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Solving the ‘Wicked Problem’ of China’s Environmental Future: Cautious Optimism in the Face of Unprecedented Threats

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Abstract

China's global position as an exporter of inexpensive, low-value goods has been sustained by a coal-fired growth model whose devastating environmental and social consequences are only recently being acknowledged properly by party leadership. A systematic review and analysis has been conducted of the most current academic literature addressing China's environmental challenges. A sizeable amount of research (around 360 publications) was amassed in this pursuit, covering not only China's environment, but also related governmental, economic, and social factors. The author has defined China's environmental future as a 'wicked problem', which creates two allowances by default. First, it communicates that the problem is highly complex, involves multiple stakeholders, and has no easy solutions. Second, it recognizes that only a uniquely multi-sectoral approach can achieve accurate forecasting and sound recommendations. This paper follows this multi-sectoral approach, crossing institutional lines in search of developments economically and politically, as well as prevailing trends in both technology and culture. Scenario building of divergent futures has been visualized in order to generate confident and informed forecasting of China's environmental future. The author remains cautiously optimistic regarding these future projections. However, heroic innovations in technology and environmental efficiency must be matched by seismic shifts in economic, social, and political policy. Real solutions and recommendations are prescribed in the final section of this Capstone. The importance of these recommendations cannot be overestimated. Expert consensus has equated humanity's avoidance of climate fallout with the need for transformative solutions in China.

Disciplines

Environmental Sciences | Physical Sciences and Mathematics

ABSTRACT

SOLVING THE ‘WICKED PROBLEM’ OF CHINA’S ENVIRONMENTAL FUTURE: CAUTIOUS OPTIMISM IN THE FACE OF UNPRECEDENTED THREATS

Jamison Maley

Stanley L. Laskowski

China’s global position as an exporter of inexpensive, low-value goods has been sustained by a coal-fired growth model whose devastating environmental and social consequences are only recently being acknowledged properly by party leadership. A systematic review and analysis has been conducted of the most current academic literature addressing China’s environmental challenges. A sizeable amount of research (around 360 publications) was amassed in this pursuit, covering not only China’s environment, but also related governmental, economic, and social factors. The author has defined China’s environmental future as a ‘wicked problem’, which creates two allowances by default. First, it communicates that the problem is highly complex, involves multiple stakeholders, and has no easy solutions. Second, it recognizes that only a uniquely multi-sectoral approach can achieve accurate forecasting and sound recommendations. This paper follows this multi-sectoral approach, crossing institutional lines in search of developments economically and politically, as well as prevailing trends in both technology and culture. Scenario building of divergent futures has been visualized in order to generate confident and informed forecasting of China’s environmental future. The author remains cautiously optimistic regarding these future projections. However, heroic innovations in technology and environmental efficiency must be matched by seismic shifts in economic, social, and political policy. Real solutions and recommendations are prescribed in the final section of this Capstone. The importance of these recommendations cannot be overestimated. Expert consensus has equated humanity’s avoidance of climate fallout with the need for transformative solutions in China.

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Dedication:

This Capstone is dedicated to my late father as well as to my mother for her unrelenting encouragement.

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I. Introduction

1.1 Opening Thoughts

I have come to terms with the fact that I am attracted to things that are both complicated and contradictory. In my free time, I like to collect fragments of Gothic Revival architecture. What could be more complicated than the lancet arches, trefoils, and tracery of this ornate historical style? What could be more *contrary* than a de facto Christian style that draws heavily on Islamic design ideas (Christopher Wren's "Saracen" theory) as well as deeply rooted pagan iconography (gargoyles, griffins, and weaponized animals). I galumphed my way through an undergraduate and graduate degree in astronomy, weathering a storm of physics concepts and topics that were relentlessly complex and contrarian. The field of astronomy is a *mélange* of counterintuitive methods and systems that seem more interested in making respectful nods to history than practicality. Contradiction even persists in the people. How does the trope of the wooden and clinical physicist explain the wild creativity and musicality of truly great physicists like Richard Feynman? Maintaining this long-standing taste for complexity and contradiction may explain what initially drew me to China, but it certainly did not prepare me for what I was about to experience when I visited with a group of students during the summers of 2009 and 2012 (Figure 1).



Figure 1 Background image taken by the author during the Haverford trip to China in 2012

To understand the soul of China, you must be willing to navigate a *feverish* degree of complexity and contradiction. During our 2012 visit to China, the students and I had an opportunity to spend a few days at a Taoist monastery near the Cicheng “Ancient Town” site located in Ningbo. I got up a few hours before everyone else, save for a few goats (Figure 2), and made my way to the top of the hill. I not only encountered a statue of Laozi (Figure 3), the author of the Tao Te Ching, but also visited temples (Figure 4) featuring the “Three Pure Ones” of Taoism. This holy trinity of sorts included Yuanshi Tianzun who supposedly held the pearl from which the whole universe issued from.



Figure 2 Walking up the hill to the Taoist temples

Figure 3 Statue of Laozi by sculptor Wu Weishan

Figure 4 One of three Taoist temples representing the "holy trinity"

Source: Images taken by the author during the Haverford trip to China, early morning in Ningbo, 2012

As a student, I had an opportunity to re-read the Tao Te Ching during a course that explored literary representations of nature and society. The prevailing narrative of the course is the following: our environmental policy is informed by historical western texts representing nature as something to be subjugated as opposed to the messages of synergy and harmony found in non-western writings. It was hard to argue with the professor's hallowing of the Tao as a high watermark for environmental stewardship, particularly with passages such as:

"All beneath heaven is a sacred vessel, something beyond all improvement. Try to improve it and you ruin it. Try to hold it and you lost it." (Hinton, 62).

However, a few days later, the true depth of the Chinese paradox began to take shape as we found ourselves in the smog-filled, doleful skies of Beijing (Figure 5) and then traveling up the river in Shanghai. When in Shanghai, you cannot help but feel like an electron bubbling through a circuit board, particularly with the mechanized landscape of skyscrapers on the east bank of the Huangpu River (Figure 6). I have heard of the fiendish build rates throughout China but soon witnessed for myself how the lion's share of an entire apartment block could

be built over the course of only a few days. An unsurprising phenomenon considering that China is not only the biggest consumer and producer of cement in the world (Shen & Cao, 1004), but that our visit fell right in the middle of the three year period (2011-2013) when China used more cement (6.6 gigatons) than the United States used (4.5 gigatons) throughout the *entire* twentieth century (Martín-Antón,10). This is a remarkable statistic.

Eight months after our visit to Shanghai, 16000 pig carcasses would appear floating in the Huangpu River courtesy of farmers from the Zhejiang province (Pappas, 606). During our final evening in Shanghai, the students and I visited the impressive house of a noted real estate entrepreneur who had connections with our host school. Waiting for us upon our arrival was a lavish dinner. The teachers were given the “very special” treat of fish caught directly from the Huangpu River. Inside the rather capacious fish on my plate was a smaller, blue-colored fish. “Very lucky” said our well-heeled and gracious host. I was fortunate enough to be sitting next to a large potted plant during the proceedings. I surreptitiously cut up the portions on my plate and placed them under the plant. As far as I know, no one saw me.



Figure 5 The CCTV building in Beijing Figure 6 Traveling up the Huangpu River
 Source: Images taken by the author during the Haverford trip to China

The Chinese word for contradiction is *Máodùn* (矛盾) where *Mao* (矛) represents a lance and *Dùn* (盾) represents a shield. The etymology of the word harkens back to the story of a man selling both lances and shields. His claim was that no lance could ever cut through his shields and that no shield could ever resist his lances. A stranger asked him what would happen if he used one of his lances on one of his shields; the man had no answer. Hence, the term *Máodùn* represents a cautionary tale about the relationship that exists between opposites. Stepping off the plane in Beijing, I felt that a dedicated regimen of book learning had prepared me for understanding the nuances and complexity of Chinese culture. This was, of course, not true. The concept of *Máodùn* seemed to exist in every facet of Chinese life. Even the portrait of Mao Tse-Tung peering down at me from Tiananmen Square during the first day of our visit presented untenable contradictions. The contradictions of a man both lionized by many of his people and trivialized by portraits on shirts and watches. A man whose policies were responsible for the deaths of 45 million people in a four year period during the catastrophic “Great Leap Forward” from 1958 to 1962 (Dikötter, X). The dizzying

spectrum of China's many contradictions extend far beyond the Jekyll and Hyde pitfalls of its leaders to the uneasy juxtaposition between ancient temples and soulless skyscrapers, the fiction of communist rhetoric versus hyper-capitalist policy, to contradictory landscapes that include both the Roof of the World and the steppes of inner Mongolia. By far the greatest of all of these complexities and contradictions is China's environment. How does one begin to reconcile the Tao Te Ching's sentiment of "longing to take whole of all beneath heaven and improve it...I've seen such dreams invariably fail." (Hinton, 62) to the World Bank's revelation a decade ago, that 16 of the 20 most polluted cities in Earth are in China (Li, L., 75)?

I have been enrolled in the MES program since 2010 and wrote about China in at least three of my courses (see Maley, 2011, 2014, and 2017). My work at Penn has inspired me to create an entire unit on China within my "Environmental Ethics" course for seniors at the Haverford School. Last year, students enrolled in both my course and Gary Kan's Chinese IV class, were required to read my SWOT analysis and weekly briefs from my 2017 independent study at the University of Pennsylvania. A collaboration ensued where my students composed e-mails to select academic authors associated with papers I had cited while Gary Kan's students translated the e-mail into Chinese characters. Yet, despite my immersion into this topic as both student and teacher, I continue to be flummoxed by China. What happened to my predilection for complexity and contradiction? Why didn't that affinity for gothic

architecture and astronomy keep me in good stead? To understand this, we need to recognize the difference between a 'tame' problem and a 'wicked' problem.

Each year in my Electronics course, seniors must derive an equation called the "RC Exponential Charge Time". This derivation is steeped in several physics concepts and requires the use of calculus. Students practice the derivation beforehand in much the same way a musician might rehearse a song. There is no grey area here; the steps are direct and with only one definitive formulation. Once the student follows the prescribed path, the problem is solved. Relatedly, consider medieval architects constructing a gothic cathedral. Buttresses absorbed lateral thrust while treadwheel cranes moved supplies over and across walls. The steps were direct, replicated, and with only one definitive formulation. Urban planner Melvin Webber and design theorist Horst Rittel would label both of these challenges as "tame" problems in their landmark 1973 paper *Dilemmas in a General Theory of Planning*. In fact, "the problems that scientists and engineers have usually focused upon are mostly 'tame' or 'benign' ones" (Rittel, 160). Problems in the "natural sciences" are "definable and separable and may have solutions that are findable" (160). Rittel continues by saying that "a problem of mathematics, such as solving an equation...for each the mission is clear. It is clear, in turn, whether or not the problems have been solved (160)". In stark contrast to 'tame' problems are 'wicked problems', a concept formally introduced in Rittel and Webber's aforementioned paper. Rittel and Webber established ten essential elements of a wicked problem, the first of which is that "there is no definitive formulation of a wicked problem" (161). Wicked problems

such as climate change, obesity, and poverty have no “optimal solutions” nor do solutions exist that present “definitive and objective answers” (160). This is because all wicked problems are highly complex, involves multiple stakeholders, and have no easy solutions. The authors went so far as to say that all “planning problems are inherently wicked” (160). As an example, consider that the PRC has modeled government leadership after a Russian technocratic system that favors officials with backgrounds in engineering. The ‘tame’ problem solving of engineers may explain why the grandiose, supply-side building projects from PRC leadership have done very little to ameliorate the wicked problem of China’s multiple environmental tipping points. As a further example, consider what made the Copenhagen Summit such a failure in 2009: an omnibus of broad and “optimal solutions” that were non-binding, vague, and milquetoast. The exact opposite of what wicked problems need, as described by Rittel and Webber. I only recently learned about wicked problems while preparing a weekly brief for my 2017 independent study. I encountered an article entitled *The Wicked Problem of China's Disappearing Coral Reefs*. It occurred to me that the *totality* of China’s environmental challenges could best be described as a wicked problem and decided to integrate the concept into my Capstone project. When Hughes revealed that “wicked problems are also characterized by inadequate governance, missing institutions, and a shortage of time before the problem becomes even harder to address” (2), I realized that I made the right choice as these descriptors perfectly typify China’s unique brand of issues. Why the use of this term is essential for the approach of this Capstone will be detailed further in

the “Methods” section. Until then, it is necessary to create a broader context for the problem by providing an overview of China’s environmental history.

1.2 Environmental History in China before the 21st Century

To understand the environmental history of China, one must acknowledge that the contradiction between the “lofty visions of harmony and destructive practice underlies the melancholic tone of nearly all surveys of Chinese environmental history” (Perdue, 254). Despite the aforementioned tenets of Taoism, it was Taoism’s philosophical contemporary, *Confucianism*, that had a more formative impact on contemporary policy in China. In fact, the decline of Marxism has led to a “modernization” (xiandaihua) of Confucianism by 21st century Chinese leadership under the auspices of “boosting its soft power” (Wu S., 320) with the more likely agenda to “maintain the current power order” (320). The problem lies in the fact that Confucianism has a more utilitarian view on nature than Taoism, as revealed in the Book of Rites’ exhortation to never “leave vast resources untapped”. Historically, some Confucian officials held in low regards those professions that did not “exhaust the earth” (jindili). The result is a contradictory and double-edged relationship with the environment throughout the history of China. What follows are some of the good and the bad.

One of the great historical figures in Chinese history is Yu the Great who, over four thousand years ago, developed a system of flood controls for the Yellow River hence “establishing the Xia dynasty, the first in Chinese history, and marking the beginning of Chinese civilization.” (Wu Q., 579). By 100 B.C.,

farmers deforested nearly all of the North Chinese plains and then migrated west and south until, by 1800 A.D., “they had covered nearly all of contemporary interior China’s cultivable area” (Perdue, 254). However, as far back as the Qin dynasty (221 B.C.), laws existed that contained “provisions reflecting environmental concerns, such as those prohibiting poaching young animals and birds in spring, and restricting deforestation and prescribing how land was to be used on hills” (Shapiro, 99). Woodland conservation also had a place during the Ming and Qing dynasties, out of a Confucian impulse to protect trees around the graves of loved ones. Such protected areas expanded into China’s mid-20th century “ecology forests” (Miller, 2). Finally, Mencius, the ‘second sage’ of Confucianism, once lamented the destruction of trees on Ox mountain at the hands of humanity who “has ‘thrown away his good mind’ (fang ch’i liang-hsin) and degraded himself” (Bloom, 37).

By the end of the mid-19th century, China found itself at the tail end of the first opium war, with a culture that struggled to adjust with protracted exposure to the west. The century that followed required a preoccupation with “the difficult replacement of new and old modes of production” resulting in an “environmental history of modern China (1840–1949)” that is “not an exceptional one” (Maohong, 483-484). This era brought the inception of modern Chinese agricultural production where “human beings altered greatly the capacity in interfering with natural environment at a larger scale” (Dong, 27).

What followed, of course, was the Mao-era of communist China from 1949 to 1976 that included the grisly legacies of the Great Leap Forward and the

Cultural Revolution. While many place the blame for China's current environmental problems on the post-Mao era of open markets and meteoric growth starting with Deng Xiaoping, Shapiro suggests that the Mao era "provides an example of extreme human interference in the natural world" (95). The rhetoric of militarism was used in a literal 'war on nature' as 'shock troops' were deployed to besiege grasslands and "defeat nature (zhansheng ziran)" (Thorner, 38). One aspect of this gormless campaign included a war on the "four pests" (Figure 7) resulting in the deaths of one billion sparrows (Lampton, 898). With no regard for the predator-prey relationship, this campaign resulted in skyrocketing numbers of locusts decimating crops as millions starved.



Figure 7: Propaganda poster for the "Four Pests" campaign, circa 1958
Source: Image taken from <https://www.procaffenation.com/story-chinas-self-inflicted-disaster/>

The last stage of this timeline begins in 1978 with Deng Xiaoping's apocryphal statement of *zhìfù guāngróng* or "to be rich is glorious". From this point onward, China officially positioned itself as a capitalist juggernaut, churning out low-value goods on the proto-globalization supply-chain. It is from this point where many analysts set the marker for China's descent into environmental fallout. As Maohong observes, "the spirit of the times which encouraged people

to get rich rapidly stimulated people to over-exploit the environment regardless of its carrying capacity and limitation...the final result was massive environmental damage in China” (492).

It should be noted that this Capstone separates pre-21st century China from the China of the new millennium for good reason. While Maohong’s statement regarding the “massive environmental damage” (492) in the wake of post-1978 reforms rings true, the breadth of the damage since the year 2000 far outpaces the preceding twenty year period. Most policy papers focus on *post-2000* decision-making in creating a context for China’s current environmental state. For the same reason, I have relegated most of pre-2000 Chinese environmental history to only two sections (1.2 and 1.3) of this Capstone. The focus of this Capstone remains centered on 21st century China.

The rationale for separating China into these two periods can be seen in Figure 8, which reveals an exponential rise in China’s carbon emission levels starting around 2001, eventually surpassing the United States in 2007. There is one word to explain this: globalization. In the west, neo-liberal economic policy and corporatism has produced programs like the North American Free Trade Agreement (NAFTA) and the recently forestalled Trans-Pacific Partnership (TPP). The resulting Wal-Mart economy has been throwing the American worker overboard for the last forty years, a period marked by the loss of “once-gainful manufacturing and public sector job opportunities” (Centeno, 326). The hallmarks of globalization, which include privatization, deregulation, and austerity measures, have strong-armed whole population centers through entities like the

World Bank and the World Trade Organization. China's spike in carbon emissions directly corresponds to PRC inclusion into the World Trade Organization at the tail end of 2001. While globalization has undeniably pulled millions of people in China out of poverty, the sheer scale of the resulting environmental impact post-2001 has had no precedent in human history. The next section of the introduction will detail some of the environmental challenges and burgeoning environmental legislation that have pre-dated this transformative period of WTO-era China. This is the period marking the calm before the storm.

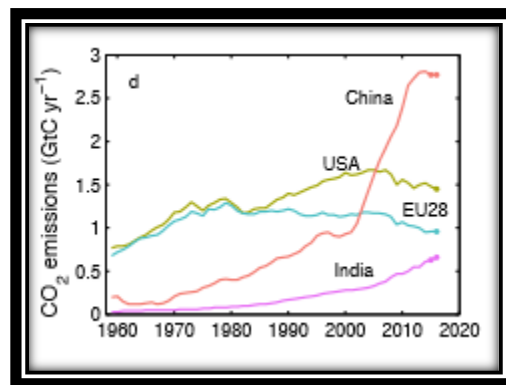


Figure 8: Carbon dioxide emissions in gigatons per year for the top emitting countries.
Source: Le Quéré, 70

1.3 20th Century China: Rising Environmental Laws to Address Rising Environmental Challenges

1.3(a) Rising Environmental Challenges

Many of the environmental challenges in China during the 20th century include increasing degradation of air and water quality as well as more frequent extreme weather events. Drivers of this degradation include changing agricultural practices, rapid industrialization, and growing urbanization. While initially started by a group of farmers in the Anhui Province, Deng Xiaoping officially codified a

“rural” reform era starting in 1980, creating a fifteen year period marked by “the triumphant success of rural industrialization”ⁱ (Zhang, Q.F., 5). This caused agricultural GDP to almost triple from 2.7% during the pre-reform period to 7.1% from 1979-1984, despite levelling off during the later reform period (Huang, J., 120)ⁱⁱ. Meanwhile, the open market reforms of Xiaoping resulted in ten million people a year moving from rural areas to urban centers in what “probably constitutes the largest migration in human history” (Fang. C., 15571). The population in urban centers increased from 17.9% in 1978 to 54.77% in 2014 (15571). From 1995 to 2005, this corresponded to annual rates of growth of 10%, 24%, 12%, and 10% for the production of energy, cement, steel, and vehicles respectively (Xing, 3119). Consequently, smog became an increasing issue of concern in Chinese cities in the 1970s while by the 1980s, southern China become one of the three areas of the world most impacted by acid rain (Qiao, X., 240). Additionally, incidents of flooding increased sevenfold since the 1950s (Dai, 311), a fact spectacularly demonstrated by the 1998 flood in the Yangtze basin that destroyed five million homes, cost 20 billion dollars, and affected 21 million hectares of land (Huang, J.K., 678). Since the 1950s, flooding of croplands have increased 50%, from 7.4 to 11.2 million hectares, while cropland drought has increased 116% from the same time period (Huang, J.K., 678).

Population increase since the 1950s combined with the aforementioned drivers of industry and agriculture have “drastically increased the demands for water from agricultural, industrial, and domestic uses, while the physical water supply remained essentially the same” (Hu., Y., 58). This has been compounded

by the fact that wastewater treatment has been outpaced by the demands of growth in these various sectors, with industrial water demand tripling between 1980 and 2007 (62) and the use of agricultural pesticides doubling between 1992 to 2002 (59). The effects of these growing demands has resulted in over 11,000 “water quality-related emergencies” since 1995 (Han, D., 1222). One such example is the eutrophication of lakes where 5% of all lakes in China were eutrophic in the 1970s. This number increased to 35% during the late 1980s and then to 75% by 2002 (Zhou & Khu, 1244). Compounding the issue is the fact that land-use type conversions covered 15.1% of China’s total area from 1980-1995 and has increased to 22.3% since 1995 (Zhang, 3).

The collective impact of the aforementioned drivers have resulted in China facing serious water shortages starting in the 1980s “of increasing magnitude and frequency for urban industry, domestic consumption, and irrigated agriculture” (Jiang, Y., 3187). Abstraction of groundwater has increased from the 1950s with a rate of around 10 km³ per year to 100 km³ per year at the turn of the millennium (Wang, Ji., 2). The crisis of water supply was famously dramatized in 1997 when the lower parts of the Yellow River dried up for 226 days (Wang. J., 9 & Jiang, Y., 3187).

Finally, China saw a significant uptick in extreme weather events throughout the latter half of the 20th century. From 1959 onwards, China experienced a “statistically significant” (Shi., J., 4) increase in hot weather events along the lines of 0.4 days per decade and a decrease of cold weather events at a rate of 3 days per decade during the same period (5). Starting in the 1990s, the

amount of extreme precipitation “increased dramatically” while the number of hot days higher than 35 degrees Celsius “increased conspicuously” (Wang., L., 60S). From 1984 to 2013, weather and climate disasters “caused direct economic losses to the tune of 188.8 billion Yuan per year” which equates to around 2.05% of GDP (Gao., Y., 238).

1.3(b) Rising Environmental Laws

During the Mao years, very little was accomplished by way of environmental protection, save for a law addressing silica dust in mines in 1956, one of the first official documents dealing with air pollution. It must be remembered that the Cultural Revolution “paralyzed China politically and significantly affected its economy and society”; in terms of environmental law, the result was “a stagnation of legislation” (Feng, L., 1552). The year that represented a turning point for China’s dedication to environmental protection is frequently recognized as 1972 (Edmonds, 641 & Feng, L., 1552). Nineteen Seventy-Two marked the year of China’s attendance at the First United Nations Conference on the Human Environment. The following year, the PRC began to integrate environmental protection into national policy and created a countrywide paradigm for environmental planning. It is worth noting how close this timeline is to the United States, which made remarkable environmental strides during the early 1970s with the creation of NEPA (1969), the EPA (1970), the Clean Air Act (1970), and the Federal Water Pollution Control Act (1972). According to the United Nations, 1972 set the stage for the development process of China’s

“Ecological Civilization” (Figure 9), a term written into the constitution by the 18th National Congress in 2012 and frequently invoked by current president Xi Jinping.

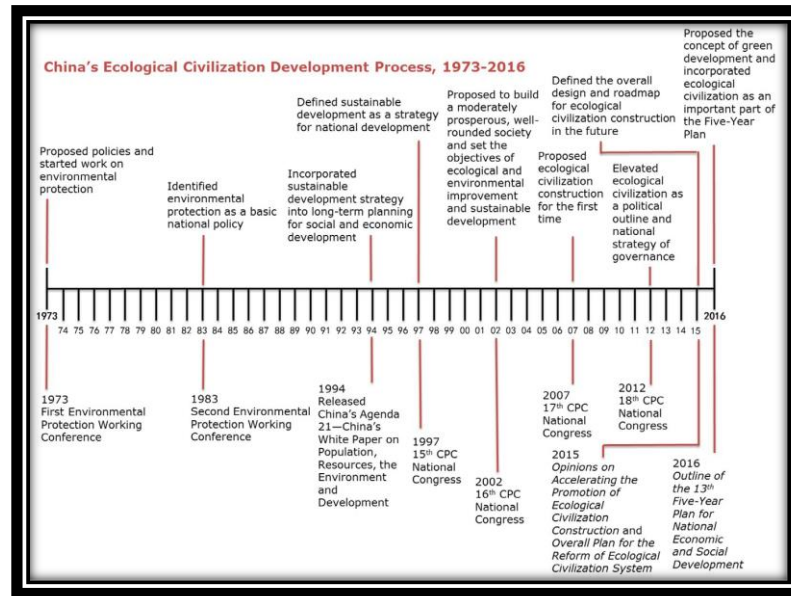


Figure 9 Increasing integration of environmental considerations into China's long-term goals starting from 1973. *Source: UNEP, 4*

The Environmental Protection Law of 1979 is seen as the official beginning of an actual, comprehensive “environmental law system” (Feng, L., 1552). The law establishes a national policy and “defines national government and territorial responsibilities for environmental protection” (OECD, 48). The provisions of this law were maintained by the National Environmental Protection Agency (NEPA) as EPBs and EPOs (environmental protection bureaus and offices) were created, with “the very first EPB inspection unit established in 1980 as a service unit in Taiyuan City in Shanxi Province” (Sinkule, 184). Ten years later, the law would be amended to allow for a “sector-specific approach (air, water, soil), environmental quality standards, and maximum pollution targets” (Brehm, 473). Three years after the Environmental Protection Law, article nine of

the constitution pledged to “ensure the rational use of natural resources and protect rare animals and plants” while article 26 pledged to “protect and improve the living environment and the ecological environment” (OECD, 48). Through the 1980s in China, the number of organizations involved in environmental protection “grew exponentially”, with environmental protection personnel doubling from 1980 to 1990. By 1990, 161,000 people were working in EPOs and EPBs (Sinkule, 9). By 1994, the Agenda 21 white paper was introduced which sought to integrate sustainable development into economic and social activitiesⁱⁱⁱ. This reflected the switch from nascent environmental provisions making inroads into national policy during the 1980s to a wholesale integration of sustainable development into policy by the 1990s (UNEP, 3). The administrative reach of NEPA was broadened and renamed SEPA (State Environmental Protection Agency). SEPA was then given ministerial status in 2008 as MEP (Ministry of Environmental Protection), and finally broadened further in 2018 as the Ministry of Ecology and the Environment.

With regard to the mounting issue of air and water quality detailed in section 1.3a, the PRC switched from a ‘hard’ approach to a ‘soft’ approach in 1990, at least with regards to water management. Unsurprisingly, technocrats in positions of authority will rely on their engineering backgrounds to ‘build’ their way out of a problem. This typifies a ‘hard’, supply-based approach. The Three Gorges Dam and the poorly conceived South-to-North Water Transfer Project are, hopefully, the final gasps of this wrong-headed approach. Technocratic vanity projects of this kind continue to exact substantial humanitarian and

environmental costs. The displacement of 1.2 million people during the construction of the Three Gorges Dam is one well-known cost. Meanwhile, the environmental costs in the water-providing areas of the South-to-North Water Transfer Project “will be large” for the purposes of a “project that is unlikely to be sustainable over the long term” (Wilson, 8). However, by the 1990s, a more ‘soft’ demand-driven approach relying on economic mechanisms of efficiency and pricing begins to emerge. The final decade of the 20th century saw an introduction of market-based approaches to water use, particularly water-pricing and water-trading mechanisms, public-private partnerships, BOT’s (Build-Operate-Transfer), and the implementation of polluter pay principles. During the mid-twentieth century, China was still reeling from war, focusing strictly on economic and social recovery. The period of 1957-1979 saw a “balanced emphasis on disaster protection and comprehensive utilization of water resources” (Liu, J., 636). By the 1980s, the focus began to shift to not only water allocation, but also “water resources protection and water pollution control” (636). By the 1990s, the aforementioned ‘soft’ approach combined with a reaction to shocking manifestations of water scarcity such as the drying up of the Yellow River resulted in a series of laws that reveal this newer, demand-driven approach to the environment (Figure 10).

1979	Environmental Protection Law (amended 1989 and 2001)
1982	Marine Environmental Protection Law (amended 1999)
1984	Forest Law (amended 1998)
1984	Law on Prevention and Control of Water Pollution (amended 1996, implemented 2000)
1985	Grassland Law
1986	Fisheries Law
1986	Mineral Resources Law
1986	Law on Land Administration (amended 1998)
1987	Law on Prevention and Control of Air Pollution
1988	Water Law (amended 2002)
1988	Wildlife Protection Law
1989	City Planning Law
1991	Law on Animal and Plant Quarantine
1991	Law on Water and Soil Conservation
1993	Agricultural Law
1994	Regulations on Protected Areas
1995	Law on Prevention and Control of Environmental Pollution by Solid Waste (amended 2004)
1995	Law on Prevention and Control of Air Pollution (amended 2000 and 2002)
1996	Law on Prevention and Control of Pollution from Environmental Noise
1996	Law on Coal Industry
1997	Law on Protecting Against and Mitigating Earthquake Disasters
1997	Law on Energy Conservation
1997	Construction Law
1997	Flood Control Law
1998	Fire Control Law
1998	Law on Promotion of Cleaner Production (amended 2003)
1998	Administrative Reconsideration Law
1999	Meteorology Law
2001	Law on Prevention and Control of Desertification
2001	Law on Administration of Sea Areas
2002	Law on Popularization of Scientific Technology
2002	Law on Safety Production
2002	Law on Environmental Impact Assessment
2003	Law on Radioactive Pollution Prevention and Control
2003	Law on Administrative Permission
2005	Law on Renewable Energy

Figure 10 PRC environmental laws revealing the transition to the ‘soft path’ approach in the 1990s as well as a growing awareness for robust laws addressing water. *Source: OECD, 48*

Although China was a far cry from the shocking 2013 “airpocalypse” in Beijing, legitimately growing concerns over air quality produced only lackluster legislation during the final decades of the 20th century. According to Lu Feng, the “broad but vague framework” of the APPCL law of 1987 (Air Pollution Preventions and Control Law) continues to be “the only specific national law” for air pollution (1551). An amendment in 1995 made a nod toward cleaner production technologies, but overall was “largely not enforced” (1553). The list of national laws for “PCAP” (Prevention and Control of Air Pollution) seen in figure 11 was provided by Feng to underscore the fact that only APPCL addresses air pollution explicitly while the other laws make only tangential connections to air quality. Understanding the epidemic of poor enforcement in China requires placement within the context of the “fragmented bureaucracy” dynamic, as detailed in section 2.2(b) of this paper.

National Laws for PCAP in China.				
No.	Name	Effective	Revised	Table of contents
1	Environmental Protection Law	13-09-1979	26-12-1989 24-04-2014	General Provisions, Supervision and Management, Protection and Improvement of the Environment, Prevention and Control of Pollution and Other Public Hazards, Information Disclosure and Public Participation, Supplementary Provisions
2	Air Pollution Prevention and Control Law (APPCL)	01-06-1988	29-08-1995 29-04-2000	General Provisions, Supervision and Management of PCAP, Prevention and Control of Pollution from Soot, Prevention and Control of Pollutant Emission by Motor Vehicles and Vessels, Prevention and Control of Pollution from Waste Gas, Dust, and Odorous Substances, Legal Liability, and Supplementary Provisions
3	Cleaner Production Promotion Law	01-01-2003	29-02-2012	General Provisions, Promotion of Cleaner Production, Implementation of Cleaner Production, Incentives, Legal Liability, Supplementary Provisions
4	Environmental Impact Assessment Law	01-09-2003	-	General Provisions, Evaluation of Environmental Effects of Plans, Evaluation of Environmental Effects of Construction Projects, Legal Liability, Supplementary Provisions
5	Energy Conservation Law	01-01-1998	28-10-2007	General Provisions, Administration of Energy Conservation, Rational Use of Energy and Energy Conservation, Technological Progress in Energy Conservation, Incentives, Legal Liability, Supplementary Provisions
6	Forestry Law	01-01-1985	29-04-1998	General Provisions, Forest Management and Administration, Forest Protection, Tree Planting and Afforestation, Forest Tree Felling, Legal Liability, Supplementary Provisions

Figure 11 Laws addressing PCAP (Prevention and Control of Air Pollution). The APPCL is the *only* law addressing air pollution explicitly. *Source: Taken from Feng, L., 1551*

Finally, the last few decades of the twentieth century began the momentum that culminated in China’s current status as the leading producer and consumer of renewable energy. During the late 1980s, a wind farm went online in the Shandong province as loans from Europe helped to bankroll prototype wind projects (Zhao, 272). By 1994, the PRC issued the ‘Regulation on Grid-connected Wind Farm’ document stating that wind power “should be fully purchased by the grid utility and wind power on-grid price be determined by production cost, interest, and reasonable profit” (272). In 1996, the government began to provide support for research and development through the ‘Ride Wind Program’ allowing Chinese firms to enter the market and through reverse engineering, learn how to produce their own models (Zhou & Xu, 14).

1.4 China’s 21st Century Coal-Fired Economy

1.4(a) Phase One – The engine that drives the economic colossus

Coal has always been deeply entrenched in the soul of the Chinese people (Figure 12). One of the earliest recorded mentioning of coal dates back to the 4th century B.C. within the beautifully illustrated pages of the Shan Hai Jing, or “Of Mountains and Seas” (山海經). By the Han Dynasty (206 BC–220 AD), an industry for coal mining had been established and by the Song Dynasty (960–1279 AD), millions of people “use coal as fuel and none of them uses firewood” (Deng, 42). This deeply rooted history with coal spans millennia (Finkelman, 580), eventually informing a 20th century “economic miracle” that was staggering in its magnitude and ambition.



Figure 12 Chinese expertise in coal mining pre-dates western advances by several centuries. *Image Source: Deng, 43*

One of Deng Xiaoping’s most enduring statements is that “*It doesn’t matter if a cat is black or white, so long as it catches mice*”. This hard-bitten pragmatism marked a turning point in Chinese history as Xiaoping opened the

borders to world markets starting in 1978. By subscribing to capitalist market principles, particularly as they applied to the “four modernizations” of defense, science, agriculture, and industry, economic growth became the state religion in the PRC. The term “economic miracle” has often been applied to West Germany in the aftermath of World War 2 where an 8% GDP growth per year was achieved during the 1950s (Eichengreen, 3). However, West Germany pales in comparison to the elephantine miracle achieved in China starting with the reforms of Xiaoping and culminating in an average annual GDP growth of nearly 10% from 1979 to 2014 (Morrison, 2). By 2010, China surpassed Japan as the second largest economy with the Chinese middle class at already around 10-28% of the population^{iv}, and likely reaching 40% by 2020 (Wu, W.C., 350). And how did China achieve this unprecedented growth paradigm and secure the global position as the de facto exporter of cheap, low-value goods? How have 800 million people been lifted out of poverty since 1978 as consumer spending reached 1.4 trillion in 2010, up from 650 billion dollars in 2000 (Towson, 1)? Clearly, many contributing factors aligned themselves during this period. Massive government spending ensued as cultural shifts also gave way to the growth of private wealth among individuals formerly decried as “capitalist roaders”. Western globalization placed China at the manufacturing nexus for the world as intensive labor demand supported a colossal export economy. However, it is China’s coal-fired growth model that has largely sustained its meteoric rise. This model has translated into environmentally catastrophic consequences for the Chinese people. This will be detailed in the next chapter of the *Introduction*.

If there was any question of the link between subsequent carbon emissions from China's coal-fired economy and resulting GDP growth, Figure 13 dispels any doubts.

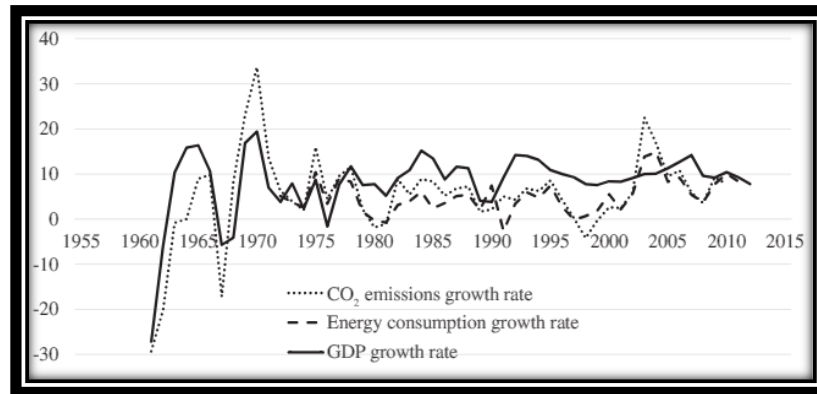


Figure 13 Rates of growth for GDP, carbon dioxide, and energy consumption
Source: Wang, R., 406

China is the biggest producer and consumer of coal in the world, almost as much as the rest of the world combined (Figure 14), consuming up to 4.49 billion tons over the course of 2017 alone. In 2008, 80% of China's electricity and around 71% of its total energy came from coal (Shome, 24). 85% of China's CO₂ emissions are associated with fossil fuel combustion; 83% of this is associated with coal (Olivier, 19). The dramatic dominance of coal in China's total energy mix can clearly be seen in Figure 15.

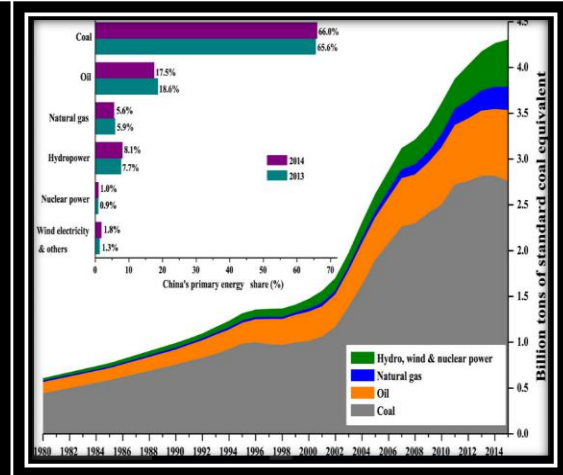
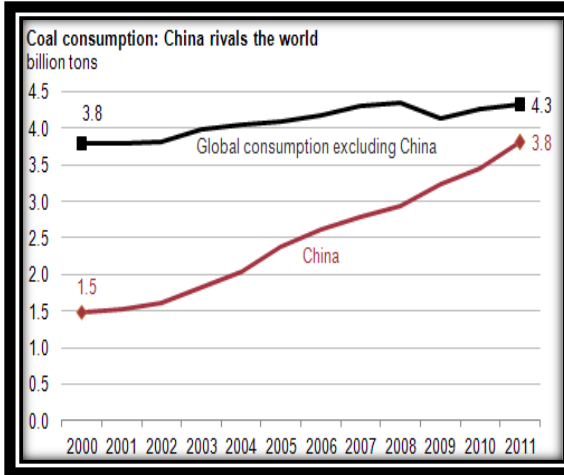


Figure 14 China nearly consumes as much coal as the rest of the world combined
 Source: U.S. Energy Information Administration International Energy Statistics
 Link: <https://www.eia.gov/todayinenergy/detail.php?id=9751>

Figure 15 Energy Consumption Mix in China, 1980-2015
 Source: Image taken from Yang, X.J., 85

Of the three types of coal in order of decreasing quality (anthracite, bituminous, and lignite), much of the high-grade anthracite lies in the northwestern parts of the country which has resulted in China's reliance on lower-grade bituminous, roughly amounting to around 54% of total reserves (Figure 16). A study by the Massachusetts Institute of Technology determined that wide scale use of dirtier coal throughout China has exacerbated already heinous levels of pollution due to, among other things, the high sulfur content. This is only made worse by "industrial consumers, poorly monitored by the state and devoid of any cleanup systems" (Steinfeld, 26). 'Poorly monitored by the state' also means that local collieries offer little by way of protection for Chinese miners. Eighty percent of mining deaths around the world occur in China, as a Chinese miner is thirty-seven times more likely to die in a mining accident than his American counterpart (Robson, 270). Apart from the localized impact on miner health, coal-burning power plants have caused a public health crisis across the nation. Air pollution is considered the fourth highest risk factor for death in all

of China and, remarkably, is responsible for 17% of all deaths (Rohde, 1). In 2014, 1.6 million premature deaths were associated with air pollution, up from 1.2 million in 2010. Some estimate have placed the number as high as 2.2 million annually, with life expectancies in northern China being reduced by 5.5 years (Finkelman, 580). Coal burning has also been recognized as the single greatest contributor to PM_{2.5} particulate matter in China, and is believed to have caused 366,000 deaths in 2013 (585). Finally, on February 21, 2013, an overdue acknowledgement came from the government (Gao, H., 284) regarding the existence of over 450 “cancer villages” throughout China, many within striking distance of coal-fired power plants. Further examples of health-related issues caused by coal burning are given in Figure 17.

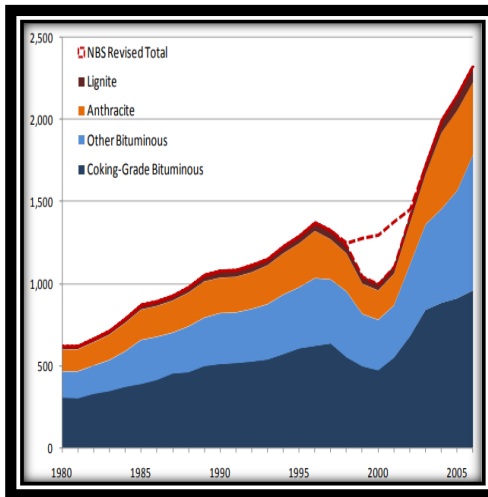


Figure 16 Coal production by type from 1980 – 2006 Source: Aden/LBNL, 9

Health issue	Cause	Estimated number of people who have been afflicted
Arseniasis	Exposure to arsenic	Tens of thousands
Fluorosis	Exposure to fluorine	More than 10 million
Selenosis	Exposure to selenium	Several hundred
Mercury poisoning	Exposure to mercury	Unknown
Coal workers' pneumoconiosis	Inhalation of pyrite	Several hundred thousand coal miners
Lung cancer	Inhalation of quartz	Several thousand
Respiratory problems	Exposure to particulates	Hundreds of millions
Various issues	Exposure to organics	Probably millions
Iodine deficiency disorder prevention	Exposure to iodine mobilized by coal combustion	Thousands

Figure 17 Various health impacts associated with coal burning and the number of people affected Source: Finkelman, 580

One final and very essential consideration. China contains 22% of the world’s population, but only 7% of the world’s water (Xu, G., 33) and 9% of the arable land (Liu, J., 633). In 2010, up to 17% of the water used in the country

was on account of coal. By 2020, coal is expected to demand up to 28% of China's water resources (Shifflet, 14). Compounding the problem is the fact that most of the coal is located in the northern regions of China where 50% of the population lives with only 15% of the nation's water. According to Zhang, this has created an "inverse pattern between spatial distribution of water consumption and freshwater resources" (Zhang, C., 14463). The result? Given China's "heavy reliance on coal, the energy-water nexus in China is dominated by coal-fired power generation" (14462).

1.4(b) Phase Two – the end of coal-fired growth?

