue to 2015 and should be published in September 2014, there were only several regulations that had not reached maturity such as GB/T 18801-2008 and GB21551.3-2010 (APIAC). These immature regulations only specified the safety performance, the electric strength, leakage current, clean air delivery rate of particle as well as noise of air purifier in China. Nevertheless, they didn't compulsively

required other performances such as applicable room area, and energy efficiency grade of purification. As a result, those phenomenons mentioned above emerged.

3.4 Tendency

As the latest standard metrics, APIAC/LM 01-2015 Indoor air cleaner's purification performance evaluation requirements has been issued and put into effect, additionally with an influx of relative corporations the air purifier market in China are being reorganized. In the next few years, development trend of air purifier market in China primarily includes:

The industry of air purifier would hardly accelerate reshuffle. Manufacturers with low-quality products must be eliminated. In addition, small manufacturers would lose advantages of price performance and would also fall into disuse. According to the 2015 China's air purifier industry report, in 2015, the turnover online of air purifier whose prices above 5,000 RMB had reached at 16.4%, increasing 127% to seize market space further against middle and low-end products (China Industry News 2016).

Internal firms step in air purifier market enable the development trend of air purifier in China become intelligent. As smart home era has come, various solutions to connect household appliances to computer networks are coming to effect. Using mobile phone to remote control household appliances has become a fashion statement. (Qian Zhan research 2015) Both domestic and foreign manufacturers agreed that intelligentization would be the primary tendency of development of air purifier industry. GFK China has shown us the statistics that at current, it has been more than 30 brands launched intelligent air purifier, and the percentage of intelligent air purifier could be found in 10% with continuous improvement of all air purifier (China Industry News 2016).

Additionally, Gao Yanmin, the director of Consumer Goods Industry Department under the Ministry of Industry and Information Technology of the People's Republic of China, advised that the whole air purifier industries should improve intelligence manufacturing level, set up smart-connected plants and digital workshop, and push out high-end intelligent air purifier, especially customizable products, enable consumers keep knowing and then like your brand, in order to expand the brand influence further more. (China Industry News 2016)

4 ANALYSIS ON FINNISH LATEST INTELLIGENT AIR PURIFYING TECHNOLOGY

After analyzing air purifier market in China, in this chapter, we will take a latest intelligent air purifier as example, which is called LA500 air purifier, designed and manufactured by a Finnish company (Lifa Air) to study Finnish latest intelligent air purifying technology.

4.1 Lifa Air

Lifa Air is a Finnish company which was built up in 1988 in Helsinki (the capital of Finland), a leading company in IAQ (indoor air quality) business particularly in ventilation system in global scale. Its slogan is “Solution For IAQ”. Its official website is <http://www.lifa.net/en/index.php>. In 2000, Lifa Air setup an Asian headquarter in HongKong, at the same time, its the most important development project for building protection -- LIFA 3G supply air filter (pat.pend) was also developed in cooperation with HongKong Polytechnic University and VTT Research Center of Finland. In 2006, Lifa Air setup its subsidiary in Beijing and served for 2008 Beijing Olympic Games.

Although Lifa Air was not well-known in China before, it is a substantial company indeed. Lifa Air’s technology was not only applied to military field, but also used for the Embassy of Finland Beijing-China, EU Medical Institutions for SARS, and 2008 Beijing Olympic Games. Last year, Lifa Air received EUR 21 million investment from the Edifier Technology who is Chinese consumer electronics manufacturer (Good News from Finland 2015). In the meantime, this two companies established a joint venture in Dongguan, China, and produced five types of intelligent air purifiers for the consumer market in China based on Lifa Air’s patented air purifiers.

Johan Brandt, the Lifa Air’s Sales and Marketing Director said, “With nowadays universal human pay increasing attention to indoor air quality, intelligent air purifiers meet consumers’ need because intelligent air purifiers make it possible to measure indoor air quality in real time and automatically optimize air quality.”

About market reaction of Lifa Air, Johan Brandt continued to introduce, “Our products have met with enthusiasm and favorable reviews in the Chinese media. Consumers are interested in the intelligent technology of our products.” (Good News from Finland 2015)

4.2 Case study – LA500 air purifier

LA500 intelligent air purifier is one of intelligent products of Lifa Air that land into China's market last year. Differ from mostly products claimed to be intelligent which can only connect to the network by application, LA500 air purifier can analyze the ambient air quality, judge by itself, and operate independently. 2015 is the first year of issue of new standard (APIAC/LM 01-2015). As LA500 has excellent performance on four core indexes of new standard, LA500 has got wide attention and favorable reviews (Chinese appliances website 2015). There is no doubt that LA500 air purifier has become one of good choices for Chinese consumers.

