FACULTAT DE TRADUCCIÓ I D'INTERPRETACIÓ

GRAU DE ESTUDIS D'ÀSIA ORIENTAL

TREBALL DE FI DE GRAU

Curs 2015-2016

China's economic development and its effects on air pollution

Accountability, policies and health risks

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Barcelona, Juny de 2016

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Universitat Autònoma de Barcelona

Títol:

- China's economic development and its effects on air pollution: Accountability, policies and health risks.
- El desenvolupament econòmic de la Xina i els seus efectes en la contaminació atmosfèrica: Responsabilitat, polítiques i riscos per la salut.
- El desarrollo económico y sus efectos en la conaminación atmosférica: Responsabilidad, políticas y riesgos para la salud.

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Estudis:

Estudis d'Àsia Oriental

Curs acadèmic:

2015 - 2016

Paraules clau:

- China, air pollution, climate change, health, environmental policies.
- La Xina, contaminació atmosfèrica, canvi vlimàtic, salut, polítiques mediambientals.
- China, contaminación atmosférica, cambio climático, salud, políticas medioabientales.

Resum del TFG:

- This project is a study of China's current environmental situation as far as air pollution is concerned. This study includes an overall look at the industrialisation process of the country as well as the energetic demands of the process. It also explains the current levels of air pollution, particularly CO_2 emissions current and past. Then it also has a look at the key points of the COP 21, both at a global and international level and at a national level, looking at China's involvement in the conference and its measures to reduce emissions. Then, it looks at the devastating effects air pollution, in particular particulate matter, has on human health. Lastly it looks at how China's pollution is moving towards the United States' west coast and affecting it's air quality and how the United States as well as other countries that import goods produced in China are partially responsible for China's air pollution.

- Aquest projecte és un estudi de la situació mediabiental actual de la Xina pel que fa a la contaminació atmosfèrica. Aquest estudi fa una ullada general al procès d'industrialització del país així com la demanda engètica que requereix. També explica els nivells de contaminació atmosfèrica, concretament els nivells de les emissions de CO_2 passades i actuals. Tot seguit exposa els punts principals de la COP 21, tant a nivell global i internacional com a nivell nacional, mirant com s'ha implicat la Xina a la conferència i les mesures que ha pres per reduir les emissions. A continuació explica els effectes que produeix la contaminació atmosfèrica a la salut. Per acabar explica com la conaminació xinesa s'està desplaçant cap a la costa oest dels Estats Units i afectant la qualitat de l'aire del país així com el fet que els Estats Units i els altres països que importen productes produïts a la Xina són parcialment responsables de la contaminació atmosfèrica que està patint el país.

- Este proyecto es un estudio sobre la situación medioambiental actual de China en cuanto a contaminación atmosférica se refiere.. Este estudio hace una ojeada general al proceso de industrialización del país así como la demanda energética que este proceso supone. También explica los niveles de contaminación atmosférica, concretamente los niveles de las emisiones de CO_2 pasadas y actuales. A ontinuación sigue explicando los puntos principales de la COP 21, tanto a nivel global e internacional como a nivel nacional, fijándose en cómo se ha implicado China en la conferencia i las medidas que ha tomado para reducir las emisiones. Entonces explica los efectos que produce la contaminación atmosférica en la salud. Para finalizar expone como la contaminación china se está desplazando hacia la costa oeste de los Estados Unidos dónde está afectando a la calidad del aire del país así como el hecho que Estados Unidos junto con los demás países que importan productos producidos en China son parcialmente responsables de la contaminación atmosférica que está sufriendo el país.

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0. Introduction

China has amazed the world with its ability to go from a mostly agricultural economy to one of the most powerful economies in the world. But such a great success in the industrialisation of such a big and populated country can't come without its problems and drawbacks, and some of them are starting to be noticeable around the globe.

Air pollution in China has been an ongoing topic of discussion for the last few years, but lately it has gone further than that. In the last few months China has reached levels of air pollution never witnessed before, but that's not all. In the last year there have been increasing complaints about the fact that air pollution generated in China is being blown by air currents into the United States' west coast, polluting the air of the coastal states of this country. These facts and the increase in pictures of Chinese cities covered in smog that can be found on the internet have made the public eye focus on China and the growing rates of air pollutant particles it releases into the air every day. With this project I intend to have a look at the situation in China and how and why this pollution is being generated. Is the cause of the pollution the fact that China has been, and still is, “the world's factory”, or “the world's production hub”, where companies go looking for cheap production costs and consumers for cheap product? What is the Chinese government's position in the recent climate change debates? What are the effects of the particles that are being released into the air on Chinese public health as well as the health of the US citizens of the west coast? These are some of the questions I expect to give answer to.

In order to try to answer these questions I have divided this project in several chapters, the first one is an overview of China's history and its process of industrialisation as well as the energy usage that this process requires. This chapter I hope will help understand the origin of most of the air pollution generated by China. Then the second chapter focuses on the current situation with air pollution. That means that this chapter describes both the past and current trends in CO_2 emissions as well as what actions China is taking to change the situation. Lastly chapter three goes on to explain the effects that air

pollution has on human health and the close ties between China and the U.S. both in the trade of goods and the trade of pollution.

1. China's development model

China has been rapidly evolving for the past few decades and developing countries sometimes look at it as a model to follow. But China's development model is very specific to the country, mainly because of the country's size as well as its population's. Also, thanks to the fact that technology had already been developing for quite some time by the time that China started the process it has helped the country keep a much faster pace than other already developed countries did when they underwent the same process. Unfortunately the fast pace and large scale of the process has had some downsides too, particularly for the environment.

This chapter gives a general historical overview of China's industrialisation process to offer a bit of historical background, then continues by explaining the energy usage that this industrialisation and development process is requiring.

1.1. Industrialisation

China has experienced great changes in the last century, in a relatively short time it has gone from an agricultural country to a global economic power. Since China began the process of industrialisation in the 1950's it hasn't stopped growing in power, but it wasn't until the 1970's that China truly developed its economy, making it roughly 18 times what it once was[1]. Two elements that have been crucial in this process have been large investments and exports. But there have been other key elements that have made China into the powerful economy it has become. Grazyna Rzeszotarska[2] describes

[1]Rzeszotarska, G. (2015). China changes the development model. *Journal of Economics and Management*, vol. 2, no. 2, p.3

[2] Rzeszotarska, G. (2015), p. 3-4

what she believes are the five main characteristics of China's development model. Firstly, China's government has been very actively involved in the country's economy, through planning, with measures like the five-year plans, and through giving economic support to certain industries. Rzeszotarska describes the way the government's involvement with this sentence: "the state has to continue to be strong, the invisible hand of the market can do its job, but when it is needed, it has to be led by the visible hand of the state"(Rzeszotarska, 2015: 2). That means that the government has let the market regulate itself through the powers of supply and demand but only when it didn't interfere with its plans, but when needed it interfered to keep it the way they wanted it to be. Neo-authoritarianism based on Confucianism adapted to modern conditions has also been a very influential factor, explains the author, who puts it in second place. Then, the third characteristic is that the country has faced the necessary changes and reforms in a pragmatic and gradual way. Some economists had suggested that those changes should be applied on a large scale and throughout the entire country all at once, but the Chinese government had other ideas and they seemed to work out quite well for them. Related to that is the next characteristic, those changes that have been applied gradually have usually had a trial period in selected regions, and only after they were deemed successful were they applied to the rest of the country and always in small steps, this fact allowed for changes and improvements before implementing them on a larger scale. Lastly, the government has been making very realistic assessments of the country's abilities and opportunities, which has also helped in its successful development.