Xi Jinping's declaration of a "New Normal" economy in 2014 represented a willful slowdown of the colossal economic growth of the last thirty years in the hopes of achieving a more "sustainable" growth. The hard truth on the ground was that the "New Normal" was also a palliative to address hemorrhaging social instability resulting from the PRC's environmental freefall. Gone was the breakneck 10% economic growth rate as the years 2014-2016 saw a precipitous drop in growth. In fact, the 6.7% rate achieved by the end of 2017 showed a "rebounding for the first time since entering the New Normal" (Hyun, 1). The New Normal has been chosen as the beginning of "phase two" in China's narrative of coal-fired growth as it has left one group of academics to declare it the new era of "post-coal" growth. Emerging from the London School of Economics and the Grantham Research Institute on Climate Change, this study sent a cautious note of optimism around the world. According to the authors, "a combination of

slowing GDP growth and a structural shift away from heavy industry, along with more proactive policies on air pollution and clean energy, has caused China's coal use to peak" (Qi, 1). Part of this is owing to the 8% decline in manufacturing and construction during the period of the 12th Five-Year Plan, two sectors that are responsible for 80% of coal use. The second catalyst for the supposed peak in coal use is a strengthening and enforcement of pollution and overall environmental policy. This conviction has been reflected by the PRC pledge in 2016 to build no new coal mines for three years and to shut down over 4300 pre-existing mines. Finally, China's latest five-year plan (2016-2020) requires "national upgrades of coal-fired power units to achieve ultra-low emissions and energy efficiency" (Central Committee, 86). The end result was a decrease in coal use by 2.9%, at a total of 4.12 billion tons in 2014 with another 3.6% decrease in 2015 despite maintaining robust growth in GDP. The result appears to be a partial decoupling of coal from economic growth as seen in Figure 18 where peaking coal use is clearly seen in green (solid line) despite a healthy rise in GDP seen in blue, with primary energy consumption given in red. A similar trend is also evident in Figure 19, as provided by Mathews (7) as well as in British Petroleum's 2017 Energy Outlook (36), as seen in Figure 20. This has led researchers like Mathews to suggest, "China may start to delink its electricity consumption from economic development" (2). This is the typical pattern that had already been established in the west as countries transition from a manufacturing economy to a service economy. Mathews not only attributes this to a growing

service economy and “high-value manufacturing activities”, but also “growing energy efficiency” (2).

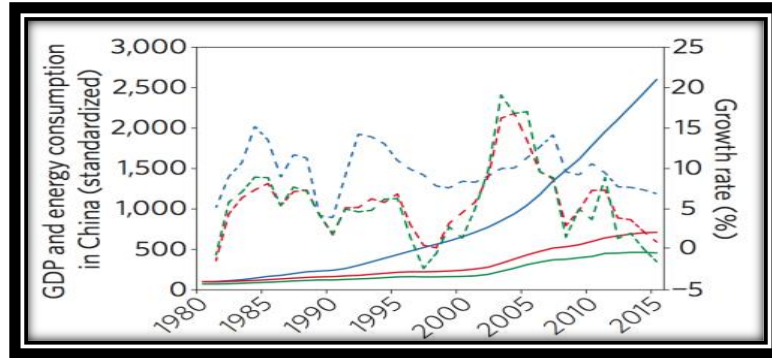


Figure 18 Comparison of energy consumption, coal growth rate, and GDP from 1980-2015 Source: Image taken from Qi, 8

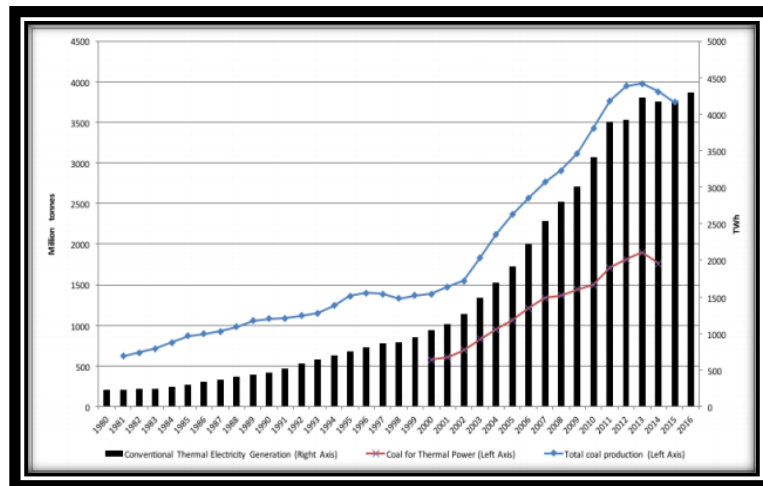


Figure 19 Coal used for thermal power (red), total coal production (blue) and conventional thermal electricity generation (black bar), in millions of tons. Source: Image taken from Mathews, 7

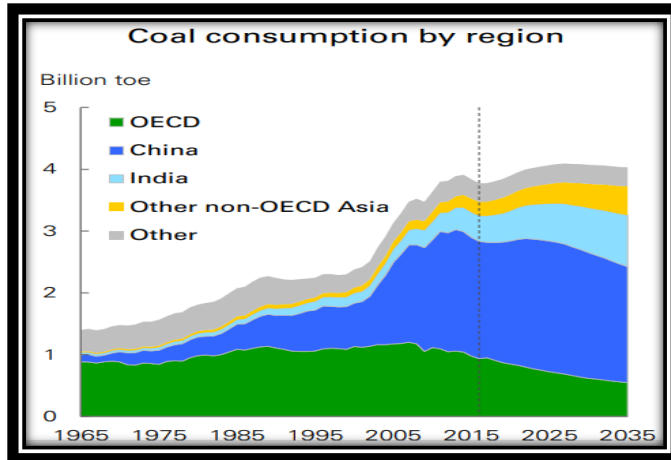


Figure 20 China's clear peak in coal use around the time of the "New Normal" declaration in 2014. Source: Image taken from BP, 36

For the reasons provided in the previous paragraph, China's coal-fired legacy has been divided into two phases. Phase one spans up to 2013, with a particular focus on the period of 2000-2013. This era of 2000-2013 is typified by double-digit GDP growth, massive investment in heavy industry like steel and cement, as well as a "high investment share of expenditure", "high profit share of income", and a "strong dependence on exports to external markets" (Green, 4-5). Phase two represents the new normal marked by a "declining share of industry in GDP" which requires a departure from exports, the aforementioned 'heavy' industry, fixed asset investment and a movement to "greater domestic consumption and tertiary production" (8). Ultimately, the best indicator to test the veracity of these trends is the share of coal in both total energy production and in electricity production. Recall the Shome statistics from 2008 that had 80% of China's electricity and around 71% of its total energy coming from coal. The 80% figure had fallen to only 64% by 2016 (Mathews, 1 (*both articles*)). These developments have led authors like Qiang Wang to declare that "China's coal

consumption has peaked, which could be a watershed moment of global response to climate change, in which China could go from being climate villain to climate leader” (701). Both Fergus Green and Nicholas Stern went so far as to predict that the implications of China’s coal peak assured a “peak in CO₂ emissions between 2020 and 2025” (Green, 19). This would be a very reassuring development in that China’s carbon dioxide emissions would peak well before the Intended Nationally Determined Contributions (INDC) pledge during the Paris conference of a peak before 2030. However, not everyone was convinced.

1.4(c) Doubts and Uncertainties Moving Forward

Many have called into question the findings of Stern, Green, and Qi. In 2018, Jiang Lin, after citing all three authors, countered their conclusions by suggesting that “preliminary data for 2017, however, shows an increase in China’s production of coal” (1) and that China’s coal use “and associated CO₂ emissions have not peaked and will continue to grow at least until 2020” (14). Lin ascribes the drop observed by Stern, Green, and Qi to a temporary decline in combustion due to a decrease in cement, steel, and thermal power production (8). Computer modeling by Lin shows a clear increase in coal demand by 2020 as seen in Figure 21. The 2017 review by British Petroleum also reveals that China will remain the world’s largest market for coal, “accounting for nearly half of global coal consumption in 2035” (BP, 37). That said, Lin’s team relies on extensive computer modeling where many such energy system models have shown a wide spread in accuracy and uncertainty. Green and Stern mention the fact that the notion of peak coal is “at odds with the vast majority of energy

systems” and that these same systems “do a poor job of predicting future emissions in the context of significant and rapid structural changes” (3). Both authors refer to a paper from Grubb that suggests that computer models are “inconsistent with the potentially transformative implications of the ‘New Normal’ policy agenda” (Grubb, S33).

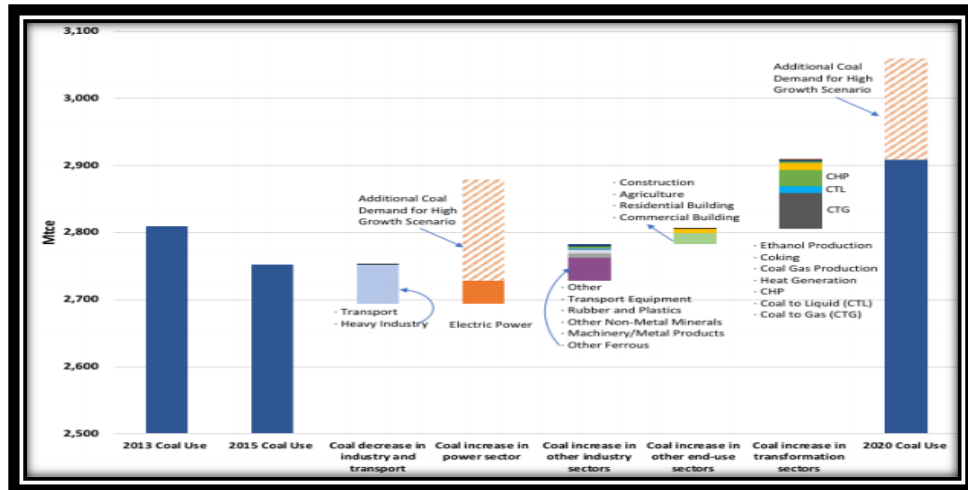


Figure 21 Coal use given in metric tons carbon equivalent. 2013 and 2015 values use actual while 2020 estimates found using the China 2050 “DREAM” model
 Source: Image taken from Lin, J., 12

While the basic tenets of chaos theory would support the statements of Green and Stern concerning energy system modeling, there is a greater uncertainty at work that transcends computer modeling that may also place their assurance of “post-coal” growth in doubt. This uncertainty is the actual amount of coal in China. This extends to current reserves, future reserves, as well as the amount produced and consumed. In China, data regarding coal reserves is notoriously spurious. In fact, much of China’s statistic reporting is described by some to be “enmeshed in a wind of falsification and embellishment” and is associated with a “universal falsification of statistics” (Hsu, 2). Coal production

and consumption data “is the least reliable and adjusted most heavily following each census” (26). Ke-xi Pan compiled a graph showing the sizeable spread in CO₂ values for China by international energy institutes owing to “increasing inconsistencies and inaccuracy of relevant basic data on coal consumptions and coal quality indicators” (1319). Korsbakken questions the aforementioned 2.9% decrease in 2014 as “inappropriate for estimating CO₂ emissions” (1) and “likely premature” due to the fact that Chinese energy statistics contain “large anomalies implying high uncertainty” (1). According to Chaopeng Hong, of China’s overall energy statistics, “coal is the dominant type of energy contributing to these uncertainties, and coal use in the industrial sector in particular is highly uncertain” (1237). Both Green and Stern have responded by stating, “There has been considerable attention paid to anomalies and revisions in China’s historic coal data”, but that the “2014 and 2015 data are likely to be relatively accurate owing to changes in calculation methods” (11). Green and Stern’s counterargument is far from compelling and seems to gloss over a cross-spectrum consensus that China’s coal estimates are not reliable. Until there is a transformative shift in more reliable estimates and energy modeling, the era of “post-coal growth” will still remain on shaky ground.

1.5 Environmental Fallout

Every nation still experiencing the growing pains of industrialization will eventually encounter an environmental tipping point. For the United States, one of these moments was on a fateful day in June of 1969 when the Cuyahoga

River caught on fire from a toxic mélange that included raw sewage, paint from a Sherwin-Williams plant, and multiple oil spills. The event happened so frequently that local news took little notice, as reflected in the Randy Newman lyrics about the Cuyahoga: “burn on, big river, burn on”. However, a sea change in the American psyche took place on that day as the environmental movement kicked into full swing; that one fire on the river became a catalyst for everything from the Clean Water Act to the formation of the Environmental Protection Agency. We have learned from our mistakes as evidenced by the fact that the Cuyahoga now hosts everything from bald eagles, otters, and herons to college rowing teams.

However, the case with China is quite different. The sheer intensity of China’s industrial growing pains has had no parallel in human history. A decades-long coal-fire growth model has not culminated in a single environmental tipping point, but several. Each was more unsettling than the next. Was it in 2007 when China surpassed the United States in total CO₂ emissions? Perhaps it was the revelation that 90% of urban groundwater and 70% of rivers are polluted or that seven of the ten most polluted cities in the world can be found in China (Li, Y., 2). Perhaps it was the fact that China was ranked 120th out of 180 countries^v in the 2018 Environmental Performance Index^{vi}, down from 109th in 2016 (Hsu, 1). Surely, the most impactful of all tipping points are the series of “airpocalypses” sustained by Beijing, which has not only earned international criticism, but also the collective rage of local citizens. Aided and abetted by the 5.5 million cars and 200 nearby coal-fired power plants, PM_{2.5} readings in Beijing reached a level that was forty times greater than the World Health Organization’s

“safe” level in January of 2013 (Figure 22). Beijing managed to hit 993 on the Air Quality Index, an unfathomably high value (for reference, New York City scored a 19 on the same day). This incident brought “tremendous attentions from both domestic and abroad” (Huang, K., 7520). In full damage control mode, PRC leadership pledged a “war on pollution” in 2014. Acknowledging that coal is considered “the number one source of air pollution” (Zhang, D., 5326), the PRC committed to building no new coal mines for three years in 2016 and promised to shut down 4300 pre-existing mines. The question, however, is whether this is too little too late. Ironically, it was on the first day of the Paris conference, November 30th, 2015, that the AQI in Beijing again reached record-breaking values with a 608, twenty-four times the “safe” level as defined by the WHO.



Figure 22 Photo taken by Feng Li of the rooftop of the Forbidden City in Beijing, January 16, 2013, for a January 30, 2013 article in The Atlantic entitled “China’s Toxic Sky”.
Source: <https://www.theatlantic.com/photo/2013/01/chinas-toxic-sky/100449/#img01>

The sobering air pollution statistics cited in section 1.4(a) would alone justify the choice of the word “fallout” for the title of this section. However, to paraphrase a lyric from Curtis Mayfield, this is “just the surface of a dark, deep well”. Over 190 million people become sick and 60,000 people lose their lives “from diseases caused by water pollution every year in China” (Wang, Q., 358 & Miao, X., 473) as around 1700 “outbreaks of water pollution incidents” (473) occur annually. As mentioned in section 1.3(a), since 1995 to 2016, there has been around 11,000 “water quality-related emergencies” (Han, D., 1222).

Equally troubling to the issue of water quality is that of quantity. As of 2017, Jinxia Wang reported that the annual gap between water demand and supply has reached 53.6 billion cubic meters (10). According to the Ministry of Water Resources in 2012, agriculture is responsible for around 65% of the total water withdrawals in China (Doczi, 11). Considering that half of China’s cultivated land is irrigated (compared with the 21% average for the whole globe), mounting agricultural difficulties continue to exacerbate issues of water scarcity. Much of China’s irrigated land has been deeply impacted by a “falling groundwater table and land degradation” as well as rising water demand, pollution, and climate change (Huang, J., 122).

Economic development has also laid siege to China’s coastal areas as well, particularly after the 1978 economic reforms (He, 8). Nian-Zhi Jiao has pointed out that “our artificial shoreline accounts for up to 80% of the natural shoreline” as the economic benefits of a 5 trillion yuan (\$802.6 billion dollars) maritime economy has resulted in marine and coastal ecosystems facing serious

challenges “due to the high intensity of human activity and climate change” (119). There is no greater bellwether of this looming threat than the finding that 73% of mangroves have been lost in China from the 1950s to 2002 (Hughes, 262). All of this is particularly tragic when considering the fact that all of China’s superlative ecosystem diversity is now ‘talking to history’. Every ecosystem contained in our global ecosystem classification system can be found in China, yet “45% of the ecosystem areas in China are at high or medium ecological risk” (Bai, Y., 349). Of the 640 total endangered species, 156 endangered species “listed in the Convention on International Trade in Endangered Species” are in China while 15-20% of China’s higher plant species (4000-5000 species) are “threatened by extinction” (349).

The anthropogenic war waged on China’s environment has, as its staging ground, a country that has been visited by natural disasters and disturbances for time immemorial. When considering both these manmade and natural stressors working in concert, one loses the ability to be surprised anymore by many of the outrageous statistics bandied around in both academic studies and the media. Yi-Ming Wei mentions an old saying in China that says that “famine happens every three years, epidemic happens every six years, and natural hazard happens every twelve years” (644). The risk of these so-called ‘natural hazards’ has been described as “not only very high, but also widespread” (Jia, H., 2031). Historically, drought was the most significant disaster in northern China and flooding was the most significant disaster in southern China (Du, X., 396). By the government’s own admission, “more than 70 percent of Chinese cities and more

than 50 percent of the Chinese population are located in areas vulnerable to serious earthquakes, or meteorological, geological or marine disasters” (CCCP, 2012, Ch.1). In 2015, China had the highest numbers of disasters among all the countries in the world at 36 (Renwick, 27), leaving many scholars to label the country “one of the most vulnerable countries in the world to disasters” (Du, X., 388).

1.6 The Stakes and Responsibilities of the World Community

One of the many things unearthed during the 2016 U.S. election were the long memories of the working class, of which the author of this paper is a product. It seemed that there was a substantial amount of vitriol that blue-collar voters reserved for establishment Democrats who, for the last forty years, have been turning their back on them in order to serve management and Wall Street. Though rarely discussed in establishment media circles, a large portion of this vitriol was a reaction to the Wal-Mart economy ushered in during the rampant corporatism of the Clinton years. Two international trade policies created during this era have dealt crippling blows to working communities that persist to this day. The first was the North American Free Trade Agreement (NAFTA). The second was Bill Clinton’s efforts to achieve trade normalization with China by including the PRC into the World Trade Organization (WTO) at the start of the millennium. This had two effects both at home and abroad. In the United States, this “China Shock” has “led to an employment reduction of 2.4 million workers” (Autor, 29). For China, securing an unfettered position as an exporter of cheap,

low-value goods has resulted in a *massive* uptick in carbon emissions, which has led to a train of devastating environmental and social consequences. As seen in Figure 8, this uptick *precisely* corresponded with China’s inclusion into the WTO. This relationship has been acknowledged in several policy papers read by the author detailing China’s timeline of carbon emissions. In fact, many authors such as Yuli Shan (1) go so far as to divide the eras of China’ carbon emissions into the “pre-WTO” (1980–2002) and WTO-era (2002 – present).

China became a full member of the World Trade Organization by December 11, 2001. Within four years in 2005, a study by Carnegie Mellon^{vii} revealed that roughly one-third of China’s carbon emissions were attributed to the export of consumer items for the west (Guan, D., 4). Unsurprisingly, the U.S. is responsible for the lion’s share of these export-oriented emissions as seen in Figure 23.

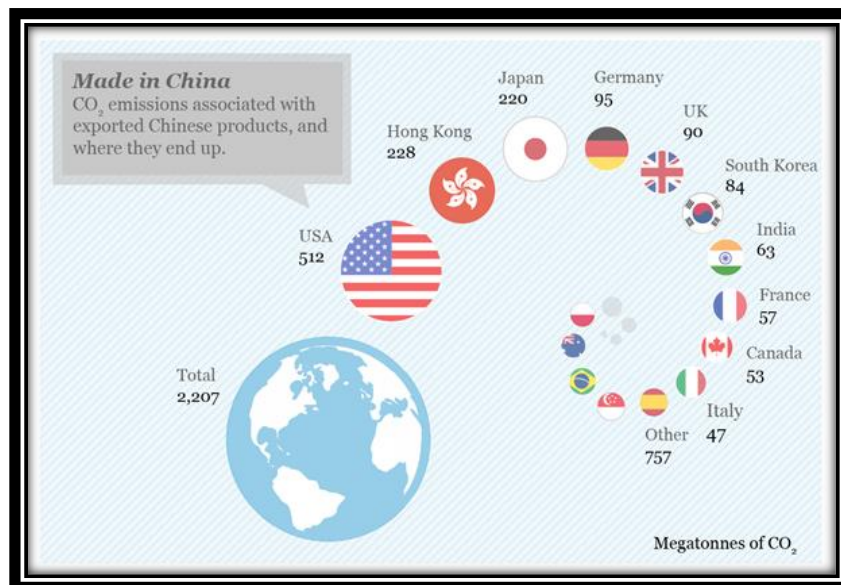


Figure 23 Portion of export-associated carbon dioxide emissions by country, given in megatons. Source: Image created by the EORA Global Multi-Region Input-Output Database VII.

The implications of this are crystal clear. The west bears significant culpability here and must make heroic efforts to help address China's environmental challenges. Part of this culpability lies with the authorship of historical precedent. According to the Center for Global Development, developed nations are responsible for 79% of carbon emissions from the period of 1850 to 2011^{viii}. Now we have shifted this burden on the developing world. As acknowledged in the IPCC's (Intergovernmental Panel on Climate Change) Fifth Assessment Report (AR5), "CO₂ emissions from fossil fuel combustion in middle income countries is released in the production of goods and services exported, notably from upper middle income countries to high income countries" (Edenhofer, 46). The other side of our culpability lies squarely in the western economic models that have been driving world markets for the past four decades. The 'Chicago School' brand of neo-liberal economic policies has dominated the Washington Consensus since the 1970s. These policies have helped to formulate a globalization agenda among developed countries that is partly responsible for China's current environmental state. Consumers in the west have enjoyed the free-flow of cheap goods and have been politely indifferent about the social and environmental consequences in China. Developed nations at the United Nations climate change conferences have been both castigatory and paternalistic towards developing nations like China. However, Annie Leonard's "Story of Stuff" reveals how developed nations "externalize the cost" by simply off-shoring the materials extraction, manufacturing, and ultimate disposal of consumer products. The idea of the environmental 'Kuznets' curve, namely that a bell-shaped curve

exists with developed nations somehow achieving a declining trend in environmental degradation, is completely undermined by knowledge of 21st century economics. We have outsourced our carbon emissions to China, plain and simple, and therefore must bear responsibility. While an argument can be made regarding China's responsibility to install the proper controls to protect their own people, one must consider the sudden and intense nature of China's so-called 'economic miracle' and the ill-equipped systems suddenly tasked to deal with it. Aided and abetted by western globalization and inclusion into the World Trade Organization, this miracle required a rapid restructuring of what Hsu and Shi has characterized as an "information poor" environment (40). Channeling Dutch sociologist Arthur Mol, Hsu and Shi describe a system in China riddled with "inconsistencies in available monitoring systems and technical capacity; political factors that limit information flows and processes; and institutional and organizational constraints that hamper information collection, processing, and dissemination" (40).

How the story of China's environmental challenges play out in the coming decades will send ripples effects that will be roundly felt throughout the world. The writing has been on the wall for a number of years as studies have already revealed how China is directly impacting the environment here in the United States. This has included everything from the alteration of our weather patterns (Wang, Y., 6894) to China's own brand of outsourcing by way of ozone concentrations on the west coast (Verstraeten, 1). As early as 2004, images from NASA satellites have revealed how China's pollution has, in NASA's words,

“slipped over the coast like water over a dam” as plumes of pollution move across Korea and Japan like some kind of science-fiction monster, on its way across the ocean towards the United States (Figure 24).

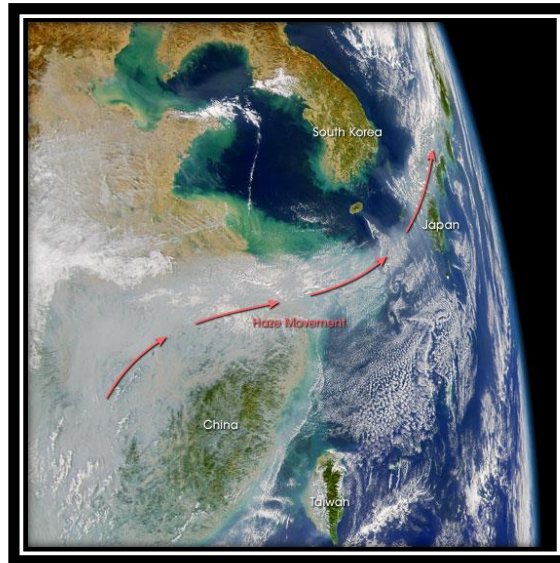


Figure 24 Image taken on October 2004 from the Sea-Viewing Wide Field-of-View Sensor
Source: <https://earthobservatory.nasa.gov/images/4950>

The author believes that this issue has achieved the level of existential threat that is reserved for water scarcity, peak oil, and climate change not only by the synergy it shares with these threats, but by its ability to impact the world community. In 2010, Chinese officials in Beijing bristled at the words of former director of the International Energy Agency, Nobuo Tanaka, when he stated that *the world would not reach essential climate targets by 2050 unless China's CO₂ emissions peaked by 2020*. What is known for sure is that 83% of fossil fuel used associated with CO₂ emissions comes from coal. Much more needs to happen with China's coal consumption than the recent 'peak' hailed by Fergus Green and Nicholas Stern which has been seen by some as a temporary anomaly. As the

Intergovernmental Panel on Climate Change stated in 2014, “in the last decade, the main contributors to emission growth were a growing energy demand and an increase of the share of coal in the global fuel mix” (IPCC, 20). China is currently responsible for 30% of global CO₂ emissions (Shan, Y., 2), emitting more than the United States and the European Union combined. China also consumes the most energy in the world, at 22.9% of the world total, surpassing the United States in 2009 as the biggest energy consumer. By 2030, this is projected to increase to 26.3% (Wolde-Rufael, 1336).

Solving this problem effectively will require the ability to address issues that cross many sectors of Chinese society from the economy, to effective governance, to even social and cultural trends. The author remains intrepid in the face of this “wicked problem” and seeks to propose reasonable policy solutions for this Capstone Project.

II. Literature Review

2.1 Economic Considerations

2.1(a) General Trends

American economist Walt Rostow and French contemporary Jean Fourastié are typically credited with the foundation of modernization theory during the 1950s. Fourastié and Rostow’s demarcation of a three-sector economy as represented by a nation’s movement through the phases of extraction to manufacturing and then to services may sound obvious to 21st century ears. It is an easy exercise in hindsight to see how all nations move from

agrarian societies to industrialized ones, and, as manufacturing shifts across national borders, to service economies (currently 80% of the U.S. economy). However, when Rostow's *The Stages of Economic Growth* was released in 1959, the concept was rather novel as the U.S. still boasted a robust manufacturing sector. Fourastié defined extraction, manufacturing, and services as primary, secondary, and tertiary economies respectively as early as 1951 (251). Technical progress is a major driver to promote movement from a primary economy to a secondary economy (also given by Roman numeral "I" and "II" in some publications), a fact readily acknowledged by Fourastié (221). For the west, neo-liberal economic policy has allowed for the movement from secondary to tertiary economies (given by "II" and "III" respectively). It should be noted that the three-sector economy consisting of primary, secondary, and tertiary sectors was proposed as early as 1939 by New Zealand economist Allan Fisher. Fisher boils down the primary sector as simply "farmers and the like" with the secondary sector consisting of "manufacturers and artisans" (24). Considering the growth of China's middle class coupled with a conscious reining in of economic growth away from feverish manufacturing and exportation, we should expect an ineluctable movement towards a stage III tertiary economy much like the west. Ke Li and Boqiang Lin have tracked this movement from 1997 to 2010, verifying this trend. The shrinking of the primary economy (I) along with gradual expansions of the secondary (II) and tertiary economies (III) can be seen in Figure 25.

Inputs structural, the level and growth rate of productivity.					
Index	Year	Labor force/employment			
		All	I	II	III
Structural (%)	1997	100	51.935	22.356	25.709
	2003	100	48.980	21.622	29.399
	2010	100	36.673	28.735	34.591
The level of productivity	1997	1.241	0.416	2.490	1.823
	2003	1.992	0.511	4.366	2.713
	2010	3.514	0.804	6.122	4.221
The growth rate of productivity (%)	1997	7.866	2.924	11.534	5.437
	2003	8.197	4.736	5.005	4.792
	2010	7.817	5.588	6.249	5.436
	Mean	8.333	5.081	7.599	6.616

Figure 25 Changing primary, secondary, and tertiary economies (I, II, and III) for China during the period of 1997 – 2010 Source: Li, K., 496)

Rostow’s chronicling of these stages is a bit more convoluted by comparison and involves five steps. According to Rostow, traditional societies (4) eventually experience a “take-off” (7) which then allow them to reach technological maturity (8) and finally mass consumption (11) as seen in Figure 26. China now sits squarely in phase 4, the “drive to technological maturity”, typified by a diverse and growing economy as well as a continually improving standard of living. The U.S. and many of its western counterparts sit at the final stage earmarked by rampant consumerism.

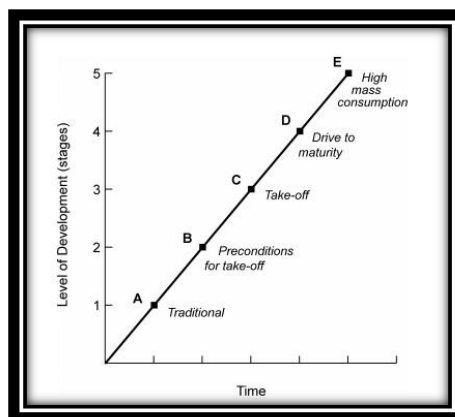


Figure 26 Walt Rostow’s five basic stages of economic growth, Source: Geyer, R., 6

Between the three economists, Fisher remained circumspect when it came to the merits of transitioning into a service economy. He cautioned against notions that “justify faith in any such pre-established harmony” (38). However, both Fourastié *and* Rostow regarded the movement to a service economy as a net-positive for all strata of society and a hallmark of any civilized nation. *Fourastié* spoke of a guaranteed ‘quality of life’ that awaits all citizenry in a service economy in his 1949 book *The Great Hope of the Twentieth Century*. Many academics have applied *Fourastié* and Rostow’s economic template to China. The implication is that, despite an intensely protracted and environmentally catastrophic period in the manufacturing sector, China will seamlessly transition into a service economy and a new, green future. However, there is no guarantee that this will be true. Rostow based his model on developed western countries without legacies of colonialism or non-capitalistic economies. Described by author David Milne as “America’s Rasputin”, Rostow was a fervent pro-west hawk whose economic model is undermined by a highly biased worldview. The mantra of free enterprise was Rostow’s solution for developing nations like China. However, as stated earlier in this Capstone, China’s path is truly unique and has had no parallel in human history. Why should that path follow the smooth linearity of Rostow’s model? Why would China necessarily follow Rostow’s economic transitions, which have been described by Geof Rayner and Tim Lang as a “modernization story with a specifically (and post-European colonial) American twist” (Evans, R., 173). Despite the repeated applications of western economic models to China, it would be a fool’s errand to

adopt a “wait-and-see” approach and assume that an eventual service economy equates to environmental deliverance.

2.1(b) The “New Normal” Economy and the Accuracy of the Environmental Kuznets Curve

In 2014, President Xi Jinping announced China’s “New Normal” phase of growth, marked by a willful reigning in of economic growth and greater regulation of the business sector. Despite the official rhetoric explaining this dramatic shift, there is no denying that one major catalyst was the 180,000 annual protests against the pollution from an out-of-control coal-fired economy (Tracy, 63). Quoted in Xinhua News Agency, Jinping stated, “We must boost our confidence, adapt to the new normal condition based on the characteristics of China’s economic growth in the current phase and stay cool-minded”. As discussed in section 1.4(b) of the *Introduction*, this has not only helped to fuel the claims from authors like Stern, Green, and Qi of an era of “post-coal” growth, but was seen by many in this camp as a confirmation of the 50s-era models of Rostow and Fourastié. Adherents to this school of thought see China smoothly shifting into a services economy and, by default, into the daybreak of environmental meliorism. This even compelled authors Fergus Green and Nicholas Stern to divide 21st century China into two phases. The first is the “heavy industry growth” period (2000-2013) characterized by double-digit GDP yearly growth and a “high profit share of income” (4-5) and the second is the “early phase of China’s new normal” (2014-present) (8).

China's environment is a highly complex system, which, by all definitions, qualifies as a wicked problem. Many academics as well as the author of this paper do not share in the confidence that Stern, Green, and Qi seem to have in some of the overly simplified and monolithic economic growth models cited in section 1a. A very popular environmental theory called the EKC, or environmental Kuznets curve, was a modification of the original curve proposed by Simon Kuznets in the 1950s, which compared economic growth and income equality. The environmental Kuznets curve has deep roots in these same 1950s-era economic theories and in many ways supports the conclusions of authors like Stern, Green, and Qi. Like the conclusions of the aforementioned authors, the EKC curve is over-simplified and does not tell the whole story.

The EKC is essentially a bell-shaped curve that plots environmental degradation versus per capita income. The idea is simple, as seen in the "EKC3" diagram in Figure 27. Environmental degradation is an unavoidable consequence as a country begins to grow in income. However, all countries theoretically reach a 'turning point' (seen at the top of the inverse-U curve in Figure 27) where, as income continues to grow, environmental degradation eventually decreases. According to Arthur Mol, this is consistent with the theory of ecological modernization, which assumes a "growing compatibility of environmental protection and economic growth" (3). This theory refers to a "restructuring of modern institutions following environmental interests, perspectives, and rationalities" (1). The notion of the environmental Kuznets curve was bandied about in the literature as early as 1991 when Gene Grossman and Alan Krueger

examined the environmental impacts of NAFTA. Both authors identified “an inverted-U shaped relationship between pollution and national income” (Grossman, G., 19).

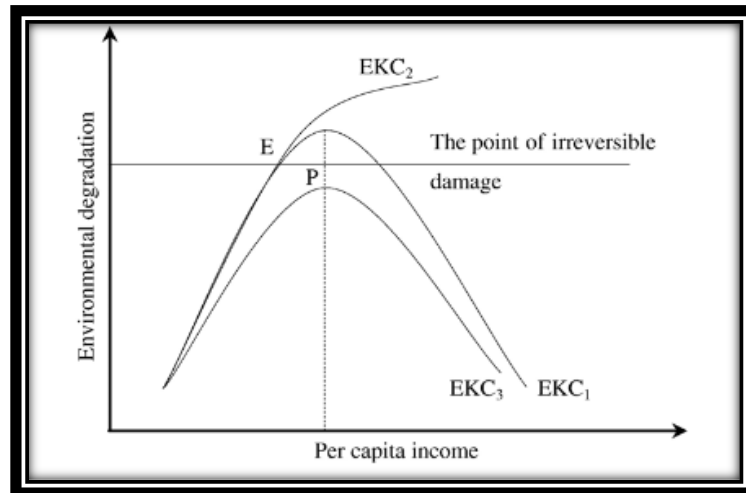


Figure 27: The Environmental Kuznets Curve. Developed nations have followed the “EKC₃” pathway of decreasing environmental degradation with increasing per capita income. *Source: Song, 382*

The environmental Kuznets curve should invite skepticism, particularly for those with just a cursory understanding of globalization and externalized costs. Have western developed countries *really* moved to the right side of the curve marked by decreasing environmental degradation? This would imply that countries like the U.S. have undergone a remarkable shift to sustainable production. This is simply not the case. Countries that move to the right of the graph have simply offshored dirty production to countries that are on the left of the graph. It is certainly true that a contributing factor to the rightward trajectory of a developed country is due to “more specialized and developed institutions that work with enforcement of environmental laws” (Nihlwing, 10). However, a significant cause of this rightward shift is due to “changes in trade patterns” (5), with many authors suggesting that the entire “EKC type relationship” is “partly or

largely a result of the effects of trade on the distribution of polluting industries” (Stern, 1426)^{ix}. Much like the idea of tax havens, the ‘pollution havens’ of the developing world are attractive due to “weak environmental regulations” allowing investors to “relocate their dirty goods production away from high income countries to developing countries” (Wolde-Rufael, W., 1338). Yemane Wolde-Rufael compares this to the more localized phenomenon of wealthy companies locating toxic facilities into poor neighborhoods (1338). One example that comes to mind is downtown Chester, Pennsylvania receiving trash from five states as well as 90% of Delaware County’s wastewater.

Even if one accepts the efficacy of the environmental Kuznets curve, there is no guarantee that China would follow this curve absolutely. In a paper assessing the role of economic policy on many of the future projections of China’s carbon emissions, Michael Grubb points out that China’s economic structure is “radically different” from OECD countries (S25). China’s economic structure, with its heavy reliance on industry and investment, has maintained an “exceptionality” compared to other countries. To dramatize this point, Grubb plots China’s gross capital formation as a share of GDP versus GDP per capita and compares to other nations as seen in Figure 28.

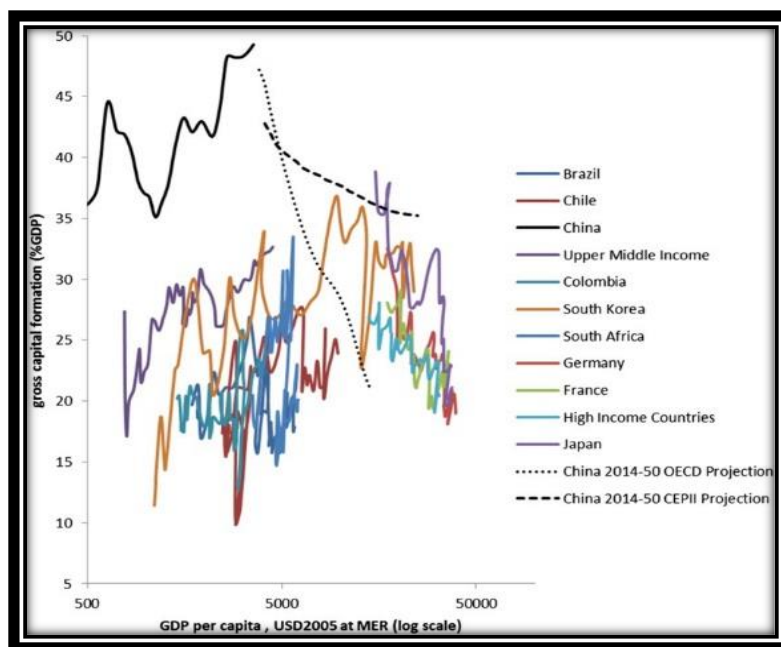


Figure 28 Real and projected calculations of gross capital formation as a share of GDP vs. GDP per capita for China compared to other nations.
 Source: Grubb, M., S27

Xiamen University's Tao Song found that in China, waste gas, waste water, and solid waste do, in fact, follow the 'inverse-U' shape suggested by the EKC hypothesis (391). However, early in the paper, Song recognizes that there is a "strong relationship between trade and environmental quality (383). Yuan Wang and Chen Zhang have criticized the Kuznets Model for suggesting that the bell-like distribution is the same across all industrial sectors^x. After extensive analysis, the authors have found "strong support for heterogeneity in the relationship between socioeconomic development and carbon emissions" (Wang, Y., 176). Such findings undermine the EKC assumption of conformism across all sectors of Chinese society. The authors plotted the natural log of CO₂ emissions (ln CE) versus the natural log of GDP per capita, measured in 1000 RMB (ln A) as seen in figure 29. With the exception of the electricity sector (rightmost graph),

neither the manufacturing or mining sector conforms to the inverted-U shaped of the Kuznets curve.

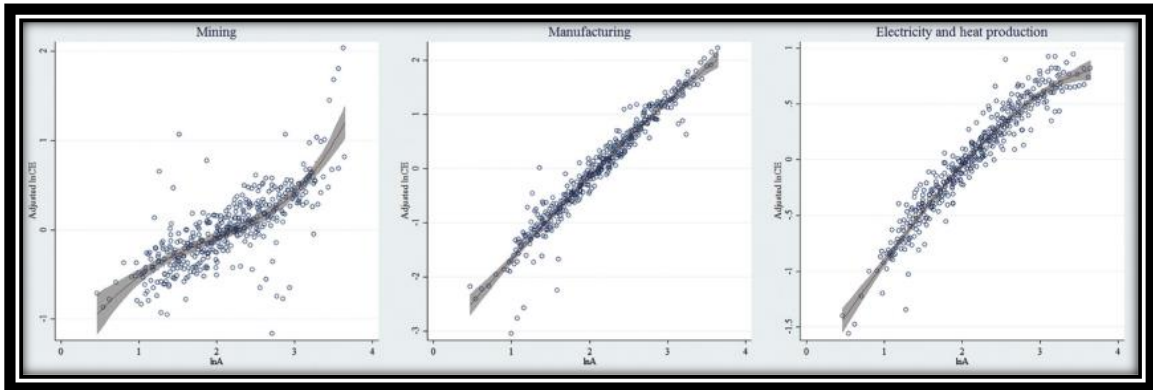


Figure 29 Natural log of carbon emissions versus GDP per capita for the mining, manufacturing, and electricity and heat production sectors *Source: Wang, Y., 177*

We have demonstrated that the environmental Kuznets curve, the “greening” transition into a service economy, and the assurance of Mol’s ecological modernization may not apply easily to China for a multitude of reasons. One final reason to consider is China’s overriding economic policies. Academics who remain assured about China’s environmental turnaround are usually invested in the tropes provided by simple economic models such as those mentioned at the beginning of this paragraph. For many of them, the triumph of these models justifies a business-as-usual approach instead of the need for transformative policy changes. This is similar to the equally unnuanced mantra of “letting the market decide”. However, this assumes that China’s economic policies will fall in line with what has been referred to as the “Washington Consensus”. This is not necessarily the case. According to Scott Kennedy, the economic modes of the Washington Consensus include trade liberalization, austerity measures, deregulation, and privatization (463). Joshua

Cooper Ramo introduced the idea of the “Beijing Consensus” in 2004 to demonstrate that China’s economic policies stand in stark contrast to the west and to western economic models. Ramo cautions that “to measure Chinese power based on the tired rules of how many aircraft carriers she has or on per-capita GDP leads to devastating mismeasurement” (2). According to Kennedy, this Beijing Consensus is typified by “opposition to the Washington Consensus”, “Chinese influence by example, not weaponry”, and “globalization on their own terms” (468). Kennedy disagrees with the notion of “Beijing Consensus” or the related “China Model”, and finds many points of intersection between eastern and western economic policies. Kennedy sees China as a unique “tinkerer advocating limited reform” then an outright opponent to western economic models (477). This idea of China as tinkerer channels Deng Xiaoping’s statement of “crossing the river by feeling the stones”. However, while similarities exist, there does seem to be a consensus that China’s singular brand of authoritarian capitalism has significant differences from the neo-liberalism of the west. In many ways, China’s high-growth economy looks a lot like post-World War II era United States, a period marked by a thriving middle class economy. However, China’s commitment to investing in infrastructure and social welfare programs suggests an unwillingness to follow the United States’ wrong turn in 1980 of transferring income gains to the top, dissolving the social contract between workers and management. The prevailing economic model that finally emerges from China may have more differences to the Washington Consensus than similarities. Whatever the case for China’s economy, as Goldman Sachs observes, the “long-

term implication for the global economy are profound”. What remains to be seen is how well our Cold War-era economic models will be able to predict those implications.

2.1(c) One Belt One Road Initiative

Just as the original Silk Road promoted trade through Europe, Africa, and Asia over 2100 years ago, the 21st century OBOR (One Belt One Road Initiative) plans to reconnect the same three continents with an ocean-based “Maritime Silk Road” and land-based “Silk Road Economic Belt” (Zhang, N., 357) as seen in Figure 30. President Xi Jinping introduced the OBOR initiative at Nazarbayev University in Kazakhstan on September 7, 2013. Sixty-six countries will be a part of the OBOR, accounting for 60% of the world’s population and 30% of the global economy as the projected cost of infrastructure will be in excess of five trillion dollars (Mathews, J., 4).