4.2.1 Overview

As the new standard request manufacturers to label several critical elements such as PM2.5CADR, applicable room area, energy efficiency of purification, energy efficiency grade of purification (APIAC/LM 01-2015 2015, 4) and CCM (Cumulate Clean Mass) (GB/T 18801-2015 2015, 2) etc. As a result, in the following section, I will show the cleaning capacity of LA500 from these elements as well as product specifications and functional parameter in table 2.

TABLE 2. Product information of LA500 air purifier (adapted from Johnson-group & Jing Dong)

| Items | Information | Unit/Remarks |
|--|-----------------------|----------------------|
| Main Body | | |
| Brand | Lifa Air | Finland |
| Type | KJ450G-L50 | LA500 |
| Category | Air purifier | Intelligent |
| Color | White | / |
| Place of origin | Chinese Mainland | / |
| Product Specifications | | |
| Net wight | 14.65 | kg |
| Gross wight | 20.15 | KG |
| Rated voltage | 24 | v |
| Rated power | 2-60 | w |
| Size of Host Machine | Diameter300*height800 | mm |
| Standby power | 0.87 | w |
| Noise | 34-63 | dB(A) |
| Applicable room area | 31-54 | m ² |
| PM2.5 CADR | 450 | m ³ /h |
| Formaldehyde CADR | 137 | m ³ /h |
| PM2.5 Energy efficiency of purification | 6.931 | m ³ /(hW) |
| Formaldehyde Energy efficiency of purification | 2.117 | m ³ /(hW) |
| Purification efficiency of PM2.5 | >99.99 (30 min) | % |

(Continues)

TABLE 2. Product information of LA500 air purifier (Continues)

| | | | |
|--|-----------------------|--|--------------------|
| Purification efficiency of Formaldehyde | | 91.33 (30 min) | % |
| | | 98.75 (3 h) | |
| Bacterial eliminating rate | | 99.9 | % |
| Hazardous gas emission | Ozone concentration | N/A | mg/m ³ |
| | TVOC | 0.003 | mg/m ³ |
| | PM10 concentration | 0.002 | mg/m ³ |
| | Ultraviolet intensity | N/A | uW/cm ³ |
| Functional Parameter | | | |
| The way of purification | | Multi-layer filter | |
| Whether multi-layer filter | | Primary filter + H12 HEPA filter + 3.5kg activated carbon (2sets) | |
| Filter particles | | 0.3 micrometer | |
| Changing notification of filter | | Support | |
| Indicator light for degree of purification | | Independently monitor/the controller presents air quality by digitization | |
| Sleep mode | | Support | |
| Automatic operation function | | Analyze the situation and operate automatically based on air quality monitored | |
| Function of removing smoke | | Support | |
| Speed setting of fan | | Support | |
| Air volume | | Auto intelligent control | |
| Timer mode | | Auto intelligent control | |
| Lifetime of filter | | 12 months | |
| Air humidity indication | | Independent monitor/controller | |
| Air quality indication | | Independent monitor/controller presents air quality by digitization | |
| Remote control | | Auto intelligent control | |

According to the new standard, CADR is one of the most important index of air purification. CADR is short for Clean Air Delivery Rate that refers to the volume of filtered air delivered by an air purifier per hour (APIAC/LM 01-2015 2015, 1). PM_{2.5}CADR is the parameter of purification performance of air purifier to PM_{2.5}. PM_{2.5}CADR of LA500 is 450 m³/h. It belongs to high-volume air purifier based on the this value. New standard requires the measured value of PM_{2.5}CADR of air purifier shouldn't be less than 90% of nominal value. China.com published a professional assessment report, and actual test data proved that measured value of PM_{2.5}CADR of LA500 was more than 90% with excellent purification capability (China.com 2016). Additionally, the formaldehyde CADR of LA500 is 137 m³/h.

Applicable room area is another important index of air purifier. Applicable room area means the maximum indoors area that applicable for air purifier when cleaning particles. The new standard requires that the nominal value of applicable room area should not be bigger than the product value which

multiples by measurable value of PM_{2.5}CADR and 0.1 (APIAC/LM 01-2015 2015, 1). As the nominal value of applicable room area of LA500 is 31-54 m², 54 m² is the maximum value, plus its excellent performance on PM_{2.5}CADR, in other word, LA500 meets the requirement of the new standard on applicable room area.

Energy efficiency of purification means the ratio of CADR and input power of purification when air purifier realizes optimum purification for particles (APIAC/LM 01-2015 2015, 2). The energy efficiency of purification for PM_{2.5} of LA500 is 6.931 m³/(hW), while the energy efficiency grade of purification for PM_{2.5} is ranking almost the grade 1 (best grade). At the same time, the energy efficiency of purification for formaldehyde is 2.117 m³/(hW), while the energy efficiency grade of purification for formaldehyde is ranking the grade A (best grade) (APIAC/LM 01-2015 2015, 3).