At the beginning of the development process of China’s economy Deng Xiaoping devised the idea of the *four modernisations* based on the ideas of his mentor Zhou Enlai. These *four modernisations* refer to, in order, agriculture, industry, national defence, and science and education. Deng Xiaoping devised these as the four indispensable areas the country needed to modernize in order for it to become prosperous, and the modernisation should take place in that order because they would need to feed the country first, then develop a fully working industry, and then they could worry about defending the country and

finally think about improving education and science in order to continue evolving.

In the endeavour of developing and modernizing the country China had some elements that were helpful, Rzeszotarska establishes five key elements. Firstly, China is a country with a very vast territory, it is the fourth biggest country in the world[3]; secondly, it is the most populated country in the world[4], which means great amounts of cheap, local labour; thirdly, when the process began the care for the environment was decidedly lacking, which helped them save in environmental measures, but this has changed greatly since then, becoming one of the country's greatest concerns, due in part to the fact that air pollution has been reaching very high, unhealthy levels; also, the state invested great sums of money into developing the economy through state subsidies; Then, last but not leas, China counted with a long historical tradition and a distinct and strongly established civilization. Despite having these advantages however, Chinese authorities were aware, according to Rzeszotarska, that without allowing foreign capital and new technologies in the rapid development they were planning wouldn't be feasible. Therefore the Chinese government allowed their entry but not without caution, and they applied certain restrictions, for they didn't want to become just a tool to be used by foreign countries. This opening up to other countries and to the global market in general allowed China to become what could be called a "global assembly line", where companies from all over the world opened factories in China where the cheap labour helped them reduce costs. Despite how successfully China became the "Factory of the world", China finds itself in need of a change. Nowadays most of what China produces is products designed by other countries and, more often than not, consumed by other countries as well. What China needs now is to become the designer and consumer of the goods they produce, although still exporting some of its goods, becoming a purely Chinese industry, or at least a mostly Chinese one.

[3] Geohive (n.d) *Global population statistics*. Retrieved from: http://www.geohive.com/

[4] Ibid.

China now faces some great challenges in order for it to continue growing at such a fast rate. It requires an implementation at a national scale of the newest technologies, for some areas of the country still run on outdated technology far less efficient than the newer versions. It also needs to improve the quality of its products and become more innovative with them, for it no longer can compete in prices with other countries of the region as far as the price of labour is concerned. Nowadays Bangladesh or Vietnam offer cheaper labour and companies are already moving their factories there.[5].

China is one of the world's most important manufacturers and industrial producers, maybe even the most important one. Manufacturing and industrial production account for more than 40% of the country's GDP, and China is also the world's largest exporter. China has become the world's biggest producer of products such as air conditioners, personal computers, solar cells, shoes, cell phones and ships. Also, despite not being the world's biggest producer in this area, China has a flourishing automobile industry, ranking somewhere around the world's third manufacturer[6].

One of the most important industries in China is its steel industry. Most of China's steel production is centred on satisfying the national demand for the product but some of it is exported to other countries. This industry is very energy-intensive and the fast improvement in the output of this energy-intensive product hasn't helped China's plight with pollution. China has become the biggest steel producer and consumer, being both the producer and consumer of about 50% of the world's steel[7].

China's production capacity total of cement and crude steel in the year 2013 was 1.7 billion tonnes and more than 1 billion tonnes respectively[8]. These

[5] Rzeszotarska, G. (2015), p. 3-4

[6] Ross, S. (n.d) The 3 industries driving China's economy. *Investopedia*. Retrieved from: http://www.investopedia.com/articles/investing/091515/3-industries-driving-chinas-economy.asp

[7] Popescu, Gh. H, Nica, E., Nicolaescu, E., Lazaroiu, G. (2016) China's steel industry as a driving force for economic growth and international competitiveness. *Metallurgy,* vol. 55, no. 1, p. 2

[8] Zhu Chen, Jinnan Wang, Guoxia Ma, Yanshen Zhang (2013) China tackles the health effects of pollution. *The Lancet*, vol. 382, no. 9909, pp. 1959

two industries are two of the major polluting industries in China, that is due to the fact that they emit CO_2 not only because of their use of energy but because of their production process as well, according to Yang Fuqiang, senior adviser on Climate and Energy at the Beijing Office of the Nature Resources Defence council[9].

China is still undergoing its industrialisation and the process of developing the country, but the path it has used until now is no longer a viable option due to the vast amounts of pollution it generates. China must find a new path to continue to prosper like it has been doing for the past few decades.

1.2. Energy usage

Since the beginning of the economic reforms in China, starting with the "open-door policy", China's economy has been growing at a staggering rate. The economy hasn't been the only thing to grow exponentially over the last couple of decades though, primary energy consumption has also been rapidly increasing. The annual growth of energy consumption has reached rates of 10.9% during certain periods in the last decade or so. When comparing the total energy consumption between 1992 and 2007 the latter is 3.5 times the amount of the former. In the year 2012 the total energy consumption of China had reached the sum of 2.43 billion tonnes oil equivalent, with a per capita GDP energy consumption 1.4 times that of the world's average[10].

Right after China's "opening to the market" energy use growth was much slower than it is now. Between the years 1978 and 2001 the growth rates of China's energy use were 4.1%, which put it at a much lower growth rate than its GDP, a GDP which at that time showed a growth rate of around 9.7%. On the year 2001 though, things started to change, China entered the World Trade Organization (WTO), and its energy consumption started growing at a faster

[9] Liu, C. (2014, November) China will limit pollution fromsteel and cement. *Scientific American.* Retrieved from: http://www.scientificamerican.com/article/china-will-limit-pollution-from-steel-and-cement/

[10] Zhu Chen, Jinnan Wang, Guoxia Ma, Yanshen Zhang (2013), p. 1959

rate than its GDP, every year it would grow at an average rate of 11.4%, while the country's GDP grew at a rate of 10.0%[11].

China is heavily reliant on coal for energy production; it is, in fact, one of the world's countries most reliant on coal for energy use[12]. Since 1978 coal consumption has steadily accounted for about 70% of the total primary energy consumption, with only small variations of about 1% throughout this period. The consumption of coal in China generates air pollutant emissions; it results in about 70% of the country's emissions of soot dust, as well as 90% of CO_2 emissions[13]. By the year 2012 coal consumption in China had reached the amount of 1.63 billion tonnes oil equivalent, which amounts to 50% of the total consumption of coal worldwide that year[14]. The year 1978 China's total primary energy consumption was 400 mega-tones of oil equivalent, also known as Mtoe. By the year 2007 it had reached 1820 Mtoe, growing annually at an average rate of 5.3%[15].

China relies so heavily on coal for energy production mainly because of their easy access to it. China has abundant domestic stocks of coal, which makes its access to it not only easy but cheap as well, thanks to the tight control the government exercises over commodity prices[16].