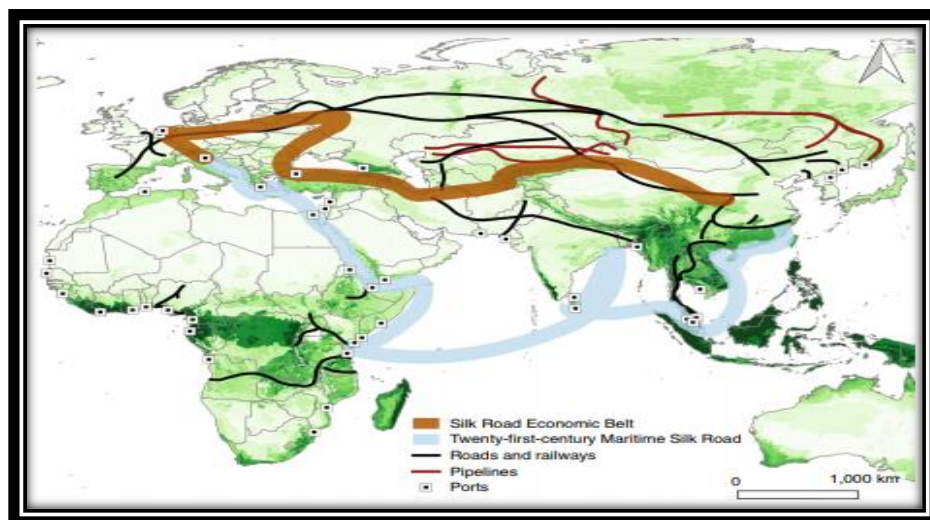


Figure 30 The two main trade corridors of the OBOR including roads, railways, and ports.
Source: Ascensão, F., 207

Some have referred to the OBOR as “Globalization 2.0” or the new Marshall Plan. Many academic authors as well as the author of this paper remain skeptical. The West has shown that globalization schemes seem to be a way of dealing with capitalist surpluses; the OBOR conveniently emerges during China’s habitual problems with overcapacity. When it comes to globalization, western countries talk about their environmental success stories, but it seems that we are just externalizing the cost of unsavory production to poorer countries with less environmental and labor protections. Will China’s “globalization 2.0” via the OBOR be much different? What will stop central Asia from being a dumping ground for some of China’s most carbon heavy processes? The fact that China’s coal use supposedly peaked a few years ago left many people feeling cautiously optimistic. However, the concern is that OBOR construction demands through carbon-heavy cement and steel production as well as an easier pathway for China to export its production through this initiative will seriously undermine some of the recent strides being made with China’s environment. It doesn’t help that at least half of the countries associated with OBOR have issues in terms of corruption indices and credit ratings (particularly in central Asian countries). Despite the serious concerns expressed by many authors, however, others retain a degree of optimism, believing that the OBOR could actually be a green opportunity for China.

(i) *Pessimistic*

Fernando Ascensão expresses concern for the OBOR’s capacity to promote “permanent environmental degradation” as the rapid expansion of

transportation networks of this magnitude could very well push ecosystems “beyond tipping points” (206). Ascensão cites a study by the World Wildlife Fund showing that the OBOR will present serious impacts to 39 critically endangered species, 81 endangered species, and 265 threatened species (206). University of Nottingham’s Alex Lechner sees the OBOR as a project that could have “disastrous consequences for biodiversity” (1). Lechner superimposed the OBOR trade routes over biodiversity hotspots as established by Conservation International in 2004 as well as the Southeast Asia’s “coral triangle”. The results can be seen in figure 31.

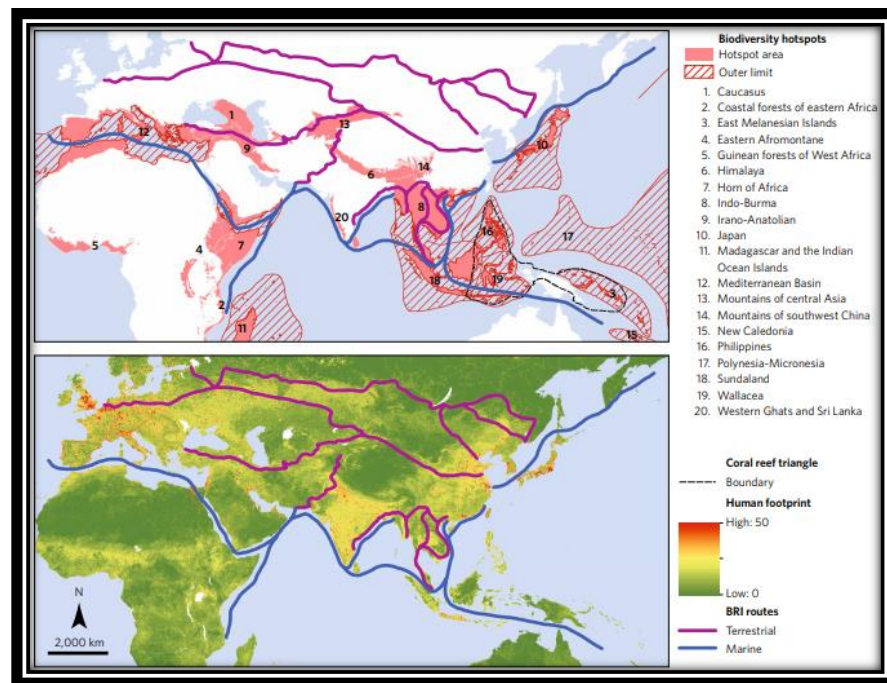


Figure 31 Plot of the land and sea OBOR trade routes with respect to key conservation areas Source: Lechner, 1

Ascensão also brings up a concern raised by many other academics that the cement production required for this undertaking is already a major contributor

to China's one-third share of the world's greenhouse emissions (206). One of these other academics includes Ning Zhang from the College of Economics at Jinan University. Many of the countries in the OBOR, particularly in central Asia, are far from developing a renewable energy mix and will need to rely exclusively on fossil fuels to meet all of the proposed construction needs. Zhang also points out that the continued operation and maintenance of this infrastructure will "continue to release considerable carbon emissions for decades" (1107). Just when China appeared to achieve a peak in coal use, Zhang discusses how the streamlining of exports through the OBOR will promote the growth of some of China's most "energy intensive industries (such as mining, iron, and steel)" (1107).

Elena Tracy raises similar concerns, roundly criticizing the OBOR's potential to cause "fragmentation, oil spills, pollution, proliferation of dust and salt, and other impacts" by building railroads, highways, power lines, and pipelines over environmentally sensitive zones (76). Tracy also expresses concern over the lack of tangible environmental considerations in much of the OBOR rhetoric. For starters, unlike the International Monetary Fund, Chinese investment and loans historically suffer from what Tracy refers to as a "no-strings attached" policy, translating into minimal environmental and social considerations (71). The 2015 policy document *Vision and Actions on Jointly Building the Silk Road Economic Belt and 21st-Century Maritime Silk Road* from the Chinese Ministry of Foreign Affairs only makes a vague reference to environmental protection in a section called "unimpeded trade" (74). A similar trilateral policy

document between China, Russia, and Mongolia regarding a proposed railway project also makes only brief mention of environmental protection (75).

Additionally, Tracy states that none of the policy documents associated with the OBOR include any EIAs (environmental impact assessments) (76).

Finally, in yet another indictment of China's fragmented bureaucracy, Jie Chen censured the "fragmented management framework" for the already poor state of groundwater near the Yinchuan Plain region of the OBOR in northwestern China (362). Chen urged for improved groundwater management as the OBOR will only further increase "industrial and agricultural activities which will put even more pressure on groundwater supplies" (356).

(ii) Optimistic

Based on the concerns raised in the previous section as well as China's overall lack of transparency, habitual environmental law breaking, and "very limited oversight by civil society" (Tracy, 79), it would be easy to dismiss supporters of the OBOR. However, once seen in the context of virtual water, Yu Zhang's support of OBOR is undeniably compelling. Zhang analyzed the trading of agricultural products between China and many of the 66 OBOR countries from the period of 2001 to 2015. It was determined that the OBOR trading scheme actually exports virtual water to water scarce countries by drawing on the water resources of countries with more robust water resources. The latter countries, in turn, have their comparatively weaker economics strengthened, resulting in the "win-win" talking point by OBOR proponents in the media. According to Zhang's findings, China exported 150.1 billion cubic meters of virtual water during the

period of 2001-2015 but gained 775.4 billion cubic meters. The virtual water trade for China during this period can be seen in Figure 32. Other countries facing water scarcity including Russia, Egypt, and Mongolia were in virtual water surplus as well. This “alleviates water shortages and benefits the economic development of each spanning country as well” (991). Meanwhile, the author also found that China exported a significant amount of its grey water footprint, while importing a lot less.

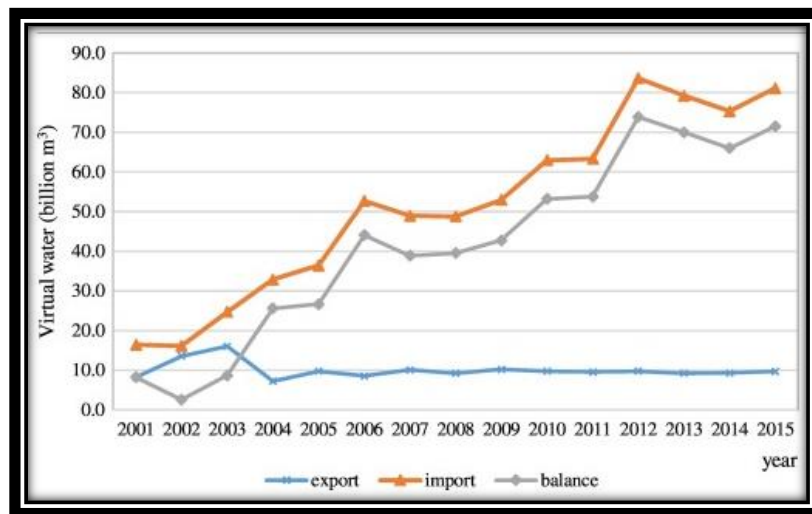


Figure 32 Results showing exported and imported virtual water for Chinese agricultural products from 2001 to 2015 *Source: Zhang, Y., 992*

The Beijing Institute of Technology’s Lei Han also portrayed the OBOR through a positive lens. While Zhang honed in on the gains in terms of virtual water and loss of grey water, Han saw the OBOR as a vehicle to promote “EE” convergence. “EE” convergence refers to energy efficiency convergence, which could serve as the necessary catalyst to decouple energy demand and economic growth. Through Han’s analysis of energy convergence among 89 countries from the period of 2000-2014, he concluded that energy convergence among low

efficiency “lagging countries” still in the process of playing catch up improved through shared energy integration with “high efficiency” countries (112-3). Han acknowledges the concerns raised by many that the OBOR could allow China to relocate energy-intensive industries to other countries. However, he suggests that this phenomenon would be offset by the EE convergence that trading would promote among less developed countries (118-9). He cautions that for this to work, it is essential that “environmental impact and performance in recipient countries needs to be managed properly” (120).

(iii) Neutral

Among the authors that appear to break even when discussing the OBOR, John Mathews and Hao Tan’s two articles in the Asia-Pacific Journal last year are standouts. At the end of the article chronicling China’s purported “green shift” in its power sector, both authors readily acknowledge that “infrastructure connectivity projects” such as the OBOR will almost certainly expand fossil fuel use (what the authors refer to as “black investments”). However, both Mathews and Tan are hopeful that the Chinese banks funding OBOR such as the Asian Infrastructure Investment Bank (AIIB) will proceed in a sustainable way, having already set a “green” precedent with projects in Pakistan. India is also mentioned as setting a tenor for “greening” its own electric grid and strongly moving towards renewables, a move that the authors believe is a willful emulation of China’s shift over the last decade. In lieu of this shift, the fact that China has identified India as the site for the “next coal boom” has left Mathews and Tan confident that green investment will begin to supersede black investments (9).

The article entitled China's New Silk Road has Tan and Mathews joining Lei Han in their recognition of the concerns of many critics that the OBOR is "really a case of China outsourcing its pollution or cutting pollution at home, while growing coal abroad" (1). They also recognize how colossal and transformative the OBOR project is and have even gone as far as to place the OBOR among the four "major steps" to Chinese development! The other three steps include Deng Xiaoping's reforms in 1978, entry into the World Trade Organization in 2001, and China's unflappability during the 2008 market crash. The authors again mention the "green" pledges of the Chinese banks backing the OBOR, specifically the New Development Bank's (NDB) "Environmental and Social Framework" which includes the "promotion of climate change mitigation and adaptation measures, and conservation of natural resources including energy" (8). The authors also brings up India's growing momentum in renewable energy growth and the "greening of India's electric power sector" as a positive development considering China's intentions to export to India a bevy of coal-fired power plants (9).

Peiyue Li from Chang'an University pulls no punches for the reader when detailing the high environmental stakes should the OBOR proceed recklessly and unsustainably. Li mentions how the route is across regions "where the natural environment is highly vulnerable and water resources are already under stress" (7268). The authors even acknowledge a fact rarely discussed by government officials in Beijing as well as establishment-friendly academics: the very real prospect of "peak coal" and the forecasts by some that China coal reserves could

be exhausted in 19 years! (7269). If this were to materialize, it would send China's economy and entire society to a grinding halt. However, Li remains hopeful and believes that the OBOR, if crafted correctly, "can be built beneficially and sustainably" (7268). Li highlights public education and scientific collaboration as essential for the OBOR to become environmentally acceptable. The authors end on a hopeful but cautious note stating that "with careful planning, sound research, good data, and the support of governments and the people at large, the New Silk Road can be developed in an environmentally sustainable manner that is a credit to all involved" (7270).

2.2 Governmental Considerations

2.2(a) General Description

Yanwei Li has classified environmental conflicts as a governance issue in China. The PRC's unique blend of concession and repression is ill-equipped to deal with mass protests over continued environmental degradation (2). The government must not only deal with case-specific protests from rural workers, but also the broader 'master frame' protests from upwardly mobile urban citizenry (2). According to Benford, a 'master frame' is a collective action frame with a broader and more generic scope than protests over specific environmental events. This form of collective action has the ability to open the door for many other, related social movements (1). Li establishes three major knowledge gaps in handling environmental conflicts that underscores the need to include governance when addressing China's environmental challenges. The first gap involves the understanding of environmental conflicts as a 'wicked problem'

embroiling a unique set of actors. The second and third gap refer to the lack of research on just how the Chinese government handles environmental conflicts and challenges, as well as the actual set of strategies being used (4). Many other knowledge gaps regarding Chinese governance fall under the umbrella term “China Paradox” used by both Li and Bo Rothstein. Namely, how does a system that has such high degrees of corruption and poor ‘QoG’ (“quality of governance”) manage to make such major improvements to overall quality of life (at least monetarily) for its people? Rothstein explains that China utilizes a form of “adaptive authoritarianism” (4) that is not fully understood by western academics and, in some ways, may even be better equipped to deal with complex problems long-term. Specifically, a single party system may be better at “channeling demands from citizens into higher levels of state capacity” (7). Rothstein explains that bureaucracy in China does not necessarily conform to the western capitalist notion of bureaucracy as posited by Max Weber. Instead, China subscribes to the ‘cadre’ system that inspires a “strong ideological commitment from the personnel (the cadre) to the specific policy doctrine of the organization” (10).

2.2(b) Fragmented Bureaucracy

(i) Needless Complexity Leading to Poor Enforcement

While the phenomenon of ‘fragmented bureaucracy’ is seen as a particular problem in China, particularly as an obstacle for effective environmental enforcement, Jinshan Li points out that all bureaucracies are susceptible to fragmentation. In fact, fragmentation is referred to as “Weber’s Problem” due to

how vulnerable *all* bureaucratic systems are to fragmentation. Daniele Brombal defined fragmented bureaucracy as “a polity where, in spite of its authoritarian features, substantial bargaining processes occur among different bureaucracies, greatly influencing policy outcomes” (3). Li believes that China has been a fragmented bureaucracy since the inception of the PRC, with fragmentation running rampant in terms of organizational value, power and resource allocation, and policy process. Li reduces this epidemic to what he terms as “turf wars” between various governmental departments.

The Institute for Development Studies’ Wei Shen blames this rigid top-down governance structure for actively squelching the adaptation of renewable technologies. However, the exponential expansion of the wind and solar markets and subsequent numbers of stakeholders has allowed for the development of a more constructive government-industry hybrid relationship. However, Shen cautions not to allow the pendulum to swing too far in the direction of business actors only, which may undermine needed regulations for wind and solar technology (91).

There is no greater example of Li’s “fragmentation in power and resource allocation” than the overlapping jurisdictions of China’s hyper-complicated system of environmental bureaus. Ruxi Wang’s fascinating study of the relationship between the government and effective environmental enforcement contained one such example that reveals this complexity as seen in Figure 33. Angel Hsu systematically identified governance gaps and failures in almost every aspect of China’s environment. Hsu reports that the involvement of “many

national ministries and departments at multiple levels” creates multiple problems in terms of knowing who is responsible for what. The biggest problem is “inconsistent data quality” (8). Hsu’s inclusion of a diagram (Figure 34) featuring all of the various government agencies involved in setting environmental policy and monitoring is unsettling in its breadth and complexity. This unnecessary complexity creates a staging ground for “discrepancies due to lack of coordination among reporting ministries” (Hsu, 8).

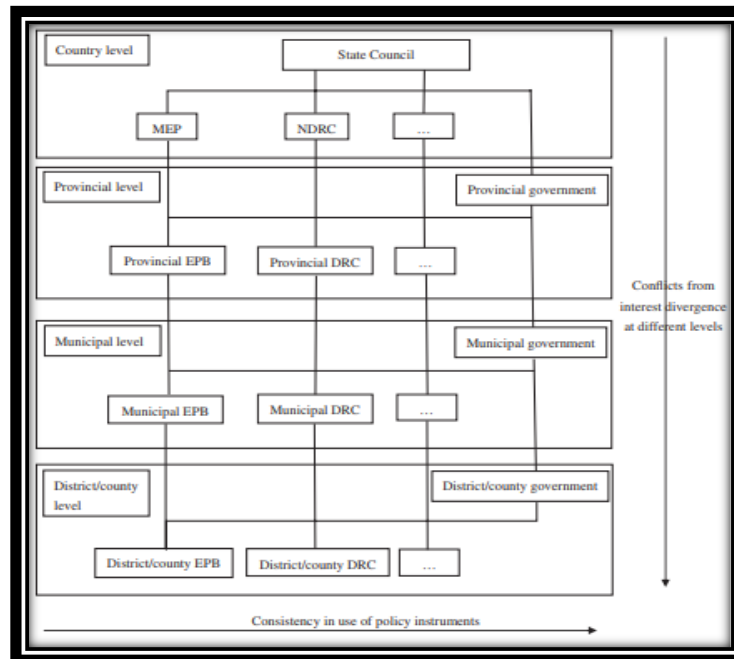


Figure 33 China’s dizzying environmental governance structure
 Source: Wang, R., 408

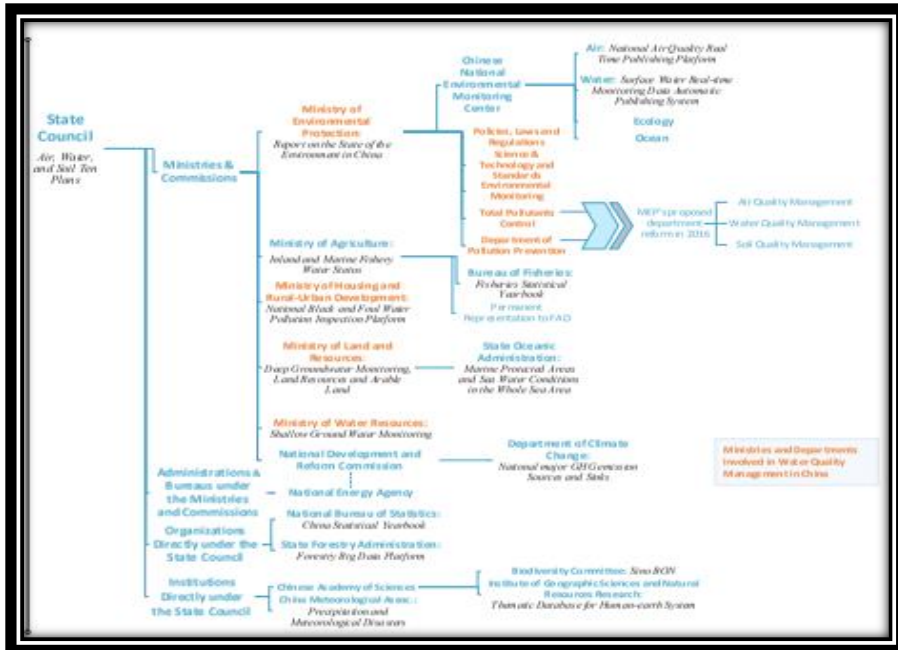


Figure 34 Though a bit pixelated, this diagram still communicates the unnecessary bureaucracy at work in China's environmental bureaus. Source: Hsu, A., 7

(ii) *Central and Local Government Disconnection also Leading to Poor Enforcement*

One of the *greatest impediments* to successfully dealing with China's environment is poor governmental enforcement of environmental laws. Grandiose environmental laws by the central government are rarely enforced by the time they reach local officials who have inordinate pressure by their constituency to prioritize economic growth over all else. This leads to the enforcement ability of local EPBs (environmental protection bureaus) getting steamrolled by the growth-at-all-costs mantra of local cadres. Examples abound and include the failure to complete 90% of the 474 pollution projects along the South-to-North transfer canal in the provinces of Shaanxi, Henan, and Hubei as reported by Elizabeth Economy. Countless papers read by the author of this Capstone have cited this dysfunctional dynamic as a major obstacle, including Arthur Mol who covers it particular well (9-12). Lund University's Stefan Brehm

working with Oxford's Jesper Svennson also analyzed this dynamic closely. Brehm describes the "local protectionism" of local governments resisting "national legislation to protect their own economic interest" (472) which translates into reporting false data, hiding pollution, poor regulation, and even granting "undefined grace periods" (472). Both Brehm and Svennson place some of the blame for local government priorities on a "Chinese fiscal system" putting "increasing strain on local budgets" (474). With regards to reporting false data, Brombal mentions a statement by the Ministry of Environmental Protection in January 2016 that described the interference by local officials "and their forging of 'fake data' as 'intolerable'" (8). Some of this manipulation is in the form of 'manbao' (underreporting), 'tuobao' (delay reports), or 'luanbo' ("messy data that lacks logic"), all at the hands of local officials focused only on 'shuzi chu guan' ("the numbers make the official") (9,7).

So endemic is this issue of poor environmental enforcement on the local level that it emerges repeatedly in the literature as a common denominator. Consider, for the moment, the conclusions among various authors discussing just the *singular issue of water pollution*. Iowa State University's Ruiqing Miao, in a revelatory article for the *China Agricultural Economic Review*, examined the relationship between companies and environmental protection bureaus as it pertains to water pollution. Early on in the paper, Miao states, "governors at any level of local government have the inclination to protect the enterprises in their local area from regulation of EPBs. This is true not only for state-owned enterprises (SOEs) but also for township and village enterprises (TVEs)..." (81).

In their examination of industrial water pollution, Harbin Institute of Technology's Xin Miao and Yanhong Tang observe that "local governments would rather chase GDP increase and local interests than enforce strict regulation on local companies". Indeed, the "interests of local governments and local companies are often intertwined" (475). Yuanan Hu's look at water pollution throughout China's period of industrialization has led to the statement that "even though the central government pushes for the protection of environment and sustainable development, local governments, which are more interested in local economic growth and social stability, often do not actively hold the polluting companies accountable" (62). According to Hu, this "lack of coordination among government agencies and weak enforcement of environmental regulations often result in discharges of pollutants far exceeding the total maximum daily loads (TMDLs)" (62). Finally, Matthew Kahn's look at the connection between water pollution management and political promotion has led him to remark that "studies of China's governance structure have noted the close ties between local officials and industry and have conjectured that this inhibits the effectiveness of regulation intended to reduce pollution" (226-7).

Ruxi Wang conducted a detailed examination of this dynamic by looking at a group of Chinese firms from a set of over 1,425 during the period of 2008 to 2012. Wang found that effective environmental actions actually follow an inverse-U shape (recall the "Kuznets Curve" shape) when moving from highly centralized government to highly decentralized government, as seen in Figure 35. In other words, as you *initially* move farther from the central government, firms

experience greater compliance pressure due to experiencing increasing levels of government, each adding regulations to those of higher administrative levels (405). However, as firms get even *farther* from central command, the more autonomy is exercised by firms due to “divergent policy priorities of governmental organs operating at a certain distance from the central government” (424). This is evoked by the phrase ‘tian gao huang di yuan’ meaning that the “emperor is as far away as the sun” (404). Brehm expresses concurrence with these results as seen in his own conclusions: “we find that economic decentralization induces a trend towards diverging compliance levels while political centralization constrains local regulatory discretion” (490). Arthur Mol, however, remains hopeful that this problem will self-correct over time. Mol believes that the eventual emergence in China of market systems and the rule of law will lead to “a modernization in environmental politics” (11).

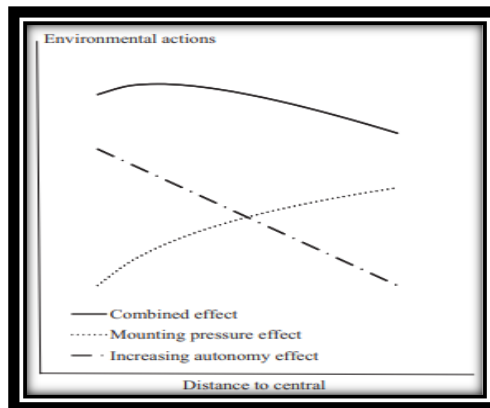


Figure 35 Relationship between corporate environmental actions and administrative hierarchical distances.
 Source: Wang, R., 410

Sichuan University’s Lei Lu found that the performance management system of local cadres had only translated to marginal improvements to the

environment during the first decade of the 21st century (658). Lu recommends strongly linking environmental protection to the mechanisms of cadre promotion. There is little precedent to suggest that this would be anything but constructive since local officials were not accountable for environmental issues until 2015 with the passing of the National Environmental Protection Law (660). An update to the 1989 EPL, the measures put forth in 2015 not only linked environmental performance to cadre promotion, but boldly sought to strengthen and institutionalize both “strategic environmental assessment” and “public participation and information disclosure” (Zhang, L.,2). International law firms like Morrison and Foerster immediately issued warning briefs to their clients about this move to improve China’s environment “meaningfully and strategically” (Falk ,5). However, it is too early to tell if all of these pledges will be roundly enforced long-term. As Morrison and Foerster advises, “we cannot be sure how successful any particular aspect of the new law’s implementation will be at this point” (5).

*2.2(c) Potentially Positive Governmental Developments on the Horizon:
Minzhu (People as Masters) and the End of Technocracy.*

(i) Growth of democracy, or “minzhu”

As discussed by Zehra Arat, Max Weber’s modernization theory suggests that as societies develop, they move inexorably towards democratization. Modern adherents to this theory discuss how growth in urbanization, education, and media eventually catapults a society toward democratic ideals (22). For many academics, China’s surging middle class will eventually set the stage for a uniquely Chinese form of democracy. The hope is that this rising tide of informed

and actively engaged citizenry will provide the necessary linchpin to deliver the nation from the brink of environmental collapse. James Fishkin's investigation into 'deliberative polling' through 'kentan' ("heart-to-heart discussions") between citizens and city officials have led him to speculate, albeit with some reservations, of a potential to "contribute to democratic development in the long term". (13). In the town of Zeguo, this burgeoning form of "deliberative democracy" through polling has led to the allocation of funds for the environment and a boost in worker protections (13). A counterpoint to this can be found in Kevin Cai's review of *Wealth into Power: The Communist Party's Embrace of China's Private Sector* by Bruce Dickinson, which maintains serious doubt about China's move towards democratization. Cai cites modernization theory by name and the assumption that economic liberalization necessarily translates into a governmental democracy (464). However, Cai's overview of Dickinson's book suggests that the rise of private entrepreneurs in China may continue unabated while natural inclinations for democratization remain suppressed. According to Dickinson, the PRC sidesteps this inclination by absorbing business firms into the authoritarian structure, preventing private entrepreneurs from organizing in opposition to government power. As long as the current transactional system makes it worthwhile to the business sector, entrepreneurs may be content with the lack of organization and a system of "crony communism" will remain (465), much like the "crony capitalism" currently ailing western nations. Another author who mentions Dickinson by name is Jie Chen. Like Cai, Chen cites modernization theory's belief in the eventuality of democracy and labels this the

“unilinear approach” which is associated with developed nations in the west (706). Chen mentions that China conforms to the “contingent approach” of developing nations where the relationship between economic growth and democratization is not guaranteed and ‘dynamic’ at best (706). Chen finds that, unlike lower classes, China’s rising middle class are not interested in democratic systems due to a continued dependence on both the state as well as economic and social status (716). Of course, many authors do not agree with this assessment. Gaobin Yang see the growth of environmental movements (particularly environmental NGOS) and democratization as going hand-in-hand (64). Environmental movements function as “laboratories” of political action fostering organization, participation, and the pushing of political limits (65). Whether China will move towards a democracy, and whether that move assures environmental mobilization and protectionism is an important factor for this Capstone to consider.

(ii) *The fall of technocrats in the government*

As mentioned in the *Introduction* (sections 1.1 and 1.3b), there has always been a preponderance of technocrats in the Chinese government, particularly in the field of engineering. One only needs to look to the backgrounds of the most current presidents in China to see this, as revealed in table 1. In many ways, Chinese techno-nationalism is an anathema to the development of comprehensive and effective environmental policy. Bruce Gilley sees an overreliance on technocrats as a logical extension of China’s “authoritarian environmentalism”, particularly as it applies to how China has approached

climate change. According to Gilley, essential public participation in this system is only limited to a “narrow cadre of scientific and technocratic elites while others are expected to participate only in state-led mobilization for the purposes of implementation” (288).

Table 1 Engineering backgrounds of the last three presidents of China *Source: Maley, 2017, 16-17*

Xi Jinping President (2013 -)	<i>Graduated in 1979 with a degree in chemical engineering from Tsinghua University</i>
Hu Jintao President (2003-2013)	<i>Graduated in 1965 with a degree in hydraulic engineering from Tsinghua University</i>
Jiang Zemin President (1993-2003)	<i>Graduated in 1947 with a degree from electrical engineering at Shanghai Jiao Tong University</i>

As mentioned previously, leadership steeped in technical backgrounds throw supply-based solutions at environmental problems with limited or even counter-productive results. An infusion of demand-based approaches are required, including heroic efforts to promote conservation and efficiency as well as the adoption of market measures. In an article for the *China Leadership Monitor*, Cheng Li shows that this process is already underway. Li’s research reveals that the number of engineers in the Central Committee has steadily declined while those with backgrounds in economics and law have increased significantly (6-9), as seen in figure 36. In figure 37, a dramatic shift can be seen away from officials with backgrounds in engineering to officials with backgrounds in law and social science. In terms of the direction China needs to go in order to achieve effective environmental policy, this is a reassuring trend.

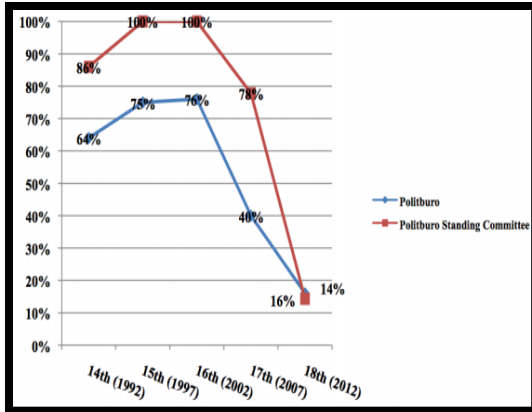


Figure 36 Falling percentages of technocrats in China's Politburo Standing Committee from 1992 to 2012 Source: Li, C., 6

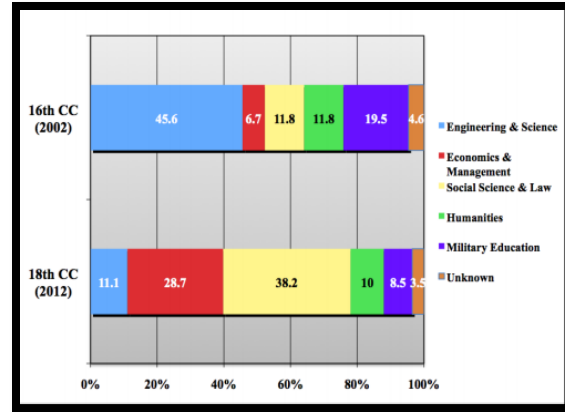


Figure 37 Shift in the educational backgrounds of the members of the Central Committee from 2002 to 2012 Source: Li, C., 9

2.3 Environmental Considerations

2.3 (a) Climate Change Adaptation

(i) Non-Renewable Energy

The link between China's use of non-renewable energy and climate change is addressed in multiple sections of this Capstone, including the *Introduction*. As mentioned previously, China surpassed the United States in CO₂ emissions in 2007. The *Introduction* also makes note of Olivier's 2016 report from the Netherlands Environmental Assessment Agency revealing that 85% of China's CO₂ emissions are associated with fossil fuel use, 83% of which comes from coal (19).

(ii) Renewable Energy

For a number of years, officials in the Chinese government have recognized the potential for renewable energy to ameliorate the impacts of climate change. One example includes former president Hu Jintao's 2009 climate change speech at the United Nations General Assembly which recognized the

importance of “vigorously developing renewable energy” (PRC, 4). Computer modeling from Hancheng Dai revealed that a comprehensive renewable energy program for China will be a key factor to help carbon emissions to peak by 2025. This would allow the PRC to be five years ahead of schedule in achieving the 2030 target date for peak CO₂ emissions as set during the Paris agreement (443). Despite its potential to combat the effects of climate change, renewable energy is highly vulnerable to those same effects. The Chinese Academy of Sciences’ Xingcai Liu and Qihong Tang point out that the projected impacts on hydrological conditions from climate change will stymie hydropower in China. Specifically, climate change will result in reduced net generation and a deepening of regional disparities with the altering of river flow and reservoir storage (3343, 3355).

(iii) Air Quality and Significant Weather Events

In terms of air quality, the direct relationship between air pollution emissions and greenhouse gases is straightforward. According to Shuxiao Wang, by reducing one, you reduce the other. Wang establishes a very direct relationship to which each percent of CO₂ reduction “would typically reduce health impacts from PM air pollution by 1%” (12). In light of this relationship, Wang proposes a hybrid, “smart mix of measures” that will “help combat climate change and air pollution more cheaply than tackling either issue separately” (12).

While the IPCC reports focus on a global scale, China’s National Assessment Report on Climate Change (NARCC) is a national scale endeavor. The first NARCC report was published in 2007. The government’s third NARCC

climate change report (2012-2015) makes clear connections between climate change and significant weather events. Yun Gao covers the prediction made within the third report that by the end of the 21st century, “ground surface temperature is likely to increase by 1.3–5°C and rainstorms, severe storm surges, and large scale droughts will increase in frequency and intensity” (237). Yun Gao interprets the report’s findings in the following way: “according to the China National Climate Change Assessment Report, continuous global warming can lead to frequent extreme weather and climate events, glacier retreats, sea level rise, unbalanced water distribution, and unstable agricultural production, thus impacting socioeconomic development and public health. For instance, over nearly 60 years, extreme weather and climate events have significantly changed in China, with an increase in the frequency of simultaneous or regional events” (238). Both Jun Shi and Li Wang offer similar interpretations. According to Shi, climate change will have “important effects on the probability of the occurrence and duration” of high-impact weather events in China (11). These high-impact weather events include an “increase in the magnitude and frequency of hot and rainstorm weather events” (11). Instead of providing auguries for the future, Li Wang focuses on the here-and-now with his observation that climate change has already “caused even more frequent and more serious floods and droughts and led to a rapid fluctuation of climate” (59).

(iv) Water Quantity

Current and projected impacts of climate change on an already water-scarce nation remain deeply unsettling. Michigan State University’s Yong Jiang

found that climate change has “decreased water resources in northern China, with the annual flows of Hai, Yellow, and Huai rivers reduced 41%, 15%, and 15% respectively”, all in the last few decades (3190). These same statistics were not only recycled by China’s Ministry of Water Resources, but also the World Bank’s report *Addressing China’s Water Scarcity* in 2009. Jinxia Wang predicts that wheat and rice output, both vital for China’s food security (7), will be reduced by 2030 as a result of climate change aggravating “water scarcity in all river basins in the north and some river basins in the south” (4).

When identifying stressors of the climate change threat, many authors cite a pattern that emerges repeatedly throughout this Capstone: the fragmentation and supply-based trappings of the government. Jianguo Liu recognizes that climate change “has already caused significant alterations of water resources in China” (641). Liu excoriates China’s grandiose water conservancy projects for functioning “without consideration of climate change”, restricted as they are by their “stationary design” (641). Future construction of water conservancy projects will only be fortified against deleterious effect of climate change if the PRC “build infrastructure in stages as ecological response and climate trends become clear. This requires a shift from pursuing short-term achievements to long-term effective functions of the projects under uncertain future climate conditions” (641). Of course, the ideal policy would require shifting away entirely from supply-based conservancy projects to demand-based programs supporting efficiency and resource management. Hefa Cheng remarks that this will be “key for China to adapt to the future impacts of climate change” and requires

“increased water use efficiency, development of market-based water allocation framework, and effective regulation enforcement, along with water pollution control” (256). As discussed later in this Capstone, reducing the number of technocrats in office will go a long way in making this happen.

Just as it is in the United States, Chinese agriculture is a major player in terms of both the management of greenhouse gases and the imperilment of China’s meager water resources. Jinxia Wang, working with Sabrina Rothausen, found that 17-20% of China’s yearly GHGs are the result of agricultural activities with groundwater abstraction being an “important source” that is “rapidly increasing” and “largely unregulated” (1). The authors found that over 33.1 MtCO₂e (metric tons of carbon dioxide equivalent) results from groundwater. This amount is equivalent to 0.58% of national emissions and 3% of agricultural emissions (6). A prescription by Rothausen and Wang is offered by way of improved electric pump efficiency. These emissions would “more than double with a 20% decrease in electric pump efficiency, whereas a 20% increase in electric pump efficiency will reduce the emission rate by a third” (7). Finally, the authors also note that “roughly 70% of the irrigated area in northern China is groundwater-fed” (2).

(v) Water Quality

Among the factors mentioned by Hefa Cheng in the previous section that are “key for adaptation to climate change”, nation-wide pollution control ranks prominently (271). Unfortunately, Ji-Hyung Park has found that like many other countries, China gives too much focus on how climate change impacts water

quantity instead of water quality (219). Despite the formidable threat posed by climate change on water quality, land use changes from urbanization and agriculture are seen as having “more marked effects on water quality” (Park, 219).

Junfeng Zhang, formerly of the University of Medicine and Dentistry of New Jersey (UMDNJ), asserts that climate change will promote “waterborne organisms including pathogens, algae and disease-carrying vectors” throughout southern China (9). Zhang believes that the increase in both temperature and extreme precipitation in southern China will “promote the survival, replication, and transmission of waterborne organisms including pathogens, algae, and disease-carrying vectors” (9).

In an ambitious study of both the Taihu Lake and the Han River (10, 11), Rui Xia from the College of Water Sciences at Beijing Normal University found that “the risk of water eutrophication and algal bloom will be increased by climate change factors” (12). Among the climate change factors spotlighted by Xia are “high air temperature ($>25^{\circ}\text{C}$), less precipitation (flowrate < 400 m/s), unstable wind speed (< 3.1 meters per second), and strong solar radiation, which could directly promote the growth of algae” (12). Bo-Qiang Qin from the Chinese Academy of Sciences conducted a separated examination of Lake Taihu and concluded that “a general warming trend reflecting climate change favors regional cyanobacterial bloom expansion, and longer periods of bloom persistence. Conditions at Taihu appear to reflect this trend” (110).

(vi) Oceans and Fisheries

Min Pan from the Center for Polar and Oceanic Studies at Tong Ji University worked with Henry P. Huntington to examine fisheries in the central Arctic Ocean. Both authors concluded that as a reaction to “the summer retreat of sea ice and the warming of ocean waters”, fish species are shifting north (153). This has prompted China to look towards the establishment of prospective central Arctic Ocean fisheries. Based on China’s historic abuse of fish populations both near and far, the United States, Russia, Canada, Norway and Denmark (“in respect of Greenland”) signed the “Declaration Concerning the Prevention of Unregulated High Seas Fishing in the Central Arctic Ocean” in 2015. Functioning as the five “arctic coastal states”, these nations hope to compel China into a policy of “cooperative governance” that subscribes to the idea of “Arctic science as a form of diplomacy” (153).

Nian Jiao is a researcher for the Institute of Marine Microbes and Ecospheres at Xiamen University. The paper by Jiao that is cited in this review not only provided many useful measurements, but also constructive suggestions. One suggestion is for long-term research facilities to replace in-situ data in order to allow China to best interpret the impacts of climate change on marine ecosystems (121). Jiao also reported that the global sea level rise rate is 3.2 – 8.0 millimeters per year. By 2050, the sea level rise rate in China will reach between 3.1-11.5 millimeters per year, exceeding the global rate (119). Jiao also found that the world’s oceans capture 55% of all ‘green carbon’, which is defined as “all the carbon captured in the world by living organisms and ecosystems” (122). To distinguish from ‘green carbon’, the aforementioned 55% of world

carbon capture by oceans is referred to as “blue carbon’ (122). Related research provided by Yang Gao and Guirui Yu shows that human activity in China accounts for 20.9%-23.7% of global blue carbon sink from fisheries (36). This amounts to a range of 6.32–7.89 teragrams of carbon per year of the total 26.58–37.6 annual global sink.

Surprisingly, Terry Hughes concluded “almost none” of the coral loss in coastal China “is attributable to climate change” (264), despite his recognition that increasing ocean temperatures and acidification from climate change impact coral reefs around the world. It is likely that Hughes wanted to bring as much attention as possible to the “ongoing overfishing, pollution, coastal development, and other human activities” that are “much more prevalent” in affecting coral reefs (264).

(vii) Ecosystems

Baoxiong Chen lists the two factors of human activities and climate change as having “great significance to ecosystem management and adaptation” (11). Yet, Chen believes that it is “almost impossible to directly differentiate between these two factors”, despite the fact they both remain the “main driving forces” for terrestrial ecosystems (11). Chen proceeded to conduct an analysis of the Qinghai-Tibet Plateau in the hopes that the region would provide him with an “objective and reproducible method” (11) to distinguish between these two forces. The Qinghai-Tibet Plateau was seen as an ideal choice for its “large variety of ecosystems” that includes “subtropical rain forest in southeast to alpine desert in the northwest” (12).

Modeling by Shilong Piao revealed that during the 1980s and 1990s, the terrestrial biosphere removed around 28-37% (0.19-0.26 petagrams of carbon per year) of carbon fossil emissions (1012). However, Mei Zhang & Xianjin Huang of Nanjing University found that land use changes have caused terrestrial ecosystems to lose 219 teragrams of carbon from 1980-1995 and 60 teragrams of carbon from 1995-2010. Zhang and Huang worked to obtain best estimates despite the fact that in China, connections between land use changes and carbon suffer from “a lack of available data” (8).

Finally, Nicholas J. Murray at the University of New South Wales announced that tidal flats will be “among the first ecosystems to be significantly impacted by rising sea levels and intensifying storms under climate change” (476). Murray has referred to the Yellow Sea Tidal Flats as endangered; from the period of the 1950s to the early 2000s, 65% of tidal flat extent has been lost (476). This percentage loss can clearly be seen in Figure 38:

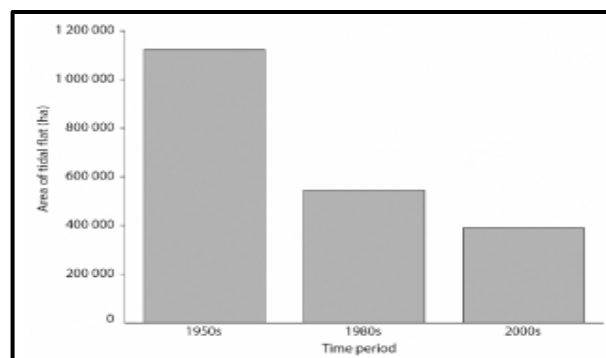


Figure 38 Plot of tidal flat area (in hectares) as seen over three time periods Source: from Murray (476)

(viii) Natural Disasters

Nanjing University's Xindong Du points out that natural disasters "are likely to become more frequent, more severe, and sustained along with climate change" (388). Many other authors have made similar observations (for example, Zhou & Wu, 2168; Yi-ming Wei, 643). In fact, according to Yi-ming Wei, the future socio-economic development of China is threatened by the fact that "heavy rainfall, floods, soil erosion, landslides and other geological disasters would increase dramatically" along with droughts due to climate change (652). Coventry University's Neil Renwick looked at the fact that natural disasters around the world tripled from the period of 2000-2009 compared to 1980-1989 and posited that 80% of this increase "has been attributed to climate-related events" (27). Echoing Renwick's findings was an article in *Disaster Advances* by Chen Sha and Xiaoli Bi. Sha and Bi blamed the intensification of climate change on "more frequent and intensified natural disasters in China" (41). The two authors made use of China's *Meteorological Data Sharing Service* temperature data during the period of 1951-2011 combined with natural disaster statistics from the same period courtesy of the *Emergency Events Database*. One disturbing relationship suggested by the authors is that "if the average temperature in China increases by 1°C, the occurrence of earthquakes (seismic activity), flood, and storm would increase by 2, 4, and 4 occurrences per year respectively" (41).