CCM is short for Cumulate Clean Mass, which is one of parameter that shows the cumulate clean capacity of an air cleaner against target pollutant including particulate and gaseous pollutant when an air cleaner is working at the rated circulation and stated test condition. CCM presents the total mass of target pollutant which is cumulate cleaned when the CADR (Clean Air Delivery Rate) of an air cleaner decay to 50% of original value. And the unit of CCM is mg (GB/T 18801-2015 2015, 2). The CCM of PM_{2.5} of LA500 is about 30000 mg, ranking the grade P4 (best grade) while more than twice the latest national standard. And the CCM of formaldehyde of LA500 is ranking the grade F4 (best grade) which also vast by latest national standard (Zhongce.sina.com.cn 2016).

Filtration system is the most important part of an air purifier. The filtration system of LA500 is composed of primary filter, 2 sets of H12 HEPA filter and 2 sets of 3.5kg activated carbon. In order to guarantee a total air purification, LA500 adopts a unique Dual Filtration system with a ring form. The primary filter is used as supporting body of activated carbon buckets. Each activated carbon bucket is filled by 1.75 kg of high quality of anti-acidity activated carbon. With total weight of 3.5 kg of anti-acidity activated carbon can make it possible to achieve formaldehyde CADR to 137 m³/h. The second filtration is done by using H12 HEPA high efficiency filter which produced by professional filter supplier, APOLLO (Japan). The extended area of 2 H12 HEPA filter of LA500 can reach at 4.6 m², enable the purification efficiency of PM_{2.5} achieve 99.99% within 30 min. It means under the same volume of air, the air speed passing filter would decrease, and make HEPA filter easily to capture the dust. In this case, the service life of filter can be increased while saving the energy. In addition, the activated carbon buckets are outside of HEPA filters can effectively avoid secondary pollution of powdered carbon. (Chinese appliances website 2015)

A good air purifier should not only possess excellent performance on purification, but also fashionable design for appearance. LA500 air purifier is cylindrical designed so that it won't take up much space. Both Full metal body using roast painting and the whole body without any physical keys make it is a good example of Scandinavian design. Differ from other air purifier, LA500 has air-flow control with on touch feature. Air speed also can be adjusted with one hand operation. Aero-compressor like inlet guide vane gives LA500 a sophisticated appearance that never outdated. (Chinese appliances website 2015)

4.2.2 Intelligent technology of LA500 air purifier

Design and intelligent technology are highlights of Lifa Air's LA500 air purifier. LA500's intelligent technology primarily reflects in four aspects: real-time monitoring air quality, intelligently calculating life time for filters, self-analyzing and auto-selecting purification method, and remote controlling.

LA500 featured with 4 precise sensors, including a laser particle sensor that can detect PM0.3, a formaldehyde sensor, a carbon dioxide sensor, and an odor sensor which reacts to unpleasant odor immediately. (Johnson-group 2015) Possessing these four precise sensors, LA500 can real time measure air quality in terms of PM2.5, formaldehyde, inhalable particles, gaseous pollutants, ozone, bacterium virus and peculiar smell even temperature and relative humidity. More important, LA500 has a carbon dioxide sensor and odor sensor and these indexes are in the form of ocular data. The carbon dioxide sensor is very practical, and it is able to remind user of opening window properly to avoid dizziness and chest tightness when the concentration of carbon dioxide is too high. The formaldehyde sensor is also useful particularly in families with children because formaldehyde is harmful to them. The divided designed monitor/controller can be break away from the power and can be moved to any corner of house for monitoring. At the same time, according to many testers, the sensitivity of these sensors were proved to be believable (China.com 2016)

User can view information of life time of filters, which are in the form of digitization. LA500 can intelligently calculate the life time of primary filter, H12 HEPA filter and activated carbon filter, and remind user when he/she should change each filter. It is very convenient for user. Generally, the normal life time of LA500 is one year or above. If formaldehyde level keeps at a safety level detected continuously then there is no need to replace the activated carbon filter (Johnson-group 2015).

Differ from other air purifiers, LA500 determines the right air purification procedure based on the detection of human activities and air pollutants levels. For instance, when indoors air quality is polluted, LA500 will automatically increase air-flow, otherwise decrease air-flow. LA500 can also judge whether user open the window or not based on the carbon dioxide sensor. If there is nobody at home, LA500 will stop operating automatically when indoors air quality is good. In this case, this breakthrough technology minimize the unnecessarily power consumption and increase the filter's lifetime.

At last, LA500 can be remote controlled by user's mobile phone. Mobile phone can become mobile terminal with the same function as the controller through Lifa Air's application. It is possible to look over the ambient air quality of controller and remote control it even though user's phone is not in the same wireless network with the controller.

4.2.3 SWOT analysis of LA500 air purifier

In this sector, I am going to analyze the strengths, the weaknesses, the opportunities as well as the threatens of LA500 air purifier based on the assessment reports by reviewers on-line, comparing with the same type products such as AC4016/00 (PHLIPS), KJ450F-JAC2022S (Honeywell), F-VXJ90C-K (Panasonic) and to dig deeper for LA500 so that come up with more selling points for marketing promotion. In the following table 3, key features of those intelligent air purifier would be compared.