The use of hydroelectric power as well as nuclear power and wind power has been increasing in China since 1978, but at a fairly slow pace. In 1978

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[11] Sheehan, P., Sun, F. (2007) Energy use in China: interpreting changing trends and future directions. *Climate change working paper.* No. 13, p. 3

[12] Garnaut, R., Jotzo, F., Howes, S. (2008) China's rapid emission growth and global climate change policy. In: Ligang Song and Wing Thye Woo (Eds.) *China's dilema: economic growth, the environment and climate change.* Cranberra: ANU E Press. P. 171

[13] Fei Li, Suocheng Dong, Xue Li, Quanxi Liang, Wangzhou Yang (2011) Energy consumption-economic growth relationship and carbon dioxide emissions in China. *Energy Policy*, no. 39, p. 568

[14] Zhu Chen, Jinnan Wang, Guoxia Ma, Yanshen Zhang (2013), p. 1959

[15] Kejun Jiang, Xiulian Hu (2008) Energy and environment in China. In: Ligang Song and Wing Thye Woo (Eds.) *China's dilema: economic growth, the environment and climate change.* Cranberra: ANU E Press. p. 310

[16] Crompton, P., Yanrui Wu (2004) Energy consumption in China: past trends and future directions. *Energy economics* no. 27, pp. 196

these cleaner energies accounted for 3.4% of the total energy consumption, in 2007 they had reached a 7.3%[17]. With these numbers it is clear that it will take a while for these cleaner energies to take an important role in energy production in China.

Energy consumption in China has shown a growth rate of around 9.98% between the years 2002 and 2010[18], which is one of the highest growth rates in the world. Two of the main factors that are generating such an elevated growth rate are the expansion of the heavy industry and the acceleration of urbanization. But China hasn't only increased its energy consumption but its energy production as well, by the year 2004 China had replaced Russia's place as the world's second biggest energy producer. China's primary energy output on the year 2006 had become 251% that of the year 1978 with an output of 2,201.56 Mega tonnes of coal equivalent (Mtce)[19]. China's coal output for that year had reached the staggering amount of 2,373 Mt, maintaining China in its position as the world's biggest producer of coal. Gas and oil output were 58.55 billion cubic meters and 185 Mt respectively and the power China generated that year was 2,865.7 Terawatt hours (TWh), which together with its oil output ranked them second place in the world[20].

China's energetic needs have been growing so much that the amount of energy it needs to keep up its current level of growth and development is more than it can generate with its own resources. For a while now China has been needing to import coal and other resources. In 2006 it imported 38,25 Mt of coal, 20 times what it was importing in the year 2000 and it also imported oil, 145,18 Mt of crude oil to be precise, as well as 46,01 Mt of petroleum products[21].

To put it into perspective let's see how China's consumption relates to that of the rest of the world. On 2003 China's coal consumption accounted for

[17] Fei Li, Suocheng Dong, Xue Li, Quanxi Liang, Wangzhou Yang (2011) p.568

[18] Zhuju Jiang, Boqiang Lin (2012) p. 608

[19] Kejun Jiang, Xiulian Hu (2008) p. 313

[20] Ibid. p. 314

[21] Ibid p. 314-315

31% of the world's total, hydroelectricity consumption for 10.7%, oil consumption for 7.6% and gas consumption 1.2%[22]. And comparatively, China in 1985 accounted for 20.7% of the global coal consumption, 4.6% of hydroelectricity, 3.2% of oil consumption and 0.7% of gas consumption[23]. If we keep in mind that on 2012 China's coal consumption amounted to 50% of the world's total consumption we can see a fast growth in consumption that appears to be accelerating.

Despite China's total energy consumption as a country being very high when you look at it from a per capita point of view it is lower than that of developed economies[24]. According to The World Bank's data[25] China's energy use in kg of oil equivalent per capita was 2,079 in 2012 and 2,226 in 2013. The United States' energy use in those same years was 6,812 and 6,914 respectively. Comparatively China's energy use per capita isn't even a third of that of the United States. Other developed countries also have higher rates, Germany's was 3,877 and 3868; and Japan's 3,543 and 3.570. China is still beneath developed countries in energy use per capita, but since it is bigger than most and has the largest population the numbers are really high when looking at it in absolute terms.

There are high expectations that China will be able to rely more on hydroelectricity for energy generation in the future, for it is believed that the country has the potential to generate 400GW[26]. The government is also counting on this resource on its plans for reducing pollution in the future and using cleaner energy sources. Right now though, China is not fully exploiting this potential. It had only exploited about 50% of its exploitable hydroelectric potential in 2010, 213 GW[27]. Unfortunately, even if the use of Hydroelectricity is

[22] Crompton, P., Yanrui Wu (2004) pp. 196

[23] Ibid. pp. 196

[24] Ibid. pp. 199

[25] The World Bank (n.d.) Energy use (kg of oil equivalent per capita). *The World Bank.* Retrieved from: http://data.worldbank.org/indicator/EG.USE.PCAP.KG.OE

[26] Gao Lu Zou (2012) The long-term relationships among China's energy consumption sources and adjustments to its renewable energy policy. *Energy policy.* no. 47, p. 457

[27] Ibid. p. 457

increasing and keeps doing so energy consumption in China is growing at a faster rate. Despite its growth hydroelectricity's share on the country's total energy consumption went from 7.1% in 2001 to 6.7% in 2008[28]. So China still has a long way to go both with energy production and finding cleaner energy sources.

2. Air pollution in China

Air pollution has become an increasingly worrisome problem for China in recent years. Development, particularly the development of its industry sector, has come hand in hand with an increased emission of pollutants, particularly air pollutants. For the last few years it has been increasingly common to see, in the newspapers and on the internet, pictures of a grey sky full of smog depicting the conditions of the air in some Chinese cities. According to a report on fine particulate matter in China[29] less than 1% of China's 500 largest cities manage to stay under the World Health Organization's air quality guidelines.

2.1. CO_2 and climate change

Climate change is a matter that has been much discussed in the recent years and has also been an growing worry for everyone. These last few years the effects of climate change are starting to be felt and fear for the future is starting make people take action. One of the main air pollutants that are causing the greenhouse effect is CO_2, it and other greenhouse gases (GHG) are the main cause of climate change. The increasing amount of CO_2 in the atmosphere is aggravating the situation and accelerating climate change, which is why CO_2 emission control has become such an important objective in recent years for most governments, including China's.

[28] Gao Lu Zou (2012) p. 457

[29] Yan-Lin Zhang, Fang Cao (2015) Fine particulate matter (PM2.5) in China at a city level. *Scientific reports no.5. Nature.* p. 1

The four greatest emitters of this contaminant are, according to a report on trends in global CO_2 emissions[30], in first place China, which accounts for 30% of the total emissions of CO_2 globally. Second in this ranking is the United States of America, which accounts for 15% of global emissions. The third greatest emitter is not a country but a region, and that region is the European Union which accounts for the 10% of global emissions. Lastly, and in fourth place, is India, which accounts for 6.5% of these emissions.

According to that same report[31] there are two factors that have contributed greatly to making China the world's greatest CO_2 emitter. Those factors are the size of the country and the size of its population, as well as that of its economy, and also the fact that China is so reliant on coal for energy generation.

China is a country that relies heavily on coal for energy use, which has made it one of the world's most carbon-intensive countries, meaning it has one of the highest carbon dioxide emissions to energy use ratios. In 2008 China overtook the United States as the largest global emitter[32], and now it doubles its emissions. But if we take a look at China's emissions from a per capita standpoint we find that China's emissions are similar to those of the European Union, and about half those of the United States[33].

China's energy consumption in 2012 was generated mostly by fossil fuel combustion, around 90% of it. Of that percentage 68% was from coal, 13% from oil and 7% from gas according to the "China's Carbon emissions report 2015"[34]. This explains part of the high level of emissions since coal combustion generates great amounts of CO_2.