For climate change, Universität Kassel's Jing Dai suggests that the best time to "motivate the population in China to support public adaptation and possibly also mitigation activities" is right after an extreme weather event (317). Dai's survey of over a thousand Chinese adults reveals a correlation between

strong climate change beliefs and “perceived experiences” of extreme weather events, particularly heatwaves.

(ix) Agriculture

University of Nottingham’s Sofie Sjögersten warns that climate change will “create major stresses” on the “whole agricultural sector” of China by 2100. According to Sjögersten, adaptation of farming systems “is crucial” in order to decrease the impact on the production of food (126). However, Shuai Chen has found that the “major stresses” referred to by Sjögersten has already happened as over 820 million dollars have been lost in the last decade in China’s soybean and corn sectors due to climate change (107). Chen also predicts a 7-19% and 3-12% reduction in soybean and corn yields respectively by 2100 (120). This is a disturbing prediction considering that China produces 6% of the world’s soybean and 20% of the corn (107).

Hong Kong Polytechnic University’s Peng Zhang criticized many climate prediction models geared towards agriculture since they only assess temperature and precipitation. Zhang adjusted the parameters of the models to include climate model variables such as humidity and wind. The result is that by 2100, Chinese rice, wheat, and corn yields will decrease by 36.25%, 18.26%, and 45.1% (28). It is important to note that these values are 4.35% and 6.41% higher than modeling with only temperature and precipitation for the case of rice and wheat (though in the case of corn, Zhang’s model is actually 2% lower). In all three cases, Zhang found that adding humidity actually decreases the yield loss due to climate change, but adding wind *significantly increased* predicted loss (26-

28). Like Chen's prediction in the previous paragraph, Zhang's findings are disturbing considering that China provides the world with 30% of its rice, 17% of the wheat, and 20% of the corn (11).

While relatively less frequent, there *are* academic studies that do suggest potentially beneficial effects of climate change as it applies to China's agriculture. An early publication (2000) from the International Institute for Applied System Analysis (IIASA) suggests that the increasing rainfall and temperature associated with climate change may *benefit* parts of northeast and northwest China. The result is a "positive influence on their arable land area and potential cereal production" (Tang, G.P., 129). A joint paper by Jinxia Wang, Jikun Huang, and Jun Yang suggest that climate models have not fully considered the "CO₂ fertilization effect" which is defined as "a probable feedback effect of the terrestrial biosphere-atmospheric carbon system where elevated levels of CO₂ increase the productivity of natural ecosystems" (Wang, J. & Huang, J., 4). The authors contend that some of the negative impacts of climate change on agriculture "become positive when the CO₂ fertilization effect is considered" (13). Additionally, market-based responses are rarely included in most modeling which may "partially mitigate either negative or positive effects of climate change" (9).

2.3(b) General Environmental Impacts

(i) Water Resources (Quality)

According to the RAND Corporation, pollution claims nearly 10% of China's GDP from the years 2000 to 2010. While 6.5% of GDP is lost to air pollution, nearly 2.1% is lost due to water pollution (Krane, C., 3). The extent of water

degradation in China is particularly dire when placed in the context of the Ministry of Environmental Protection's own "Environmental Quality Standards" as seen in Figure 39. According to Dongmei Han and Matthew Currell, 61.5% of Chinese groundwater and 31.4% of river water is given a rating of class IV-V (Han, D, 1223-4). Of the 31.4%, 14.9% of monitored rivers falls below class V which indicates a "complete loss of potential for all consumptive uses or human contact" (1223). Yun Zhou from the Beijing Normal University School of Environment states that water falling in the range of IV-V is "regarded as bad and can only be used for recreation and irrigation" (1243). Equally unsettling is Zhou's finding that "only 5% of the entire two million square kilometers of shallow groundwater aquifers surveyed and evaluated" qualifies for either grades I or II (1248). Compounding this problem is agriculture's rapid expansion in east China which has now made non-point source pollution an equal threat to point-source pollution (1246). Finally, Han and Currell express strong concern over the particularly low rating for such a large swath of China's groundwater considering that it is responsible for "one-third of total water usage across the domestic, agricultural, and industrial sectors in China, and approximately two-thirds of cities utilize groundwater as a major water supply" (1223).

Grade	Classification/applicable uses
I	Pristine water sources (e.g. river headwaters and protected natural catchment areas)
II	Class A water source protection areas for centralized drinking supply
III	Class B water source protection areas for drinking supply and recreation
IV	Industrial water supply and recreational water with no direct human contact
V	Limited agricultural water supply
VI	Essentially useless

Figure 39 The “Environmental Quality Standards” for water quality, represented by six “grades” as created by the Ministry of Environmental Protection in 2002. *Source: Han, D., 1227*

Hong Yao identifies surface water pollution accidents (SWPAs) as the “most dominant type of environmental accident in China” (1). SWPAs are associated with over eight different kinds of economic losses (Figure 40) with the “biggest proportion of the total loss” ascribed to loss of environmental property (11).

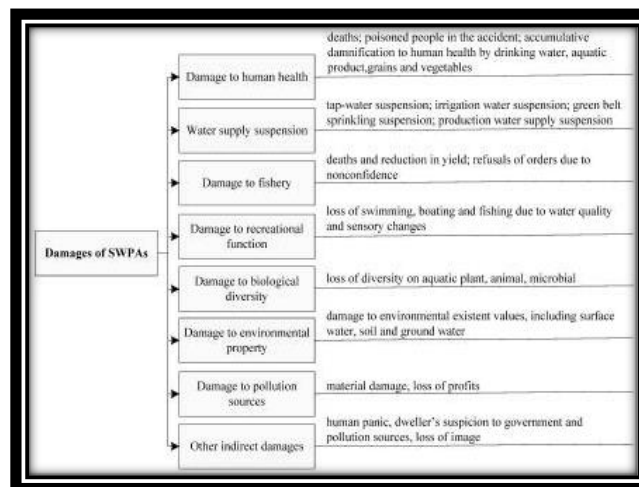


Figure 40 Chain of Negative Impacts Associated with Surface Water Pollution Accidents *Source: Han, D., 1227*

The social toll resulting from some of the statistics above has been covered extensively in the literature. The direct result of 71.8% of the population “feeling under the threat of water pollution” (Wang, Q., 358 & Miao, X., 473) is “thousands

of incidents of civil unrest”, mostly in rural areas, each year (Han, D., 1222). Wang also points out that “researchers have reported connections between water pollution and acute water-borne diseases which include hepatitis, cholera, dysentery, cryptosporidiosis, giardiasis, diarrhea, and typhoid” (358). Junfeng Zhang found that 2% of China’s rural GDP is needed to treat the health impacts of over 300 million people who are forced to rely on “hazardous drinking sources” (7). This statistic was also cited in a paper by Yonglong Lu from the Research Center for Eco-Environmental Sciences in Beijing (7). Water pollution has been identified by Matthew Currell as an issue of transnational environmental justice since those garnering the most benefits from widespread pollution in China are “not necessarily those who have suffered the major health and other environmental consequences of the associated pollution” (19). Currell also states that three of the five major causes of cancer (lung, stomach, liver, esophagus, and colorectum) can be linked to water pollution in China while “the first of which can be attributed to air pollution” (23). Qing Wang from the Dalian University of Technology studied 51 cities in China and concluded that the physical and mental health of low-income people were disproportionately affected by water pollution (361-363).

Much has been made of China’s infamous “cancer villages” which are defined as “population centers where the incidence of cancer morbidity or mortality is significantly higher than national averages” (Han, 1229). Yonglong Lu revealed that many such villages “cluster along the major rivers and their tributaries, especially in rural areas” (10). This is almost certainly due to the fact that “large

amounts of industrial, agricultural, and domestic waste water have been discharged into the rivers and lakes” (Lu, 10). Lu also found that almost 60% of cancer villages are less than 3 kilometers from a major river with 81% less than 5 kilometers from a major river (11). This causal relationship can be seen in Figure 41. One last staggering statistic: as mentioned by Zhao Chen, 40% of all water-polluting industries are situated in 85 cities along the Yangtze River. This same river provides drinking water for one-third of the entire population (12).

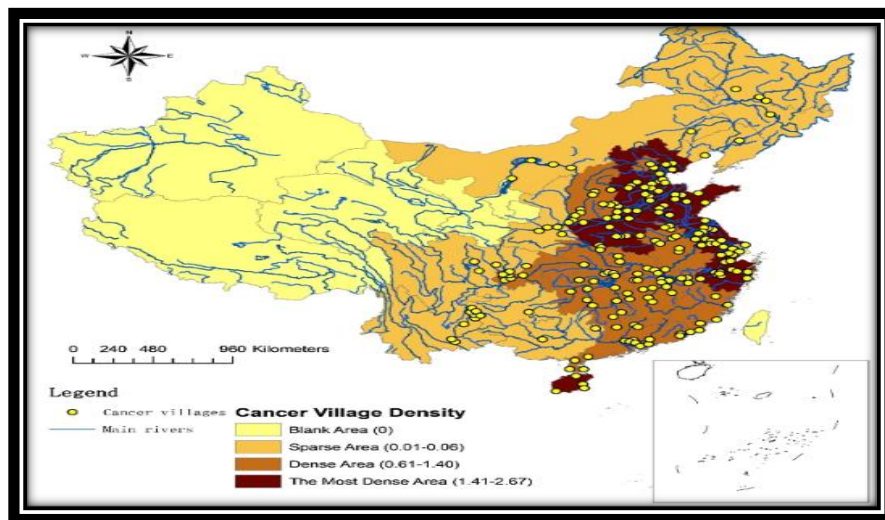


Figure 41 Tendency of cancer villages to be located near rivers and major tributaries
Source: Lu, Y., 12

Any reader of the *Introduction* should be unsurprised by Hefa Cheng’s revelation that China’s water quality issues are due to “rapid industrial growth and insufficient attention paid to environmental protection in the past three decades” (262). However, Cheng’s paper the following year with Yuanan Hu provided a more nuanced analysis beyond identifying the obligatory stressors of urbanization, industry, and agriculture. In the “Root Causes of Water Pollution”, the duo considers such factors as the lag time between urban infrastructure and

wastewater collection and treatment, over-zealous use of agrichemicals and soil erosion from grazing and deforestation (Hu, Y., 58). Hu then provides a scathing indictment of PRC governmental failures by identifying 'policy' as the weakest driver to ensure water quality due to a "long standing culture of government inaction and bureaucracy" (68). Consistent with the recurring 'fragmented bureaucracy' theme covered in other sections of this Capstone, the PRC's poor water resource management can be ascribed to a lack of legal enforcement and coherence, a lack of authority and resources by governmental subunits like the EPBs (mentioned earlier in this paper), and "conflicting interests at different levels of the administration" (Cheng, H., 275). The China Center for Economic Studies' Zhao Chen even goes so far as to suggest that poorly-crafted regulation has actually *increased* water pollution by merely shifting polluting sources further upriver (21). China's "differentiated regulatory intensity" (18) has resulted in downstream cities subscribing to more stringent regulation than upstream cities. This regulatory differentiation has resulting in the upriver shift in pollution as described by Chen, which has "unintentionally exacerbated the pollution problem" (18). Hu boldly connects the habitual discharges of water pollutants exceeding the total maximum daily loads (TMDLs) to poor coordination and enforcement by government agencies (61-62). Finally, Matthew Kahn from the University of Southern California states that in China, the "effectiveness of regulation intended to reduce pollution" is inhibited as a result of "close ties between local officials and industry" (226-7).

(ii) Water Resources (Quantity)

As observed in section 1.4(a), both Junguo Liu (633) and Guanghua Xu (33) have revealed China's unenviable position of having only 9% of the arable land and 7% of the world's water despite being home to 22% of the world's population. Cheng (262) and Liu (634) both make the observation about how capacious China's freshwater resources are (at 2.8 million m³, it is ranked sixth in the world). However, according to the World Bank, China's per capita availability of water resources is "only one-fourth of the world average of 8,549 m³ per year and among the lowest for a major country" (Xie, J., 20). Yong Jiang from the UNESCO-IHE Institute for Water Education sees spatial distribution as a major driver of water scarcity due to the fact that 45.2% of the population lives in northern China where only 19.1% of the country's water is found (3189). To make matters worse, the arid, northern parts of the country face "increasingly severe water scarcity" (3194). All of these factors culminate in an unsustainable gap between water demand and supply along the order of 53.6 billion m³ according to Peking University's Jinxia Wang (2). Additionally, issues of water quality and quantity plunder up to 2.3% of China's GDP (Xu, G., 34).

As with most of what ails the Middle Kingdom, all roads lead back to government as the weakest link in combating water shortage. The expected truism of poor enforcement and fragmented bureaucracy applies here as over eight agencies have all been put in charge of water management. Despite pledges to reduce bureaucracy, this dizzying rolodex of agencies include the Ministry of Water Resources, Ministry of Environmental Protection, Ministry of

Housing and Urban-Rural Development, Ministry of Agriculture, State Forest Administration, National Development and Reform Commission, Ministry of Transport, and Ministry of Health! Hefa Cheng's investigation into governmental mishandling of water supply management has led him to conclude that these agencies have "significant overlaps", "lack of cooperation", and "inconsistent policies and conflicting interests" (14-15). The one aspect of the Chinese government that has had the gravest impact on water resource quantity is an issue that will be addressed with more scrutiny in a later section and was also touched on toward the end of section 1.1. This issue is the preponderance of technocrats in positions of leadership, many of whom draw on engineering backgrounds to solve problems. This has historically led to policy that leans heavily on supply-based solutions as opposed to demand-based mechanisms of conservation, efficiency, and pricing.

A disregard for appropriate pricing has led to costs that are far below the "long-run marginal cost", with inadequate pricing of water ranking "among the world's cheapest" and becoming a "major cause of low water use efficiencies" (Cheng, 273). Specifically, this not only "perversely encourages waste but also discourages the development and implementation of water-conserving technologies" (273). Jiang expounded on the idea of long-run marginal cost by observing that "since water prices rarely reflect the full cost of supplying water, including operation and maintenance costs plus overhaul and replacement costs for water delivery systems, lack of maintenance is common for irrigation infrastructure, further increasing insufficient water use" (3192).

This is particularly true in the agricultural sector, which accounts for 70% of yearly use (3192). A wrong-headed pricing paradigm is used in China for farmers where they are charged based on the “number of acres irrigated rather than the actual amount of water used for irrigation” (3192). This is reminiscent of the decreasing block tariff structure used in many United States cities which is fortunately being phased out. Clearly, this provides no incentive for Chinese farmers to conserve water resulting in “the low adaption rate (<20%) of water-saving technologies such as plastic sheeting, sprinkler systems, drip irrigation, and other efficient, less capital- and energy-intensive techniques in water strapped northern China”. However, other studies have suggested that appropriate water pricing for farmers may devastate the considerable population of poor farmers throughout China. Pricing will only achieve water-saving effects when raised beyond the shadow price, resulting in many adverse impacts. After conducting an analysis of farmers from the Heihe River Basin, Minjun Shi suggests that quotas would work better than pricing as “reducing water demand requires a large price rise for irrigation water, which will lead to a big loss of farm income and high negative impacts on crop production” (7617).

The supply-based ethos of a full-blown technocracy has also led to two monolithic approaches in Beijing. The first is the rampant damming projects of which the Three Gorges Dam is the most notable; the second are the monstrous water transfer projects to shift water from the south to the parched regions in the north. A study by Brooke Wilmsen from LaTrobe University in Australia showed that “no risk strategy” exists in China to save the millions of people displaced by

dam building from subsequent poverty (147). As home to half of the world's dams (140), China's involuntary resettlements inordinately affect vulnerable groups such as the elderly, women, children, and the disabled. The *2000 World Commission on Dams Report* has shown that those groups incurring the largest impacts both socially and environmentally share the least in the project benefits (148). Water transfer projects leave a similar wake of forced relocation and environmental destruction as China's dam building. The South-North Water Transfer Project (SNWTP) has supposedly earmarked 62 billion dollars for construction, twice the cost of the Three Gorges Dam. However, as of 2014, the cost has risen to 77 billion dollars. While the tide is slowly turning to the "soft" approach of market mechanisms and efficiencies, "hard" approaches like water diversion projects continue to drive policy. As Liu and Zang point out, "without adjusting the economic structure and capping water use, the water diversion projects alone cannot solve water scarcity projects" (640). Jing Ma, working with Arjen Hoekstra (who is responsible for the whole notion of a "water footprint"), reported a damning statistic regarding the SNWTP. While the project will redirect 44.8 billion m³ annually from the Yangtze River to the north through a system of canals, over 52 billion m³ of "virtual" water is still sent *in the other direction* from the agricultural water use needed to export food from the north to the south (839). While in the past, southern China served as the nation's breadbasket, this label has been reassigned to the north. According to Ma, this shift is due to "substantial areas" of fertile land in the south being used up for "manufacturing prosperity and the construction of infrastructure" as most jobs in the south shifted

from “agricultural to secondary and tertiary industries” (837). The end result is the inverse exchange between actual water and virtual water between the north and south of China.

Many other authors offer similar criticisms of China’s attempt to address water scarcity through diversion projects. Ximing Cai goes so far as to say that it is “increasingly difficult if not impossible” for water transfers to meet water demands in an area without undermining supplies in another area (19). Cai also sees the transfer projects as a vectoring agent for social instability, particularly in northern China where they have created a “pressing concern for social equity” (16). Jianguo Liu and Wu Yang’s examination of the Luanhe-to-Tianjin transfer project led them to conclude that the project will actually “encourage consumption and increase demand” (540). The University of Melbourne’s Michael Webber offers the best parting words (378) here by stating that the SNWTP is emblematic of “an official technopolitical regime that privileges concrete over management”. A large extent of the literature roundly criticizes the SNWTP, ranging from claims that touted economic benefits do not “justify the direct costs” (Berkoff, 6) to claims that the project is emblematic of China’s heavy-handed, authoritarian approach to the environment (Moore, 959). A review of the literature yields little positive analyses beyond the potential for the project to “only decrease” groundwater exploitation in Northern China. (Ye, 5765).

(iii) Oceans and Fisheries

Stanford University’s Ling Cao has published over 32 papers covering oceans and fisheries. According to Cao, over 20,000 marine species can be

found in China, including 43% of mangrove species, 33% of the “Indo-west Pacific’s coral reef species”, and 14% of the world’s fish species (6). Unfortunately, China’s marine life has been devastated over the last few decades. Terry Hughes, once called the “reef sentinel” by Nature, found that nearly 80% (Figure 42) of the “coral cover on fringing reefs along the Chinese mainland and around Hainan Island” have been lost since the 1980s (264). Over 73% of all mangroves in China have also been lost from the 1950s to 2002 (262). A related study by Yisheng Peng found that during the 1950s to the 1990s, southern China saw a reduction in mangrove area from 40,000 to 15,122 hectares with an 82% overall loss in Guangdong Province specifically during this same period (1). The damage incurred by marine fisheries from industries on land have also resulted in a cost of half a billion dollars annually (Cao, 9).

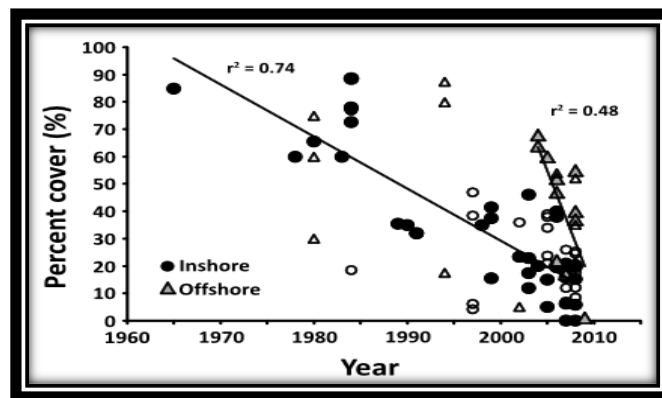


Figure 42 Reduction of coral cover over time in the South China Sea for “inshore reefs and on disputed offshore reefs”. Hughes’ statistic regarding the 80% loss of coral cover since the 1980s can clearly be seen here. Source: Hughes, T. P., 264

It should be no surprise to anyone that breakneck economic growth is an anathema to environmental protection. Beijing Normal University’s Qiang He states that economic growth “alone can accelerate coastal degradation even when human population size remains constant” (4). It should therefore be even

less of a surprise, then, that precipitous coastal degradation resulted after Deng Xiaoping's economic reforms in 1978. Qiang He shows this quite clearly as seen in Figure 43 where a noticeable trend of degradation appears right after the year 1978, as delineated by the dotted line.

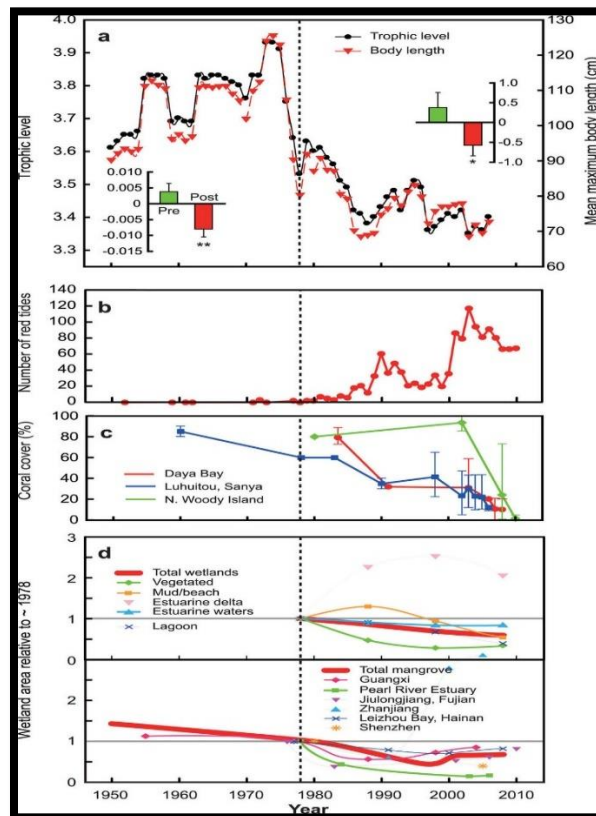


Figure 43 Historical Trend of Coastal Impacts Resulting from Human Activity Source: He, Q., 7

Once again, governmental failings have exacerbated this problem. Only 0.05% of the oceans are “strongly protected in no-take zones” while a mere 0.5% of China’s total marine area is actually covered by the forty-nine “Marine Protected Areas” (Cao, 9). Cao also found that China maintains over fifty-one marine germplasm resource conservation zones, but “monitoring and enforcement of these protected areas has been deficient” (9). Hughes also

blames the loss of coral reef habitat on “a failure of governance” (265). Shen and Heino’s study of marine fisheries management reveals the government’s lack of “efficient enforcement and supervision” (7). The failing of marine management is underscored by the fact that both fishing vessel engine power and the number of fishermen has risen despite government promises to reduce both. In the case of fishermen, the number has risen from 1,224,000 to 3,690,000 from 1980 to 2011 (3). As usual, the issue of “fragmented bureaucracy” and the prevailing “top-down” approach emerges to prevent an effective paradigm of marine resource management that “must come from the bottom up” (Cao, 10)

The lack of government action may not be entirely surprising when seen in the context of how astronomically profitable the fishing industry is in China. For starters, China is responsible for one-fifth of the world’s catch volume (Figure 44) and is the largest producer of seafood in the world. It also provides 60% of the world’s aquaculture volume, half of the aquaculture value, and one-third of the global fish supply (Cao & Naylor, 133). According to Jacobs, this is aided and abetted by the 22 billion dollars spent subsidizing the fishing industry from 2011 to 2015, an amount three times higher than the previous four years.

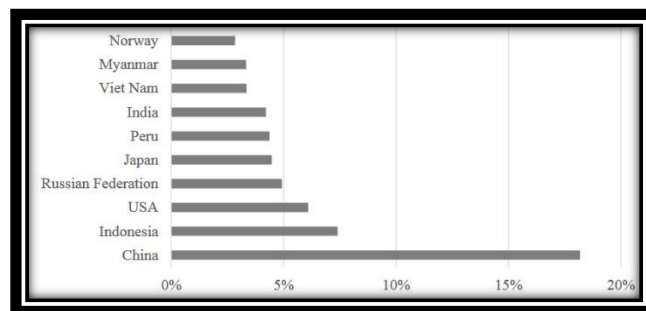


Figure 44 Percentage of global catch volume by country, with China clearly approaching twenty percent.
Source: Cao, L., *Supplemental, 2*

In 2012, China achieved an aquaculture output of 40 million metric tons, which was four times the amount in 1990. The amount of space dedicated to fish farming also doubled to 8 million hectares (133). Cao reports that during this time, China provided over “90% of the world’s carp, 50% of global penaeid shrimp, and 40% of global tilapia” (133). All of this has led to a remarkable statistic: according to Nian-Zhi Jiao of Xiamen University, the marine economy actually has outpaced the national economy starting from the time of China’s 11th Five Year Plan (119). In fact, from 1990 to 2010, Cao reports that the marine economy has contributed around 10 percent of China’s annual GDP (8). As of 2016, marine product equaled 9.5% of China’s GDP. This is equivalent to around 7 trillion Yuan as shown from Leiden University’s Xuechan Ma in Figure 45.

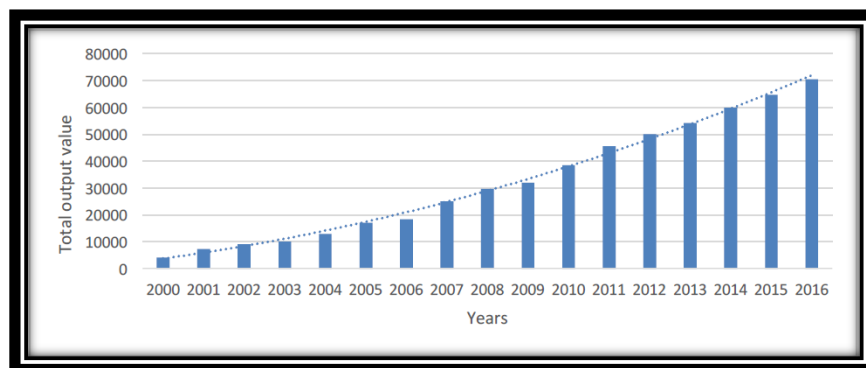


Figure 45 Value in units of 100 million RMBs of China’s “Oceanic Industry” from 2000 to 2016. Source: Ma, X., 2

(iv) Agriculture

From the period of 1970-1978, annual growth rate of agricultural GDP was at 2.7% and then shot up to 7.1% from the period of 1979 to 1984. From 1985 onwards, GDP fell into a value around 4%. The average from 1978-2014 was

4.6% (Huang and Yang, 120-121). This robust annual growth rate of 4% for agricultural GDP during the 'later reform' period from 1985-2014 was to be expected considering rising trends in both urbanization and population.

Unfortunately, Wenhui Chen from the School of Economics and Management at Beijing Forestry University found that the *added value* of Chinese agriculture fell from 28.19% in 1978 to 10.01% in 2013 (Chen, W., 651). Ruoxi Lu defines value-added agriculture as the “portfolio of agricultural practices that enable farmers to align with consumer preferences for agricultural or food products with form, space, time, identity, and quality characteristics that are not present in conventionally-produced raw agricultural commodities” (2). According to the World Bank, the value fell further to 8.556% in 2016. When agriculture falls below 10% of a nation’s economy, “the government needs to put more into agriculture to develop it” (CDRF, 292). Chen chronicles this in Figure 46 where, comparatively, the ‘added value’ of manufacturing seems to stay flat while the service industry rises.

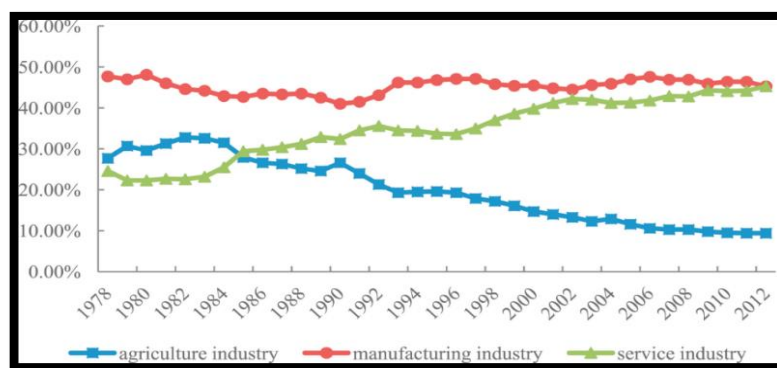


Figure 46 Added values from the period of 1978 – 2012 in China for the agricultural, manufacturing, and service industries Source: Chen, W., 651

China's rising service economy as seen in the figure above is consistent with the path of modernization theory as reflected by the nearly 80% service economy in the United States. The obvious downside of a subsequent rising middle class with disposable incomes is a desire to copy western patterns of consumption. Huang and Rozelle have found that urbanization and rising living standards have created seismic changes in agricultural production as reflected in "the demand for meats, fruits, and other non-staple food" (2). As seen in Figure 47, livestock output has increased from 14% to 35% as fishery product has quintupled. Despite the appearance of falling crop output, Huang and Rozelle observed that maize output is growing to maintain the rise of China's livestock production. By 2050, China is projected to spend 150 billion dollars importing meat.

	1970	1980	1985	1990	1995	2000	2005
Share in agricultural output							
Crop	82	76	69	65	58	56	51
Livestock	14	18	22	26	30	30	35
Fishery	2	2	3	5	8	11	10
Forestry	2	4	5	4	3	4	4

Figure 47 Percentage of the total agricultural economy for each product in China from the period of 1970- 2005 *Source: Huang, J., 2*

Blindly following western styles of consumption is problematic in a country with only 8% of the world's arable land (Chen, S., 105). When comparing Chinese and U.S. agriculture, Iowa State economics professor Wendong Zhang found Chinese agriculture "far more volatile" than the United States. Meanwhile, the expected migration of 100 million farm producers into cities as well as governmental preference of national food security over farmer support systems will only make this situation worse (1-2). Another example of this volatility are the

findings by Guo-Jing Yang that poor agricultural practices in China are part of a “vicious cycle” that leads to the outbreak of infectious diseases (404). A publication last year in *Global Food Security* by Jinxia Wang and Yangrong Li found that even without factoring in the significant impact of climate change, wheat and rice output will drop from 4-16% and 13-16% respectively in surveyed areas by 2030 (5). Wheat and rice are essential crops to achieve food security in China; at these projected levels of decline, the PRC’s “realization of the food security objective” will never be achieved (7).

(v) Natural Disasters

As cited previously, Xindong Du considers China to be one of the most vulnerable places across the globe to disasters. While Du acknowledges that disasters in China are subject to a “high variability and different changing trends” (396), a pattern emerges in Figure 48 where hail occurs in the northern and central parts of the country, frost in the southern parts, and typhoons along the southeast coast (396). There is some crossover with Huicong Jia’s research showing that areas of serious risk have increased greatly over time and have expanded into the northeast, northwest, and south (2034). Looking through the lens of social impacts, Zhou and Shi suggest that over the decades we have seen a shift in the social vulnerability to such disasters from the western and northern regions of the country to the areas along the east coast (633). While both authors acknowledge that “rapid population growth increases the vulnerability of developing countries” (619), the high social vulnerability of the eastern regions “may be ascribed to the combined effects of multiple factors”

(626). Some of these additional factors highlighted by the authors include age (children), rural character, development, and economic status (622-624).

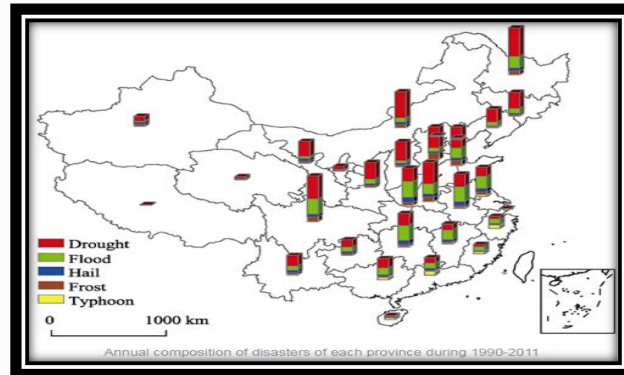


Figure 48 Spatial distribution of disaster types across all provinces in China. *Source: Du, X., 392*

Yi-ming Wei also recognizes that China is a country severely affected by disasters with a “high frequency and wide distribution” (642). Wei provided a compelling analysis of China’s disaster management readiness using the takeaways of the 2008 Wenchuan earthquake as a backdrop. Wei identified the high vulnerability of the Chinese economic system to natural disasters, particularly in lieu of the fact that disasters from 1989-2010 claimed (Figure 49) a full 2.5% of GDP annually (650, 652).

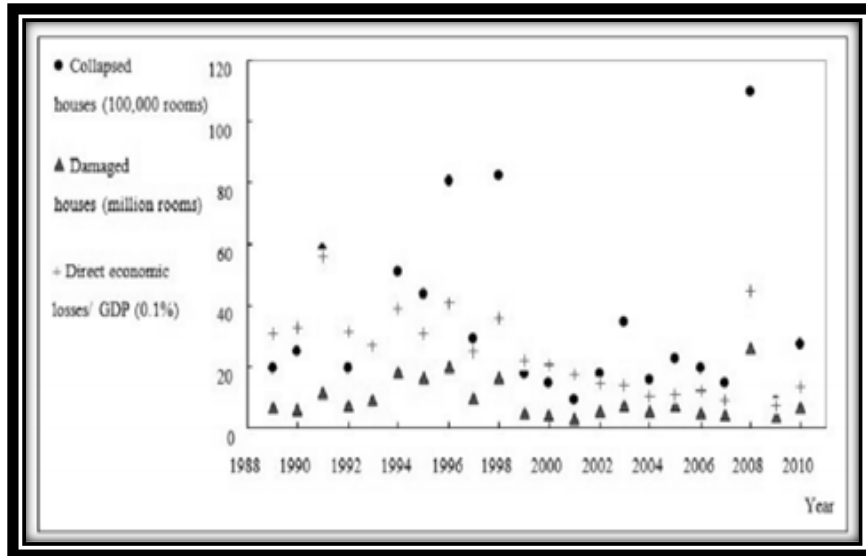


Figure 49 Economic loss as a proportion of annual GDP from natural disasters during the time-period of 1989-2010. Overall range moves from 0.7% to 5.6% with an average of 2.5% according to Wei. Source: Wei, Y. M., 650

Wei has been willing to acknowledge that China has made some efforts to create regulations and laws with respect to natural disasters. Examples cited by Wei include “Law of the People’s Republic of China on Protecting Against and Mitigating Earthquake Disasters”, the “Flood Control Law of the People’s Republic of China”, and the “Law of the People’s Republic of China on Safety in Mines” (660). However, the laws that do exist are only geared for single disaster types leaving Wei bemoaning the lack of any “systematic and comprehensive series of laws” (660). Such a series of laws would lend itself to an integrated disaster risk management scheme (INDRM) which is well overdue for China.

Quite a few other authors have investigated the economic impact of natural disasters in China. Jia reported that a yearly loss of 200 billion RMB has occurred in the last decade due to natural disasters (2024). Zhou and Shi’s examination of the period from 1990-2011 places the yearly loss at around 250 billion RMB (616). A publication by Yang Zhou in *Natural Hazards* truly highlights

the degree of economic loss from natural disasters. Some of the totals featured include the 22.3 billion dollars from the an ice storm in 2008, the 28.7 billion RMB lost each year from tropical cyclones making landfall from 1983-2006, the 20 billion dollars lost in the 1998 Yangtze River floods, and the aforementioned Wenchuan earthquake resulting in 100 billion dollars lost and 69,225 deaths (Zhou, Y., 2167).

Some authors have not only connected natural disasters to economic *loss*, but also to economic *development* as well. Zhou and Shi have found that Chinese economic development is more willing to invest in areas that are at high risk to natural disasters if those same areas offer higher productivity (633). Two standout examples of this are the cities of Shanghai and Beijing that make “more people and assets exposed to natural hazards leading to the increase of social vulnerability” (Zhou, Y., 2183).

(vi) Ecosystems

As mentioned at the end of section 1.5, China has some of the richest biodiversity on the planet. According to the United Nations Environmental Program, China is third in the entire world for “higher plant species”, contains 13.7% of the world’s vertebrate species, and “hundreds of endemic species” (22). Zhiyao Tang has described China as one of the “megabiodiversity” countries in the world (347). However, according to Hai Ren, this biodiversity has been “destroyed badly” (1). In an analysis conducted by Ren over ten years ago, the particular combination of factors impacting China’s ‘degraded ecosystem’ were

both “diverse and complicated” (11). Ren placed these factors into one of three sets: population pressures, industrial pressures, and market pressures.

The government’s treatment of ecosystem services is poorly lacking as are the fledgling attempts to create ‘payment for ecosystem service’ (PES) systems. An exhaustive analysis conducted last year by Hongqi Zhang found that insufficient consideration is being given to ecological functions by the PRC’s current land use system (122). Zhang boldly suggests a complete overhaul of the current system, proposing a new approach that is more mindful of ecosystem stewardship. This new system would use various combinations of the words ‘productive’, ‘ecology’, and ‘living’ to create a completely novel land use planning system, a prototype of which is seen in figure 50. Unfortunately, no efforts have been made to update the current, outmoded system with any of the progressive models suggested by researchers like Zhang.

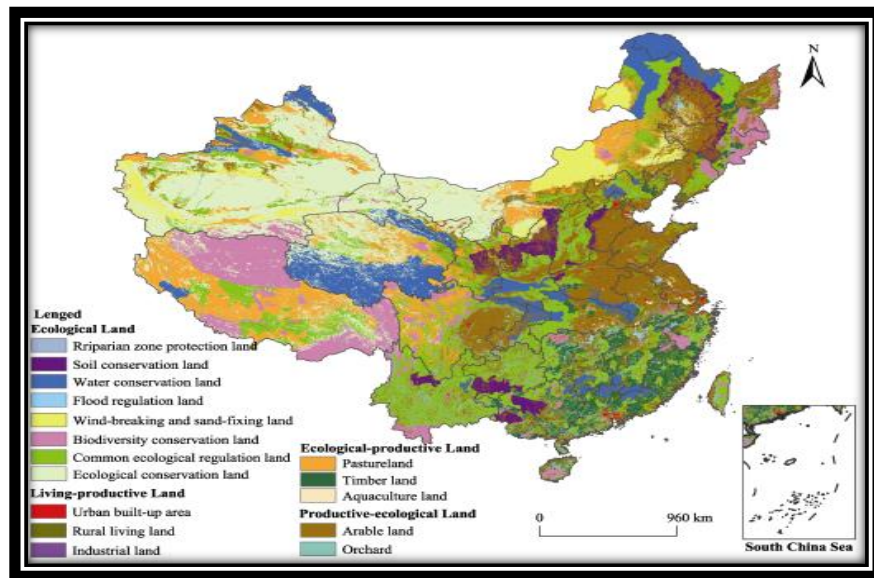


Figure 50 Zhang’s “ecological-living-productive” prototype to create new land use classification in China. *Source: Zhang, H., 127*

Writing for the *Chinese Geographic Service*, Jian Peng concluded that the current valuation of ecosystem services is ill-equipped to work across regional ecosystems and address sustainability issues. Peng identified this as a “supreme methodological shortcoming” (499). The University of Southampton’s Ke Zhang looked at the detrimental effect that attempts to reduce poverty through agricultural expansion has had on ecosystems. Zhang focused the study specifically on the Lower Yangtze River Basin and the progressive decline of ecosystem services since the 1970s. Despite the increase in provisional services (energy or material outputs), Zhang found that ecosystem regulating services continued to plummet as seen in figure 51.

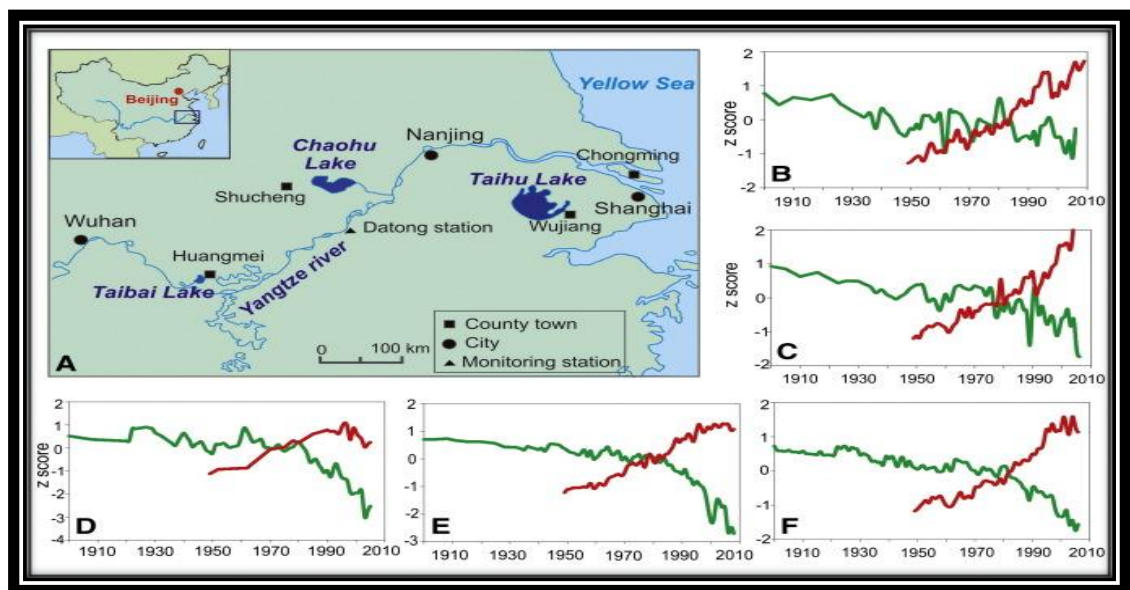


Figure 51 Provisional services (in red) and regulating services (in green) for the lower Yangtze River Basin over the past century Source: Zhang, K., 166

Zhang concluded that there was “no evidence” in sight for a possible turning point towards “improved environmental conditions” (169). The author does try to temper this rather unpropitious forecast by adding that the globalized nature of

agriculture could offset regional deterioration through imports. The upsurge of agricultural imports could provide a “potential transfer of ecological degradation through telecoupling” (169). In a separate study called “China farming boom has left ecosystems in danger of total collapse” by Zhang’s co-author John Dearing, Dearing urged that sustainable agriculture should be a major priority for national policy (1). A fascinating counterpoint raised by John Zinda appeared in a short article for *Science*. Zinda points out that an overly zealous system of ecosystem services in China could actually become an environmental justice issue. The unceremonious ejection of Tibetan herders for the sake of grassland protection was one example cited by Zinda to support his argument that poor residents would be sacrificed in order to provide ecosystem services for the growing urban elite (657). Under the auspices of “national ecologic security”, a grassland restoration program in Sanjiangyuan required the relocation of Tibetan shepherders to ramshackle settlements. This forced relocation has ushered in “health problems, unemployment, declines in living standards, and loss of Tibetan language and cultural practices” (658). While the importance of ecosystem services cannot be overstated, China still regards them as one of many “national-scale” improvements. Such improvements have always come at a “cost of environmental justice toward poor, marginalized, and ethnic minority communities” (657).

Much like Hongqi Zhang’s proposal for a new land use classification, Xingliang Pan proposes a much more effective “eco-compensation” system to update China’s current ‘payment for ecosystem services’ programs. The current

PES systems are not adaptable to changing dynamics such as continual migrations of rural residents into urban centers (205). Pan believes that conservation awareness for PES programs are undermined by overreliance on funding from the central government (206). Pan proposes a hybrid funding scheme which leans on the private sector and the market so PES systems won't be "weakened in the long term" (205).

(vii) Non-Renewable Resources

It is reasonable to say that an unofficial and rather comprehensive 'literature review' had already been conducted in the *Introduction* regarding coal, particularly in section 1.4. When it comes to China, all roads lead to coal. Does this mean that other forms of non-renewable energy such as oil, natural gas, and nuclear power have less bearing than coal when cultivating sensible policies for China's near-term future? Actually, yes. However, consideration of their collective impact (and ideal reduction in use) are essential. That said, they remain beyond the scope of this Capstone and will be given brief treatment in this section.