TABLE 3. Comparison of key features of different intelligent air purifier (adapted from Jing Dong)

| Brand | Lifa Air (Finland) | PHLIPS (Holland) | Honeywell (America) | Panasonic (Japan) |
|----------------------------|---|--|---|---|
| Type | LA500 | AC4016/00 | KJ450F-JAC2022S | F-VXJ90C-K |
| Filtration system | Primary filter+H12HEPA filter+Activated carbon filter | Primary filter+FY3107 nanoscale filter | Primary filter+HiSiv filter(HEPA+Activated carbon filter) | Nanoe purification (HEPA composit filter) |
| Filter particles (microns) | 0.3 | 0.02 | / | 0.3 |
| Lifetime of filters | 12 months | / | / | / |
| Technology | Intelligent | Intelligent | Intelligent | Intelligent |
| Function | Remove smoke, dust, bacteria, formaldehyde | Remove smoke, dust, bacteria, formaldehyde | Remove smoke, dust, bacteria, formaldehyde | Remove hydrogen from viruses, bacteria, odors and allergens |

(Continues)

TABLE 3. Comparison of key features of different intelligent air purifier (Continues)

| | | | | |
|--|--|--|--|---|
| PM2.5 CADR (m ³ /h) and removal rate | 450; 99.99% within 30 min | 274; 99% within 40 min | 451; / | About 479; / |
| Formaldehyde CADR (m ³ /h) and removal rate | 137; 98.75% within 3 h | 200; 99% within 2 h | 67; / | / |
| Applicable room area (m ²) | 31-54 | 21-36 | 31-54 | 66 |
| Noise (db) | 34-63 | 31-62 | 67.1 | 18-55 |
| Price (RMB) | 5,980 | 1,999 | 3,999 | 5,999 |
| Favorable reviews on-line (Jingdong) | 99% | 95% | 99% | 93% |
| Advantage | <ul style="list-style-type: none"> - Automatically monitor (real time) air quality and adjust air-flow - Save power - Extend life time of filters - Sensitive response of sensors - With human activity sensor - Valuable display functions of concentration of Carbon dioxide and formaldehyde - Display lifetime of filters can remind user to change - Good appearance - Humanized usage (easy to use) - Support remote control (APP) | <ul style="list-style-type: none"> - High popularity - High price competition - Enable to remove particles of 0.02 microns - High CADR value of formaldehyde - With indicator light to remind user when the filters should be changed - With indicator lights of three grades of air quality - With air speed setting | <ul style="list-style-type: none"> - High price competition - High CADR value of PM2.5 - More applicable room area - With touchscreen+wifi - Support remote control (APP) - Automatically monitor air quality with two sensors, and adjust purifying method - Extend life time of filters | <ul style="list-style-type: none"> - High popularity - High CADR value of PM2.5 - More applicable room area - Less noise - With humidifying capacity - With extra washable filter protects against sandstorms - About 60% energy saved - With easy clean design - With human activity sensor |

(Continues)

TABLE 3. Comparison of key features of different intelligent air purifier (Continues)

| | | | | |
|--------------|--|--|---|--|
| Disadvantage | <ul style="list-style-type: none"> - Low popularity - Less price competition - no use special and unique “3G filter” technology of Lifa Air which is more competitive due to positioning function - Not easy for women and elderly to remove the damp-proof packing before first use or change filters | <ul style="list-style-type: none"> - Low CADR value of PM2.5 - Less applicable room area - Not automatically intelligent (need user to adjust air speed) - Not reflect the lifetime of filters (indicator lights only flash when user should change filters, not clear enough) | <ul style="list-style-type: none"> - Low CADR value of formaldehyde - Not reflect the lifetime of filters | <ul style="list-style-type: none"> - Key features online are not detailed enough, eg: CADR value of PM2.5 and formaldehyde - The actual appearance is not good as the pictures online - Higher defective percentage |
|--------------|--|--|---|--|

The LA500 of Lifa Air has many strengths and LA500 has highlighted its all outstanding characteristics on the packaging of the product. First, detect air quality without dead angle. Second, independent monitor with multi-sensors. Third, high CADR value of PM2.5. Forth, with 3.5 kg anti-acid activated carbon. Fifth, removal rate of PMA2.5 reach at 99.99%. Sixth, long lifetime design for filters. Seventh, fast clean. Eighth, simply design style and humanized usage.

PM2.5 CADR of LA500 arrives at 450 m³/h and the applicable room area is 31-54 m² which are much competitive of its kind while LA500 only takes up space of 0.07 m² with diameter of 30 cm². However, KJ450F-JAC2022S of Honeywell (America) and F-VXJ90C-K of Panasonic (Japan) are slightly better according to their PM2.5 CADR value and the applicable room area.