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[30] Olivier JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2015). Trends in global CO2 emissions. 2015 Report. The Hague: PBL Netherlands Environmental Assessment Agency; Brussels: Joint Research Centre. p.6

[31] Ibid. p.7

[32] Garnaut, R., Jotzo, F., Howes, S. (2008) p. 171

[33] Olivier JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2015). p.7

[34] Zhu Liu (2015) *China's carbon emissions report 2015*. Cambride: Harvard Kennedy School. p. 12

China is a country with a manufacturing industry that's very fossil fuel intensive, the volume of manufacturing in China is very large and the country has had relatively weak emission controls, although they are trying to change that. That translates into China being a country that generates far more pollutants per unit of GDP than some other countries that have more advanced technology in the industrial field as well as the emission control field[35].

Lately China is showing a slowdown in the growth of CO_2 emissions. In the year 2014 there was no increase in coal demand, and CO_2 emissions increased by only 0.9% when compared to the previous year. This is the smallest increase in the last decade[36]. This is due to the growth of the service sector in the country which now represents 48% of the country's GDP[37]. The service sector now surpasses the industry sector in GDP percentage, becoming the largest economic sector; seeing as the service sector is less energy-intensive this has affected the country's CO_2 emission pattern. The industry sector, which is the most energy intensive, has started to stall in growth, and the service sector, which is far less energy-intensive, has started growing again these last few years.

The slowdown in CO_2 emission growth is also due to an increase in consumption of oil products and natural gas. In 2014 the consumption of oil products increased by a 3.3%, and the consumption of natural gas by 8.6%. The CO_2 emitted by the use of oil and gas amount to a 20% of the total emissions from fossil fuel combustion[38]. Generating energy with oil and gas emits less CO_2 emissions than doing it with coal which is why an increase in oil and gas consumption paired with a stalling in coal consumption helps keep the CO_2 emission growth rate much lower.

Coal consumption accounts for 73% of fossil fuel consumption, but generates 83% of the CO_2 emissions generated by fossil fuel combustion in

[35] Jintai Lin, Da Pan, Steven J. Davis, Qiang Zhang, Kebin He, Can Wang, David G. Streetsf, Donald J. Wuebbles, and Dabo Guan. (2014). pg 1736

[36] Olivier JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2015). p.6

[37] Ibid. p.12

[38] Ibid. p.20

China. Although natural gas consumption is still on the rise it appears that the growth in consumption is slowing down, for the previous years it had increased 12% and 13% in 2012 and 2013 respectively, which is also a smaller increase compared to the year before in which it averaged at around 18%[39].

Cement production is another source of CO_2 emissions in China. Cement production grew by a 2.3% in 2014, and the emissions of CO_2 related with the production of it accounted for 7% of the country's emissions[40]. In 2012 China produced 2.3 billion tonnes of cement, accounting for 60% of the total of cement production worldwide[41].

In 2014 there was a slight decrease in the generation of thermal power, which is mostly generated in coal-fired power plants, the decrease was of a 0.3%. This decrease which helps explain the decrease in growth of CO_2 emissions is in turn explained by the slowing down of the growth rate of total power consumption. The total power consumption grew only a 3.8%, which is significantly smaller than the growth rate of the previous years which was in the double-digit area[42]. Most of these figures are at their lowest since the beginning of the twenty-first century.

According to the "China's carbon emissions report 2015"[43] carbon emissions are mainly due to fossil fuel combustion, which accounts for 90% of the emissions, and cement production, which accounts for the remaining 10%. Manufacturing and the generation of power added up to 85% of China's total carbon emissions in 2012. In this same report it is explained that around 25% of the country's carbon emissions are generated manufacturing products that are intended for foreign consumption.

[39] Olivier JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2015). p.20

[40] Ibid. p.20

[41] Zhu Liu (2015) p. 3

[42] Olivier JGJ, Janssens-Maenhout G, Muntean M and Peters JAHW (2015). p.20

[43] Zhu Liu (2015) p.1

According to Greenpeace[44] China's $PM_{2.5}$ levels, another air pollutant, appear to be improving slightly these first months of 2016, but it appears that although pollution is getting better in cities to the east of China cities to the west and centre of the country are experiencing higher pollution levels. It would seem that the government gave permission to open new coal fired power plants, 210 of them, in 2015. But due to the stricter regulations being applied on the eastern side 75% of those plants will be built in more central or western regions.

2.2. COP 21 Paris Sustainable Innovation Forum 2015

According to the World Meteorological Organization[45] (WMO) during the year 2015 the planet experienced the hottest temperatures ever recorded. The temperatures were about 0.76º Celsius above the average recorded between 1961 and 1990. This increase in temperatures is still going in these first months of the year 2016. According to the scientists if the world reaches a temperature 2º Celsius above the average at the beginning of the twentieth century we will have reached the point of no return. They explain, though, that if we manage to stay below a temperature rise of 3º we might still manage to avoid the worst of the effects. The most important thing, they say, is to reduce as fast as possible and as much as possible the carbon dioxide emissions and that we have to be well prepared for the consequences of the climate change that we are going to face in the coming years. Things like early warning systems as well as management tools for droughts, floods and counteracting the effect on our health that the rise in temperatures will have are very important to ensure that we can face what is to come.

In 1997 the Kyoto Protocol was adopted. This protocol, which is linked to the UNFCCC, United Nations Framework Convention on Climate Change, is an agreement in which all its parties, the different governments of countries all over

[44] Dong Liansai (2016) *China's air pollution problem is heading west.* Retrieved from Greenpeace website: http://www.greenpeace.org/eastasia/news/blog/china-air-pollution-heading-west/blog/56213/

[45] WMO (2016) Hotter, Drier, Wetter. *World Meteorological Organization Bulletin vol. 65(1)*

the world, commit to emission reduction targets, to reduce greenhouse gas emissions. This protocol entered into force the year 2005, with 187 parties signing the protocol. China and the United States, the world's two biggest emitters, didn't sign it[46]. The specific details of the workings of the protocol were established at COP17 in Marrakesh, in 2001. The first commitment period was from 2008 to 2012.

The Kyoto Protocol and the Marrakesh Accords, which are the rules of implementation established in Marrakesh at the COP17, are the predecessors of the Paris Agreement. In fact, the COP17 is also responsible of producing the Durban Platform, a platform that managed to secure the tentative inclusion of the United States and China in the Kyoto Protocol, which in turn eased the way for the Paris Agreement.

2.2.1. COP 21 and the Paris Agreement

In December of 2015 representatives from 195 countries of the world came together to discuss the current problems with climate change at the COP21 held in Paris. The conference ended with an agreement signed by all the participants to cooperate in this fight to stop the global rise in temperatures. As the UN Secretary General Ban Ki-moon put it: “For the first time, every country in the world has pledged to curb emissions, strengthen resilience and join in a common cause to take common climate action.”[47]

The main target of this cooperation agreement is to keep the planet's temperature from rising to that 2 degrees Celsius mark. Furthermore the agreement intends to limit the increase of temperature to 1.5 degrees Celsius

[46] United Nations Framework Convention on Climate Change (n.d.) *Kyoto protocol.* Retrieved from United Nations Framework Convention on Climate Change website: http://unfccc.int/kyoto_protocol/items/2830.php

[47] United Nations Framework Convention on Climate Change (n.d.) *Historic Paris Agreement on Climate Change 195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius.* Retrieved from United Nations Framework Convention on Climate Change website: http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/

above pre-industrial levels[48]. This goal has been set 2100[49] so there's still a long way to go.