Dominic Barton's study for McKinsey & Company in 2013 revealed that China exceeded the United States in the total amount of oil imported (1). The demand for oil will rise considerably based on McKinsey & Company projections that by 2022, 75% of China's urban population will achieve middle class status (1). This socio-economic shift is directly proportional to a glut in car ownership and an unprecedented demand for oil. What remains to be seen is how the brutal eventualities of 'peak oil' will allow for the projected 400-600 million cars on the road in China by 2050.

The contrast between the use of natural gas and coal in China is stark. Consider the Shome statistic cited in the introduction that had 71% of China's energy coming from coal. A 2015 study by Xin Li revealed that natural gas was only responsible for a mere 6.2% of China's total energy mix, up from 2.2% in 2000 (4). In order to meet the progressive rhetoric and promises after the Paris summit, it is likely that the PRC will increase production of natural gas in order to shift from coal. However, attempts to recreate the United States' shale boom has not been successful, due to persistent infrastructure and policy shortcomings. Compared to the 82,000 drilled gas wells in the United States, China's current number is only 400, while most shale deposits are located far from the coastal areas that need them the most.

Lastly, there is nuclear power contributing only 2% to China's energy mix. Social instability brought on by unparalleled level of air pollution has compelled Beijing to consider increasing this percentage. There is a wide spread of forecasted percentages among policy papers when it comes to nuclear power and China. The 2017 British Petroleum energy report predicts a substantial 11% growth per year (39). Yican Wu conducted a cross-analysis of multiple public surveys to determine risk perception for nuclear power plants after the 2010 disaster in Fukushima. According to Wu, 72% of the Chinese public did not oppose the construction of new nuclear power plants (8) and that "Chinese participants have less knowledge about nuclear energy than OECD's counterparts and are excessively optimistic". Wu's cheerleading of nuclear development offered little by way of counterpoints and suggested a clear bias. It

should be noted that Wu is a member of the “Institute of Nuclear Energy Safety Technology” whose motto from the INEST website is “better nuclear technology, better life”.

(viii) Significant Weather Events and Overall Air Quality

The *Introduction* has already illustrated for the reader just how hyper-disastrous China’s air quality truly is. What we are seeing is the logical outcome of a coal-fired economy that has struggled to maintain staggering production rates of energy, cement, steel, and vehicles as cited by Xing in section 1.3(a). Shuxiao Wang identifies some of the same factors as Xing and suggests that their rates will only grow more severe with the expected economic growth over the next ten to fifteen years. The end result will be even more “increases in multiple pollutant emissions” (Wang, S., 2). Industrialization and urbanization remain the greatest drivers of these rates. According to Chuanglin Fang from the Chinese Academy of Sciences, rates of urbanization had already reached 56.1% of the population by 2015 compared to 17.9% in 1978 (15571). Fang used 2014 emission data from 243 cities and concluded that urbanization trends will continue unabated for the next thirty years with the “conflict” between urbanization and the atmospheric environment continuing “for the foreseeable future” (15571). This “conflict” will not only continue to rob people of productive, long lives but also a sizeable portion of GDP. In 2005, ozone and particulate matter claimed 5% of GDP at 112 billion dollars. According to Fang, air pollution currently exacts a cost equivalent to 6.5% of GDP. Harvard’s Francesca Domenici concluded that Beijing is one of the most polluted cities in the world

(2101). Domenici found that $PM_{2.5}$ levels averaged around $100\mu g/m^3$ during 2010 and 2011. For reference, $100\mu g/m^3$ is ten times higher than acceptable levels as determined by the World Health Organization ($10\mu g/m^3$) and eight times higher than the acceptable air quality standard in the United States ($15\mu g/m^3$). As Ernest Tambo reports, $PM_{2.5}$ rightfully demands more attention than particulate matter of other diameters because “a build-up of $PM_{2.5}$ in the lungs has been associated with respiratory and cardiovascular illnesses, soft tissues and mental damages as major public health concern and burden among the most vulnerable elderly and children population” (155). One shocking figure provided by Domenici that compared $PM_{2.5}$ levels in Beijing before, during, and after the 2008 Olympics was noted by my professor during a 2017 independent study (Figure 52).

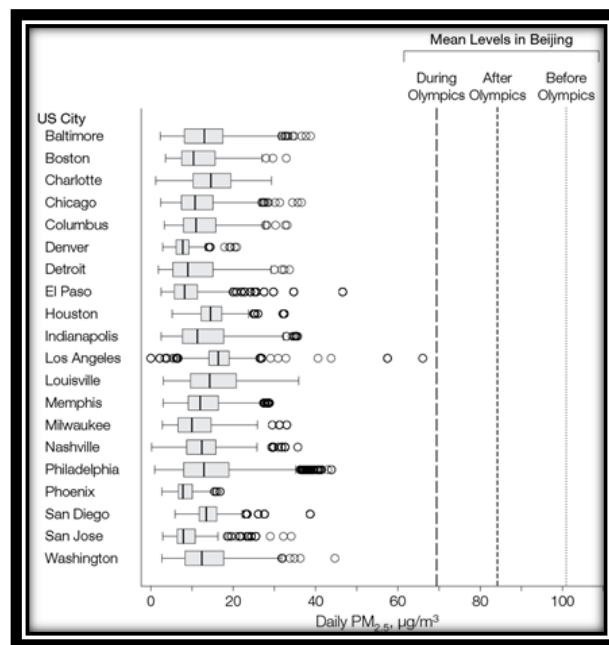


Figure 52 Comparing $PM_{2.5}$ levels in Beijing before, during, and after the 2008 Olympics to levels in major U.S. cities. Source: Domenici, 2101

Both Xue Qiao (1, 9) and Shuxiao Wang (6) have criticized China's "National Ambient Air Quality Standards" as a more watered-down version of the more rigorous guidelines established by the World Health Organization. As Qiao observed, while China has lifted the AQL (Air Quality Levels) template from the United States, "the concentration breakpoints are weaker" (9). PM_{2.5} levels were not even included in PRC air quality ratings until 2012 with the "Standards and Rules on the Standard for Compulsory Retirement of Motor Vehicles". While certainly late in the game, Lu Feng acknowledged that this new set of standards in 2012 was a "significant step directly toward prevention and control of PM_{2.5}" (1553).

While not commanding as much of an economic toll as air pollution, Jun Shi has found that extreme weather events have resulted in a loss of GDP between 3-5% (1) since 1990. Jun Yang, from the National Institute for Communicable Disease Control and Prevention, determined that the most catastrophic weather events were "dust haze" incidents. These incidents had a sizeable influence on mortality risk in urban centers (19). Shi also utilized temperature data from over 604 weather stations and concluded that from 1959 to 2014 the number of cold days have experienced a "significant decrease" (10) from 1959 to 2014. Shi also found a "rapid increase" of hot days from 1996-2014 (10) with hot weather events increasing since 1959. Overall, average annual temperature in China has increased by 1.38°C from 1951 to 2009. Looking toward the future, Ji-kun Huang suggested that by the end of the 21st century, temperatures will increase by 2.5-4.6°C (677).

Several authors have recognized both flooding and drought as significant weather threats throughout mainland China. Research by Jing Dai has observed that flooding in southern and western China has increased sevenfold since the 1950s (311). Ji-kun Huang also noted that the amount of cropland impacted by flooding since the 1950s has gone from 7.4 to 11.2 million hectares (678) while cropland impacted by drought has gone from 11.6 to 25.1 million. The loss of cropland to drought specifically resulted in a yearly grain production loss of “more than 27 million” tons in China (678). Maastricht University’s Li Wang analyzed the toll from flood disasters in 2008 alone and found that 171 people had died, 27.7 million RMB as well as 133,900 homes were lost, and over “20 provinces, autonomous regions, and municipalities were hit by flood disasters” (60). Wang also observed that extreme weather events have increased the incidence of infectious diseases like malaria and schistosomiasis near the Yangtze River Basin and select areas in southern China (60). Wang’s assessment of the current emergency response system used by the Chinese government reveals a familiar pattern of poor management due to being “still a highly traditional top-down system” (65) that “lacks a multidisciplinary approach” (66). A publication by Edoardo Bucchignani in the *International Journal of Climatology* suggests that extreme weather events will only get worse in the future. Using climate projection models to the period of 2041-2070, Bucchignani and his colleagues found that there will be increases in both extreme precipitation events and minimum and maximum temperatures with southeast China “particularly affected” (1592).

(ix) Current Status of Renewable Energy

Writing for *Energy Policy*, Zhen-Yu Zhao reported that by 2014, China led the world in both new and cumulative installed wind capacity (465). Estimates vary regarding China's wind capacity, though all estimates indicate a formidable untapped potential. Zhao estimates the total capacity of China's offshore and onshore wind resources to be 2000 gigawatts and 23,800 gigawatts respectively. However, Yi Feng observed that the total "*technically exploitable*" offshore and onshore capacities are 600 GW and 1400 GW (848); Xiaoli Zhao reported 500 GW and 2600 GW (270) in 2016. According to the International Energy Agency in 2016, China also leads the world in annual installed (34.5 gigawatts) and cumulative installed (78.1 gigawatts) PV capacity.

However, major challenges thwart the continued expansion of wind and solar power in China. In the case of the photovoltaic industry, Honghang Sun identified some of these challenges as "international trade conflicts and market competition as well as domestic problems such as vicious competition between enterprises, financial issues such as loan-withdrawing and stint loans by banks, and business triangle-debts" (1). Another major issue covered extensively in the literature is the phenomenon of 'overcapacity'. In a fragmented bureaucracy, local governments take unbridled liberties to generate economic growth at all costs. The direct consequence is the issue of overcapacity, one of the major problems associated with both China's wind and solar industries. Overproduction of inferior product not only resulted in PV production reaching 43 gigawatts at the end of 2015, but, according to Chun Yu (Jonathan) Poon, also resulted in produced capacity outnumbering global need by 35 gigawatts per year (1). Yet another issue that is

just as problematic as overcapacity is that of curtailment. David Xu found that in 2009 only one-third of generated wind power was actually transferred successfully to the grid (2). Zhen-Yu Zhao blames wind curtailment for the fact that only 2.6% of China's electricity comes from wind (465). Overproduction of wind power continues to be out-of-sync with infrastructure challenges. Among these challenges include the need for a comprehensive ultra-high voltage (UHV) power-line system across the mainland to transfer the energy from wind resources of north-west China to areas in eastern and central China that make up "75% of electricity needs" (Zhao, Z., 471).

China's dominance in hydroelectric power is well established. Xingcai Liu, hailing from the Institute of Geographical Sciences and Natural Resources Research at the Chinese Academy of Sciences, reported that China achieved the highest absolute growth in hydropower since 1990, growing 11% per year in the last decade to 248 gigawatts in 2012 (1). 17% of China's entire electricity production and 80% of China's renewable energy comes from hydropower (1). Yuyu Zhou from the Pacific Northwest National Laboratory estimated China's hydropower potential to be second only to Russia in 2015 at 2329 Terawatts (Figure 53).

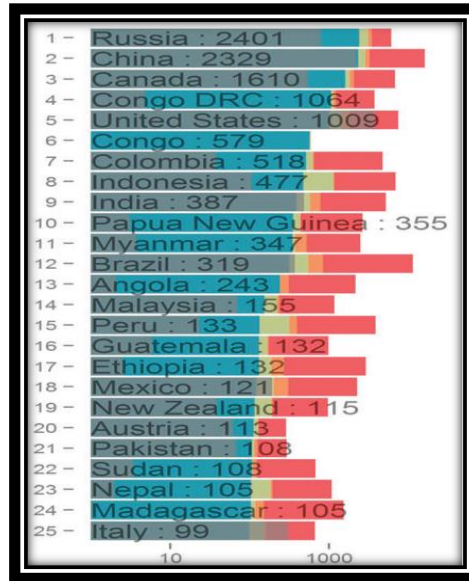


Figure 53 Hydropower potential of countries given in terawatts. This is a sample of the first 25 countries in a figure by Zhou featuring 100 countries.
 Source: Zhou Y., 2627

Other forms of renewable energy do not approach the sheer magnitude of hydropower and are in nascent stages of development. Plans by the PRC to triple geothermal production by 2020 will only result in a 1.5% share of the total energy mix. A brief but superlative article in the *China Economic Review* by Matthew Nitkoski shows that the dependence on geothermal on the right hydrology and optimal heat flow makes it very location-dependent. Consequently, most of the high-temperature geothermal heat seem to be restricted to the area of southern Tibet as seen in Figure 54.

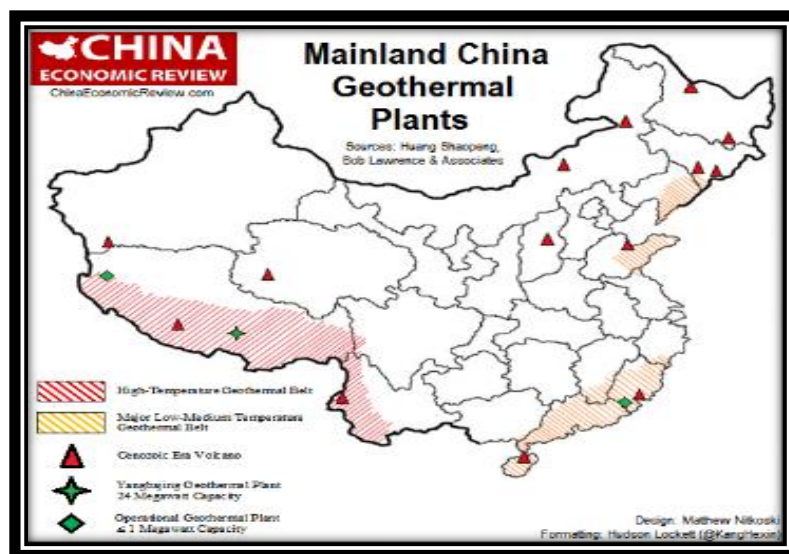


Figure 54 Map of China showing the high temperature geothermal belt near southern Tibet. Source: Nitowski (no page number)

Finally, regarding biomass, China's National Energy Administration reports that total biomass resources amount to 500 million *tons of coal equivalent*. Unfortunately, X. Jin Yang found that only 4.82% of biomass resources are currently used in China (86).

III. Methodology

3.1 The Author's Approach

3.1(a) Collecting the Most Current Research

I have purposely kept the scope of this Capstone as broad as possible in an attempt to emulate the multi-sectoral approach found in policy reports and books. This required me to amass a sizeable amount of research that not only covers China's environment, but also covers related governmental, economic, and social factors. In my estimation, inclusion of *all* of these factors provides the only

pathway that allows for confident recommendations and solutions. Academic papers covering a very singular aspect of China's environmental woes (say, PCB levels in birds found in northern China) may offer little by way of problem solving across various sectors and disciplines. For instance, you may hear little from the authors about how this epidemic traces to the "fragmented bureaucracy" of governmental enforcement bureaus. However, during previous academic work in 2011, I became familiar with extended policy reports from management consulting groups such as McKinsey & Company. I found it compelling that governmental officials and major institutions around the world actually deferred to the predictions of these publications. As mentioned in the proposal, the goal of this Capstone project is to aspire to the same predictive rigor achieved by these policy reports. Such reports are ambitious affairs, sometimes in excess of one hundred pages, calling on research from several authors and organizations in order to assess external influences across *many* factors. This provides the reader with an informed intuition as to where political, social, and economic trends appear to be shifting, and ultimately what this may mean for an environment on the brink.

Replicating this approach for my Capstone required a consumption of a vast amount of information as well as a crusade to find all the points of intersection linking this information in order to support the overall narrative. There were times that I would sit for hours feeling overwhelmed and at a loss as to how to get started. However, as an intellectual exercise, I found this challenge appealing. Could I distill countless academic papers down to only those essential points that

will support my multi-sectoral approach? This was accomplished, in part, through a rather primitive, but effective approach that will be detailed in the next section, *Organizing and Grouping the Most Current Research*.

In terms of the acquisition of current articles, previous academic work by way of an independent study already provided me with over one hundred articles, quite a few of which had been released during that year (2017). Since my weekly briefs broke down the political, social, and economic factors in their explication of China's environment, I also had an excellent starting point for my multi-sectoral approach. The weekly briefs and final SWOT analysis produced during this study has even been featured by the Haverford School and is available for download (see: "Science: Faculty Research" at <https://www.haverford.org/about-us/news-publications/school-magazine/haverford-school-today-winter-2018>). Combined with articles I read about China for previous academic work in two additional classes, I possessed an enviable collection of some of the latest research on China's environment, stored in three towering boxes in my living room.

I spent the spring semester at the Haverford School revisiting many of these articles, and even created a unit in my own course requiring my students to read the briefs and final SWOT paper I wrote during an independent study over the summer and report back to me. This also re-familiarized myself with some of the notable authors and standout papers. However, as mentioned in my proposal, China is in such constant flux that *new* research published even within the last year has the potential of radically altering the final recommendations made by this Capstone. I began hunting for articles published within the last year

regarding China's environment as well as articles covering influential factors not considered before. For example, the potential of the "One Belt One Road" initiative to upend many of China's environmental vows in the wake of the Paris summit should have been addressed by me at some point during the 2017 independent study, but wasn't. Interestingly enough, it was one of my students that brought it to my attention in my Environmental Ethics class; his father works on investment strategies associated with the OBOR, tracking both price and yield performances on the stock market.

Acquiring academic papers for my Capstone published during the period of 2017-2018 relied almost solely on Google Scholar. Google Scholar has kept me in good stead since my start in the MES program in 2010. No other search engine comes close in terms of the relevant breadth and quality of academic papers made available. Google Scholar certainly has its weaknesses. However, years of use courtesy of my MES courses has allowed me to anticipate some of these shortcomings when conducting my research surveys. I might add that these shortcomings are minor quibbles at best. Joost DeWinter observes that a weakness of Google Scholar is "that it has a broad definition of 'scholarly'" (15). I do not entirely agree with this assessment, although there has been a few times when DeWinter's observation rings true. In my own experience, Google Scholar occasionally features Master's Theses from graduate students interspersed with academic papers from established publications. Additionally, Google Scholar's 'cite' function is extremely useful and allows the reader to pick their format of choice for the citation. However, sometimes part of the citation is missing while

the listing of incorrect page numbers occurs quite often. I usually remedy this by filling in the rest of the citation myself or counting the pages back to provide a page range that conforms to the actual numbering of the publication.

Using Google Scholar consistently over my eight years in the program, I have noticed how more and more links are beginning to appear on the right of each article in the lists provided, allowing the option for a free download. This has been a reassuring trend to observe, as all knowledge should be disseminated freely. As of 2018, quite a few articles still require subscriptions, which I have always circumvented by using Google Scholar through Penn library. Admittedly, the new system introduced by the library in the last year or so has created a slightly more convoluted alternative to the old system of simply logging in to Penn InTouch and conducting a search in Google Scholar. However, previous course work addressing professional communication strategies taught me the functionality of *ArticlesPlus*, which has reliably provided me with access to any article imaginable, ranging from the game-changing to the recondite.

a. *Organizing and Grouping the Most Current Research*

The sheer number of articles consulted for this Capstone can be seen in Figure 55 (this picture does not include all of them). As outlined in my *Proposal*, a system must be devised to allow relevant articles to be grouped by related systems and factors (e.g., economic, political, social, cultural, etc.) and/or environmental issues (e.g., air quality, agriculture, water scarcity, climate change, etc.). The simple organizational system of using a yellow stick-it note placed on the front page of each article to summarize key items of interest including page

numbers was employed in previous academic work for multiple courses. The *Proposal* provides the reader with pictures of this system being utilized in two of the three aforementioned classes. Figures 56 and 57 show this same system applied to some off the articles collected for this Capstone during the spring of 2018. Figures 58 and 59 reveal some of the typical content on the yellow notes. Observe the boxing around general themes such as ‘government/regulation’ and ‘OBOR’ in order to allow for quick grouping of related papers, an extra touch that became very helpful long-term.

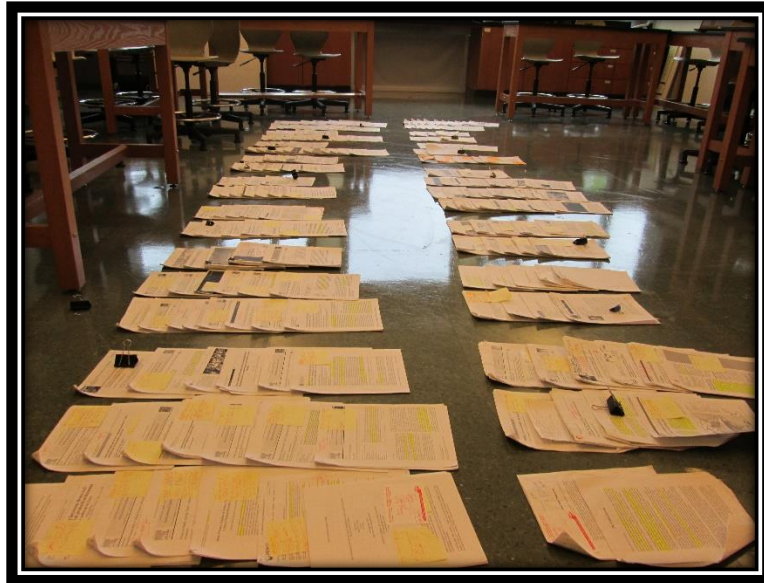


Figure 55 The reason why a robust organizing and grouping scheme is needed. The top deck features environmental publications used both for this Capstone and for my 2017 independent study. The bottom deck includes government and economic-themed papers read over the course of this year in preparation for the Capstone. *Source: picture taken in a Haverford School classroom.*

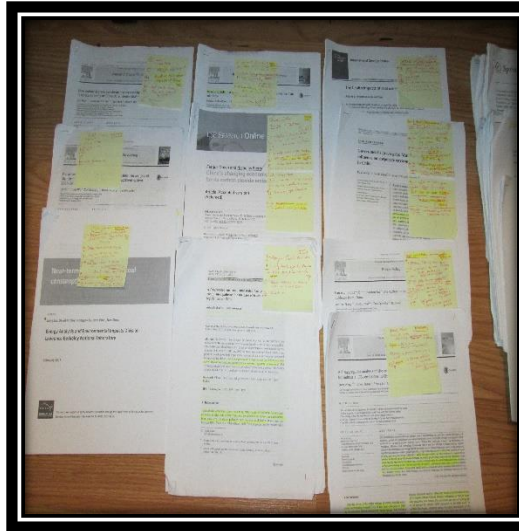


Figure 56 Sorting system applied to a sample of academic papers collected from 2017-2018

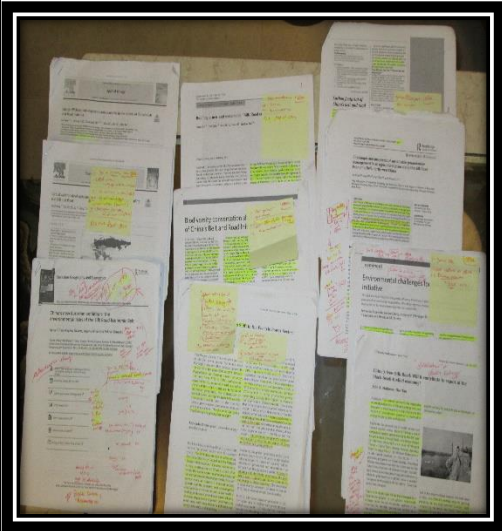


Figure 57 A sample of the academic papers covering the One Belt One Road, subject to the same system.

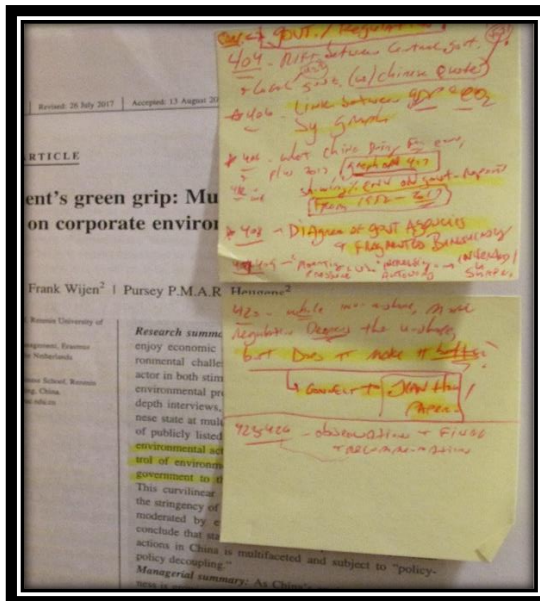


Figure 58 Content of yellow stick-it notes showing page numbers of note, with highlighting for particularly useful sections.

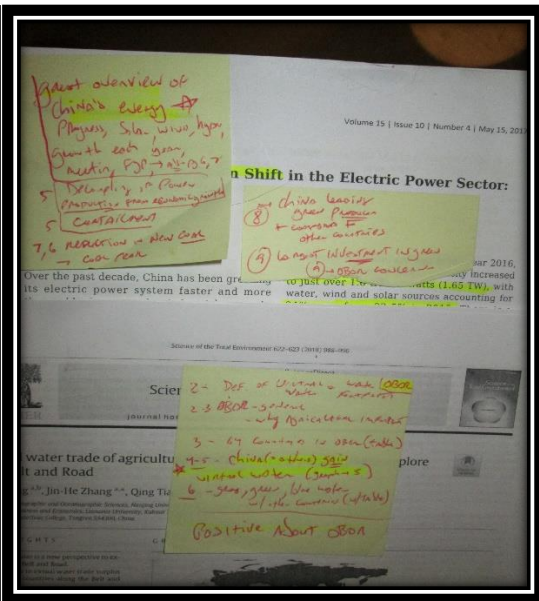


Figure 59 Yellow stick-it note on a paper covering the OBOR initiative. Notice the boxing around "OBOR" (and boxing around 'govt/regulations' in previous figure). This method allowed for quick grouping.

Additional methods for organizing and grouping were employed during the creation of the *Introduction* section. In writing section 1.3 (20th Century China:

Rising Environmental Laws to Address Rising Environmental Challenges), many of the academic papers were painstakingly revisited for references to Chinese environmental legislation *pre-2000*. Fortunately, the yellow stick-it notes had indicated which articles made mention of any semblance of environmental law regardless of context. Electronic copies of the pre-existing hardcopies were re-accessed which allowed blocks of text that broached the subject of legislation to be copied and pasted into a Word document. Again, only environmental laws enacted before the start of the millennium were used; post-2000 environmental laws are relegated to latter Capstone sections for dissection and analysis. Some (but not all) of the collected passages from various articles can be seen in Figure 60. A red marker was then used to construct a chronology and link texts from different publications based on theme. A sample of this approach can be seen in Figure 61. Once a workable timeline emerged, I was able to craft my own narrative for part 1.3, supported by research from several authors working in concert.

During the creation of section 1.4 (*China's 21st Century Coal-Fired Economy*), a technique similar to the yellow stick-it notes was used in order to provide a quick reference guide to bundled stacks of academic papers. As can be seen in Figure 62, 4 x 6 note cards affixed to each stack immediately revealed which papers in the stack contained *any* useable reference to coal-use in China. A system of circled numbers used on each line of the card contained a short summary. These circled numbers were then written in red marker on the corner of the corresponding papers. Once time was spent thinking about how the

narrative would unfold in section 1.4, papers were excised and quoted at each stage of the writing process courtesy of this organizational system in order to tell the complete story. A closer look at the typical content of one such 4 x 6 card can be seen in Figure 62.

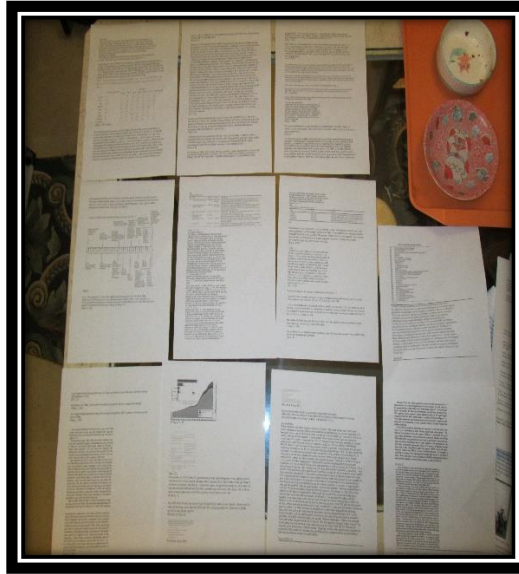


Figure 60 A sample of pages from the Word document containing all relevant passages from the literature covering pre-2000 environmental laws in China.

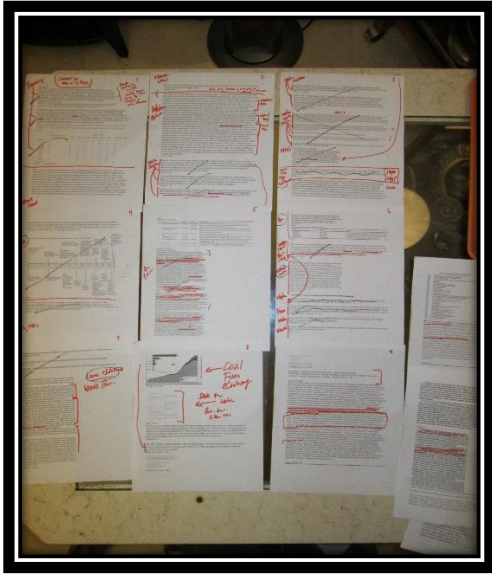


Figure 61 Using a red marker, passages were linked together in terms of similarity in content and time period.

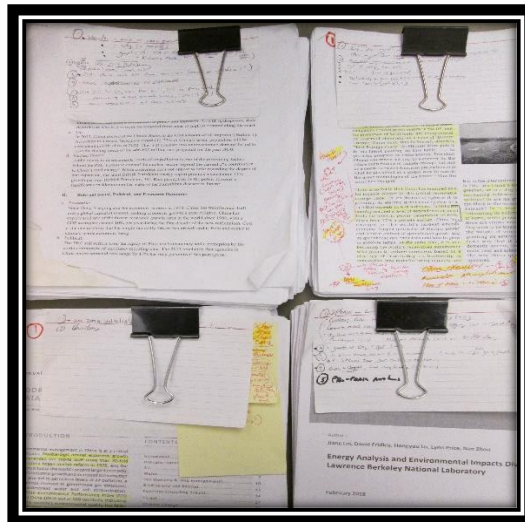


Figure 62 4x6 cards were used to locate all papers contained in each stack that make reference to coal use.

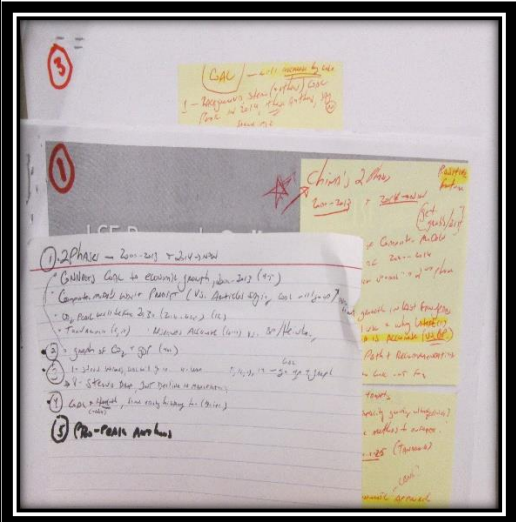


Figure 63 A closer look at the 4x6 cards shows a system of circled numbers allowing quick access to related articles.

3.2 *The Author's Design*

3.2(a) *Using the Term "Wicked Problem" For a Multi-Sectoral Approach*

While mentioned previously, one source of information warrants revisiting here due to its essentiality. The nine briefs written during a 2017 independent study provided me with an indispensable feedstock for the "environmental" part of my literature review. This part of the review was separated into two distinct subsections, one covering climate change (2.3a) with the other covering the nine environmental subject areas originally delineated for the briefs (2.3b). This required me to first extract all mention of climate change from each of my nine briefs and combine them into one interlinking narrative for section 2.3a. The briefs then became a perfect source of information for the second part of the literature review entitled *General Environmental Impacts*. There were also many compelling facts that were initially moved to the 'endnotes' of my original briefs. I chose to combine these with the information appearing in the body of the briefs when putting together my total review. Unlike the original briefs, I gave a more formal treatment when citing authors for the *Literature Review* of my Capstone. I researched each author in order to provide full names and quite often included associated institutions. What emerged was a very comprehensive literature review of China's environmental challenges.

The inception of the term 'wicked problem' starting with Rittel and Webber's landmark 1973 paper has been covered at the tail-end of section 1.1 of the *Introduction*. The applicability of the term to this Capstone was also explored

in this section as well. However, the choice to integrate the term into the title of this Capstone as a strategy for justifying a multi-sectoral approach needs further development in the *Methodology* section. Despite its cache in the fields of sociology and psychology, the concept of a 'wicked problem' continues to make inroads into the environmental field as an appropriate descriptor. As Stephen Howes points out, wicked problems are "dynamic, complex, encompasses many issues and stakeholders, and evade straightforward, lasting solutions". For this reason, the term is ideally suited within the context of environmental issues. Columbia's Ruth DeFries applied the term to ecosystem management, suggesting that the advent of the 21st century marked a period of "increased wickedness" for ecosystem management (2). It should be no surprise that climate change is often described through the lens of a wicked problem. University of Minnesota's Jim Perry describes the 'wicked' nature of implementing effective climate change adaptation at World Heritage sites due to both "the insidious nature of climate change and by weak governance" (8). Marshall Kreuter also labels public environmental health problems as "wicked" due to involvement of multiple stakeholders, a fact revealed in Figure 64. Finally, the aforementioned Howes' analysis of wicked problems throughout Asia includes groundwater loss in India, deforestation in Indonesia, and hydropower issues in the Lower Mekong Delta. For policy makers, Hughes acknowledges that wicked problems do not "stand still" and present a "moving and changing target" which resists any hope of a full resolution (31).

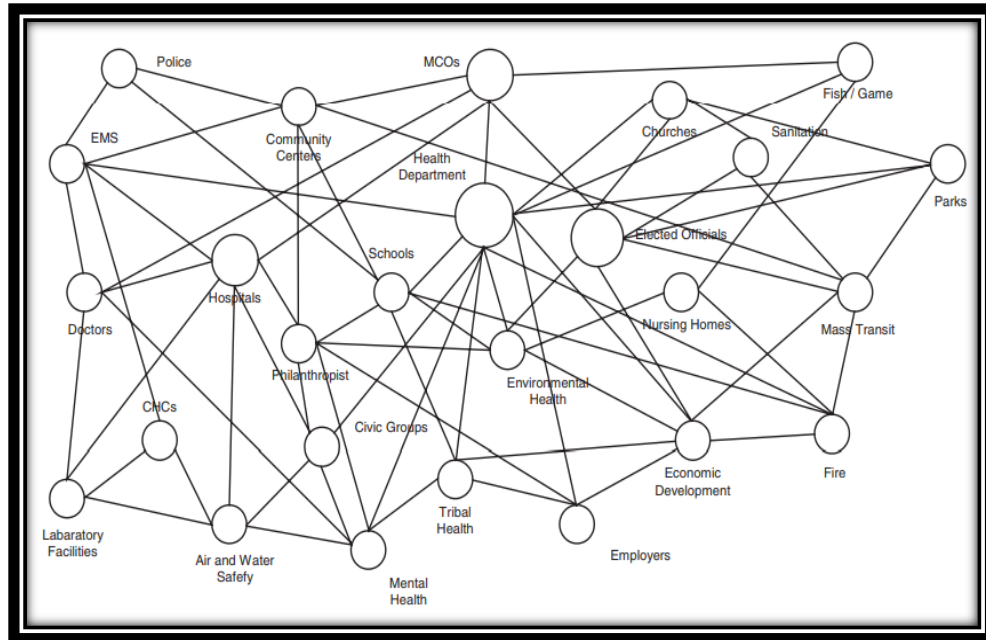


Figure 64 All of the multiple stakeholders and players associated with the public health system.
 Source: Kreuter, M.W., 442

3.2(b) Defense of the Design: Justifying a Multi-Sectoral Approach and Applying the “Wicked Problem” Label to This Approach

The kind of “ecological modernization” that is essential for China to achieve requires a restructuring of modern institutions to follow environmental interests (Mol, 1). According to Arthur Mol, cultural, political, and economic institutions will not be understood without linkages to environmental “logics and perspectives”. Studies of ecological modernization invariably include political modernization, economic and market dynamics, and the development of a civil society (5). Herein lies the need for the implementation of the multi-sectoral approach in the sections to follow in this Capstone. As Howes points out, all of the aforementioned sections share an “interdependency” with each other. Introducing a new environmental policy sends ripples across multiple sectors due to a “combination of competing interests and the multi-faceted linkages between

them” (32). Indeed, “any solution will impact or involve all these groups, and, for a single group, potentially in counteracting ways” (32).

Howes is correct by observing that this places any policymaker in a rather “unenviable position” as every solution seems to invoke the need for a new set of strategies on the next level, *ad nauseam*. For this reason, the term “wicked problem” is adopted in this Capstone since its invocation, by default, necessitates a consideration of multiple factors and players. No other approach will solve China’s environmental crisis due to its multitude of interlinkages. Labeling the crisis as a wicked problem in the title acclimatizes the reader to the author’s approach from the very beginning. Howes states that for any policy-oriented attempt to deal with Asia’s major environmental challenges, “the ‘wicked’ difficulties of finding a desirable solution set are self-evident” (33). It should be noted that the Howes paper was encountered *after* I committed to using this term; this leads me to believe that I am on the right track.

China’s environment is very similar to Kreuter’s assessment of public health. Both issues are “uniquely defined by its history and culture, values, and social, economic, and political circumstances” (444). The onus is therefore on researchers to “realize that problem solving is as much a social and political process as it is a scientific endeavor” (441). If there is any hope of delivering China from a flurry of environmental tipping points, we must treat the problem as a wicked one. There is absolutely nothing ‘tame’ about China’s problem, no singular set of solutions that will work. Authors like Kreuter would give their imprimatur to the approach of this Capstone by recognizing that “wicked

problems are best resolved through a planned process with input from multiple sources” (448).

3.2(c) Importance of Integrating Scenario-Building

Coursework encountered by the author in 2011 introduced students to the idea of scenario building (see *Maley, 2011*). Students were required to blend this process into their final papers, providing them the opportunity to not only make informed predictions but to exercise their creativity. My paper addressed China’s coal use. However, unlike this Capstone, my final paper did not make use of a multi-sectoral approach, attempt a comparable degree of breadth, or a policy-report stylization. The three scenarios presented in 2011 involves an economic growth at all costs scenario (worst), a business as usual scenario (medium), and a ‘green revolution’ (best). The worst scenario led to chilling endpoints involving water wars with neighboring countries and untenable degrees of social unrest. Ultimately, “further social and environmental costs therefore lead to economic collapse for China as it reverts to a third-world country” (Maley, 16). Scenario building will be also used in this Capstone, with the same three-tiered outcomes explored. Scenario building will be a useful exercise by merit of its ability to tie together all the sectors under consideration. Much like a “SWOT Matrix”, scenario building will allow the reader to spot intersectionality and cross-pollination between all of China’s many economic, social, political, and environmental factors.

“Wicked problems” are rife with uncertainty. According to Dalhousie University’s Peter Duinker, scenario planning is a “powerful tool for asking ‘what

if' question to explore the consequences of uncertainty" (209). If done correctly, my scenario planning should conform to Duinker's description of "describing images of the future that challenge current assumptions and broaden perspective" (210). Axel Volkerly also recognizes the power of scenario planning to help policymakers deal with "deep uncertainties" when setting future strategies. Scenario building is an appropriate choice when dealing with wicked problems like China's environment, or any mosaic of "difficult to predict factors beyond their control" (1198). In Jay Alcamo's book *Environmental Futures: The Practice of Environmental Scenario Analysis*, scenario planning has a history tracing back to World War II with the advent of environmental scenario planning having roots in the revelatory *Limits to Growth* study in 1972 (3). Alcamo's list of advantages for effective scenario planning reveals why this approach is ideal for China's wicked environmental problems. According to Alcamo, scenario planning provides an "interdisciplinary framework for analyzing complex environmental problems and envisioning solutions to these problems" (3). Scenario planning also "can be helpful for organizing and communicating large amounts of complex information about the future evolution of an environmental problem" (4). The author of this Capstone is eager to apply this technique in his quest to arrive at realistic, workable solutions.

IV. Analysis & Discussion

4.1 Rays of Hope and Reasons for Cautious Optimism in the New Millennium

4.1(a) Social Stability and China's Five Year Plans

The United States' historic approach to solving our persistent domestic problems is to declare "war" on them, from Lyndon Johnson's "War on Poverty" and "War on Crime" to Nixon's "War on Drugs". It would appear that China has co-opted our "war" rhetoric when addressing their most pressing domestic issue. Standing in front of the 3000 members of the yearly parliamentary meeting, Chinese Premier Li Keqiang declared "war" on pollution in 2014, a resolution that arrived a full year after Xi Jinping's call to strengthen the "ecological civilization" first invoked by the 17th National People's Congress in 2007. However, the use of military rhetoric is where the similarity ends when comparing Chinese governance with the United States. Much like the authoritarian regimes found in countries like Chad, Syria, and Tajikistan, China's unique form of authoritarian capitalism has one overriding concern as shared by the other three: an overarching need for social control. This need is a direct response to the consequences of Chinese authoritarian capitalism. Laurence Ma defines authoritarian capitalism as a "coalition of political, economic, and intellectual elites working at the top levels of the state" that have caused "serious social inequality" despite bringing "remarkable economic benefits to the nation" (2). Ma suggests that the "long-term sustainability of China's authoritarian capitalism hinges on the ability of the nation to reduce inequality and improve environmental conditions" (2). The rising tide of protests ("mass incidents" as described by the PRC), mostly over environmental issues, surpassed 180,000 in 2010 alone (Tracy, 63). The need to maintain social control may very well be the single driving factor compelling party leaders to rebrand China from economic

behemoth to “ecological civilization”. Among Xi Jinping’s list of “14 principles” during the 19th Communist Party Congress in October of 2017, he described policies that actively focus on “ensuring harmony between humankind and nature”. In 2019, it is hard to imagine any establishment politician in the United States, regardless of party affiliation, making such a statement; proposals like the “Green New Deal” only find support among an embattled and highly marginalized group of “progressive” representatives.

It is important to recognize that Jinping’s words are far from empty rhetoric, driven as they are by party fear of losing social order over the current environmental fallout. Poorly understood by western critics, this need for order has deep roots in Confucianism. As Dean Rojek observes, “This system of social control is intensely proactive; that is, it does not wait for the individual to violate a norm but rather seeks compliance by inculcating powerful forces of internal social control and encouraging strong community pressure and coercion” (143). During my efforts to “reach out to experts in the field” for previous academic work, I maintained a brief correspondence with Jack Fitzgerald, Senior Analyst at the United States Environmental Protection Agency, who stated:

“Chinese officials have two overarching objectives – economic development and social stability. The latter objective has profound implications for the former”. (Maley, 2011, 13)

Fitzgerald continues addressing the issue of social stability, seen in the context of, at the time of the correspondence, China’s 12th Five Year Plan:

“For example, their new 5 year plan (2011-2015) reflects an understanding that the benefits of economic development must be more widely diffused throughout the society for stability to be maintained. Similarly, the national leadership understands that relatively dirty energy development will ultimately contribute to social unrest domestically

and increased tensions internationally. Consequently, the leadership is committed to achieving the maximum amount of clean and efficient energy use as is consistent with an economy that is growing sufficiently to provide increasing per capita wealth and employment. As a group, senior Chinese officialdom takes the long view and sees energy efficiency and environmental quality as essential to a wealthy and stable society.” (Maley, 2011, 13)

Based on the Five-Year Plans started under Stalin in the Soviet Union in 1928, China’s first Five-Year Plan was drafted under Mao in 1953, providing a metric for economic and social targets. Five-year plans tend to be strictly followed with the evaluation of party officials hanging in the balance. A 2015 article by Celia Hutton for the BBC’s *China* blog speaks to the almost obsessive need to reach target values set by the current FYP, where wider objectives tend to be “thrown out the window in order to achieve an obscure data point”^{xi}. Tsinghua University’s An-Gang Hu describes China’s Five-Year plans as “one of the most significant national policy tools in China” which is “vital for propelling the management and implementation of the nation” (223). It would therefore be reasonable to suggest that the appearance of environmental goals within the absolutist framework of China’s FYPs may be the only true sign of significant policy redirection. Hu goes so far to suggest that the increased focus on the environment within the four most recent FYPs is responsible for China becoming “a pioneer in green development and the biggest green energy country in the world” (227). Tables created during an independent study in 2017 compiled the appearance of environmental goals in the four most recent FYPs. These tables can be found in Appendix A (goals appearing for the 10th, 11th, and 12th FYPs) as well as in Appendix B (goals appearing in the most recent 13th FYP). The increasing appearance of concrete environmental benchmarks moving through

the four FYPs is dramatic, as a perusal of Appendix A and B reveals. The difference between the profoundly ambitious goals of the current FYP compared to the call for the “greening” of urban areas in the 10th FYP is something of an astronomical leap. As of the writing of this thesis, the goals of the 13th FYP must be met within the next two years. How likely is it that China’s can meet all of the goals outline in Appendix B? The answer, it seems, is quite likely, particularly in lieu of how handily China has met the environmental goals of the past two FYPs. The 20% reduction achieved at the end of the 12th FYP actually exceeded the original target of reducing CO₂ emissions per GDP to 17%. According to Hu, the 11th and 12th FYPs originally set the total energy consumed per GDP at 20% and 16% respectively with 19.1% and 18.2% actually being achieved for each of the five-year periods (225). The 13th FYP goes even further, with “a greater number of green development quotas than previous FYPs, direct promotion of a green economy, and the creation of an emissions trading system to be completed by this year” (Maley, 2017, 4). As Isabel Hilton, writing for the Oxford Energy Forum, stated: the 13th FYP proves that “the world’s largest industrial economy is continuing on a path, begun five years ago, towards a leaner, greener, more efficient, and more sustainable model, and that cleaning up the legacy of the previous 30 years – including its GHG emissions – remains a key priority” (27).