LA500 adopts a special way that the intake air enters into LA500 from 360 degree via equally distributed and densely small holes on the side face shown by figure 10, and the clean air is delivered from the top of LA500. The densely and equably small holes are used to make sure the trapping efficiency no matter the machine is located along the wall or in the center of the room. And due to the special design of fan blade, the clean air would be diffused towards to ramp above by 45 degree as figure 9 shows. In this case, the diffusion rate of clean air would much faster than vertical jet.



FIGURE 9. Diagram of how LA500 delivery clean air (adapted from LIFA air official website)

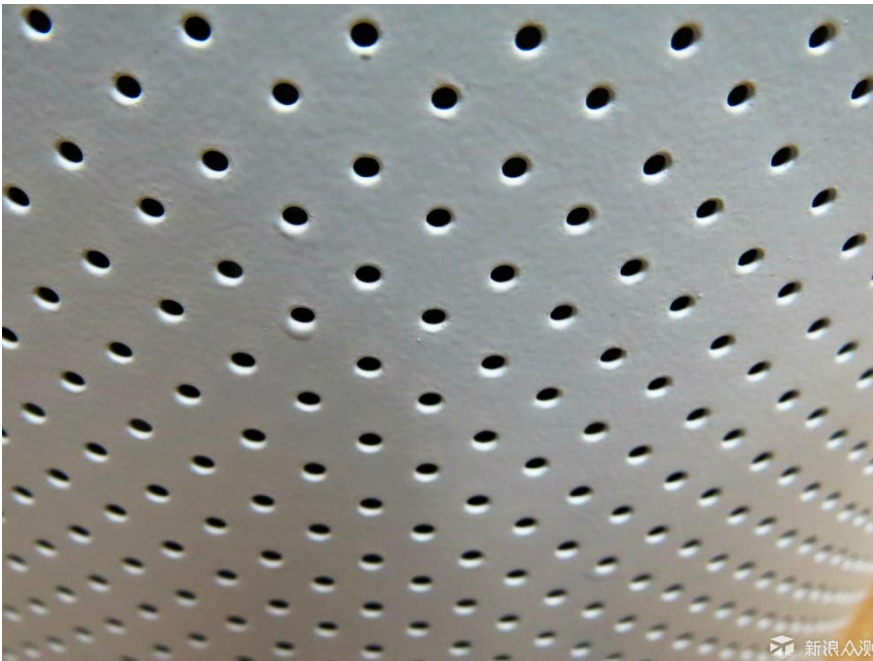


FIGURE 10. Appearance of LA500 (adapted from LIFA air official website)

LA500's power interface is on the bottom of the machine. All of the filters must be separate and remove the damp-proof packing on the activated carbon buckets before first use. This is not so humanized because the net weight of LA500 is 14.65 kg, which approximately amount to a pail of purified water of

15L. It is a little difficult for the elder, women, teenagers, and disabled people to put down the LA500 and remove the damp-proof packing.

When put down the LA500, its detailed introduction is found on the cover at the bottom, including PM2.5 CADR, Formaldehyde CADR, PM2.5 CCM, Formaldehyde CCM, energy efficiency grade of purification, noise, and applicable room area. According to the detailed introduction, LA500 shows good merits at four core indexes in the latest national standard, especially the CCM and the energy efficiency grade of purification have already significant to surmount the latest national standard.

Noise is an important index which relates directly to the comfort level among all performance. In fact, noise performance is often in conflict with air treatment capacity. However, LA500 balances them well. The main reason is that LA500 adopts DC motor (Direct-current dynamo). DC motor costs much more than normal motor, which costs at least 500 RMB on China's market. In addition, the usage of DC motor makes LA500's power consumption at lower level. According to the latest national standard GB/T 18801-2015, when an air purifier operates, the noise value corresponding to the measured value of CADR should meet a specified standard. Based on the noise standard presented by table 4, these four air purifiers are qualified.

TABLE 4. Noise standard (adapted to GB/T 18801-2015 2015, 4)

| CADR/(m ³ /h) | Noise/db(A) |
|--------------------------|-------------|
| $Q \leq 150$ | 55 |
| $150 < Q \leq 300$ | 61 |
| $300 < Q \leq 450$ | 66 |
| $Q > 450$ | 70 |

Note: If air purifier can remove more than one kind of target pollutant, take the maximum CADR to determine the corresponding noise value in this table.

In addition, LA500 meet the requirement in 8.1.2 of GB/T 18801-2015 that the performance characteristics should include CADR(pollutant), CCM(particulate), CCM(odor), energy efficiency of purification, noise, and applicable room area.



FIGURE 11 . LA500's filter combination of a primary filter, 2 sets of H12 HEPA filter and 2 sets of 3.5kg activated carbon (adapted from LIFA air official website)

As figure 11 shows, LA500 adopts special design of filtration system including primary filter, 2 sets of 3.5kg activated carbon and 2 sets of H12 HEPA filter. The activated carbon buckets are outside of HEPA filters can effectively avoid secondary pollution of powdered carbon and extend the life time of HEPA filter because the activated carbon can remove certain particles as well.