The Agreement has five key elements which all the participants have agreed to adhere to. Those key elements are described at the European Commission's webpage[50] as, first, "Mitigation", which refers to the reduction of emissions generated by each country. This first point's aim is to try to ensure that the countries that ratified the agreement make sure that their emissions peak as soon as possible and from there on those emissions are reduced quickly so that the main goal of the agreement, keeping the temperature below those 2 degrees Celsius, is reached.

The second key element is called "Transparency and global stock take", this refers to the fact that the governments agreed to report, both to each other and to the public, their progress in implementing the previously set targets. Also this point includes the fact that those targets are to be reset every five years and they have to be equally or more ambitious than the ones before. Total transparency and accountability is expected from them as well.

Third, we have "Adaptation", which requires the governments to ensure their ability to deal with climate change and its effects, as well as providing help for developing countries to ensure they have that ability as well.

Fourthly, there is "Loss and damage", this point refers to the importance of averting when possible, and when not minimising, the loss and damage related to climate change. This point also believes it's important that they ensure the recovery from the effects of climate change, as well as the need to cooperate and support each other in developing early warning systems.

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[48] United Nations Framework Convention on Climate Change (n.d.) *Historic Paris Agreement on Climate Change 195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius*

[49] United Nations Conference on Climate Change (n.d) *2°C target : result of State contribution.* Retrieved from United Nations Conference on Climate Change website: http://www.cop21.gouv.fr/en/2c-target-result-of-state-contributions/

[50] European Comission (n.d.) *Paris Agreement.* Retrieved from European Comission website: http://ec.europa.eu/clima/policies/international/negotiations/paris/index_en.htm

Lastly we have "Support", which refers to the continued support of developed countries to help developing countries with their climate actions to reduce emissions and build up resilience to the effects of climate change and other countries are also encouraged to help. A part of this support is economic, which they expect will reach the 100 billion U.S. dollars per year by the year 2020[51].

The agreement also established that by the second half of the century we should achieve greenhouse neutrality[52]. It was also emphasized that developed counties should support financially the efforts of developing countries to use cleaner energies and other initiatives that work towards the goal of stopping climate change[53].

Renewable energies are expected to take on a more important role as a source of energy; some countries even established mid-term goals. Japan aims for renewable energies to account for 22 to 24% of total power generation in 2030, as opposed to the 13% it was in 2013. The European Union also aims for renewable energies to amount to 27% of the total, instead of the 11.8% it was in 2013[54].

Early warning systems have become a priority for a group of 50 countries which hope to develop them to ensure their populations safety from extreme climate events.

2.2.2. China's involvement

Chinese President Xi Jinping reaffirmed a previously made pledge that china had intentions of reducing its carbon emissions by 60 to 65 percent of its

[51] European Comission (n.d.)

[52] Mabey, N., Burke, T., Gallagher, L., Born, C., Kweley, B. (2016) *Judging the COP21 outcome and what's next for climate action*. Retrieved from: https://www.e3g.org/library/judging-cop21-outcome-and-whats-next-for-climate-action

[53] United Nations Framework Convention on Climate Change (n.d.) *Historic Paris Agreement on Climate Change 195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius.*

[54] United Nations Conference on Climate Change (n.d*) 2°C target : result of State contribution.*

2005 levels by 2030[55]. If you take into account that China is one of the world's main emitters of carbon emissions the impact of this reduction of emissions would have a great impact worldwide. Not only does China intend to reduce its carbon emissions but also increase the use of renewable energies, until they cover 20% of its overall energy consumption. Moreover, China's 2016-2020 Five Year Plan has put great emphasis on the development of low-carbon and low-polluting industries[56].

One other way in which China intends to reduce carbon emissions is with technologies for Carbon Capture and Storage, known as CCS. One of the main uses for CCS technologies would be China's high-carbon emitting coal-fired power plants. This plants are the main source of power in China and some of them use very low-quality carbon which generates high levels of carbon emissions. The government is already taking steps to close the mines that produce such low-quality carbon[57].

China has also promised at the COP 21 to reduce the emissions they generate with their power plants by modernizing them. The aim is that this measure should reduce their pollutant emissions by 60%. In doing so they would reduce their CO_2 emissions by 180 million tonnes each year, as well as saving 100 million tonnes of coal yearly. China also believes that their CO_2 emissions will peak around the year 2030[58], which would mean that from then on their emissions should diminish year by year.

China offered 60 billion dollars for the development of projects at the Forum on China-Africa Cooperation[59]. China also is part of a nineteen countries

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[55] Alvin Cheng-Hin Lim (2016) *China and COP 21.* Retrieved from IPP review website: http://www.ippreview.com/index.php/Home/Blog/single/id/36.html

[56] Ibid.

[57] Ibid.

[58] United Nations Framework Convention on Climate Change (n.d.) *China has promised to cut emissions from its coal power plants by 60% by 2020.* Retrieved from United Nations Framework Convention on Climate Change website: http://www.cop21.gouv.fr/en/china-has-promised-to-cut-emissions-from-its-coal-power-plants-by-60-by-2020/

[59] Mabey, N., Burke, T., Gallagher, L., Born, C., Kweley, B. (2016)

group that are committing to double their investments on renewable energies R&D over the next five years.

The Paris Agreement established that every five years every country that had signed the agreement would hand in an INDC, an Intended Nationally Determined Contribution, which is a document where it explains which measures the country intends to take to reduce emissions and stop climate change before it reaches that dangerous 2 degrees Celsius mark.

China's INDC[60] starts by explaining the measures that it has already taken and the results that it already has achieved which are the following:

By 2014 the following has been achieved:

• Carbon dioxide emissions per unit of GDP is 33.8% lower than the 2005 level;

• The share of non-fossil fuels in primary energy consumption is 11.2%;

• The forested area and forest stock volume are increased respectively by 21.6 million hectares and 2.188 billion cubic meters compared to the 2005 levels;

• The installed capacity of hydro power is 300 gigawatts (2.57 times of that for 2005);

• The installed capacity of on-grid wind power is 95.81 gigawatts (90 times of that for 2005);

• The installed capacity of solar power is 28.05 gigawatts (400 times of that for 2005); and

• The installed capacity of nuclear power is 19.88 gigawatts (2.9 times of that for 2005). (Su Wei, 2015: 3)

Then it goes on to explain the measures that it intends to implement and its plans for the future. It has set several goals that have to be reached by 2030 and those goals are the following:

[60]Su Wei (2015) Enhanced actions on climate change: China's intended nationally determined contributions. Retrieved from: http://www4.unfccc.int/submissions/INDC/Published%20Documents/China/1/China's%20INDC%20-%20on%2030%20June%202015.pdf p.3-4

• To achieve the peaking of carbon dioxide emissions around 2030 and making best efforts to peak early;

• To lower carbon dioxide emissions per unit of GDP by 60% to 65% from the 2005 level;

• To increase the share of non-fossil fuels in primary energy consumption to around 20%; and

• To increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level. (Su Wei, 2015: 4)

Right after these goals it states that China will adapt in a proactive way to climate change and enhance its mechanisms to defend against climate change risks. This is clearly referring to the third key point of the agreement where it is stated that governments should ensure their ability to deal with climate change and its effects.