It would be understandable for the reader to dismiss the reported percentages and hopeful statements from the last paragraph out of hand, particularly considering that China’s authoritarian regime has long been a byword for corruption, opacity, and false reporting. These chronic issues are identified in

previous sections of this paper, particularly in 1.4(c) and 2.2(b)ii, and are described well by one reader as a simple case of “cooking the books” in order to mollify the public as well as international agencies. However, what may be surprising to those in the west is just how much progress has been made in China in terms of accurate reporting and transparency in the last five years. This, by no means, is the result of some radical restructuring of an authoritarian system but rather, a recognition of mutual interest shared among multiple actors.

In 2009, Ben Block from the World Watch Institute wrote an article entitled “China Gradually Improves Environmental Transparency”^{xii}. This transparency has improved in leaps in bounds in the ten years since this article was released. Block was celebrating the progress that had been made since 2006 when 100 cities did not even provide public data on water quality, despite the fact that by 2009, China’s experiment with transparency was still considered to be in its nascent stage. The major milestone that set the precedent for transparency was established right around the time of Block’s article. In 2008, the MEP established the “Measures on Open Environmental Information”^{xiii} which provided the public with a pathway to monitor and report industry emissions. Ma Jun, later described by the author of this paper to be “the most important environmental activist in all of China” (174), immediately capitalized on this new policy. Currently a global fellow at the Wilson Center, Jun organized a collaboration as director of the Beijing-based Institute of Public and Environmental Affairs with the U.S.-based NRDC (National Resources Defense Council). The result was the *Pollution Information Transparency Index (PITI)*, which kept tabs on how accurately and

effectively pollution information was disclosed in the wake of the 2008 ruling by the MEP. Annual reports from PITI are available on-line allowing the author of this paper to compare progress from the second annual report covering the period of 2009-2010 to the most recent report available covering 2017-2018. According to Jun and his associates, transparency in China has improved significantly during this period, a major development that remains underreported in western media. In the 2009-2010 transparency assessment of 113 Chinese cities, it was found that “environmental transparency in China showed both progress and retreat over the past year, and many implementation challenges still remain” (IPEA, 2010, 2). A reading from the 2017-2018 assessment of 120 Chinese cities revealed just how much transparency has evolved in China during that eight year period:

“Over the past decade, due to unremitting efforts by the Chinese government, as well as continuous attention from and promotion by all sectors of society, the disclosure of pollution source supervision information – a key category of environmental information – saw breakthrough progress between 2017 and 2018” (IPEA, 2018, 1)

Of particular note is the use of Jun’s “Blue Map”, which is highlighted in a latter part of this Capstone (176). According to the 2017-2018 report, use of the Blue Map revealed 320,000 “corporate violation records” up from only 2000 in 2008. In addition, now the “public can access approximately 70% of environmental administrative punishment information through public channels” (1).

It is understandable for the reader to remain circumspect in light of some of these new developments. However, when China’s significant improvement in environmental reporting and transparency is seen in the context of mutual convenience and pragmatism, the pieces of the puzzle begin to fit together.

UCLA law professor Alex Wang^{xiv} spent seven years doing “on-the-ground work in China” during the period of 2004 to 2017 for the purposes of “information disclosure and legal reform advocacy” (Wang, A., 870). This placed Wang in a position of contact with multiple stakeholders, including “civil society advocates, lawyers, scholars, journalists, and community members” (870).

In terms of why China’s authoritarian regime remains strong while so many other authoritarian systems over history have self-destructed can be explained by China’s unique brand of “deliberative” democracy (see page 70) which has created a kind of “consultative” form of authoritarianism (873). This is described by Wang as a kind of “state resilience through a greater focus on environmental performance and a pragmatic willingness to introduce potentially risky liberal legal transplants” (873). This has been bolstered by a new era of social mobilization due to the “dramatic changes in technology, international trade, and outside engagement” (873). It is the concurrent engagement of multiple stakeholders that has been a key to the success of China’s transformative improvements in the availability of accurate environmental data. According to Wang, once it became clear that all parties could mutually benefit, a “zone of compatibility” began to emerge where “disclosure simultaneously enhances environmental performance, facilitates citizen autonomy, and enhances state control and legitimacy” (883). The author has detailed how each of these various groups have benefited from improved information disclosure in Table 2. Suddenly, “party-state leaders, citizens and civil society, and

environmental regulators” all rallied around a “common goal of environmental protection” (883).

Table 2 How each stakeholder benefits from accurate and transparent environmental reporting

<p>Party Leadership</p>	<ul style="list-style-type: none"> • <i>Poor environmental reporting has become synonymous with illegitimacy, slipping social stability and a failed system of meritocracy (868)</i> • <i>Information disclosure is now being recognized for its potential as a tool to solve “economic development and stability problems” (885)</i> • <i>Public involvement in the data collection process has been seen by the PRC as providing citizens with a “safety valve to release social pressure” (885)</i>
<p>Advocacy Groups and NGOs</p>	<ul style="list-style-type: none"> • <i>Access to information helps these groups to “identify problems and propose solutions” and hence “place pressure on local governments or companies” (886)</i>
<p>Local Regulators</p>	<ul style="list-style-type: none"> • <i>Highlight problems that are beyond the resources of local agents which require the intervention of large bureaus (887)</i> • <i>Generate attention for new innovations and “attract international investment” (888)</i> • <i>Access to information helps these groups to “identify problems and propose solutions” and hence “place pressure on local governments or companies” (886)</i> • <i>Build trust with citizens who are a vital component of the enforcement paradigm (868)</i>
<p>International Entities</p>	<ul style="list-style-type: none"> • <i>Transparent and reliable reporting is commensurate with the strategic plans of “rule of law” and “good governance” from organizations like the World Bank and the Asian Development Bank (887)</i> • <i>Will help to change enduring perceptions by both the U.S. and E.U. as to China’s overall reporting accuracy (888)</i> • <i>Multinationals dealing in China can demand compliance through supply-chain strategies (901-902)</i>

<p style="text-align: center;">Citizens</p>	<ul style="list-style-type: none"> • <i>Can function as “fire alarms” for the state through active real-time monitoring by covering areas that the government is not able to due to resource limitations (889)</i> • <i>Can function as whistleblowers safeguarding against data manipulation, as was the case in false data from a Nanjing cement plant (891)</i> • <i>Helps to reduce feeling of helplessness and provide a feeling of empowerment through the possibility of “self-help” (902-903)</i> • <i>In an atmosphere of expected disclosure, sudden periods of no disclosure will signal to citizens the possibility of wrongdoing and the need to mobilize.</i>
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Wang traces the real turning point for China’s improved transparency to the mounting public pressure over untenable PM_{2.5} levels during the years of 2011 and 2012. This eventually led the MEP to require, and this is a critical point, *“real time” information* about pollution levels. By 2014, 65% of polluting facilities (roughly over 15,000) were mandated to provide hourly water and air emission data which, according to Wang, was a “requirement not found in any other country” (881). In that same year, the Environmental Protection Law was changed to include “Information Disclosure and Public Participation” as “the focus of one of only six chapters of the law” (882).

Finally, a word needs to be said about the role of international actors and multinationals, particularly the efficacy of the “supply-chain strategies” mentioned in Table 2. As Wang mentions, multinational corporations have the power to demand that suppliers fall in line with set environmental standards and can

“conduct auditing to support compliance” (901). In 2014, the author of this paper provided an example of just how strong an influence multinational actors (in this case, Timberland) can have in promoting accurate reporting and compliance:

“...the case in Dachang Township where citizens complained of the Fuguo tanning company’s rampant pollution. During 2009, NGO’s revealed to the CEO of the multinational Timberland company that their client (Fuguo) was polluting the area. This multi-stakeholder approach culminated in a meeting between the citizens, the NGO, the media, and members of the Timberland MNC that resulted in a comprehensive pollution monitoring program. As Tan points out, “the problem was resolved only when an additional actor – the MNC – was brought in and when multiple stakeholders were simultaneously engaged” (Maley, 2014, 12-23)

Alex Wang also highlights the case of Apple who “had previously refused to disclose any information about its Chinese suppliers” and eventually “reversed course after public criticism from Chinese NGOs” (901). No doubt Wang is referring to the well-publicized and grisly events at FoxConn, Apple’s electronics supplier, which led management to install suicide nets around the periphery of the factory. Since this time, Apple has tripped over itself to showcase how environmentally sustainable it has been in China, releasing annual “Environmental Responsibility Reports” with an inordinate focus on new-found successes in China. With 23 references to China, the Apple’s 2018 report claims to have developed “485 megawatts of wind and solar projects across six provinces of China to support upstream manufacturing” (Apple, 15). Apple has also played a role in increasing “responsible management of working forests in China—by creating up to 300,000 acres of FSC-certified forests, and up to 700,000 acres of forests under improved management” (28).

4.1(b) China’s Leadership Role at the Paris Summit

One of the more enduring images of the 2009 Copenhagen (Cop15) Summit was the wave of protestors outside of the summit, hundreds of whom were arrested. Inside the summit, the African delegation could be seen chanting “Two degrees is suicide! Climate justice now!” after a leaked document revealed a shift away from the Kyoto Protocol with clear biases allowing rich countries to abdicate their climate responsibility. Sudanese diplomat Lumumba Di-Aping described the summit as the “the lowest level of ambition you can imagine. It’s nothing short of climate change skepticism in action.”^{xv} The western media generally portrayed China as playing an obstructionist role during the proceedings. The proposition by President Obama to use satellite imaging to monitor China’s emission levels on the international stage was the straw that broke the camel’s back as talks between China and the United States continued to flounder. The Cop21 Paris Summit six years later revealed an abrupt about-face from Chinese leadership in terms of environmental policy. China’s unwillingness to budge at Copenhagen was interpreted by one analyst as a calculated move “in order to avoid the risk that it might be called on to be more ambitious in a few years’ time”^{xvi}. China’s stance at Cop21 would go on to reveal just how inaccurate this statement turned out to be. From November 30th to December 12th at the United Nations Climate Change Conference in Paris, China distinguished itself as a leader, a move that was augmented from Trump’s withdrawal from the summit on June 1st. Each nation had to submit their particular pledges (INDC’s or the “Intended Nationally Determined Contributions”) to address climate change in advance of the conference itself; 165^{xvii} of 196

nations had made submissions by November 17, 2015 while China submitted early on June 30th. China's INDC pledges were quite ambitious, promising to reduce CO₂ emissions per unit of GDP to 60-65% relative to 2005 levels while delivering on a peak in carbon emissions before 2030. Many of the various pledges put forth by China can be found in Appendix C from a table originally created for my independent study in 2017. Proof of the boldness of China's INDC pledges can be found in a 2015 analysis provided by the *Center for Climate and Energy Solutions* revealing the targets to be of "greater ambition than the most optimistic BAU scenario"^{xviii}.

Probably the most significant takeaway from the Paris Summit was China's willingness to reposition herself as a country open to dialogue and cooperation with western nations in order to achieve collective mobilization against environmental threats and climate change. Part of these agreements include an agreement of funding from the European Union towards China's Emissions Trading System (still not fully finalized at the time of this writing (December 2018), experiencing only a 'soft' launch in 2017) as well as further cooperation during the EU-China bilateral summit in June of 2017. Both entities agreed to sign *The Work Plan 2017-2018 of the EU-China Roadmap on Energy Cooperation*^{xix}. The subsequent EU-China summit in Beijing during the month of July in 2018 (Figure 65) represented an even greater level of commitment and cooperation and included a "partnership agreement on oceans" where both nations would seek a more improved international governance of oceans to ensure conservation and sustainability.



Figure 65 Chinese Premier Li Keqiang with Donald Tusk, President of the European Council, and Jean-Claude Juncker, President of the European Commission
Source: <https://www.consilium.europa.eu/en/meetings/international-summit/2018/07/16/>

4.1(c) Power Systems Shifting from Black to Green: Skyrocketing Renewables, Freefalling Coal

(i) Skyrocketing Renewables

China's wind power capacity is phenomenal (Figure 66). In 2009, a joint study by Harvard and Tsinghua University revealed that all of China's electricity demands by 2030 (twice the current demand) could be met by wind power alone (McElroy, 7)^{xx}. Now add in for consideration sprawling deserts ideally suited for solar power and China's thriving domestic economy. The combination of these factors and more pre-ordain China as having all the makings of the definitive world leader in renewable energy. Unsurprisingly, China has achieved this on the production-side of the equation, being home to 4 of the 10 largest onshore wind turbine companies in the world as well as 7 of the world's 8 biggest solar photovoltaic manufacturers (Mathew & Tan, 4).

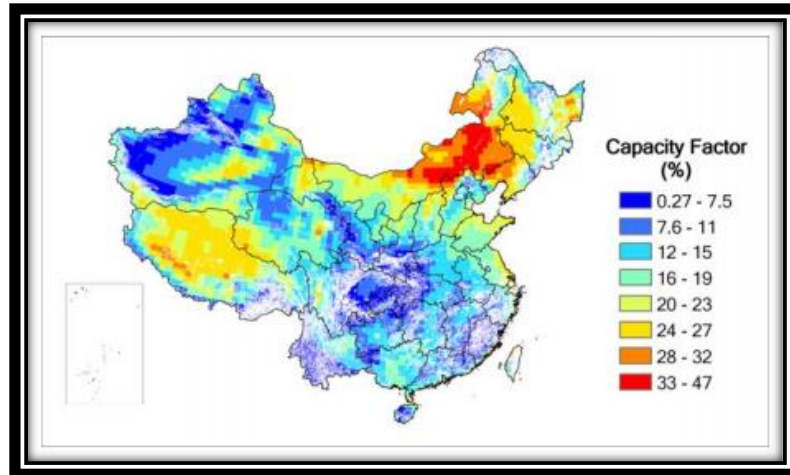


Figure 66 Wind map of China for a planned distribution of 15 megawatt land-based wind turbines. Capacity factor percentages represent the ratio of average power to rated peak power (Source: McElroy, 14)

The question remains: has China capitalized on this unique permutation of factors to set a path for a green “new deal” on the home front amidst the chaos of “airpocalypses”, looming threats of subsidence and rampant desertification, and 60% of underground water “unfit for human contact”? Can China achieve a heroic green shift despite the lack of “transitional” options afforded to nations like the United States by way of the fracking boom? In keeping with the Chinese paradox, the answer is a resounding ‘yes’. Described by Mathew and Tan as a “significant green shift that is comparable to the best in the world” (1), China’s renewable generating capacity grew to 35.5% in 2016, up from 20% in 2007 (3) as seen in Figure 67.

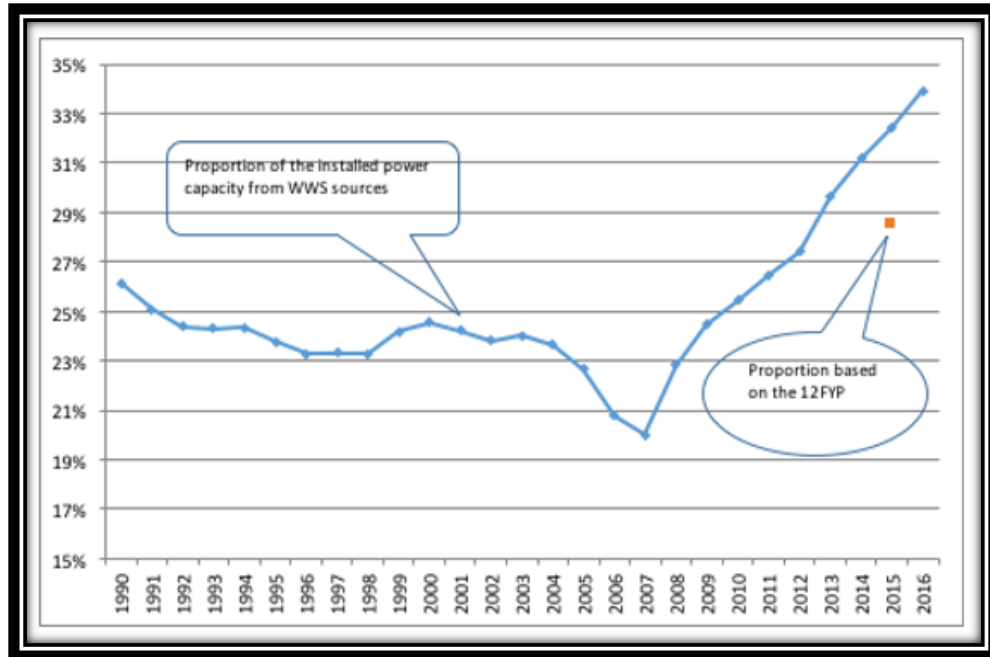


Figure 67 Percentage Growth in Generating Power from “WWS” (Wind, Water, Sunlight) from 1990 - 2016. Of particular note is the 14.5% growth from 2007 to 2016. (Source: Mathews and Tan, 3)

The bold renewable energy pronouncements of the 13th Five-Year Plan are likely to be reached and even exceeded, particularly the 210 gigawatts capacity goal for wind power originally set for 2020. The likely achievement of 170 gigawatts of wind capacity by the end of 2018 has Chinese officials already considering the possibility of increasing that 210 gigawatt goal to as high as 270 by 2020^{xxi}. The 13th FYP goal for solar energy (110 gigawatts) is also likely to be surpassed as well “since it implies less than a further doubling between now and 2020” (4). China’s 13th FYP distinguishes itself from the previous plan by merit of the fact that environmental protection factors increased by 70% (Wang, R., 406) while “green development” was considered one of the top five considerations for the country as a whole in addition to “innovative development”, “coordinated development”, “open development” and “shared development” (Zhao, L., 19). The verbiage of green technology has increasingly moved front-and-center in

governmental policy as revealed by Figure 68 where 1% of the yearly report for 1985 included environmental considerations compared to 2017 where these same considerations commanded *one-eighth* of the entire report (Wang, R., 406).

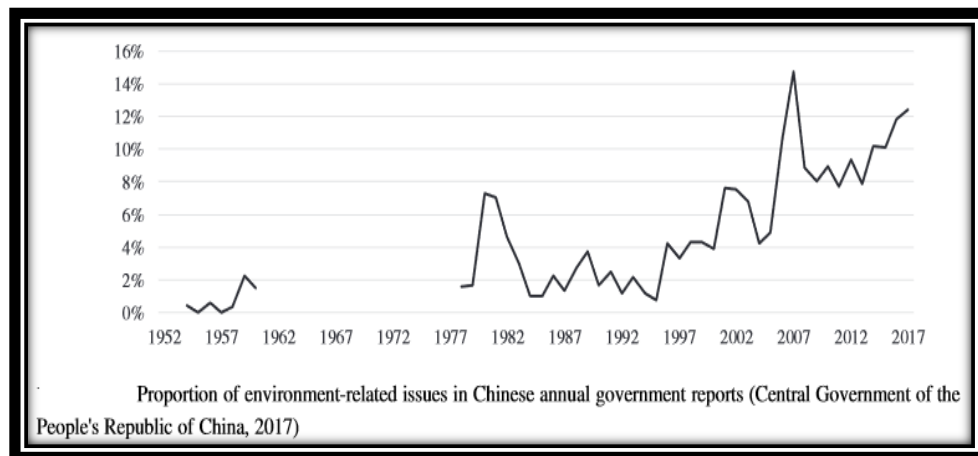


Figure 68 Environmental considerations can clearly be seen at the 1985 mark only commanding 1% of China's yearly report for that year. 2017 remains a stark contrast with more than 12.5% of annual report contents addressing environmental concerns. (Source: Wang, R., 407)

While in 2018, the United States spends four times more on the military than China^{xxii}, much of China's dramatic rise in renewable production, installation, and consumption is due to staggering amounts of investment in green technology. According to a 2016 briefing paper released by climate change think tank E3G (Third Generation Environmentalism), the previous five years has already witnessed China catching up "to the EU on per capita investment in clean energy and overtaken the EU on renewable energy build rates, R&D spending, power transmission grids and electric vehicles" (Ng, 1) (Figure 69). According to Bloomberg New Energy Finance (BNEF), world investment in renewables topped 287.5 billion dollars in 2016 with China responsible for over 30% of that investment at 87.8 billion (Mathews and Tan, 9). According to the World

Economic Forum, that number increased to 126.6 billion dollars in 2017, with China outspending the United States at a ratio of three to one^{xxiii}, once again outperforming “the rest of the world in terms of investment in clean energy” (9).

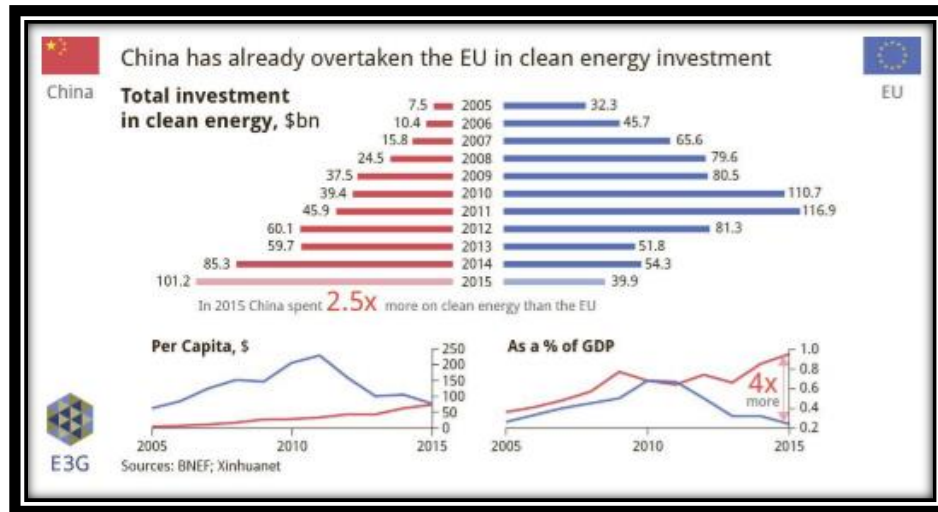


Figure 69 Comparison of Chinese investment in green energy with that of the European Union from the period of 2005 - 2015 (Source: Ng, 1)

Earlier in this Capstone, one critical statement alone helped to elevate China’s environmental woes to an existential, world threat. It was a statement quoted by the author of this Capstone on more than one research paper due to its overall import and, in part, due to the gravitas of the individual making the statement. In 2010, former director of the International Energy Agency, Nobuo Tanaka, boldly stated to Chinese officials that *the world would not reach essential climate targets by 2050 unless China’s CO₂ emissions peaked by 2020*. Eight years on, China has emerged as the leading producer and consumer of renewable energy in the world. Has Tanaka softened his assessment since 2010 in lieu of China’s green shift? One thing the author learned through independent study coursework is to take a chance and reach out to world experts; you might just be surprised^{xxiv}. Mr. Tanaka was contacted in May of 2018 (Figure 70) and

appeared to have, indeed, softened his assessment of China, *citing China's "green revolution" as one of the four "upheavals or revolutions in the energy sector"*. According to Tanaka, three of these four "upheavals" are led by China^{xxv}.



Figure 70 Email Communication with Nobuo Tanaka on May 2018. (Source: Penn Email and some internet sleuthing)

(ii) Freefalling Coal

In March of 2017, The Guardian announced that coal was in “freefall” with the production of new coal plants falling by two-thirds during the previous year; the plunge was “overwhelmingly due to policy shifts in China and India” (Vaughan, 1). In 2016, only 22 gigawatts of newly built coal-fired plants met with approval, down significantly from the 142 gigawatts approved in 2015 (Mathews & Tan, 6). In 2014, China’s National Development and Reform Commission passed the “Action Plan for the Upgrading and Reconstruction of Energy-saving and Emissions Reduction for Coal Power (2014-2020)” stating that newly constructed coal-fired units should “adopt units with capacity of no less than 600 MW ultra-supercritical coal-fired power generation” (Yu, 614 & Hart, 9). Enforcement of much stricter standards have resulted in the PRC shutting down over 104 coal-fired plants across 13 provinces in 2016. The end result was the subtraction of

over 120 gigawatts of coal-fired thermal capacity (Mathews & Tan, 7 & Hart, 12). Additionally, by 2020, pre-existing plants that do not achieve an “average coal consumption for power supply of serving coal-fired power units” of less than 310 gce/kwh^{xxvi} will be shut down (Yu, 612 & Hart, 9). Remarkably, according to Hart, this means that every current coal-fired power plant in the United States would be illegal in China by the year 2020 (9).

To understand the impact of the previous sentence, it is necessary to understand the power plant triumvirate: *subcritical, critical, and supercritical*. Whether a power plant falls in one of the three categories depends on the “quality” of the steam produced as a function of both pressure and temperature. The increase in pressure and temperature associated with supercritical power plants makes the Rankine steam cycle (the process of converting heat into mechanical work) much more efficient. This “decreases the amount of fossil fuel consumed and the emissions generated” (Susta, 5). For context, an increase from 30% to 50% of cycle efficiency could “decrease CO₂ emissions by more than 30% as well” (5). Much like our aging fleet of nuclear reactors built well past their shelf life despite continued relicensing, most coal plants in the United States have an average age of 39 years (Hart, 5). For comparison, the oldest of the top one hundred plants in China was built in 2006. Of those 100 plants, 90 are supercritical plants; currently the United States has *only one* supercritical plant in operation (Patel,8).

Early this year, the *New York Times* published an article^{xxvii} stating that “Four Years After Declaring War on Pollution, China Is Winning”. While in the United

States, many of these policy maneuvers would be accompanied by the usual hemming and hawing and political brinksmanship, China's often reviled authoritarianism worked quite well when it came to setting stiff guidelines for coal plants. Plants not in compliance? Unceremoniously shut down. No appeals, no lobbying, no revolving doors. As the "wicked problem" of China's environment is broken down and analyzed by factors later on in Section IV, the issue of governance, particularly the idea of authoritarian environmentalism (AE in the literature), will seriously be considered.

4.2 Persistent Causes of Concern Moving Forward and the Final Justification for the "Wicked Problem" analysis

4.2(a) China's 2014 Coal Peak – Transformative Moment or "Temporary Blip"^{xxviii}?

A quote often attributed to Confucius is that it's "better to light one candle than to curse the darkness". Certainly, the progress made in the last five years as detailed in section 4.1 is laudatory. However, there is still much to do; China has a long way to go to achieve an acceptable level of insulation from the looming threat of multiple environmental tipping points. According to Edenhofer, the amount of added coal emission leading up to the year 2030 (26%) will still be more than twice the increase from all other emissions, as seen in Figure 71. Edenhofer points out that despite China's reining in of coal, there is a staggering increase of coal emissions projected for countries like Pakistan, Bangladesh, Egypt, and Vietnam as seen clearly in the diagram.

	Change in emissions from coal-fired power plants (2012–2030)	Change in all other emissions (2012–2030)
China	26%	12%
India	84%	23%
Turkey	412%	50%
Vietnam	948%	14%
Indonesia	196%	105%

Figure 71 Increase in coal-fired emissions over the period of 2012 to 2030 compared to all other forms of emissions for China, India, Turkey, Vietnam, and Indonesia. (Source: Edenhofer, 4)

Many of these projections have led Edenhofer to suggest that while “the Chinese coal use has recently slowed, and might even have passed its peak...data suggest that China will invest in coal-fired plants abroad, while their domestic market increasingly saturates” (4). When considering the “economic” factors later in Section IV, careful consideration must be given to China’s One Belt One Road Initiative (see Section 2.1(c)) to make sure these projected increases in other countries are not due to China’s exportation of carbon emissions, a typical method for dealing with capitalist surpluses.

A report from the PRC’s National Bureau of Statistics revealed that after a three year decline, coal use actually increased by 0.4% during 2017 (Feng, E., 1). It is important to note, however, that total consumption of energy overall rose and that the percentage of coal use in the total mix continued to fall an additional 1.6% in 2018. Modeling conducted by Qiang Wang and Rongrong Li maintain that after the 2014 coal ‘peak’, consumption will continue to fall as long as the PRC can maintain a GDP growth of under 8.2% (699). Both authors cite the belief by organizations like the International Energy Agency (IEA) and the Energy

Information Administration (EIA) that the decline will continue based on the three drivers of “economic deceleration, industrial restructuring, and rapidly scaling-up non-fossil fuel energy” (696). However, as discussed in section 1.4(c) (“*Doubts and Uncertainties Moving Forward*”), findings at the Lawrence Berkeley National Laboratory from February of 2018 disagree. Using the DREAM and LEAP^{xxix} modeling programs, the authors conclude that China’s coal use “and associated CO₂ emissions – have not peaked and will continue to grow at least until 2020” (Lin, J., 14). The LBNL study determined that the 2014 decline was simply a temporary dip in heavy industrial commodities (power generation, cement, and steel production) (8); modeling predicts a rise to a minimum of 2908 Mtce (Metric Tons Carbon Equivalent) to a high of 3060 Mtce as featured previously in Figure 21. As seen in the diagram, decreases in heavy industry are offset by expected increases in several other factors. The two very different conclusions that emerged from modeling by Wang and Li and LBNL reveals the need for a very different approach to predicting China’s future, one that is sensitive to complex systems and transdisciplinary research.

4.2(b) Treating China’s Environmental Future as a “Wicked Problem” vs. More Conventional, Monolithic Approaches

In 1963, Ed Lorenz’s landmark publication in the *Journal of Atmospheric Sciences* introduced the world to the notion of chaos theory and the “butterfly effect”. The story is well-known. While running a computer model informed by atmospheric equations, Lorenz found that slight changes in initial conditions translated into radically different outcomes. Since Lorenz’s discovery, chaos theory explains why it “may be impossible to make accurate, long-term

predictions of system behavior” for rule-governed systems like the weather and the stock market (Hibbert, 219). Complex systems are best understood through the lens of chaos theory, as one author has shown in a unique application of this concept in predicting the rise of the Arab Spring^{xxx}. The non-linearity of complexity science helps to decode chaos theory and wicked problems where conventional, monolithic approaches fail. As mentioned previously in this Capstone, Michael Grubb addresses the inadequacy of conventional computer modeling as it applies to China’s environment. Grubb posits that no models could have “projected the explosive growth of Chinese energy and CO₂ after 2000; no one predicted the sudden halt in 2014” (S32). Energy system models are “inconsistent with the potentially transformative implications” of Xi Jinping’s “new normal” policy for China moving forward (S33). The 2014 slowdown in China “illustrates, if nothing else, the far greater complexity of the real driving forces” (S31). Grubb also refers to the failure of standard models to predict the 1973 and 1979 oil shocks in the United States as well. The “far greater complexity” that Grubb is referring to is the non-linear dynamism of a “wicked problem”, a term that perfectly describes China’s environmental future as seen in Figure 72.

Property	Wicked problems	Complex adaptive systems (CAS)
Problem definition and boundaries	Each issue/problem conceived as symptom of others. They are interactive, complexly related, and dynamic. Each is unique and no definitive definition is possible. No definitive boundaries	System definition can appear reasonably clear, and system definition can be determined in physical CAS, while social systems share no definitive boundaries. Permeable boundaries at multiple levels and across institutions
Holistic	Need to be dealt with holistically because piecemeal solutions do not work, because of interconnectedness, interrelatedness, and interdependence of elements	Need to be understood holistically, since the whole is different from the (sum of) parts, and all parts are interdependent, interconnected, and interrelated
Dynamics	Non-linear, cause-effect relationships difficult to determine. Emergence and co-evolution are characteristic. Highly interactive and complex. Can seem unorganized, though fractal qualities can be present, co-evolution is difficult because of dynamism and lack of definitional boundaries though possible	Non-linear, cause-effect relationships difficult to determine. Emergence, adaptation, and co-evolution are characteristic. Greater complexity operating at the "edge of chaos." Spontaneously self-organizing systems (sometimes), process of creative destruction, emerging from interaction, and interdependence of stakeholders, with layers sometimes having fractal qualities

Figure 72 A sample of a larger table describing the properties of a Wicked Problem, taken from the Journal of Organizational Change Management. Notice the reference to the "edge of chaos". (Source: Waddock, 999)

Despite the more extensive justification given in Section 3.2 (*The Author's Design*) for describing China as a 'Wicked Problem', one last point needs to be considered before the actual multi-sectoral analysis is applied in section 4.3. As described in Christian Pohl's excellent "Addressing Wicked Problems through Transdisciplinary Research", the inter- and transdisciplinary approach is ideal for China in that it:

"integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice" (4)

4.3 Wicked Problem Analysis: Predictions and Recommendations S.T.E.P. (Social, Technological, Economics, and Political)

For the purposes of this analysis, "political" and "social" will be grouped together as will "technology" and "economics"

Covering each and every element of the four factors listed above is, obviously, an impossible task. Therefore, the author of this Capstone has elected to include only those elements that he feels could have the most transformative effect on China's environmental future

4.3(a) Analysis and Prediction of Likely Economic and Technological Trends

- (i) **Economic** China's Prevailing Model Moving Forward: Steering Clear of Western Neo-Liberalism to Achieve Environmental Stability.

The trappings of neo-liberal economic policy in the west are explored in section 1.5 and in the “Economic Considerations” of 2.1. The triumph of privatization, deregulation, austerity, and free markets characterize neoliberalism as an anathema to environmental stability and presents the worst economic option for China. As Minqi Li points out, “the massive expansion of global capitalism has rested upon the exponential growth of material production and consumption, which has been made possible by the massive consumption of fossil fuels” (278). Durham University’s Niv Horesh states that the “biggest challenge to American hegemony is scarcely military” (167); rather it is China’s breathtaking economic rise. The resulting rise of China’s consumer class, high-growth economics, and the globalization-minded “One Belt One Road” initiative has led many analysts to assume that China would adopt the neoliberalism of the west. This, however, is unlikely. While academics like Scott Kennedy skewer the notion suggested by Joshua Cooper Ramo (see section 2.1(b)) of a “Beijing Consensus” or even a “China model” that radically departs from western economic theory, China will continue to play the role of ‘tinkerer’, creating something uniquely its own. Clearly, China and the United States have lots of similarities; as Horesh points out, they are both “big polluters, big military spenders, capital-punishment enthusiasts...they are now more economically

interdependent than at any other point in history” (171). However, there are critical differences that will ensure that China is not following a neo-liberal path of free-market anarchy that would push its population off an environmental cliff.

While China is by no means a closed economy, Xi Jinping is putting even more power in the hands of state-owned enterprises as ever before as western companies are prevented from infiltrating major brand names and media. Rothstein suggests that among authoritarian states, single party regimes like China have the highest QoG (“Quality of Governance”) towards economic prosperity and excel at “channeling demands from citizens into higher levels of state capacity” (7). Chinese leadership seem to take more of a lead from Singapore than the west in that the government is willing to make massive investments into programs that yield an actual return for the population, not to only a small and elite group of plutocrats. One example of this is China’s achievement of universal healthcare in 2011 while still a developing nation of nearly 1.4 billion people. According to the RAND Corporation’s Hao Yu, the World Bank has described this achievement as “unparalleled” (Yu, H., 1145). For comparison, among the 33 most developed nations of the world, the United States is the only country that still does not offer universal healthcare. China’s wealthiest entrepreneur, Jack Ma, highlighted this issue during a meeting at the World Economic Forum in Davos, Switzerland in January of 2017. Ma urged the United States to stop spending all of its money on wars, to the tune of over 14 trillion dollars in thirty years. He posited the following: “what if they spend part of that money on building up the infrastructure, on the white collars and the blue

collars...you are supposed to spend money on your own people...you do not distribute the money and things in a proper way”^{xxxix}. Despite the electoral system in the United States, some political candidates must first seek tacit approval by donors and corporate interest *before* their presentation to the voters. The commitment of environmental protection frequently stands in diametric opposition to the bottom-line mantra of political donors. The result is the very real potential for regulatory capture in all three branches of government. Political paralysis in Washington sets in when it comes to achieving anything meaningful with climate change or other environmental challenges. In China, leaders are carefully vetted through each stage of their career until they have achieved a level of proficiency appropriate for their office, as Xi Jinping’s rise from deputy party secretary of Zhengding County to president attests. Since 2002, Jinping has ascended through the ranks of a rigorous cadre selection process that the University of Michigan’s Qingjie Zeng describes as a unique form of “intra-party” democracy mixed with “organizational vetting, deliberation and decision” (Zeng, Q., 4). Since Jinping’s term as president, this process has achieved “an increasingly balanced PES^{xxxii} system where all types of work targets are indispensable to a successful performance, and shortfalls on some targets can no longer be outweighed by impressive performance on others” (Wang, Z., 72).

Economically, many see similarities between China and the trade tariff “protectionism” that characterized the United States during the 19th century. This was an economic phase of the U.S. characterized by state planning and mercantilism (Horesh and Lim, 23). The mistake is in assuming that China’s

current protectionism is a logical prelude to eventual adoption of neoliberal economic policy. Neoliberalism, in this context, is best defined by Clark

University's James McCarthy^{xxxiii} as:

“an alliance between certain fractions of capital (notably finance capital but also other technology- and information-centered industries) and cosmopolitan elites, who used a superficial commitment to the politics of recognition and meritocracy to mask neglect of or direct assaults on the interests of the industrial working class and many rural populations” (304).

However, China's likely path is more consistent with Lenin's New Economic Policy (NEP), offering authoritarian capitalism with strict state control. As stated by Horesh and Lim, China's goal is to “engage the global system of capitalism while keeping intact its primary domestic focus of state-led development” (23). This is achieved through the maintenance of state-controlled enterprises “in the ‘commanding heights’ of the economy” (24).

The prediction in this Capstone that economic neoliberalism will not frame China's environmental future is because it simply *could* not. Western globalization has dubbed China as the ‘world's factory’, the bullseye for the developed world's ejected manufacturing sectors. Over the last few decades, a vast proletariat has been created in China, a voluminous, industrialized working class. As Minqi Li observes, if neoliberalism has failed western workers, how could it sustain the “several billion workers” from non-western worlds while “averting the global ecological crisis” (277). As a regime obsessed with social stability, Beijing already recognizes neoliberalism as a dangerous fit. The hybrid patchwork of Lenin's NEP and “creative lesson drawing and policy transfers from other countries” (Horesh and Lim, 23) will hopefully create a social system built “not for endless accumulation but for ecological sustainability” (Li, 284).

(ii) **Economic** Solving the Enforcement Issue on the Local Level: Breaking the “Growth-at-all-Costs” Mindset of Local Officials

Section 2.2(b) of this Capstone addresses the issue of China’s fragmented bureaucracy with section ii focusing on the disconnection between central and local government officials. There is such an inordinate pressure on local officials to maximize economic growth, rendering both environmental enforcement and the legitimacy of local EPBs as nothing more than paper tigers. One question that is not answered in section 2.2 is *why* local officials in China are subject to such pressure to maximize growth to the detriment of the environment. Local ‘developmentalism’ was a direct reaction to the recentralization of the fiscal system by the central government during the 1990s, which “pushed spending responsibilities downward” (Su, F., 231). The result was “serious fiscal shortages” on the local level as local officials had to concurrently adjust to a strong, sudden trend of privatization and trade liberalization (231). The result was a persistent aversion to enforcement just as China was entering the paroxysm of environmental destruction. However, very positive changes are happening within the last five years by way of a simple remedy: *tying environmental performance into the promotion mechanism of local officials*. Apart from the realization that environmental issues are the primary catalyst for social discord, local officials are also realizing that “a strong focus on environmental concerns” is seen as “an advantage for attracting high value-added investments” (Brehm, 475). The central government has been introducing new legislation geared at “stimulating local environmental commitment” (5). One such piece of legislation is the State

Council's 2014 "Evaluation Method of the Implementation of Atmospheric Pollution Prevention and Control Action Plan" (Liu, L., 656) which tied cadre evaluation to reaching particular environmental targets. A proliferation of "EPPE" (Environmental Protection Performance Evaluation) mechanisms have spread to several local governments in the last decade. However, the nuances of linking promotion to environmental performance is still a relatively novel concept in China, and the system is still in need of improvement. Only the city of Shenzhen has a long enough duration to function as a legitimate case study (2007-2015). The findings of Lei Liu from Sichuan University is that local officials in Shenzhen were more concerned with air pollution than water pollution owing to a hyper-focus on reaching the benchmarks set by their superiors as opposed to giving equal consideration to concerns voiced by local citizens (664). The EPPE system has since been refined and duplicated at various locations across China. The impressive evolution of the EPPE system as used in Shenzhen can be seen in Figure 73. This approach has demonstrated a lot of potential in nullifying the growth-at-all-costs mindset of local officials, hence correcting one of the most formidable obstacles to effective enforcement in China.

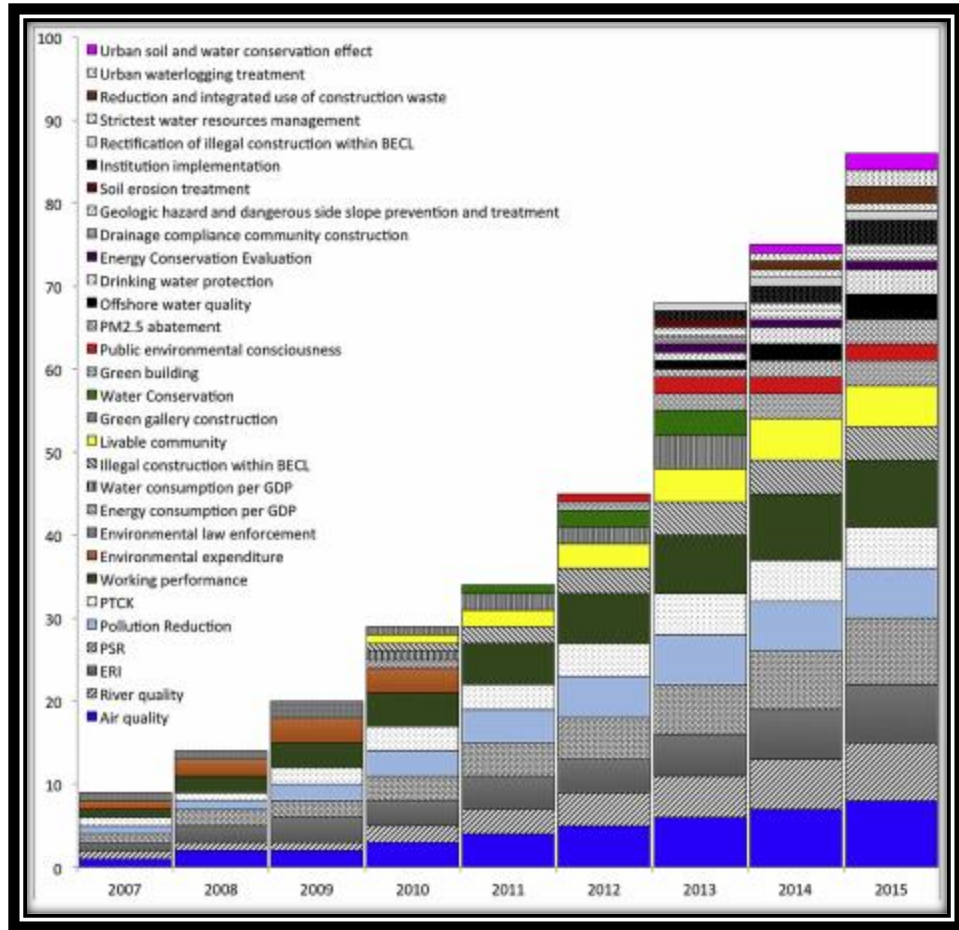


Figure 73 Evolution of various “performance indicators for district governments” in Shenzhen during the period of 2007 to 2015. (Source: Liu, L., 662)

- (iii) **Economic** The “One Belt One Road” Initiative – an Opportunity to Export a Green Economy over a Black Economy.