The filter on the market is divided into two kinds by different wind path design, ring form and flat form. The biggest advantage ring form has is it can realize the maximum extended area with minimum volume. The bigger extended area air purifier has, the better purification efficiency it owns. The extended area of 2 H12 HEPA filter of LA500 can reach at 4.6 m^2 , enable the purification efficiency of PM_{2.5} achieve 99.99% within 30 min.

The filtering effect of HEPA filter is based on the size of particulate. Choosing particles of 0.3 microns (PM_{0.3}) as the yard stick due to its penetrability. Particles of bigger than 0.3 microns and smaller than 0.3 microns are much easier to be removed. Therefore, some reviewers think if manufacturer only mentions PM_{0.1} or PM_{2.5} when advertising HEPA filter, it is likely to mislead consumer. At present, mainstream material of HEPA filter is fiberglass which shown by figure 12.



FIGURE 12. LA500’s HEPA12 filter (adapted from LIFA air official website)

One reviewer collected the filter classification and its effect from different countries. In a word, it can be concluded as the following table 5.

TABLE 5 . HEPA filter’s classification (adapted from Zhongce.sina.com.cn 2016)

| America’s MERV Classification | Filtering effect on particulate whose diameter range from 0.3 microns to 1 microns | EU’s BS EN1822: 2009 testing standard classification | Filtering effect on particulate whose diameter range from 0.1 microns to 0.3 microns that most penetrating | China’s GB/T 13554-2008 efficient air filter classification | Filtering effect of efficient (diameter \geq 0.5 microns) and super efficient(diameter \geq 0.1 microns) |
|-------------------------------|--|--|--|---|--|
| 1-12 | / | E10 (primaryH 10) | \geq 85% | Efficient A | \geq 99.9% |
| 13 | <75% | E11 (primaryH 11) | \geq 95% | Efficient B | \geq 99.99% |
| 14-15 | 75-95% | E12 (primaryH 12) | \geq 99.5% | Efficient C | \geq 99.999% |

(Continues)

TABLE 5 . HEPA filter's classification

| | | | | | |
|----|--|-----|--------------|-------------------|-------------|
| 16 | >=95% | H13 | >=99.95% | Super Efficient D | >=99.999% |
| 17 | >=99.97% (aims at PM0.3) | H14 | >=99.995% | Super Efficient E | >=99.9999% |
| 18 | >=99.99% (aims at PM0.3) | U15 | >=99.9995% | Super Efficient F | >=99.99999% |
| 19 | >=99.999% (aims at PM0.3) | U16 | >=99.99995% | | |
| 20 | >=99.999% (aims at particles whose diameter range from 0.1-0.2) | U17 | >=99.999995% | | |

When it comes to the filtration system of LA500, there is a pity that LA500 doesn't adopt the "3G filter" designed and developed by Lifa Air or a better grade HEPA13, which are more efficient and durable than normal HEPA filter due to positioning system. Product engineer of LA500 explained that considering requirement for CCM and design requirement for wind resistance, adopting HEPA12 filter can balance these requirement while ensuring efficiency of purification.

HEPA filter of LA500 is known to cost 598 RMB for two, and activated carbon bucket cost 898 RMB for two. Generally, HEPA filter of LA500 needs to be changed once a year while activated carbon bucket once two years depending on the using environment. If the using environment does not contain over much formaldehyde etc harmful gaseous pollutant, that there is no need to change the activated carbon bucket.

The attachment of LA500 includes independent monitor/controller, power adapter and power line of monitor/controller, power adapter and power line of main machine, can be seen in figure 13. Some reviewer asked questions about the power adapter of LA500 because more people are accustomed to those facility that internally adapter and externally single plug. Another puzzle is the power adapter and power line of the monitor/controller. The power adapter of the monitor/controller is a folding two-pin plug. But why not using a three-pin plug to expand the usable range? The same problem with the power line of the monitor/controller. Take a broad view of those monitors and intelligent hardware on China's market, mostly are using micro usb as connector to make it simpler for users that match their smart phones and power line of tablet computer.



FIGURE 13 . Attachment of LA500 (adapted from Zhongce.sina.com.cn, 2016)

The most outstanding characteristic of LA500 is its real intelligence. The independent controller can automatically monitor the real-time air quality and adjust its air-flow. In this case, it can save power and extend the lifetime of filters. More detail introduction to the monitor/controller would be found in the following paragraphs. The independent monitor/controller would be called LAM01 for short.

The biggest difference between Lifa Air's LA500 and other three air purifiers (PHILIPS's AC4016/00, Honeywell's KJ450F-JAC2022S, and Panasonic's F-VXJ90C-K) is LA500 has an separate monitor/controller, and other three have built-in monitors. In the figure 14, the components of LA500's controller would be seen then.