Following these goals China's INDC[61] lists the policies the country needs to undertake in order for the goals to be reached. The listing, which lists around one hundred ideas, is divided in fifteen big categories. The first two are implementing proactive national strategies on climate change and improving the regional ones. Then it continues with building a low-carbon energy system, building energy efficient and low-carbon industrial system and controlling emissions from building and transportation sectors. The next one, number six, or F as is marked in the INDC, is called increasing carbon sinks. A carbon sink is defined, according to the Collins English Dictionary[62], as: areas of vegetation, especially forests, and the phytoplankton-rich seas that absorb the carbon dioxide produced by the burning of fossil fuels.

It continues with G, or the seventh category, promoting the low-carbon way of life, enhancing overall climate resilience, innovating low-carbon development growth pattern, enhancing support in terms of science and technology, increasing financial and policy support, promoting carbon emission trading market. As well as improving statistical and accounting system for GHG

61 Su Wei (2015) p.5

62 Carbon sink (n.d) *Collins English Dictionary – Complete & Unabridged 10th Edition.* Retrieved from Dictionary.com: http://www.dictionary.com/browse/carbon-sink

emissions, broad participation of stakeholders and lastly promoting international cooperation on climate change. Underneath all those headings there are more specific plans for action but they have yet to be made into a law, a policy, or anything that can be implemented. So far those are only China's good intentions and only the future will tell if all of them end up being applied and how successfully they are applied.

If nothing more those are some interesting goals to set and promising ideas for future policies which show China's interest in changing the country's situation with GHG emissions. This last few years China's air pollution levels have often been making the headlines in newspapers all over the world and the increasing number of days with heavy smog are starting to awaken China's society and its government and forcing them to take steps to improve the situation. At least with this INDC it is clear that China's government is finally taking steps to make a better and healthier future, not only for the country itself but for the entire world, since the fact that China is the world's greatest emitter means those measures, if applied, will affect the entire world.

3. Air pollutants

In 2006 the coal-mining and washing industry emitted 145,000 tonnes of sulphur dioxide 122,000 tonnes of smoke and 176,000 tonnes of industrial dust. Also the mining of the coal and its processing emitted 5 billion cubic meters of methane as well as 2.3 billion cubic meters of mine water[63].

Other major atmospheric pollutants in the process of energy production are sulphur dioxide, nitrogen oxides and soot from thermal power plants. It is due to the increase in coal consumption that in recent years China's thermal power industry, which uses mostly unwashed steam coal, has become the main source of air pollution[64]. In 2006 the emissions of the thermal power industry were 12.041 Mt of sulphur dioxide, which accounts for 59% of China's total

[63] Kejun Jiang, Xiulian Hu (2008) p. 316

[64] Ibid. p. 316

emissions, 3.467 Mt of soot and 14,000 tonnes of industrial dust[65]. That same year the industrial sector was responsible of emitting 10.18 Mt of sulphur dioxide. These emissions came mostly from: non-metallic mineral products production, smelting of ferrous and non-ferrous metal and the chemical industry, representing the 18%, 15% and 11% respectively[66].

More recent data shows that China's total sulphur dioxide emissions were, according to the 2015 China Statistical Yearbook[67], 19,744,200 tonnes, the nitrogen oxides emission 20,780,000 tonnes, and smoke and dust emissions 17,407,500 tonnes.

A study on Shanghai's air pollution shows that between the years 1998 and 2007, the city only reached the PM_{10} air-quality guidelines set by the World Health Organisation on 29,1% of the days, as for nitrogen dioxide it reached the standards set by the WHO 50% of the days, and for sulphur dioxide only 10% of the days. Only 5% of the days did the levels of all three pollutants stay below WHO standards[68]. Another study done in 190 cities in China[69] found that 167 cities couldn't manage to meet the National Ambient Air Quality Standards (NAAQS) set by the Chinese Ministry of Environmental Protection (MEP). Those standards, the NAAQS, are already set at higher levels than the ones in Europe and much higher than those of the WHO, which should make them easier to reach.

3.1. Public health

[65] Kejun Jiang, Xiulian Hu (2008) p. 316

[66] Ibid. p. 316

[67] National Bureau of Statistics of China (2014). China statistical yearbook. Retrieved from: http://www.stats.gov.cn/tjsj/ndsj/2015/indexeh.htm

[68] Health and Mortality Transition in Shanghai Project Research Team (2008) The impact of air pollution on mortality in Shanghai. In: Ligang Song and Wing Thye Woo (Eds.) *China's dilema: economic growth, the environment and climate change.* Cranberra: ANU E Press. p. 298

[69] Yan-Lin Zhang, Fang Cao (2015) Fine particulate matter (PM2.5) in China at a city level. *Scientific reports no.5. Nature.* p. 2

Air pollution is formed by a combination of both solid particles suspended in the air and gaseous pollutants. The most studied and referred to when talking about air pollution are $PM_{2.5}$ and $PM_{10.}$ Each of these names refers to particulate matter with an aerodynamic diameter of either less than 2.5 μm or less than 10 μm. $PM_{2.5}$ is also referred to as fine particles[70].

Particulate matter is, of all air pollution, the most harmful to humans. The WHO describes PM's major components as being: sulphate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water[71].

The composition of $PM_{2.5}$ and $PM_{10\text{-}2.5}$ is very different which affects the effects they have on human health. The composition of $PM_{2.5}$ is, among other organic and inorganic compounds, sulphate, organic and elemental carbon, nitrate, earthen dust and biological materials. On the other hand $PM_{10\text{-}2.5}$ is predominantly composed of crustal related materials like aluminium, calcium, magnesium, silicon, iron and primary organic materials (spores, pollen and animal and plant debris)[72].

A study on the effects of outdoor air pollution on premature mortality on a global scale[73] estimated that outdoor air pollution, mostly $PM_{2.5}$ leads to close to 3.3 million premature deaths each year all over the world, although predominantly in Asia. The emissions with the largest impact on premature mortality are those generated by residential heating and cooking, common in China and India. $PM_{2.5}$ from coal combustion has been found to lead to increased mortality risk from cardiovascular disease as well as lung cancer. This study shows that the global mortality related to $PM_{2.5}$ in 2010 was 3.15

[70] Renjie Chen, Yi Li, Yanjun Ma, Guowei Pan, Guang Zheng, Xiaohui Xu, Bingheng Chen, Haidong Kan (2011) p. 4934

[71] World Health Organisation (2014) Ambient (outdoor) air quality and health. *WHO factsheets.* no.313. Retrieved from: http://www.who.int/mediacentre/factsheets/fs313/en/

[72] Renjie Chen, Yi Li, Yanjun Ma, Guowei Pan, Guang Zheng, Xiaohui Xu, Bingheng Chen, Haidong Kan (2011) p. 4937

[73] Lelieveld, J. Envas, J. S., Fnais, M. Giannadaki, D., Pozzer, A. (2015) The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature.* no. 525. pp. 367

million people, with the main causes being cerebrovascular disease, approximately 1.31 million people, ischemic heart disease, approximately 1,08 million people, the secondary causes were chronic obstructive pulmonary disease, 374 thousand people, acute lower respiratory illness, 230 thousand people, and lung cancer, 161 thousand people. The estimate for O_3 related mortality by chronic obstructive pulmonary disease was 142 thousand people. This adds up to approximately 3.3 million premature deaths. These numbers don't include premature death caused by indoor air pollution, which has an even higher impact on human health with a higher toll of premature deaths[74]. Of that total of 3.3 million China accounts for 1.36 million premature deaths a year, India for 0.65 million premature deaths, followed by Pakistan with 0.11 million premature deaths due to air pollution. Residential and commerce energy use (RCO) is the main contributor, not only in outdoor air pollution but also in indoor air pollution. RCO is also the most important contributor in Asia, meaning that it isn't only the main contributor worldwide but also the main contributor in the most affected areas, putting it in first place followed very far behind by the next one, which is agriculture. Agriculture has a great impact on $PM_{2.5}$ and is the leading contributor in the west, Japan and Korea[75].