Section 2.1(c) details the various spectrum of opinions regarding the OBOR initiative. The fact of the matter is that China has poured colossal amounts of foreign direct investment into this 900 billion dollar masterplan, resulting in outbound investment exceeding inbound investment in 2016 (Tracy, 73). Earlier in the ‘pro’ perspectives detailed in section 2.1(c), Lei Han spoke of the possibility of “energy efficiency” convergence being reached by the act of China’s exporting industries reaching “lagging countries” such as those in Central

Asia, thereby allowing low efficiency countries to “catch up with high efficiency countries” (113). Yu Zhang also contended that when the OBOR is analyzed through the template of ‘virtual’ water, a water trade surplus is created which “alleviates water shortages in China and benefits the economic development of each spanning country as well” (991). However, most analysts remain circumspect about OBOR’s positive effects, convinced that the OBOR is a globalization scheme giving China a carte blanche license to export dirty production to corrupt and poorly regulated countries like Tajikistan. After all, this is exactly what the west did, relegating the production of our consumer detritus to China. However, there is no way to know this for sure. China’s unique brand of environmental authoritarianism has no analog in the rest of the world. As Tracy states, China’s environmental governance is much like its economic governance in that it is “unlike that of any other state and therefore is unlikely to follow any existing blueprint” (61). Tracy suggests that China take a page from Scandinavia’s brand of democratic corporatism where a “consensual policy deliberation approach” includes the input of environmental groups, specifically the “Green Tax Committee” in Norway (61). The growing movement of “deliberative democracy” in China, as detailed in section 2.2(c) is consistent with this model and could also be exported as an essential conditionality to developing countries within the OBOR. In the very least, the environmental standards maintained within China should be enforced in the host OBOR countries, a requirement echoed by both Tracy (78) and Ascensao (207).

One of the biggest concerns detailed earlier in this Capstone is the conspicuous absence of any impact statements or environmental standards in the literature regarding the OBOR from Beijing. For the OBOR to succeed on an environmental level, China needs to institute some variant of the NEPA (National Environmental Policy Act) as created here in the United States back in 1969. All OBOR projects must be subject to an environmental impact statement (Ascensao refers to this as a 'SESA' (Strategic Environmental and Social Assessment) for the "BRI and along each major economic corridor" (207)). At the heart of NEPA is the element of public participation, bringing to mind the words of Justice Louis Brandeis that "sunlight is the best disinfectant". This will require China to be willing to reverse long-standing policies on transparency, if not for the home front, then at least for the OBOR member countries in question. As with NEPA, a rating system must be given for each building project. An adjudicator will be in place to resolve inter-department disputes, much like the Council on Environmental Quality here in the United States. Tracy's suggestion is also an excellent one: the onus will be on those members of the Asian Infrastructure Investment Bank (the 'financing arm' of the OBOR), particularly select Scandinavian countries with progressive environmental policies, to apply the necessary pressure on China to meet expected environmental requirements.

(iv) ***Economic*** Demand-Side Solutions: Smart Subsidies, Taxes, and Pricing

In part ii of section 2.2(c) ("Fall of Technocrats in Government"), the steady decline of technocrats in the Chinese government is hailed as a positive

development due to the pressing need to move away from grandiose supply-type solutions to a more demand-based approach to solving environmental problems. The ascension of Premier Li Keqiang is certainly a step in the right direction. As a trained economist, Keqiang uses economic measures to drive policy decisions and has even created what has been dubbed the “Keqiang index”, a more sophisticated alternative to GDP. However, implementation of economic mechanisms in China are still in need of development. This section will provide both positive trends and recommendations for improvement.

(a) Subsidies

China’s indiscriminate use of subsidies has resulted in the depression of world markets and the current crisis of overproduction as it applies to solar panels and wind turbines. Since China’s inclusion into the World Trade Organization at the start of the millennium, subsidies are responsible for 20% of the growth in manufacturing. Subsidies have been used to promote production of goods regardless of quality in an attempt to strong-arm world markets and throttle foreign competition. China’s wind turbine market, for instance, relied heavily on price competition where consumers pick options based on the cheaper price as opposed to non-price competition where quality craftsmanship plays a crucial role. Price competition in China’s renewable markets “reduces concerns regarding quality and reliability and even gives rise to cut-corner issues” (Lin, Y., 488). A predictable result of this blind approach is an untenably high failure rate among China wind turbines, as seen in Figures 74 and 75.



Figure 74 A fire breaks out at the Xilingol wind farm in Inner Mongolia
(Source: Lin, Y., 483)



Figure 75 Total turbine collapse in Gansu at the North Bridge wind farm.
(Source: Lin, Y., 483)

China has since overhauled their renewable energy subsidies program completely. In February of 2017, the National Development Reform and Commission announced a Renewable Energy Certificate Program to go into effect in July of that year^{xxxiv}. The new REC program allows subsidies to be tradable between solar and wind producers and state-owned and private companies, thereby promoting greater infiltration of renewable energy into corporate markets. However, subsidies are subject to China's RPS ("Renewable Portfolio Standard") which carries a system of penalties for not meeting minimum renewable energy targets. As of September of 2018, the RPS now positions renewables to share 35% of electricity consumption by 2030. This is yet another step in the right direction^{xxxv}.

As China continues to ramp up environmental regulations, many analysts have invoked the "Porter Hypothesis" from Harvard Business School's Michael Porter back in 1991. The hypothesis suggests that "regulation promotes innovation aimed at lowering the cost of compliance, which would in turn

increase resource efficiency and product value, offset compliance costs and enhance firms' productivity" (Hou, J., 1062). However, Jian Hou shows that this hypothesis may not be suited to the landscape of heterogeneity in China where too much regulation may backfire owing to those industrial enterprises that "have low levels of benefit and outdated technical equipment" (1068). As China's application of subsidies continues to evolve, Beijing should consider an equivalent to the Renewable Energy Certificate Program, namely a subsidies program that will allow struggling industries to meet compliance standards. Specifically, subsidies should be given to promote the kind of technological innovation that would make the Porter hypothesis applicable across the country.

(b) Taxes

The reader may recall Fergus Green and Nicholas Stern as the names behind the bold announcement that China's coal use peaked. In that same paper from 2016, Stern and Green also suggested increasing "effective carbon prices on fossil fuel energy sources", specifically through a "rising coal tax" which would be a "highly efficient and administratively effective measure, well-suited to China's institutional context" (18). Both authors offers the alternative possibility of a "well-designed and implemented emissions trading scheme" which could "achieve similar results" (18). Since the publication of Stern and Green's paper, both programs have been developed and applied in China.

On January 1, 2018, China passed an "Environmental Protection Tax Law", a much more aggressive update to the loophole-laden "Pollution Discharge Fee". Considered "among the most ambitious forays into green incentives ever

attempted”, the tax law’s success is touted as a “matter of global significance” (Wu, J., 223). A closer look, however, reveals room for improvement. The tax applies to industrial noise, water and air pollution, and solid waste. Curiously, carbon dioxide emissions are exempt from taxation. Additionally, far too much independence is afforded to provinces that can exercise the option of applying tax rates that are ten times higher than the base rate. On paper, this appears to allow provinces to adjust based on unique sets of environmental factors. In actuality, the level of local autonomy provided by the new tax law may allow for the possibility of mismatching environmental standards from region to region, or as Jian Wu suggests, creating a network of pollution ‘havens’.

Given a ‘soft’ launch around the same time as the Environmental Protection Tax Law, a national Emissions Trading Scheme (ETS) was created and has been described as “a powerful signal about the country’s mitigation commitment” (Swartz, J., 8). China’s newly minted ETS system also provides an excellent opportunity for international cooperation. The Paris Climate represented a major turning point in China’s willingness to work collectively with the European Union. The European Union has maintained an ETS system of their own since 2005 and includes thirty-one countries. China will need guidance to make sure that the ETS system does not face derailment by the usual suspects of non-uniform enforcement and inadequate reporting and monitoring as well as any deviation from the INDC targets set in Paris (9).

(c) Pricing

There are innumerable aspects of Chinese society that could be improved by sensible pricing mechanisms. Without question, the one area that could provide the most significant returns in terms of China's environment would be the pricing of water. The issue of water scarcity in China is quite dire and has been addressed in previous academic work by the author on multiple occasions. China remains a country with increasing demand and decreasing supply, containing 20% of the world's population but only 6% of the water. As discussed previously in 2.3(b), 61.5% of Chinese groundwater and 31.4% of river water is rated as IV-V (see Figure 39). Appropriate pricing must be applied to those sectors that consume the most amount of water in Chinese society. As to be expected, residential water use makes up only a small percentage of total use, while agriculture and industry are responsible for a large majority of water use as seen in Figure 76.

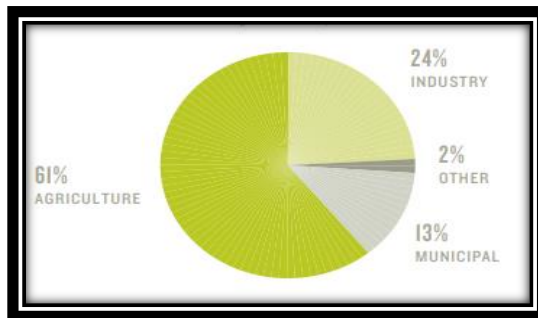


Figure 76 China Water Use by Sector, as reported by the National Bureau of Statistics (Source: Chong, B., 10)

In terms of the industrial sector, coal use alone accounted for 17% of China's total water consumption in 2011 which will likely rise to 27% by 2020 (Caldecott, 28). Bernton reports that the Datang International Power Plant alone could potentially use up to 7 billion gallons of water each year (1)^{xxxvi}. A "market-

approach of environmental taxes, draconian volume-based fees for water pollution, water-pricing mechanisms, and quotas” (Maley, 2014, 14) could compel the industrial sector to improve the unacceptably low water-recycling rate of 40% (compare with the 75-85% achieved by many developed countries) while inspiring the agricultural sector to employ water-saving techniques such as soil moisture monitoring and drip irrigation. An overdue pricing mechanism for both of these sectors is the IBT (Increased Block Tariff) system seen in Figure 77 where an operation is charged more for greater water consumption. For contrast is the DBT in the lower diagram (Decreased Block Tariffs), charging less with greater volumes of consumption.

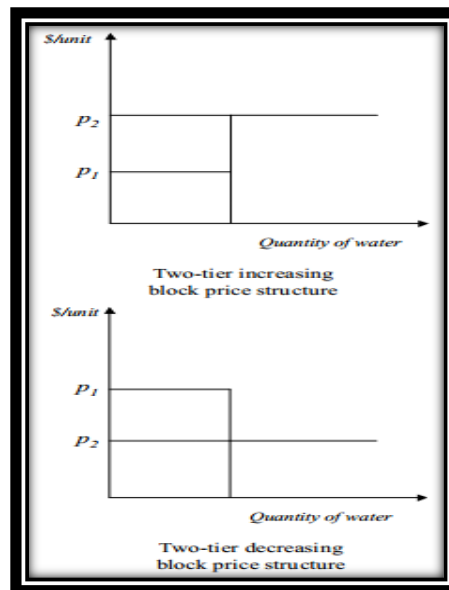


Figure 77 Diagram showing the change in cost with quantity in an increasing block structure (top diagram) as well as a decreasing block structure (bottom diagram) (Source: Olmstead, 16)

Currently, China is using a flat ‘unitary’ approach which does not inspire conservation let alone feedback to the water utility. According to Yong Jiang from

Michigan State University, in many agricultural areas, charges “are still based on the number of acres irrigated rather than the actual amount of water used for irrigation”, providing no incentive for Chinese farmers to conserve water (3192). Consequently, among farmers there is a “low adaption rate (<20%) of water-saving technologies such as plastic sheeting, sprinkler system, drip irrigation, and other efficient, less capital- and energy-intensive techniques in water strapped northern China” (3192). A sensible, volumetric approach to water pricing could remedy this problem. Huijuan Dong said it well when he stated that “policy makers could easily raise awareness through economic instruments, a language heard all too clearly by industry” (222).

(v) **Technological** Preserving China’s Water

Air-cooled power plants and desalination were first explored in 2014 during previous academic work. Five years later, the author of this Capstone still believes them to be among the most compelling options for preserving China’s water.

(a) Air-Cooled Power Plants

In terms of thermo-electric power generation, the cooling phase has the most voracious appetite for water use. A typical configuration is the “once-through” system that draws water from a nearby lake or river into a condenser. The condenser then receives the resulting exhaust from steam used to turn the turbine(s) to generate power. Once interacting with the condenser, the hot water is then looped back to the waterway. The “recirculated-wet” cooling is similar with the exception that the hot water may than be directed to a cooling tower. However, air-cooled or “dry cooling” plants are beginning to make traction in China. Here, a series of ‘finned tubes’ (Figure 78) are utilized to condense steam

coming from the turbine as cooling is achieved via a kind of ‘natural draft’ system in the tower or from a very large fan. The Union of Concerned Scientists conducted an analysis of these three systems (Figure 79) and found that when compared to wet-cooling systems, dry-cooling systems *can save 90% on overall water consumption* (UCS, 2). A more recent article from November 2018 suggests that the water savings could be upwards of 99% (Zhou, Y., Cheng, Y. L.,1)

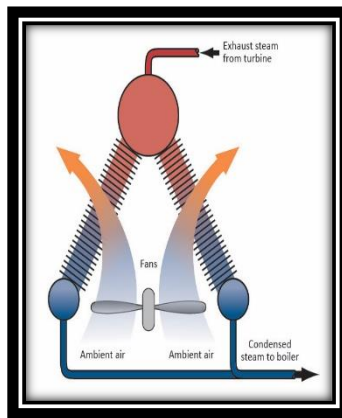


Figure 78 Dry cooling system using a large fan to direct air on a series of finned tubes. (Source: Bushart, S., 3)

	Once-through		Recirculating		Dry-cooling	
	Withdrawal	Consumption	Withdrawal	Consumption	Withdrawal	Consumption
Coal (conventional)	20,000 - 50,000	100 - 317	500 - 1,200	480 - 1,100	N/A	N/A
Natural gas (combined cycle)	7,500 - 20,000	20 - 100	150 - 283	130 - 300	0 - 4	0 - 4
Nuclear	25,000 - 60,000	100 - 400	800 - 2,600	600 - 800	N/A	N/A
Solar thermal (trough)	N/A	N/A	725 - 1,109	725 - 1,109	43 - 79	43 - 79

Water withdrawn and consumed for power plant cooling, in gallons of water required per megawatt-hour of electricity produced[5].

Figure 79 Analysis by the Union of Concern Scientists revealing the remarkable amount of water savings associated with dry-cooling power systems (Source: UCS,2)

The author of this Capstone strongly feels that the wide-scale use of air-cooled plants could be a transformative step in terms of managing China's water scarcity. In a 2010 article for the China Daily, general manager of the Huadian Ningxia Lingwu Power Company, Li Qihao, reported that two air-cooled power plants would save 26.6 million tons annually. This is equivalent to the annual amount of water used by 800,000 people^{xxxvii}. By the end of 2012, thermal power generation from ACC plants made up 14% of the total. By 2020, this percentage is expected to increase to 22% (Zhang, C., & Mo, H., 11082). The proliferation of air-cooling technology throughout the energy sector has the potential of translating into significant water conservation for China's industrial sector.

(b) A Comprehensive Desalination Program

While most associate desalination with small, oil-rich gulf countries (70% of desalination occurs in the Middle East), it remains a viable solution for the looming water scarcity besieging China. This is particularly true considering the preponderance of both China's economic activity and population along coastal areas. China has already achieved over 135,700 tonnes of water (where 1 metric ton = 1 m³) on a daily basis through desalination with an additional 600,000 tonnes promised by both the National Development and Reform Commission and the State Oceanic Administration in the next five years. This will entail the construction of over one hundred desalination projects spanning sixteen different provinces. By 2020, the hope is that desalinated water will be the main source for many of China's outlying islands that have been struck by water scarcity. Israel-

based IDE Technologies constructed the largest desalination plant in all of China, located in Tianjin and seen in Figure 80.



Figure 80 Tianjin: home to the largest desalination plant in China

(Source: https://www.ide-tech.com/en/our-projects/tianjin-desalination-plant/?data=item_1)

Avshalom Felber, the former CEO and current executive chairman of IDE, has stated that China will “eclipse the Gulf market within two decades”, a bold statement indeed (Wong, G., 4). Yuan Zhou conducted an exhaustive study of the economic feasibility of wide-scale desalination for China, expertly chronicling the falling prices of both MSF (multistage flash distillation) and RO (reverse osmosis) as seen in Figure 81 and 82 respectively:

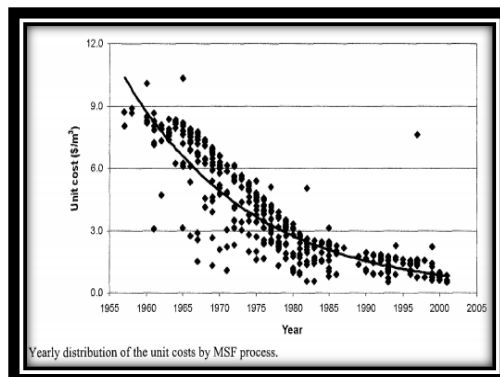


Figure 81 Falling costs of multistage flash distillation over a fifty year period (Source: Zhou, Y., & Tol, R. S., 228)

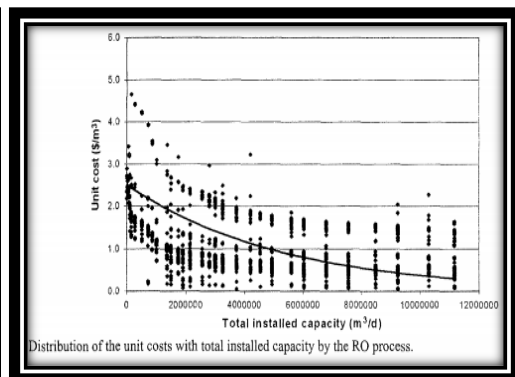


Figure 82 Falling cost of reverse osmosis with increasing installation capacity (Source: Zhou, Y., & Tol, R. S., 230)

Just as the federal funding to the tune of 1.5 billion dollars from the 1950s through to the 1980s allowed for the growth of desalination projects in the United States, so too will China need to provide serious subsidies for wide-scale desalination. As stated in a report from the author in 2014, “Serious government subsidies from the PRC will be needed to get a nationwide desalination project off the ground in China. However, in the long run, government support must eventually yield to a market economy for desalination to become truly entrenched. The cheap price of desalinated water versus the expense to produce the same volume of that water still remains a challenge” (Maley, 2014, 8). As Zhou suggest, “as water prices increase and desalination costs continue the trend of decline, it will create higher favorable conditions for desalination use in China in the future” (237). Back in 2014, the author wrote to Dr. Zhou to see if he changed his opinion, considering the publication date of his initial article (2004). His response can be seen in Figure 83:

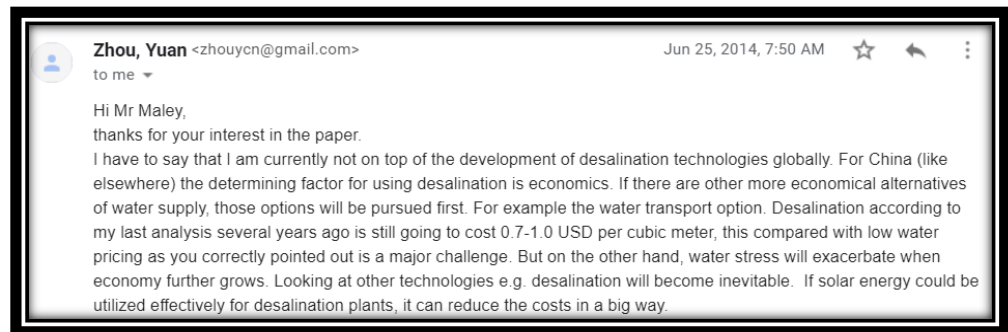


Figure 83 Email Communication with Yuan Zhou on June 2014. (Source: Penn Email)

(vi) **Technological** Preserving China’s Air

(a) Public Participation through Social Media

Ma Jun is widely considered to be the most important environmental

activist in all of China. More than one publication has compared his 1999 book *China's Water Crisis* to Rachel Carson's *Silent Spring* in terms of its impact and the environmental awakening that it helped to foster. The author of this Capstone would consider it a major coup to be able to establish communication with Mr. Jun and quote him in this Capstone. Unfortunately, no reply has been received to an e-mail sent in early December of 2018^{xxxviii}.

One of Ma Jun's most laudable accomplishments was the establishment of an 'app' that allowed everyday Chinese citizens to track AQI (Air Quality Index) scores for multiple locations across the country. The creation of the "Blue Map" app was a masterstroke in that its inception occurred during the convergence of two major events: the decision by the Chinese government to release real-time emissions from the top 40,000 polluters and the market proliferation of smartphones which allowed this information to be shared through China's equivalent to twitter, Weibo. The author of this Capstone checked the Blue Map on New Year's Eve, 2018. The following map was recovered, courtesy of Jun's Institute of Public and Environmental Affairs (IPE), as seen in Figure 84. Notice the 500 AQI currently in Turpan. For reference, consider Section 1.5 ("Environmental Fallout") which described the "Airpocalypse" in Beijing where the AQI reached 608.

For those who remain understandably skeptical with regard to the accuracy of the data, consider the following: 203 companies across China responded to EPB write-ups generated by Ma's citizen-led IPE apps (Wang, A., 895) in a campaign of "naming, blaming, and claiming" (896). Alex Wang himself

wanted to test the accuracy of the app while in China and used it to submit a complaint, which received a response from the offending company through the local EPB the next day, noting the problem and detailing the steps taken to correct it (896).

Perhaps an even greater move towards accuracy and transparency emerged around the same time as Jun’s Blue Map by way of China’s richest man, Jack Ma. The Alibaba founder released his “Danger Maps” which provided citizens with water-testing kits at a nominal cost of around ten dollars to do their own testing and the opportunity to submit the results to the app. While discussing data-driven approaches to governing, D’Ignazio mentions Ma’s “Danger Maps” after concluding that “one of the best ways to ensure legibility and relevance, we suggest, is for communities to pose, frame, and find ways of generating answers to the questions themselves” (117).

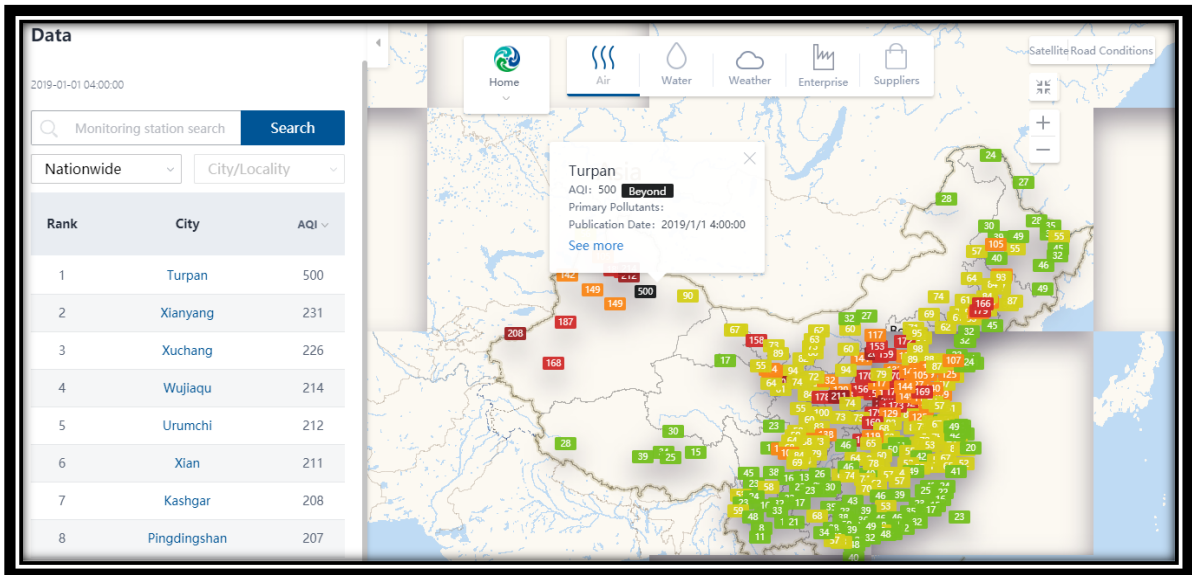


Figure 84 Ma Jun’s interactive “Blue Map” App for December 31, 2018.

Source: http://www.ipe.org.cn/AirMap_fxy/AirMap.aspx?q=1

Ma Jun's Blue Map App is essential in that it marks a rising tide of public participation that will help catapult China's environmental transformation forward. Citizens using the App have placed significant pressure on regulatory bodies to reprimand companies and industries not in compliance. Once people began using social media to identify officials and regulatory bodies by name, officials could no longer ignore the problem and had to act. The prospect of public shaming carries a lot of currency here, compounded by increasingly tying environmental performance into mechanism of promotion. Jun frequently tells the story of a Beijing steel plant that frequently was in violation of SO₂ emissions, with levels ten times higher than allowable values. Appeals to the plant feel flat until the App appeared and citizens began putting pressure on officials to do something about it. The end result was the removal of 2,600 tons of SO₂ due to the forced shutdown of over three production lines^{xxxix}. One actor in this process that is even more likely to take action than the government is multinationals. Companies like Apple and Walmart, the former of which used the App to castigate suppliers who were not in compliance in 196 separate cases, know that China has a rising consumer class who will "vote" with their wallets. Apple already has a tenuous relationship in China, one marked by sweatshop conditions, hazardous waste, and even child labor practices; the aforementioned tragedy in 2010 at Apple manufacturer *Foxconn* (see page 142) made things worse. As a result, the spotty track record of multinationals in China make them particularly susceptible to wide-scale boycotting. Jun's App has brought empowerment to China's citizenry. As Jun stated in an article for the South China

Evening Post in December of 2017, “with more public information disclosure, public participation, companies are finally starting to take initiative to care about the environment...the risks of not doing so are too high”^{xl}. It is public participation and empowerment like this that will be instrumental in China’s environmental turnaround. Recall the growth of ‘deliberative democracy’ as discussed in 2.2(c) as well as the increasing premium that the ruling elite places on Confucian social order, as discussed in 4.1(a). Recent developments in public participation underscore the fact that deliverance will arrive concurrently from the bottom up and the top down.

(b) On the Cutting Edge of Research and Development

As distasteful as it may be to many scientists, particularly those in the ‘hard’ sciences of physics and astronomy, periods of war and geopolitical brinksmanship lead to more jobs in the sciences. When the author earned his Masters in Astronomy at the end of the 1990’s, job prospects were grim. Most academic positions all seemed filled by professors in a very particular age range, namely those that entered the job market during the Cold War. The Cold War translated into a great deal of funding for physics and astronomy. As Lankford points out, “federal dollars were channeled into universities in order to strengthen the sciences. Astronomy benefited from this practice” (218). Spending on NASA claimed 4.41% of the federal budget in 1966 compared to the less than 0.5% it has been hovering at for the last five years. It seems that declarations of war always lead to greater funding in research and development. China is no different on this front. Once Premier Li Keqiang declared a “War on Pollution”, funding for

research and development in China has soared. The result is the creation of cutting-edge technologies that have taken an unorthodox approach to dealing with China's air pollution. The 2018 overview by the National Science Foundation has revealed that the number of science and engineering degrees acquired in China has easily outpaced all countries, including the United States (Figure 85). The steady climb for the last fifteen years seen in Figure 85 has resulted in China now ascending to second place behind the United States among the countries leading the world in research and development (Figure 86).

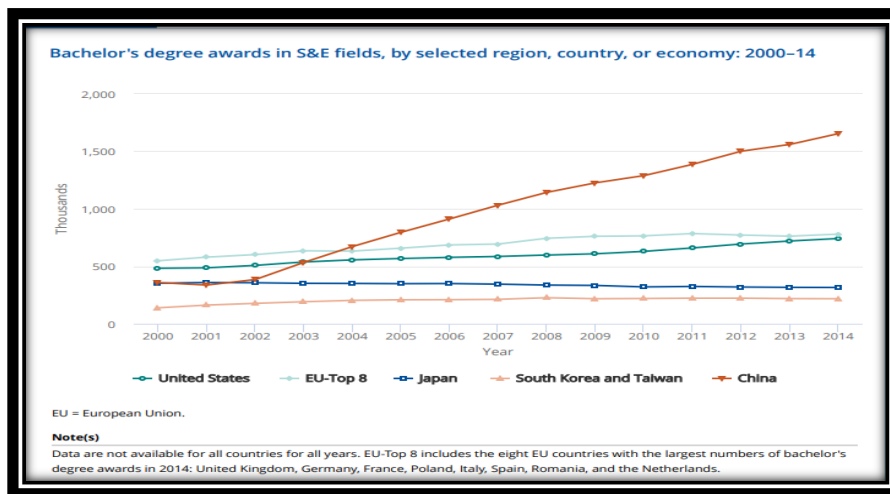


Figure 85 Acquisition of bachelor's degrees in science and engineering given in the National Science Board's "Science & Engineering Indicators 2018" (Source: NSB, 5)

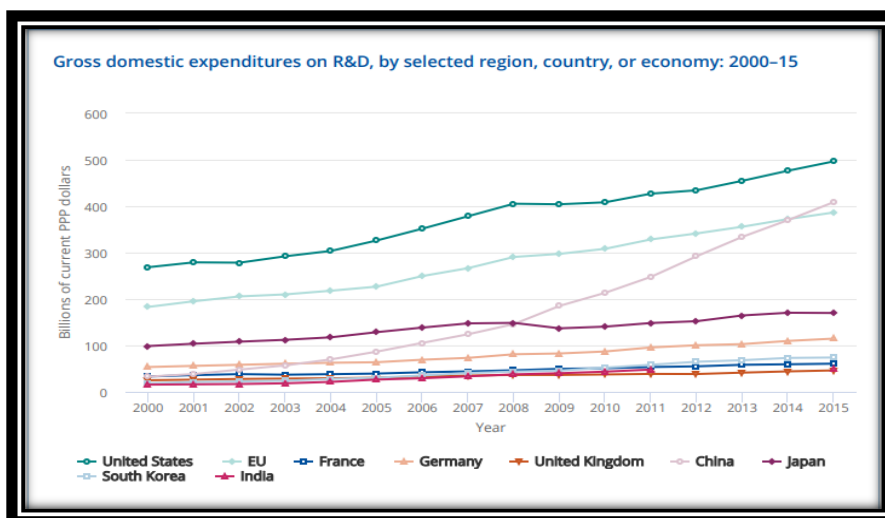


Figure 86 Spending by various nations on research and development. Observe China overtaking the European Union in 2014, securing the second position behind the United States. (Source: NSB, 13)

The author of this paper had once described China as a “nexus of raw creativity and innovation” (Maley, 2014, 7). If China managed to achieve exponential economic growth, surprise the world, and single-handedly lift countless numbers of its citizens out of poverty in the process, why could it not achieve the same thing in the area of technology? At the rate that research and development is growing in China, it is likely that the world will be surprised again rather soon through heroic and innovative technologies to improve the environment. The next two sub-sections will highlight just two of these innovations among many that the author found particularly interesting.

(i) The World’s Largest Air Purifier

In 2008, the author had an opportunity to attend the annual “GCGW” (Global Conference on Global Warming) in Istanbul thanks to funding from the Haverford School. One presentation that left a strong impression was from a Libyan engineer named Muftah Elarbash. Elarbash was proposing to populate

regions of Northern Africa with a series of “solar chimneys”. The concept was simple – sheeting about six feet in height would extend out horizontally from the base of a large chimney. The sunlight enters through the sheeting (typically a material such as Tedlar), but then is trapped, heating the air underneath. Since hot air rises, the air’s only path is up through the chimney in a gush (called the ‘Stack Effect’) where an awaiting turbine generates electricity. One such solar chimney was built in Manzanares, Spain back in 1982 until it was toppled seven years later. The author of this Capstone found a way to integrate this innovative idea into the course content of his own *Environmental Ethics* class at the Haverford School every year since. The University of Minnesota’s David Pui, working with Qingfeng Cao, proposed a unique variation on this theme in a paper released in 2015. Pui’s solar-assisted large-scale cleaning system or ‘SALSCS’ works on the same premise as solar towers, namely the “Stack Effect”, but with one critical difference. Instead of a turbine, Pui proposed lining the inside of the chimney with a bank of air purifiers; as the air rushes up through the chimney and is cleaned in the process (Figure 87). Based on the model generated, the authors suggest that a volumetric flow rate of $2.64 \times 10^5 \text{ m}^3/\text{s}$ could be achieved, “meaning that 22.4 km^3 of air can be cleaned by the system in 24 hours” (Cao, Q., 9).

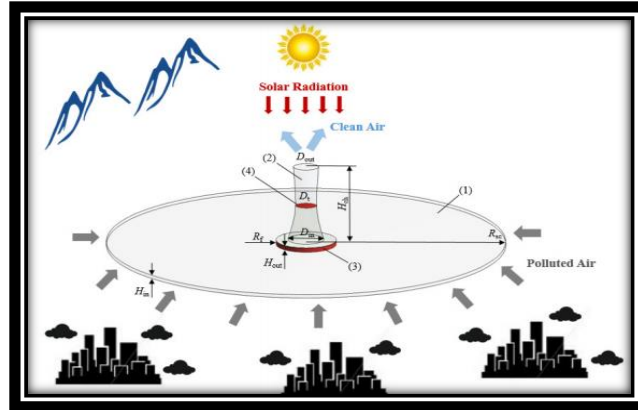


Figure 87 Cao and Pui's SALSCS model, elegant in its simplicity, and based on the concept of the solar tower (Cao, Q., 2)

With little fanfare, Cao Jinji, the director of the Earth Environment Center at the Academy of Sciences, orchestrated the construction of a 60-meter tall SALSCS tower in the town of X'ian as seen in Figure 88. The tower produces 10 million m^3 of clean air on a daily basis, with Jinji reporting a 19% drop of $PM_{2.5}$ levels over a 3.86 square mile area around the tower. These results inspired both Pui and Cao to publish a two-part evaluation and analysis in 2018 complete with recommendations for improvement (Cao, Q., 2018). Pui has since proposed a system of SALCSC units, creating an AMSA (Adaptive Matching Spray Array) as a prerequisite for newly built communities as seen in Figure 89.



Figure 88 Functioning SALSCS prototype tower in X'ian

(Source: <https://www.nbcnews.com/mach/science/skyscraper-sized-air-purifier-world-s-tallest-ncna858436>)



Figure 89 Pui discussing AMSA Green Communities protected by multiple SALSCS units

(Source: <https://www.thebeijinger.com/blog/2018/01/16/china-has-worlds-biggest-air-purifier-and-didnt-bother-tell-anyone>)

(ii) Metal-Organic Frameworks (MOF)

Much has been made of the insidiousness of $PM_{2.5}$ particles in the wake of various “airpocalypses” in Beijing. By merit of their small size (less than 2.5 micrometers), $PM_{2.5}$ particles can elude our bodies’ natural defenses (mucus in the throat, hair in the nose, cilia in the lungs) and find their way to our vital organs. The proliferation of air purifier towers, as featured in the previous section, has the potential of effectively reducing this threat. In this section, another fascinating innovation from China also promises to help reduce the threat of $PM_{2.5}$ particles.

Metal-Organic Frameworks, or “MOFs”, are very tiny, modular structures made from a hybrid of metals and organic linkers. These porous structures can be blended into nanofibrous filtering systems that have the ability of detoxifying solids, liquids, and gases by “caging” the pollutant in a kind of three-dimensional mesh. The Beijing Institute of Technology has been working extensively on this process, directed by Wang Bo. Taken from one of Wang Bo’s many papers regarding the efficacy of MOFs, Figure 90 reveals that MOFs can capture $PM_{2.5}$ particles as well and are able to store ten times more pollutants than regular filters. The team have recently developed a “roll-to-roll” hot pressing method for producing MOF filters for wide-scale distribution. The resulting study has yielded

very promising results: at room temperature, 99.5% of PM_{2.5} particles and 99.3% of PM₁₀ particles are removed. Increasing the temperature to 200°C (392°F) barely compromises MOF effectiveness: 96.8% of PM_{2.5} particles and 95.8% of PM₁₀ particles are removed (Chen, Y., 1).

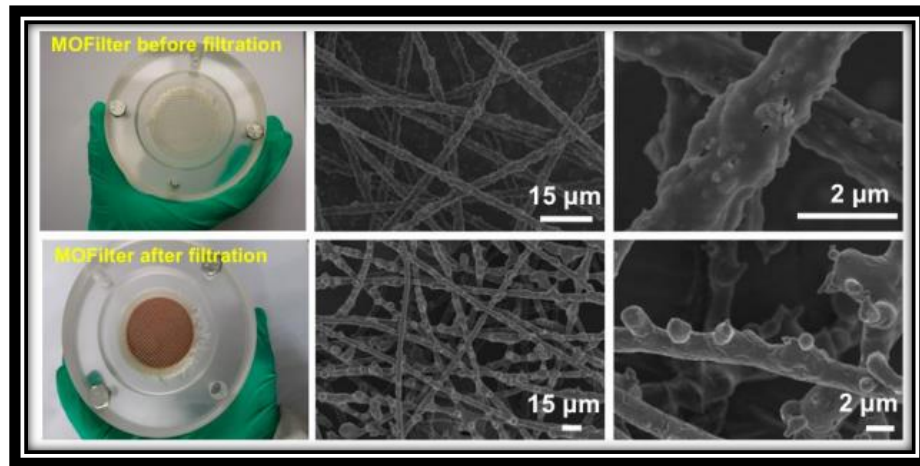


Figure 90 Microscale imaging reveals the ability of MOF filter systems to catch particles.
(Source: Zhang, Y., & Yuan, S., S21)

(vii) **Technological** Land-Based

China is planning to spend up to 360 billion dollars on renewable technology by 2020 for the goal of achieving the 20% renewable energy mix by 2030, as pledged during the Paris Summit. Arguably the biggest challenge is not that of production and operation of renewables, but the transference of generated renewable power into China's grid system. In 2015 alone, China experienced a 15% curtailment of wind resources which incurred a cost of 1.4 billion dollars. The issue of solar and wind curtailment remains one of China's biggest technical hurdles. Five years before the Paris Summit in 2011, the author wrote a final paper for a summer course describing how China was attempting to solve the issue of transporting hydroelectric water power from China's underdeveloped

west (and coal from the north) to reach the coastal cities in the east. This was accomplished through the construction of ultrahigh voltage (UHVDC and UHVAC) power transmission systems. Power is a function of both voltage and current and when traveling through wires, power is shed through heat due to wire resistance, which is a function of current. Therefore, “step-up” transformers are employed outside power stations to “step up” the voltage and drop the culprit for energy loss, which is the current. Due to the mismatch between resources and load demands, China must transport energy over great distances. Therefore, over the last ten years, an “ultra” high voltage transmission system was introduced to the grid in order to maximize voltage as much as possible, thereby reducing energy loss through resistive heat (Figure 91).



Figure 91 Workers upgrading ultra-high voltage lines on April 13, 2011 in Henan Province's Nanyang region.
Source: <http://en.people.cn/102774/7680026.html>

In 2011, the author remarked that:

“China also needs to continue to develop its ‘smart grid’ system to maximize energy efficiency and manage demand. According to Beebe, 80% of China’s electricity is controlled by “State Grid” whose “Smart Grid Plan” two years ago outlined a comprehensive game plan for implementing a nationwide smart grid plan until 2020”. (Maley, 2011, 21)

Since 2011, China's implementation of a smart-grid system has yet to be fully realized, despite the intention of investing over two trillion dollars into grid infrastructure improvements. The growth of UHV power lines have been outpaced by the installation capacity of solar and wind power, as China's own National Energy Administration admits in a public statement: "lag of the construction of the delivery channel, which is far behind the growth of renewable energy installed capacity and power generation"^{xii}. Complications by way of limitations in transmission capacity also arise since UHV lines must concurrently conduct intermittent wind and solar power along with steady coal-fired power (Luo, G., 14).

The next complication occurs once the transmission lines send the power to the stations themselves. Most coal-fired and nuclear power stations are considered 'base load' in that they are consistently on and producing steady power. In this way, they provide the constant electricity available throughout the 24-hour cycle, regardless of peak use in the afternoon and evening. The intermittent nature of solar and wind power does not provide base load, but lend themselves to 'peaking' and 'load-following' power plants. However, China's generator load centers are not sophisticated enough yet to provide adequate switching time and load-following to work with the intermittency of renewable energy output. The National Energy Administration mentioned as early as 2014 that the 13th Five Year Plan would "include commitments to addressing grid planning, smart grid development and integration, and thereby resolve the problem of curtailment" (Wang, H., 24). An entire section of the latest FYP (Section 3 – "Smart Energy Systems") in Chapter 30 ("Build a Modern Energy

System”) is dedicated to expanding and refining the smart grid (CCCP, 85). China has been proactive in addressing this issue since the inception of the latest FYP and must continue to prioritize smart energy systems as a major national policy objective.

4.3(b) Analysis and Prediction of Likely Political and Social Trends

(i) **Social** Bucking Western Modernization Theory for a Distinctly Eastern Paradigm

Dean Rojek tells a story where a warden was asked why the gates of a large Chinese prison was left open. The warden’s reply spoke volumes: “We have never had an escape; there is nowhere a prisoner can escape to in China; no one would help an escaping prisoner because it violates the needs of socialism” (152). In China, pressure by the collective and social control is as valued by the populace as it is the ruling elite (as detailed in 4.1(a)). When thinking about possible trajectories for this Capstone, the author asked an overly precocious Chinese exchange student named Henry Sun at the Haverford School about the likely prospects for electoral democracy reaching China. He said it would never happen, not because of being squelched by rulers in power, but because the people do not want it either. He said that China would always want to do something different than the west “simply because it can”. Rojek points out that China and the United States are so different culturally, that “neither political system could adopt in any significant way the practices or ideologies of the other” (152). The tenets of Confucianism casts a long shadow through the ideology of China’s ruling class as social order is elevated far above any notions of individual

rights and privacy (144). Western scholars still subscribing to Max Weber's Modernization Theory (as covered in section 2.2(c)i) are still equating China's rising middle class with eventual democratization. They will be waiting in vain. Understanding these overarching cultural differences is critical in charting China's environmental future. It will also help justify the argument for environmental authoritarianism made by the author of this Capstone in section ii.

The unlikely march to democracy envisioned for China by some in the west^{xlii} is referred to as the "unilateral" approach by Jie Chen. In this approach, a "rising middle class universally embodies these attributes and serves as the main thrust of the democratization movement" (706). However, latecomers to the game, namely developing countries who have experienced very recent industrialization and rapid economic growth, typically do not follow this pattern^{xliii}. These latecomers typically produce middle classes that have a very interconnected and dependent relationship with the state (712). China is better described as being subject to a "contingent" approach where "the middle class does not necessarily support democratization, especially when it is heavily dependent upon or closely associated with the authoritarian state, socially/materially well off or satisfied, fragmented as a class, and/or worried about political instability" (706). Confucian deference to authority aside, much of this reaction can be understood as conforming to a base human proclivity independent of location, as captured by the quote from the late comedian Patrice O'Neal: "good is good if it's good for me". For many middle class Chinese, Chen points out that "material interests" is a likely motive for the middle class "favoring social order over democratization"

(708). Chen concludes that as long as the “ruling elite of the state remains determined to maintain the current authoritarian, one-party system, therefore, the middle class is likely to continue to be indifferent to democracy” (716). This is revealed in a poll conducted by both Chen and Lu where only 25% of those polled in the middle class would seek active participation in government while only 28% think that ‘ordinary people’ should play a role in decision making^{xliv} (Figure 92).