Currently, for those air purifiers which built-in monitors, luminous diode is seen as the major mean to calculate the amount of particulates in the air. Additionally, there are two mainstream monitoring modules are used to judge indoor air quality through feedback voltage. One is made by SHARP, and another is made by SAN YING (Korea). Their precision are about 1 microns. Both of them are not so sensitive. In some assessment reports by reviews on-line, those built-in monitors are denied, because luminous diode's cost determines its monitoring precision is not so sensitive. A professional monitor that truly judge the indoor air quality usually adopts laser to calculate the amount of particles in the air,

whose precision is really high. However, it is impossible to integrate this laser into an air purifier. First, the cost must be much more. Second, even though an air purifier is integrated by laser, it can only monitor the indoor air quality besides the air outlet. However, when indoor air quality becomes good at the far corner, the whole indoor air quality can be real good. As a result, a separate monitor is essential.

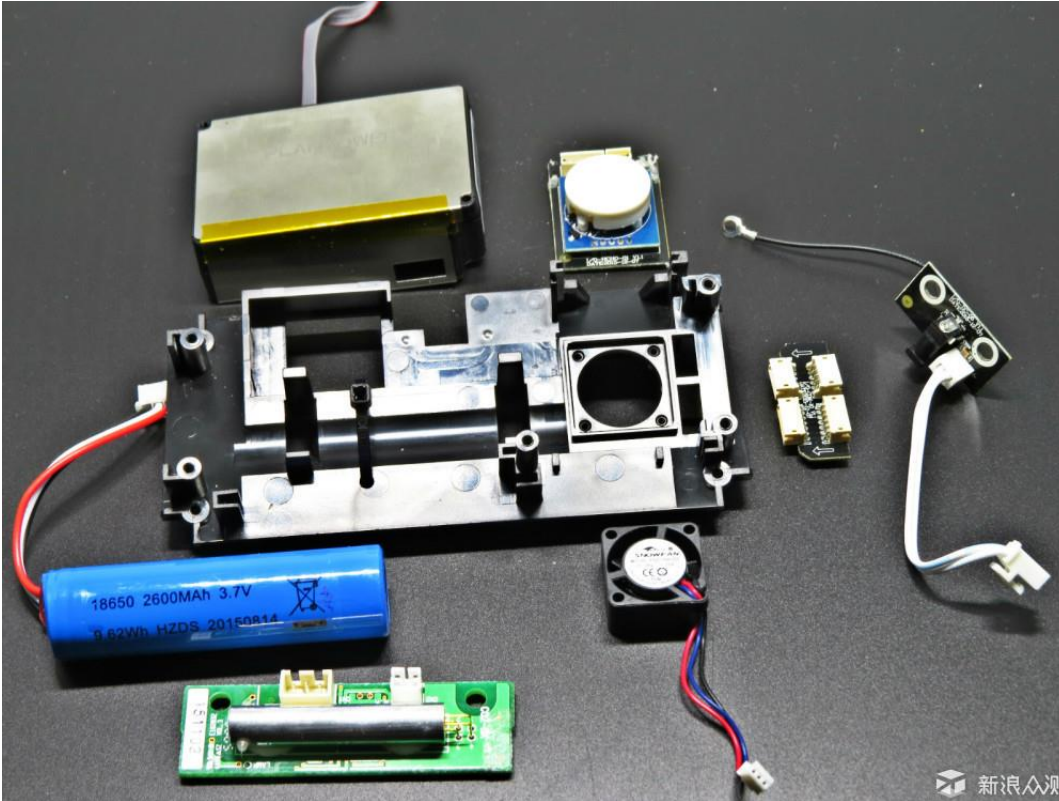


FIGURE 14 . Components of LAM01 (adapted from Zhongce.sina.com.cn 2016)

LAM01 costs around 2000 RMB, it contains a PMS 1003 particulate sensor (PLANTOWER). This sensor belongs to digital laser sensor for particulate concentration, used to acquire amount and quality of particulate in the air per unit volume, and output in the form of digital connection. It can monitor and provide users with accurate concentration data. It can recognize PM0.3. This sensor reserves install space for temperature and humidity module. The applicable range of temperature is from -20°C to 50°C . The lifetime of this sensor is 30000 hours, after that, the monitor data it gets might go awry. For sure, it happens with any kind of sensor. LAM01 also contains a DS-HCHO (PLANTOWER) formaldehyde sensor, whose lifetime is also 30000 hours. Additionally, LA500 contains a carbon dioxide sensor, CO2-8K, which come from a Japanese company called NiCeRa. CO2-8K adopts the currently most advanced method to measure carbon dioxide, no need to sample with accurate measurement, qualified by national standard, and with small volume, easily to use, response quickly, high stability as well as high consistency.