The WHO estimated that in 2012 outdoor air pollution caused 3.7 million premature deaths worldwide[76], 88% of those premature deaths were in low- and middle-income countries. Those deaths are due mainly to particulate matter PM_{10} or smaller. In the year 2013 the WHO concluded that outdoor air pollution was carcinogenic with its effects mostly associated to lung cancer. It has also been found by the WHO that there is a correlation between outdoor air pollution and cancer of the bladder.

A study done in three Chinese cities[77], Beijing, Shanghai and Shenyang, showed a direct correlation between an increase in $PM_{10-2.5}$, the particulate

[74] Lelieveld, J. Envas, J. S., Fnais, M. Giannadaki, D., Pozzer, A. (2015) The contribution of outdoor air pollution sources to premature mortality on a global scale. *Nature.* no. 525. pp. 367

[75] Ibid. pp. 367

[76] World Health Organisation (2014)

[77] Renjie Chen, Yi Li, Yanjun Ma, Guowei Pan, Guang Zheng, Xiaohui Xu, Bingheng Chen, Haidong Kan (2011) p. 4935

matter with aerodynamic diameters between 10 μm and 2.5 μm, and an increase in total mortality. The association found in the study is that for every increase of 10μg/m^3 of $PM_{10-2.5}$ there was a 0.25% increase in total mortality. More specifically the increase in cardiovascular mortality was a 0.25%, and in respiratory mortality 0.48%. The study also shows the results for the association between an increase in $PM_{2.5}$ and increased mortality. An increase of the same amount mentioned before, 10μg/m^3, of $PM_{2.5}$ was associated with an increase in total mortality of 0.32%. In particular cardiovascular mortality showed an increase of 0.46% and respiratory mortality an increase of 0.50%. This study also shows that once the association of $PM_{10-2.5}$ with daily mortality was adjusted for $PM_{2.5}$ the results were so low as to be negligible, meaning that the $PM_{2.5}$ is the only one truly proven by the study to be associated with daily mortality.

The particles that compose $PM_{2.5-10}$ are mostly nature-generated and have been found to have less harmful effects on the cardio respiratory system than the more combustion-related particles. In fact the same study[78] as before shows that the toxicity levels are related to the size of the particles, with small particles being the most toxic to our cardio respiratory system, the ones smaller than 1.7 μm, and the less toxic being the bigger ones, the ones bigger than 3.5 μm. Another fact about $PM_{10-2.5}$ that may also be a contributing factor to its lower toxicity levels, found the study, is that it has a lower concentration of soluble transition metals. Lastly, the fact that depending on the size this particles deposit themselves in the lungs in different patterns also supports the hypothesis that $PM_{2.5}$ is more toxic to our respiratory system.

According to the Global Burden of Disease Study 2010[79] $PM_{2.5}$ is the fourth most important risk factor for premature death. Furthermore, lung cancer death rates have been steadily rising since the year 1970 and nowadays lung cancer has become the first cause of death from malignant tumours[80]. The

[78] Renjie Chen, Yi Li, Yanjun Ma, Guowei Pan, Guang Zheng, Xiaohui Xu, Bingheng Chen, Haidong Kan (2011) p. 4936

[79] Zhu Chen, Jinnan Wang, Guoxia Ma, Yanshen Zhang (2013) p. 1959

[80] Ibid. p. 1959

deaths by lung cancer reached the rate of 30.84 every 100,000 people in 2004-05. If we compare it to the rates of 1973-75 the death rate increased by a 464.8% and the age-adjusted death rate increased by a 261.4%[81].

According to several studies about the effects of air pollution on health done by the World Bank, the Chinese Academy of Environmental Planning and WHO reached the conclusion that somewhere between 350,000 and 500,000 people die prematurely in China each year due to outdoor air pollution[82]. What is more, according to the Global Burden of Disease Study 2010 around 1.2 million people died prematurely in China as well as 25 million disability adjusted life years were lost as a result of air pollution in 2010[83].

According to the WHO small particulate pollution has an impact on our health no matter how low the concentration, which means that there's no threshold below which we are safe from its effects[84]. The implications of that are that we should not only attempt to reduce the concentration of PM in the air but we should aspire to someday completely eliminate it from the air we breathe as well. For now though, the WHO offers some guideline limits in an attempt to achieve the lowest concentration possible.

Despite PM being the most harmful of air pollutants, ozone and nitrogen dioxide, as well as sulphur dioxide also have an impact on our health[85].

3.2. Particle migration to the US coast

Air pollution has become an increasingly worrisome problem not only inside of China but also for the US, due to the fact that some of the particles are being blown towards the west coast of the United States becoming a health risk for both United States citizens and Chinese ones alike.

[81] Zhu Chen, Jinnan Wang, Guoxia Ma, Yanshen Zhang (2013) p. 1959

[82] Ibid. p. 1959

[83] Ibid.p. 1959

[84] World Health Organisation (2014)

[85] Ibid.

In the year 2015 the news that air pollution was travelling from China to the west coast of the United States were everywhere. Headlines like "China's air pollution blowing into the United States, study finds"[86] or "China 'exporting' ozone to US, study says"[87] and even "Air pollution from China undermining gains in California, Western states"[88]. Those particular headlines were all referring to a study done by NASA's Jet Propulsion Laboratory (JPL) together with scientist from the Netherlands. According to that study the US had reduced its emissions of ozone but when measuring the ozone contents of the air above the west coast the levels there were higher than expected. The scientists ran a model simulation and discovered that 43%[89] of the difference between the ozone levels they measured and the levels that they were supposed to find was due to Chinese pollution being transported on air currents to the west coast of the United States.

But when the news of this phenomenon appeared in newspapers there was one thing that wasn't mentioned, and that is that a part of the environmental problems that China is facing nowadays can be related to American consumption. What I mean by that is that an important part of the products consumed by the United States is, at least partially, manufactured in China, or as McKay Jenkins[90] puts it "China produces, America consumes". Jenkins explains that neither country could continue on the path it is at the moment if it weren't for the other. China depends economically from its exports to the US, and the US relies on the cheap products it can get from China.

[86] Breslin, S. (2015) China's air pollution blowing into the United States, Study finds. *The Weather Channel*. Retrieved from: https://weather.com/science/environment/news/china-emissions-reach-america

[87] Phys.org (2015) China 'exporting' ozone pollution to the U.S, Study says. Retrieved from: http://phys.org/news/2015-08-china-exporting-ozone-pollution.html

[88] Scauzillo, S. (2015) Air pollution from China undermining gains in California, Western states. *San Gabriel Valley Tribune*. Retrieved from: http://www.sgvtribune.com/environment-and-nature/20150810/air-pollution-from-china-undermining-gains-in-california-western-states

[89] Jet Propulsion Laboratory (2015) Nature, Chinese pollution offset U.S. western ozone gains. Retrieved from: http://www.jpl.nasa.gov/news/news.php?feature=4685

[90] Jenkins, M. (2013)

Jenkins points out that a lot of industrial plants have been closed down in the U.S in the last decade only to be replaced by new ones in China. In that same period import of consumer goods from China has gone from 62 billion dollars to 246 billion dollars in the United States, according to Jenkins. According to the U.S. Census Bureau[91] the 2016 U.S.'s trade in goods with China was 73,306.5 million U.S. dollars, a total that only includes the months of January and February. The total for 2015 was 481,880.8 million U.S. dollars for the entire year. If we go back a decade and have a look at 2005 we find that the total then was 243,470.1 million U.S. dollars, approximately half the amount of 2015. If we go back as far as the year 2000 the U.S.'s trade in goods with China amounted to 100,018.2 million U.S. dollars, almost a fifth of what it was last year according to the bureau. This data proves the growing dependence of the U.S. on the Chinese industry.

Jonathan S. Watts in his book "When a billion Chinese jump"[92] cites Pan Yue, the deputy minister of environmental protection saying:

> Developed countries account for 15 percent of the world's population, yet use over 85 percent of its resources. They raise their own environmental standards and transfer resource intensive and polluting industries to developing nations; they establish a series of green barriers and bear as little environmental responsibility as is possible. (Watts, 2010: 94)

Watts continues explaining that between a 15 and a 40 percent of China's CO_2 emissions are attributable to the production of exports. According to Jintai Lin et. al[93] of all the air pollutants that China emitted on the year 2006 a 36% of all the anthropogenic sulphur dioxide emitted, 27% of the nitrogen oxides, 22% of carbon monoxide and 17% of black carbon were associated with export goods production. About 21% of those were related to China-U.S. exports. If we keep in mind the data mentioned before where we saw that the

[91] United States Census Bureau (n.d.) Trade in goods with China. Retrieved from United States Census Bureau website: https://www.census.gov/foreign-trade/balance/c5700.html

[92] Watts, J. S. (2010) p.94

[93] Jintai Lin, Da Pan, Steven J. Davis, Qiang Zhang, Kebin He, Can Wang, David G. Streetsf, Donald J. Wuebbles, and Dabo Guan. (2014). pg 1736

exports from China to the U.S. almost doubled between 2005 and 2015 then we can safely assume that this percentage has probably grown as well.

Jintai Lin et. al explain in that same study[94] that some of this export-related pollution was transported to the west coast of the United States and contributed 3-10% of the annual concentration of mean surface sulphate as well as 0.5-1.5% of ozone in 2006. Since the United States started outsourcing manufacturing to China sulphate pollution decreased on the eastern part of the U.S. but increased on its western side. This fact makes obvious that there are two competing forces affecting the country's air pollution, the fact that they moved certain manufacturing plants to China improved the air quality of the country, but on the other hand, the pollution that those same factories produce in a country where the emission of pollutants isn't as tightly controlled is being transported through the atmosphere and can reach the westernmost part of the United States.

Several studies that look into China's air pollution problems have brought up the question: who should be held accountable for the pollution that's created producing export goods? In the study done by Jintai Lin et. al[95] these emissions are called EEE, which stands for emission embodied in exports, and they say that there are two ways to look at these emissions. The first option is to hold the producer accountable for any and all emissions it generates, this options is usually the default accounting for most emission inventories like the Emission Database for Global Atmospheric Research. The second option would be to base accountability on consumption, meaning that all emissions related to producing goods for other countries would be the responsibility of the country that consumes them, meaning that all goods consumed by China and the emissions their production generated would be China's responsibility, no matter whether or not they were produced in China; also all goods that were for the consumption of the United States and the emissions related to their production

[94] Jintai Lin, Da Pan, Steven J. Davis, Qiang Zhang, Kebin He, Can Wang, David G. Streetsf, Donald J. Wuebbles, and Dabo Guan. (2014). pg 1736

[95] Ibid. pg 1736

would be the responsibility of the United States, including goods produced in China.

In that same study[96] they explain that during the years 2000 through 2009 the emissions generated by the United States, Europe and Japan have decreased, but the global overall emissions have not decreased due to the increase of emissions from China. We have to keep in mind though that 36% of all Chinese So_2 emissions as well as 27% of NO_x emissions in 2006 were directly related to goods for consumption exported outside of China. If we looked at the emissions from a consumption point of view the emissions of the United States of SO_2, NO_x, CO and BC for the year 2006 would have been 6-19% higher. What is more is that even relocating certain manufacturing plants to China the United States still receive some of the pollution generated by China to produce all those products.

China has found in producing for exportation a great economic benefit but as Dan Yuting[97] says: "...in satisfying the needs of foreign producers and consumers, China paid a heavy environmental price." (Dang Yuting, 2015: 44)

Huibin Du et al did a study on embodied emissions in the bilateral trade between China and the U.S.[98] and found that the export-embodied CO_2 emissions from Chinese exports to the U.S. in 2007 were 812.01 Mt CO_2, which accounted for 12.08% of China's total emissions of CO_2 that year.

So with this we see that China and the U.S. are not only economically intertwined but also the pollution one generates can affect the other. It is then in their best interest to present a united front against GHG emissions as well as any other air pollutant for they are too closely related to be able to really improve their situation without the other acting towards the same goal.

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[96] Jintai Lin, Da Pan, Steven J. Davis, Qiang Zhang, Kebin He, Can Wang, David G. Streetsf, Donald J. Wuebbles, and Dabo Guan. (2014). pg 1736

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4. Conclusions

So to sum it up the industrialisation process of China is one of the main causes of the country's air pollution, due to the fact that until recent years there weren't measures in place to limit the emission of air pollutants. So as to the question about how and why the vast amounts of pollution are being generated in China we have seen that its great reliance on coal to generate energy is one of its main causes and the lack of controls on the generation of these pollutants in the past hasn’t helped either. But another main cause is the vast amount of companies that have moved their manufacturing plants to China because of the cheap price of labour there and the lack of control of air pollutants emissions. So in answer to the question posed at the beginning of whether the pollution was due to the companies that go to China in search for cheap labour the answer is that as most things it isn't black or white but a shade of grey. In this case both national authorities and foreign companies are to blame.

As far as the measures China is taking to reduce emissions China has shown in these last few years a great interest in controlling and reducing them. China hasn't only started establishing control and reduction measures since the COP 21 but it had already been some years since China had awakened to the problems of air pollution and started taking measures to control it. But aside from that China has shown initiative and great economic support at the COP 21 conference and has set ambitious goals for the reduction of emissions for the near future. Now we have to wait to see how China fulfils those goals and what goals it will set next. If it truly manages those goals, although we will still be far from reducing emissions enough to stop the temperatures rising those 2 degrees Celsius that mark the point of no return in climate change, we will definitely see an improvement in the world's air pollution levels.

Air pollution poses a great threat to our health and we need to start reducing emissions as soon as possible, not only China but the entire world. The COP 21 centred its talks on the effects that not reducing emissions will have in the future by accelerating climate change, but we should all worry about the dire effects air pollution has on our health. Every year millions of people die prematurely because of air pollution and we are all to blame for that. The Paris

Agreement is a tentative alliance that has united the nations of the world in a fight against air pollution, but the fight is not only for the future but for the present and the people that see their lives cut short because of the particles that our modern world releases into the air.

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