In conclusion, there are a variety of intelligent air purifiers on China's market, by contrast, we can easily see the obvious advantages of Lifa Air's LA500. First, LA500 shows its real intelligence by using an independent monitor which can monitor real time air quality automatically and adjust its air flow on time. At the same time, independent monitor is more sensitive and precise than built-in monitors, and easily to use, reacts quickly with high stability. Second, LA500 shows good merits at CADR value, CCM, removal rate of PM2.5, and balance noise and air treatment capacity well. Third, adopting special designs make LA500 have faster diffusion rate of clean air, more efficient and longer life time. At last, LA500 has simple design style, easily to use, and more humanized. As a result, LA500 could be really competitive and gain more market shares as long as perfecting its disadvantages like the adapters' and chargers' problems and make it easily for users. Among those disadvantages of LA500, low popularity is the most important which concerns its market share in China. To expand popularity and market share, advertisement and promotion are crucial means for LA500. It will be discussed to detail in the following sector.

5 SUGGESTIONS ON MARKETING PROMOTION FOR LIFA AIR

According to Gfk China, the trusted source of relevant market and customer information, thinks that nowadays intelligent home appliance has become latest consumption trend. It is vital for enterprise to seize the opportunity and forge better product and service method that consumer really required. Unlike intelligent television which is entirely intelligent, most of home appliance have low smart rate. In 2016, the retail-sales number of intelligent big home appliance only take 12.7% in big home appliance market, however, small intelligent small home appliance only take 3.0% in small home appliance market. (Gfk China 2017)

Faced with this situation, intelligent home appliance must first resolve questions of marketing strategy, and the priority one is to improve the connection rate between own product to the market. In 2016, Lifa Air recruited testers to the public on Weibo and successfully collected a large number of test data and reports. (Xin Lang Zhong Ce 2016) It is a good way to connect product with consumers. For Lifa Air's marketing strategy, I still have some following suggestions.

First of all, continuously improving product quality and make it the most intelligent. With the increasing development of modern intelligence technology, product needs to be upgraded all the time to achieve unwavering success. Only based on high smart connection rate can it make sense with the service, the scene and the ecology intelligent appliances envision. And it would be good for Lifa Air to take part in more relative industry summits for technology communications inside the industry. Second water and air purifier industry summit and central ventilation system media comment standard conference was hold in Shanghai on 7th June. The summit invited famous industry experts of water and air purifying industry as well as five popular enterprises representatives including Honeywell and Yadu to give a speech surrounding purifying technology (Gfk China 2017).

Second, focus on user experience, because user's comment may bring useful and creative suggestions. It would be good for Lifa Air to take part in more home appliances fair or intelligence technology exhibition which are hold in China. It's a good opportunity to connect products with consumers by displaying what are the components inside the air purifier, presenting products function and advantages, how intelligent it is, and even by doing a small experiment to show its outstanding purification capability. Not only take part in the exhibitions in China could be a good way to connect products with consumers, but also airports in Finland could be a good place to do presentation and promotion, because a growing

amount of Chinese tourist is visiting Finland every day. Like the drones brand Yuneec, it presents its products and technology to hundreds Chinese tourists in Helsinki Vantaa Airport every day.

Third, to know Chinese consumers better by using top market research specialists like Gfk China who turns big data into smart data, enabling clients to improve competitive edge and to make smarter decisions. China's market undoubtedly is a big consumer group whereas China's market is dynamical and rapidly changing all the time. Who knows the consumers better, who might get the initiative in the competition. Lifa Air may also co-operate with the biggest online marketing platforms like Jingdong, Taobao to know intelligent home appliance consumption patterns in China's online market.

Last but not the least, to attract more investor in China and do effective advertisement can become vital methods to improve brand awareness and sales. In recent years, being a sponsor for variety entertainment program and displaying products on TV show's scene, using star effect have become a successful way to promote products as well as to improve brand awareness. For example, promote one kind of intelligent electric water heater in a reality show in which some popular stars need to live in a remote village and experience self-reliant living as wood-burning stoves and grow food. Besides, on one hand, traditional ads on TV, public service ads on bus or metro and on social media are still good method to promote a brand, on the other hand, programs like offering some products for free for those public institutions like hospitals, schools, and libraries etc can be done to improve brand awareness.

6 CONCLUSION AND DISCUSSION

Overall, the severity of air pollution in China is undoubted, and it necessarily leads to an increasing growth on demand for air purifier in recent years. With comparison, the potential of LIFA air's air purifier has been presented in this dissertation in terms of its core competitive advantages like intelligence technology, human-oriented design and aesthetic appearance. As a outstanding representative in air purifying industry of Finland, LIFA air must lead more excellent enterprises of Finland moving towards China, enable potential Finnish intelligent air purifying technology have a place on China's market.

However, there may be some limitations in this dissertation due to rapid development techniques from other enterprises all over the world and the dynamic changes on the China's market. The findings and results are preliminary, future studies are suggested carried out.

However, doing this dissertation may makes a positive influence on those Finnish enterprises who possess good intelligent air purifying technology and prepare to enter China's market. Hope this dissertation can be used as a reference.

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