	Supportive response by the middle class (%)	Supportive response by the lower class (%)	Factor loading
In general demonstrations should not be allowed because they frequently become disorderly and disruptive. (Disagree)	22.9	35.6 ^a	.860
The harmony of the community will be disrupted if people form their organizations outside the government. (Disagree)	23.5	37.4 ^a	.860

	Supportive response by the middle class (%)	Supportive response by the lower class (%)	Factor loading
Government leaders are like the head of a family; we should all follow their decisions and don't need to participate in government decision making. (Disagree)	24.9	33.7 ^a	.817
Measures to promote political reform should be initiated by the party and government, not by ordinary people (<i>laobaixing</i>) like me. (Disagree)	28.1	40.1 ^a	.817

Figure 92 Polling comprised of 739 middle-class respondents and 2,170 lower-class respondents (Source: Chen & Lu, 709)

While not seeking an electoral democracy per se, Chinese citizens have an expectation that local cadres are “aware of public demands (including beliefs and values) and thus take into account the people’s responses to policy” (Rothstein, 4). This is synonymous with a kind of ‘adaptive’ authoritarianism (see the following section) instead of a western democracy. According to Rothstein, citizens are concerned more for the ‘output’ side of government, namely that political legitimacy is maintained as opposed to “the standard set of liberal

democratic rights” (5). This can be seen in the relatively higher amount of trust afforded to China’s government institutions when compared to other countries (Figure 93).

Generalized Trust, Confidence in Institutions, and Economic Growth						
	China	Peru	India	Morocco	Brazil	Mexico
Generalized trust (%)	52.3	6.3	23.3	13	9.4	15.6
Confidence in institutions (%)						
Police	80.1	15.8	64.1	61.4	44.8	33.6
Civil services	85.8	6	54.3	51.3	52.4	25
GDP growth (%)	9.1	5.02	3.77	3.32	2.66	0.83
GDP per capita growth (%)	8.37	3.55	2.17	2.09	1.25	-0.19

Figure 93 Rothstein’s “Quality of Governance” comparison between China and other countries (Source: Rothstein, 4)

Part of maintaining this political legitimacy in the eyes of the people is the triumph of the public good, symbolic values, and what Steinhardt calls a broad “imagined community” of multiple cities and regions. The prioritization of the “public good” does as much to explain the vector of environmental protests in China as it explains why no one would help the escaped prisoner mentioned at the beginning of this section. To understand the heart and soul of what drives the population at large (it’s certainly not an inexorable push for western democracy) is to understand the trajectory of environmental protests and how best to address them. According to Steinhardt, the turning point occurred in Xiamen in 2007. Efforts were underway to build a PX (paraxylene, derived in part from benzene and used in certain clothing and plastic bottles) chemical plant that was perilously close to a residential area of Xiamen. Once a campaign was launched to save “beautiful Xiamen” as a *public good*, an important transformation took place in the timeline of environmental protests. This transformation was the broad mobilization of citizens who are “unknown to each other” but motivated by the

preservation of “public good, policy concerns, or symbolic values relevant to a broad ‘imagined community’ of a city or even the whole country” (77). A perfect storm of other variables also helped to change the landscape of this protest: instantaneous spread of information through the internet and social media (millions of cellphone received text messages, including nearly every phone in Xiamen), participation among high-profile actors, media, and NGOs, and recent availability of pollution figures by the government.

Environmental protests within an authoritarian system can work, particularly this ‘new breed’ of protests using the framing of a “public good” which automatically recruits multiple actors to the foreground, uniting citizens across the nation who see a localized environmental issue as a collective affront on everyone. Just like the 1.6 billion dollar PX plant in Xiamen was mothballed, so was an underground railway in Nanjing rerouted once protests emerged about the removal of historical trees, once again buttressed by NGOs, activists, academics, and even a member of Taiwan’s Kuomintang Party (71). The construction of a similar PX plant in Kunming was also placed on hold by the mayor once NGOs, a wide-scale internet dissemination campaign, and public outcry over transparency reached a fever pitch. Once people began to define environmental grievances in terms of a “public good”, the nature of protests had evolved as seen in Figure 94.

	Main Repertoire since the 1990s	The New Repertoire since the Mid-2000s
Protest constituencies	Narrow, closely knit communities of "victims"	Broad "imagined communities" of cities or regions
Mobilizing grievances	Exclusive (private)	Nonexclusive (public)
Sequence of resistance	Ex post facto	Preventive
Protest and policy advocacy	Hardly any linkages	Mutual reinforcement; sometimes sustained advocacy with NGO participation

Figure 94 The evolution of environmental protests in China, thanks to the 'transformative' events in Xiamen, 2007 (Source: Steinhardt, 77)

It is important to recognize that all authoritarian regimes have a small element of democracy and all democracies have a small element of authoritarianism. That small, quasi-democratic element residing in China's authoritarianism is likely the "deliberative polling" mentioned in section 2.2c(i) as explored by Fishman in the town of Zeguo. In fact, officials who are generally presumed guilty before proven innocent when it comes to corruption find the transparency associated with deliberative polling and townhall meetings to be increasingly palatable. Officials "may learn to use transparent and inclusive deliberative decision-making to avoid or reduce accusations that their decisions have been bought by developers and other business elites" (He & Warren, 13)

From now on, social movements in China, as they apply to the environment, must continue to push for the dual catalyzers of transparency and education. Transparency in both the private and public sector as well as accountability must be the continual demand of population centers. Transparency does not have to be an anathema to authoritarian regimes, as Singapore demonstrated when attempting to bounce back from the Asian financial crisis in 1997. This was a period for Singapore marked by reforms "directed at improving disclosures of private commercial interests and data facilitating them" (Rodan,

49). EPBs in China have harbored a long-term fear of public disorder, dissuading them from conducting public survey activities. This presents a kind of Catch-22, “trapped in the contradiction between the commitment to protect the environment and people’s health on the one side, and on the other the fear that popular discontent might erupt if the extent of environmental issues is fully disclosed” (Brombal, 9). However, transparency in China has increased in leaps and bounds, with Brombal stating that “remarkable progress has been made in terms of information disclosure in the last decade” (9).

Finally, this transparency must be equally matched with education. Beihang University’s Xueying Yu conducted an exhaustive study examining environmental attitudes among urban and rural dwellers, finding that “pro-environmental attitudes are more likely to be found among young people, women, the educated, and those most personally affected by environmental degradation (41). Yu concludes that “education is the key factor that leads to the rural-urban differences in environmental attitudes in China” (43). A system of “modularized seminars” pitched to older, rural residents may be the solution to close the environmental education gap across the country (47).

(ii) ***Political*** An Argument for Environmental Authoritarianism

The mentioning of Singapore by Rodan is entirely appropriate considering how much China has borrowed from Singapore over the years, evidenced by the great deal of attention given by Chinese officials to the death of Singapore’s trailblazing Prime Minister, Lee Kuan Yew in 2015. Yew introduced the notion of Singapore as a “Garden City” in 1967 as the government’s authoritarian

approach to the environment has persisted despite the trends in many other parts of the world “of deregulation, liberalization, and privatization” of economies (Han, H., 4). Singapore’s unique brand of non-participatory, top-down, authoritarian environmentalism has resulted in mandatory green building after 2008, elimination of materials impacting the ozone layer in 2002, and “the lowest level of water pollution in Asia” (9) (Figure 95). Like so many policies co-opted by China that have seen their inception in Singapore, China is adopting this same approach to the environment and getting results.



Figure 95 The 164 foot “Super Trees” of Singapore’s “Gardens by the Bay”
(Source: <https://destinationmagazine.com/stories/singapore-city-in-a-garden/>)

The author of this Capstone believes that authoritarian environmentalism, not democratic environmentalism, is the best approach for China. For reasons provided in the previous section, an *electoral* democracy is not only ill-suited to the Chinese people, but by all accounts, unwanted^{xlv}. State-sponsored dominance is ingrained in the psyche of the population, and speaks to deeply held traditions tracing back to the “Mandate of Heaven”. Foisting an electoral democracy in China could take years of adjustment by way of social engineering and cultural shifting that the immediacy of China’s environmental problems will

not sit around and wait for. The wolf is already at the door and the PRC must use mechanisms already at their disposal, that, with some fine-tuning, could work exceedingly well. Bruce Gilley, while remaining circumspect about authoritarian environmentalism (referred to as “AE” for the rest of this section), has written one of the definitive papers on the subject as evidenced by how often his name appears in other papers. His definition for AE is the following: “a public policy model that concentrates authority in a few executive agencies manned by capable and uncorrupt elites seeking to improve environmental outcomes” (288). The outcome of AE is typified by a “rapid and comprehensive response to the issue and usually some limits on individual freedoms” (288). This, of course, presumes that the hyper-informed collection of “eco-elites” are beyond corruption and remain loyal to the Chinese concept of governmental meritocracy.

Proponents of democratic environmentalism in the west believe that they have achieved a successful paradigm of “top-down and bottom-up mechanisms” that could not be duplicated by any alternative approach (299). As one of the author’s professors stated during the writing of this Capstone, “in the USA we have a system that involves the federal regulators to ensure a level playing field – i.e., no pollution havens that allow local governments to attract industry by having soft enforcement”. However, Gilley suggests that China has the advantage of “relatively strong institutions that could, *if directed*, manage the participatory process” so as to achieve the same level of complementarity. The persistent concern with AE is the “fragmented bureaucracy” and the barriers to local enforcement due to the economic prioritization of local cadres, an issue

covered previously in this Capstone. However, as we will see later in this section, China has made very significant strides to correct this issue courtesy of the continued enforcement of the Environmental Protection Act in 2014. In either case, if we take a long, hard look at the western paradigm of democratic environmentalism and the system of checks and balances circa 2019 between the federal, state, and local governments, how well is it all really working? Is the current climate of lobbying and regulatory capture in the United States superior to AE and a more effective system to address China's environmental chaos? The recent lawsuit regarding Monsanto's use of glyphosate reveals a timeline of ruptured checks and balances and a regulatory system in dire need of correction (Figure 96).

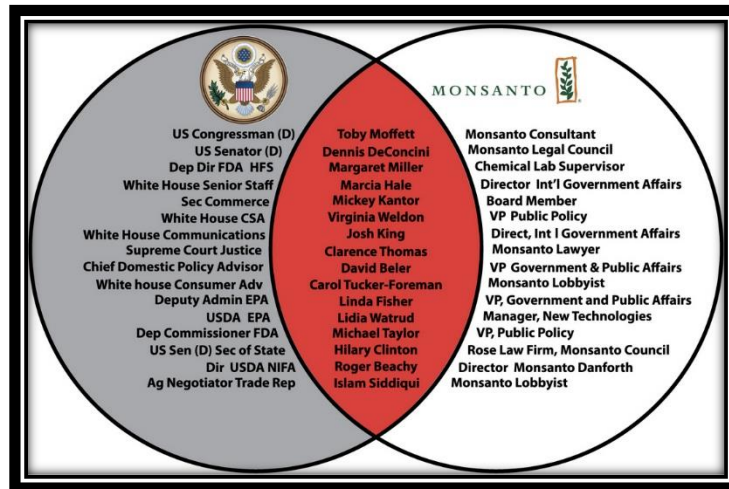


Figure 96 One of many 'revolving doors' between government and industry in the United States (source: <http://occupysonomacounty.org/content/some-history-federal-governmentmonsanto-revolving-door>)

Geoffrey Chen discusses the superiority of AE over the neo-liberal framework of the west when dealing with the environment by discussing the different approach both systems take towards climate change. Chen, quoting an earlier paper, suggests that western governments too often place the onus on the

“consumer-citizens” to alter behavior as opposed to government or industry under the premise that the actions of everyday people will somehow “deliver what neither the globalized economy nor the decapitated state are able to achieve” (213). During previous academic work covering water scarcity, the author discovered something rather interesting. At the time, California’s Governor Brown placed mandatory restrictions on water use for residents, as people were even called to spray paint their lawns green to conserve water despite no restrictions placed on agriculture. Agriculture is one of the biggest donors to Governor Brown and responsible for 80% of the water use in California.

As author Richard Wright once said, “don’t leave inferences to be drawn when evidence can be presented”. The University of Oslo’s Anna Ahlers, working with Yongdong Shen, provides evidence of AE’s efficacy in the case study of Hangzhou. Both authors believe that, compared to democracies, AE is “better equipped with institutional and procedural features that allow for faster, more rigorous responses to environmental problems” (299-300). The use of AE to address the poor air quality of Hangzhou resulted in the Hangzhou city government drafting its own air pollution action plan after the national version was issued in 2013. Notorious polluting industries in Hangzhou were forcibly shut down starting in 2007 as a moratorium on license plates was created during a period of time in 2014 before the introduction of a “lottery and auction system” (307). As one local official remarked, “had the government included the public to discuss the issue first, the number of new registered cars would have increased sharply in the meantime...but the purpose of the regulation was to reduce the

number of cars” (309). By the end of 2014, the amount of PM_{2.5} emissions associated with vehicle exhaust was reduced to 28% (310). While initially frustrated by the “without warning” policymaking, residents of Hangzhou began to see this as an effort “that now everyone simply was obliged to contribute to” (311). The issue was now seen through the lens of the “public good”, a communal conviction that was addressed in 4.3b(i), and a necessary linchpin for AE to function correctly.

A second case study in Hangzhou centered on particularly egregious industrial polluters found citizens mobilizing themselves for collective action and monitoring, two dynamic outcroppings of AE in Asian countries. As Ahlers reports, “residents were encouraged to express their complaints and demands, while the companies’ executives were expected to provide them with answers and to come up with plans for the reduction of industrial air pollution” (313). Ultimately, 450 enterprises were either relocated or shut down from 2007 to 2013. Of those 450, 24 were state-owned enterprises (315).

A large part of the success of AE in Hangzhou is an element of public participation. As Gilley points out, “society does not become dormant even in an authoritarian model, but merely shifts its involvements towards acceptable areas” (292). This public participation has been “given its most elaborate institutional form through participatory impact assessments and public hearings on environmental issues” (293). Gilley also suggests that in China, it is in the environmental arena where participatory processes have been “the most advanced” (293). This kind of “community-based environmental monitoring” (298)

is consistent with a more nuanced understanding of China's AE practices. The effectiveness of AE in China relies on a kind of "adaptive authoritarianism", what Yanwei Lei calls "responsive authoritarianism" where the state "adjusts policies in order to accommodate public opinion" (6). Ahlers uses the alternate term "consultative authoritarianism" (301) where public participation is elicited for environmental solutions in the process of "effectively implementing them" (301).

In order for AE to be successful for China moving forward, there are select areas that will require a vigilant eye. China must be careful in its over-zealous application of the Singapore model. In the case of Singapore, Heejin Han warns, "environmental concerns such as ecosystem diversity and climate change that do not generate immediate utilitarian values have not received the state's attention for a while" (11). In the last five years, China has demonstrated a commitment to all environmental areas, regardless of whether they translate into a profit model geared for a development mindset. Mobilization to protect ecosystems and recognition of climate change for the existential threat that it is: both are evidenced in China's 13th FYP and the Paris Summit. China's interventionist state model is characterized by Chen as a "template" that can reasonably replicate "the same degree of state capacity to protect human civilization under the threat of global warming" (217).

The second hurdle that must be overcome for the successful implementation of AE is, unsurprisingly, the dynamic at the local level of governance. Local cadres must have extended assignments that are longer than the current four-year turnover rate (Chen and Lees, 218), a fact that works

against the achievement of networks and trust building in the community. The fragmented bureaucracy that has translated into poor local enforcement of environmental law remains an issue and its repeated appearance in this Capstone reveals its status as an essential piece to the China puzzle. However, in the wake of the amending of the Environmental Protection Act in 2014, there has been a notable improvement in this area.

Successful “bottom-up” management cannot be achieved in AE “without the participation of local level stakeholders in their formulation” (Howes, S., 36). However, in terms of the incentive and promotion system of low-level officials, “since 1980s, GDP growth and economic performance have become leading indicators for promotion” (Jinshan, L., 10). Section 4.3a(ii) reveals how this is changing, as the PRC is finally heeding the advice of Ruxi Wang and “revising the processes of performance assessment” for lower-level governmental bodies by tying environmental protection into mechanisms of promotion (426). Perhaps no instrument has done more to accomplish this than the Environmental Protection Law in 2014, first highlighted in Section 2.2(b)ii. Article 47 requires careful monitoring of local governments to make sure that they fall in line with the central government’s environmental objectives, aligning performance to officials’ promotion prospects (Chen and Lees, 222). The Law also includes the right to sanction or detain the property of enterprises that are not in environmental compliance (222). “Environmental Inspection Teams” will also be deployed to make spot checks in local towns, described as a “top-down mode of inspection” that was further strengthened by the “Deepening Reform Leadership Small

Group” in 2015 (222). Finally, the “central government introduced standardized guidelines for the accounting and reporting of greenhouse gas emissions to preempt problems of asymmetric information in the central-local leadership” (224). It is important to place these guidelines for emissions reporting within the larger context of improved environmental data accuracy as covered in pages 141-146. The new style of leadership by Xi Jinping and Premier Li Keqiang has been described as a “more explicitly” top-down style of leadership, ideal for reconciling the divide between economic growth and environmental enforcement (225). Drafted during the same year as the Environmental Protection Law was the “National Guidelines of New Urbanization, 2014–2020”. These guidelines directly sought to fix fragmentation by a rigorous scheme of “top-down planning” where each department “must accept higher level institutions, such as the State Council, to coordinate various department in the governance system” (221). Also found in the document is a championing of the precautionary principle, the hallmark of progressive European countries. This “new policy thinking”, according to both authors, “incorporates the precautionary principle in tackling environmental problems at their source” (221). Both Chen and Lees goes so far as to say that the approach of the current leadership “reverses the trend towards what many China scholars have called fragmented authoritarianism” (225). In this way, the new administration is reversing one of the most enduring barriers to effective environmental enforcement in China. In the process, we arrive at yet another reason why AE remains the best approach for China’s environmental future.

(iii) ***Political, Part II*** China's Unique Brand of Environmental Authoritarianism vs. Classical Definitions of Authoritarianism as Understood in the West.

For many in the west, the mere mention of authoritarianism “almost always invokes negative feelings, and anything relating to it is normally deemed undesirable and must be rejected” (Ma, L., 1). Unfortunately, China's checkered history as an authoritarian country has provided many of the touchstones contributing to the long and dark shadow of this word in modern history^{xlvi}. However, at issue is the expectation by western thinkers that “historical patterns elsewhere will ultimately replicate the Western experience and culminate in similar forms of political practice and economic structures” (Beeson, M., 35). Beeson (also McCarthy, 307) identifies this as a “pervasive Eurocentrism that often fails to acknowledge” that uniquely different experiences have existed outside the “core Western states that were largely responsible for developing industrial capitalism and liberal democracy” (35).

In previous sections of 4.3(b), the case was made for authoritarian environmentalism in China. This command-and-control approach seems to be the most immediate choice for a country on the environmental brink, providing the kind of “effective ecological, climate, and resource protection policies” that are only possible through “painful cuts in individual consumption” and “sober revisions of all kinds of growth patterns” (Ahlers, A., 299). This draconian approach enforces directives such as “excluding polluting enterprises from receiving state bank loans, directly shutting installations down, and enacting intentional power cuts to achieve energy reduction targets” (Engles, A., 3).

Greater than the entire population of the United States, China's soaring middle class of 400 million people are a very different breed than the democratic freedom fighters of the Tiananmen Square protest from thirty years ago. In an era where the "global projects" of the Washington Consensus have "failed miserably" (Ma., L., 1), Asian countries have eschewed democratic principles and turned toward the reliable groove of mutual interest offered by authoritarian rulers. Yu-tzung Chang points out that "where people have experienced (within memory) a variant of soft authoritarianism that delivered social stability, economic development, and at least the appearance of resistance to money politics, democracy now seems to be having a hard time winning hearts" (75). A kind of "authoritarian nostalgia" is growing in countries such as Mongolia, Thailand, and the Philippines while observing China's economic success in contrast to Japan's floundering democratic economy (73). Ironically, it has been the corruption in Asian *democracies* such as Japan that "seems to have done as much to hurt public confidence in democratic institutions" (74). There seems to be a growing awareness that wealthy, democratic countries have achieved admirable environmental track records by simply outsourcing problems to their southern neighbors. Japan is "perhaps the quintessential example of a country with a vastly improved domestic environment, but one that has been largely achieved at the expense of its neighbors in the region" (Besson, 36). Meanwhile, when it comes to dealing with issues such as climate change and energy transitions specifically, authoritarian governments may be better positioned to

“take strong action and address the critical issues at which democracy has failed” (McCarthy, J., 306).

Skepticism regarding authoritarian environmentalism (called AE henceforth) is certainly understandable. Dr. Stephan Ortmann from the University of Hagan offered a dismal assessment of the prospects of AE in China simply because the paradigm of AE’s success in Singapore (see 4.3(b)ii) would supposedly not translate to a more populous and complicated nation. Ortmann cautions that authoritarian systems only achieve environmental success when environmental prerogatives synchronize with *economic* goals. Once a divergence is encountered, environmental stewardship is relegated to the backburner. Ortmann also reminds the reader that Singapore’s success as a garden city was purely driven by economic targets while tasks that did not translate into a profit motive, such as the protection of endangered animals, fell by the wayside (17). However, Ortmann believes that only a small city-state such as Singapore could use AE effectively, while it is “very unlikely” to work in China. Reasons include China’s “lack of transparency” (18), “accountability of local officials” (18), the need to allow “NGOs more influence” (19)^{xlvii}, and the need for the public to “be allowed to play a greater role in the process” (19). Many of these same concerns were expressed by one of the author’s professors (email communication, June 2, 2019) and include “corruption, falsifying data, spotted history in complying with agreements” and, of course, the linchpin of proper environmental law, *public participation*.

In order to address these concerns, one must start by dismissing historic, entrenched notions of authoritarianism because the phenomenon we see emerging from China in the last decade is completely unique. Many of the trappings of classical authoritarianism cited at the end of the previous paragraph and addressed extensively in this Capstone (lack of public participation, inaccurate data collection, fragmentation, etc.) are certainly anathematic to effective environmental policy; there is certainly no disagreement there. However, it is important to recognize that the gestalt emerging out of China, a kind of 'consultative authoritarianism' (Ahlers, A., 331 & Beeson, M., 39), really has no historical precedent for comparison. Indeed, many authors caution against making "assumptions of AE that has, as yet, been surprisingly under-researched in the case of China" (Ahlers, A., 301), and "making definitive judgments about an intersecting environmental and political process that is unfolding on a historically unprecedented scale and speed" (Beeson 39). According to Besson, in China's 'consultative authoritarianism', "technical expertise and local knowledge are recognized as potentially important parts of successful environmental management" (39). This local knowledge includes a growing form of public participation that many in the west may find surprising, a rising tide of citizen engagement met with a concurrent improvement in reporting (see pages 140-147).

Anita Engels suggestion for critics who presume that China's AE approach must automatically equate to non-participation from the public is the following: "it becomes increasingly obvious that participation is not only occurring, but is also

crucial for effectively implementing any large-scale program on the ground” (4). Ahlers mentions several case studies, including “the deployment of solar water heating systems in two Chinese cities” that could not have happened “without the consultation and active participation of citizens or local groups” (4). Among these multiple actors include business leaders “because government agencies are strongly dependent on information, e.g., on operational data from companies, market analyses, and trend forecasting” (4). The deep decarbonization aggressively pursued by Beijing in the last five years “will require any country to win the support of its population, not only to achieve passive acceptance but also to gain their support as actors in adopting new daily practices” (4)^{xlviii}. It should be noted that Engles adds: “this effort is difficult in pluralistic democratic systems, as is well understood” (4).

In the previous section (ii), the case studies provided by the University of Oslo’s Anna Ahlers and Yongdong Shen were offered as evidence of AE’s effectiveness. Ahlers had found that events such as the relocation of the Wanli Chemical Plant, where citizens were invited in as compliance inspectors for the new plant, represent a new era marked by an ongoing “dialogue platform between enterprises and residents” (*changqun duihua pingtai*) (313). Both authors concluded that “during the last decade the Chinese political authorities have shown themselves to be increasingly sensitive and responsive to public concerns and, as has been documented, even purely verbal demands can turn into a driving force for political action” (304). The fact that China’s AE is, in actuality, a “mixture of authoritarian and democratic features” becomes one of

the authors “core observations” (316). Ahlers sees China undergoing “a remarkable environmental policy change, which reflects the accommodation, to a certain extent, of enormous public anxiety and mushrooming civil engagement” (316). This has been achieved by “considerable shifts in the interfaces and interactions of local governments, residents and the business/industrial sector”, with public inclusion needing “a greater emphasis in descriptions of a Chinese AE” (316). Another case study will be offered to the reader by Tsinghua University’s Xiao Tang who asks the question: “Do Authoritarian Governments Respond to Public Opinion on the Environment? Evidence from China”.

Xiao Tang dismisses the notion that China’s government only responds to public complaints when those complaints happen to align with government objectives (3). Tang’s exhaustive survey work has shown that the need for social stability is the real driver for the rise in public participation in the last five years, as “public dissatisfaction has significantly influenced quantities of environment-related investments by provincial governments in China” (2). The fact that environmental petitions during the period of 2000 to 2014 have increased by five times has a clear causal link with the fact “that the government’s complaint handling and resolution rates remained above 95% during this period” (3). This has led Tang to the conclusion that “environmental petitions have had an evident impact on the environmental governance behaviors of local governments” (3). Quantitative proof of this was found when local government investment in “industrial pollution governance” would drop when polling found public opinion moving from “very unsatisfied” to “very satisfied”. Meanwhile, when the pendulum

of public consensus swung in the other direction, over half of local governments would increase investments by 5.8 times (7) and in the case of waste gas governance specifically, “more than nine-fold” (8).

Tang’s main takeaway is the fact that local governments will selectively react to those environmental concerns that mobilize the most public discontent. While water pollution is just as insidious as air pollution, “public complaints were associated with visibility rather than the actual hazards of pollution...people can physically witness atmospheric pollution as well as consult mobile apps to acquire knowledge of accurate pollution indicators”. Consequently, the public is familiar with atmospheric pollution, which evokes strong emotions of discontent” (9). Therefore, it is essential that the public is educated about the threats of pollution that may not be as demonstrable as air pollution. Part of this effort would require improved access to monitoring equipment, namely that “the provision of public environmental information products should be enhanced to facilitate a more comprehensive understanding of environmental conditions among members of the public” (13). Tang also suggested promoting a greater diversity of public inroads into policy beyond the ‘deliberative polling’ covered earlier in this Capstone, specifically “leaders’ mail boxes and hotlines, government consultancy platforms, polls, and reports on public opinion should be promoted and connected to various sectors related to the environmental policy development process” (13). Finally, while the government has already made strides into the issue of fragmentation by tying promotion of local cadres to environmental performance standards as seen in Figure 73 (a move being heard

loud and clear by town officials), Tang suggests moving a step further by even incorporating “the number of environmental petition cases along with performance in environmental governance” (13).

It is understandable for the reader to look upon all of this with a jaundiced eye; the seeming improvements in public participation as well as data transparency (see pages 141-147) – what is the real reason for all of this? Surely this is a veneer, much like China’s last-minute efforts to remove the layers of blue-green algae days before the 2008 Olympic sailing competition in Qingdao^{xlix}. The aforementioned skeptic Stephan Ortmann would write this off as simply a momentary point of intersection where economic interests and environmental protections meet. However, China’s policies have evolved in leaps and bounds since 2008, and while the ongoing commitment to the environment may be driven by self-interest, there are *many* factors at play other than economic, each more compelling and immutable than the next. Indeed, China’s AE is more “the result of a coincidental alignment of interests than the outcome of an intentional top-down steering process” (Engels, A., 3). Xi Jinping’s famous declaration of the “New Normal” economy of reduced growth was a direct response to the fact that China’s position as the world’s factory was “a significant threat to sustainable growth” and that a “low-carbon industrial revolution is therefore essential to propelling China into a new round of sustainable economic prosperity” (Lo, K., 153). While the resulting AE that has emerged “appears highly authoritarian, the situation on the ground is much more ambiguous, displaying a mixture of authoritarian and liberal features” (158). The ‘coincidental’ alignment of interests

that has served as a vectoring agent for increased transparency and public participation includes the “drivers for a low-carbon economy” such as “energy security”, the “health and legitimacy crisis”, and “limits of the economic growth model” (3). Among the main drivers for this new path are not only economic metrics, but also the “anticipation of protest as well as general awareness that environmental problems can have a considerable effect on public health” (Ahlers, 304). Engels attributes improvements in public participation to the realization that a low-carbon pathway will not be possible “without the active, local participation of a wide range of multiple actors” as “successful diffusion of a favorable low-carbon technology depends not only on physical and technological conditions but also on the complex socio-spatial embeddedness of the new technology” (4).

Finally, a word needs to be said about another driver that may not be getting the attention it deserves. Chinese leaders have rightfully weathered a firestorm of criticism from the public over their past handlings over the environment. Above all else, one could make the argument that Chinese leaders have more pressure to maintain their legitimacy in the eyes of the people than in other parts of the world. This is particularly true in a non-electoral meritocracy where leaders are chosen through a rigorous PES (see section 4.3(a)i) system that holds each person to an archetypal skill-set. In such an arrangement, “not only is China’s political system based on functionally superior meritocratic principles, but that it is actually also more likely to deliver good environmental outcomes than its democratic counterparts as a direct consequence” (Beeson, 37). Beeson argues that China’s meritocracy requires public participation by

default “as the key payoff for the authoritarian regime in this context is enhanced legitimacy as various stakeholders —and potential sources of social unrest—are included in a consultative process” (37). Beeson concludes that “China’s policymakers seem to realize that their own immediate political prospects are likely to be determined in large part by their capacity to either make real progress in actually fixing environmental problems, or controlling the all-too-likely social unrest if they fail” (43).

4.4 Scenario Building: *Best Case, Business-as-Usual, and Worst Case* as Expressed Through *S.T.E.P.* (Social, Technological, Economic, and Political)

4.4(a) Introduction

Previous academic work introduced the author to the whole notion of scenario building back in 2011. Interestingly enough, this experience from eight years ago also played a major role in further entrenching the author’s interest in China’s environmental problems. Creating scenarios was a vital part of the final paper requirements for this class, and so a set of three scenarios were created for China’s future, which followed the usual policy trajectories of “best case”, “worst case”, and “business as usual” (BAU). These scenarios were reanalyzed in the spring of 2019 for the purposes of this Capstone. It was not entirely surprising that academic papers amassed during the final paper in 2011 dated so poorly over the last eight years considering China’s constant state of flux. What *is* surprising is how well the *scenarios* have held up since that time. For the sake of reference, these original 2011 scenarios are presented in full in Appendix D. Note that figures and tables referred to in the text throughout were not included in order to conserve space.

A perusal of the “worst” scenario from Appendix D reveals an apocalyptic vision of complete climate fallout. It is safe to say that this was a creative exercise by the author. However, in the eight years since this was written as well as the five years since the IPCC’s 2014 AR5 report, bellwethers of impending environmental tipping points are revealing themselves at every turn. The revelation was made in the summer of 2018 that we may be heading towards a “Hothouse Earth” pathway that would result in a “much higher global average temperature than any interglacial in the past 1.2 million years” (Steffen, 8252). Perhaps this makes the creative hyperbole of the author of this Capstone’s 2011 scenarios not hyperbolic enough. Last year also saw China receive an “elevated warning” from the 2018 “Fragile States Index” report (Messner, 6). The immediacy of the situation has reached such a fever pitch, that business-as-usual scenarios have been shifted to worst-case scenarios in order to underscore the amount of sacrifice that needs to be made.

For this reason, a good way to quantify the three scenarios presented for China is to line them up with the RCPs (Representative Concentration Pathways) used in the IPCC’s AR5 report. The RCPs presented include the 2.6 (which we will consider the best case), the 4.5 & 6 (which we will consider the BAU), and the 8.5 (which we will consider the worst case). The numbers represent the radiative forcing in watts per square meter (W/m^2) as seen in Figure 97.

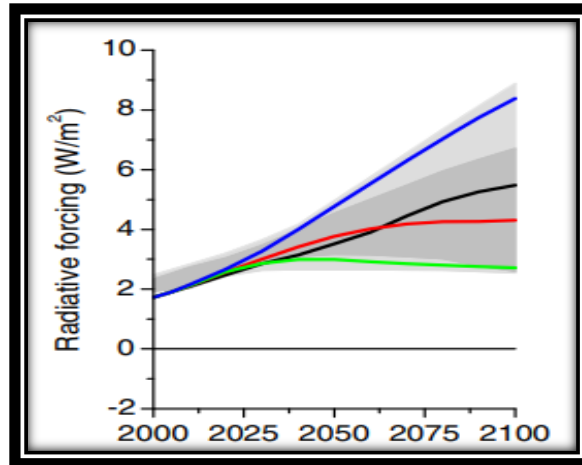


Figure 97 Radiative forcing plotted as a function of year for the RCP_{8.5} (blue), RCP₆ (black), RCP_{4.5} (red), and RCP_{2.5} (green) scenarios. Source: Van Vuuren, 24. Also addressed by the IPCC as seen here: http://sedac.ipcc-data.org/ddc/ar5_scenario_process/RCPs.html

Forcing refers to the ratio of the sun’s incident radiation to what the earth is able to successfully reflect. It should be noted, in keeping with statements from the previous paragraph, that the RCP_{8.5} scenario is not even considered the ‘worst’ scenario in the literature, but rather a particularly leaden form of the BAU trajectory. As Riahi points out, the RCP_{8.5} “depicts thus a relatively conservative business-as-usual case with low income, high population and high energy demand due to only modest improvements in energy intensity” (43). The RCP_{8.5} scenario is associated with high population growth, lower development of technology, persistence of “non-climate policy”, and overuse of cropland and grasslands to cater to the growing population (Van Vuuren, 17, 19, & 20)¹. However, the optimal way to visualize not only the RCP_{8.5} scenario, but all *three* of these pathways is to associate each of them with a particular temperature range.

In a paper that includes contributions from a team including Corinne Le Quéré of the Global Carbon Project, Sabine Fuss established a range of 3.2 – 5.4°C for the RCP_{8.5} scenario, 2.0 – 3.7°C and 1.7 – 3.2°C for the RCP_{6.0} and RCP_{4.5} scenarios respectively, and 0.9 – 2.3°C for the RCP_{2.6} scenario (Figure 98). Other publications yield temperature values for each scenario that fall rather close to the values supplied by Fuss, as seen in a separate study by Joeri Rogelj from the Institute for Climate Impact Research in Switzerland (Figure 99). All of these ranges represent temperature increases above pre-industrial levels. These pathways have emerged from years of United Nations climate talks that have decided that the world must stay below a 2°C (3.6°F) temperature increase above pre-industrial levels. The 2°C climate goal clearly aligns with the RCP_{2.6}.

However, with every passing year and with every new climate conference, it seems increasingly unlikely that the world will stay below the 2°C climate goal without herculean efforts on a scale unheard of in human history. Adding to the problem is the inertia created from a world that had followed the RCP_{8.5} scenario until 2005 (Sanderson, B., 7135, 7137). With every passing second and every missed opportunity, reaching our climate goals become even more difficult. We are rolling the dice on the hopes that a technological innovation will emerge in the near future that will provide an as-yet-unknown technique for rapid de-carbonization. According to Sanderson, the INDC pledges during the Paris Summit simply will not bring about the 2°C climate goal. “In order to achieve 2°C with an RCP_{2.6} level of long-term carbon removal, 2030 net GHGEs must be reduced by 10% from 2015 levels, significantly more than the

unconditional INDC (which allow 2030 and 2015 emissions to be effectively equal)” (7140).

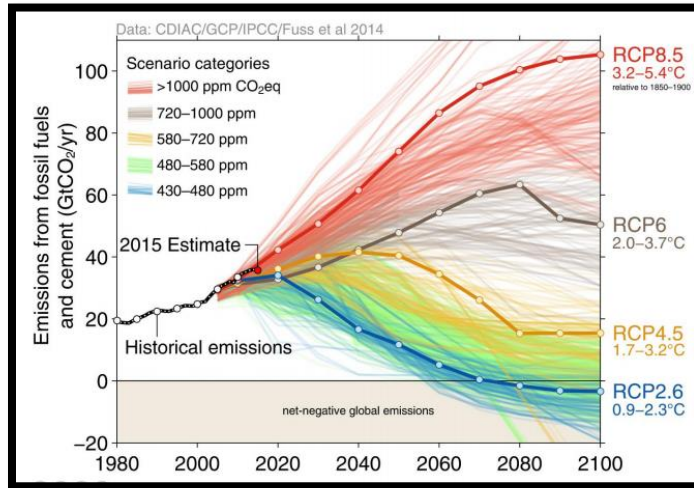


Figure 98 Temperature ranges associated with each of the three RCPs (Representative Concentration Pathways), as featured in the rightmost vertical margin. (Source: Fuss, S., 851)

This study	Median	66% range
SRES B1	2.4	2.0-3.1
SRES A1T	2.9	2.5-3.7
SRES B2	2.9	2.4-3.5
SRES A1B	3.4	2.8-4.2
SRES A2	3.9	3.2-4.8
SRES A1FI	4.7	3.9-5.8
RCP3-PD	1.5	1.3-1.9
RCP4.5	2.4	2.0-2.9
RCP6	2.9	2.5-3.6
RCP8.5	4.6	3.8-5.7

Figure 99 Median and greater than 66% probability temperature ranges for each of the three RCPs courtesy of Joeri Rogelj (Source: Rogelj, J., 251)

Again, the evaluation of the RCP scenarios in this introduction is an attempt to provide a template on which to graft *our* three scenarios (particularly the “T”, or technological, part of the “S.T.E.P.”). Here, the RCP_{8.5} will align with the worst case technological scenario, the RCP_{6.0} and RCP_{4.5} with the “BAU” scenario respectively, the RCP_{2.6} with our best case. This is also a willful attempt to create something unique from what the author had put together back

in 2011. It should be noted that the author's choice to brand this issue as a "wicked problem" and take a multi-sectoral approach (via S.T.E.P.) seems to fall in line with the prevailing consensus as it applies to scenario building. According to Wilkinson, scenario building is ideal for dealing with wicked problems as "the ability of groups and organizations to appreciate and take action in relation to 'wicked' environmental change and challenges can benefit from the anticipation of future possibilities" (2). However, Wilkinson offers some words of caution: "the persistence and growth of scenarios has also been, we believe, shaped by the clear inadequacy of systems modeling when applied to wicked problem such as environmental change" (4). Finally, Wilkinson adds, "there has been limited examination of how scenario thinking or planning works in contexts of multi-actor and inter-jurisdictional challenges, such as global environmental change" (4).

4.4(b) Worst Case Scenario

(S.T.E.P. Analysis (Social, Technological, Economic, and Political))

- (i) Social: Admonitions and Warnings From China Scholars Go Unheeded
Prediction: Very unlikely due to rising trends in public mobilization and solidarity

Appendix "D" provides the reader with the three scenarios for China originally created during previous academic work by the author in 2011. This will allow the reader to compare and contrast these scenarios with the ones now generated for this Capstone eight years later. A perusal of the 'worst-case' scenario from Appendix "D" (originally seen in Maley, 2011, 14-16) finds the author taking creative license, presenting an apocalyptic vision for the future:

“Faith in the ruling party deteriorates as party members become increasingly corrupt and ineffective. The effect of their failure to address China’s environmental woes galvanizes people’s resentment, particularly in the hardest hit rural parts and also fosters a more militant environmental movement in the country. The government’s reaction is swift and severe, serving to only embolden rebellion and further rioting in the country. Civil war ensues, stoked by a climate of environmental desperation. Corruption still reigns as the reaction of some in the government during this meltdown is a ‘pay-to-play’ system rife with bribery where basic items needed to survive can be had at the right price” (Maley, 2011, 15).

The result of these series of events? “Further social and environmental costs therefore lead to economic collapse for China as it reverts to a third-world country” (Maley, 2011, 16).

The worst-case scenario that will be presented in this Capstone will not contain the same level of hyperbole and doom-laded pronouncements as the 2011 scenarios. This is not because the stakes have gotten any less serious; on the contrary, they have become much more so. Much has changed in the last eight years in terms of the realization of our remaining carbon budget, the IPCC’s latest conclusions, and China’s role as both perpetrator and victim in the face of increasingly existential climate threats. A shift has occurred; what were previously considered “business-as-usual” models have been demoted to “worst case” once it was realized that climate change is not as bad as we thought, it is actually much worse. Therefore, in the worst-case scenario for “social” factors, the images of social revolt and complete societal meltdown presented in 2011 will not be present. The stakes for 2019 are high enough that it only takes the failure to implement *some* of the social mechanisms highlighted in the literature for China to gutter ball into a ‘worst’ case scenario. A great deal of this literature has been featured in section II (“Literature Review”) of this Capstone. We will use

some of these same sources as feedstock to generate our worst-case scenario for China's "social" factors.

In our worst-case scenario, the assault on public health chronicled earlier in section 1.4(a) has only made nominal improvements. Air pollution is still considered the fourth highest risk factor for death in all of China, and its staggering responsibility for 17% of all deaths (Rohde, 1) has only improved slightly. The previously cited figure of 180,000 annual protests against pollution (Tracy, 63) has fallen, but collective anger and the number of so-called 'mass incidents' remain high. Water-related pollution is a crisis elevated to "a transnational environmental justice issue" (Currell, M., 20), due to the fact that "there is a close relationship between the locations of China's major rivers and that of 'cancer' villages" (Lu, Y., 10). Our future scenario finds water pollution and other environmental scourges turning China into a case-study for environmental justice reform. Struggles fall along class lines because issues like water pollution "more significantly influenced mental and physical health among low-income participants" (Wang, Q., 361) while "rich individuals are able to engage in behaviors that counteract some of the negative health consequences" (363). Meanwhile, our scenario finds China, the country that possesses only 7% of the world's water, unwilling to break from previous methods of addressing water shortages. Grandiose building projects, reminiscent of the early 2000's, persist in our future scenario. Initiated in 2001, the South-to-North Water Transfer Project had its inception during this period, though its origins go much farther back to Mao Zedong in 1952 (Magee, D., 1501). Water transfer projects, and the hosts of

issues associated with them (see pages 93-95), further contribute to social instability in rural areas (Cai, X., 20) as water demands in one area decrease availability in others (19). Wholesale relocations of large populations of people continue into the future, with resettlements that result in “the abandonment of those displaced to conditions of chronic impoverishment” (Wilmsen, B., 141).

China may still be the biggest producer and consumer of renewable energy, but never quite achieves a comprehensive, nation-wide renewable energy program. This is partly due to a failure to garner public acceptance by framing renewables in the context of energy security (Chen, D., 3756), as well as Beijing’s failure to improve “access to information and enlisting public participation” (Economy, E.C., 3). Governmental failure to also achieve social acceptance for smog governance “creates a major barrier” for any hope of a “smooth implementation”. (Sun, C., 322).

By the year 2030, 68.7% of China’s population will reside in urban areas; by 2050, that number will increase to 75% (Farrell, K., 98). Since our “economic” worst-case scenario presumes that China will attempt to reproduce western-style globalization and neo-liberalism, it is likely to also see an inordinate concentration of capital in urban centers and consequent gentrification of all major cities in China. This dynamic will greatly deepen the already significant divide between the urban rich and China’s rural poor. In our worst-case scenario, it is not surprising that the rural poor, particularly farmers, are impacted the hardest. There is a long history of the marginalization of farmers in China “since the start of communist rule in 1949” (Zhang, W., 5). In the worst-case economic

scenario, the livelihoods of farmers “will be made more precarious and exposed to the vicissitude of markets, as the scaled-up, capitalized agriculture which their wage work contributes to, undermines the viability of their own small-scale, under-capitalized family farming” (Zhang, Q.,18). Wrong-headed agricultural practices and climate change will contribute to the “vicious cycle” of infectious diseases, with both factors altering “the areas of transmission and the intensity of important vector-borne diseases still not eliminated in the country such as dengue and schistosomiasis” (Yang, G., 404, 400).

Another consideration is the government’s poor assessment of social vulnerability to natural disasters. This has been covered in 2013 by Wenfang Chen and addressed by others authors since (including Yang Zhou and Ning Li in two separate 2014 papers). Social vulnerability in this context is defined as “a measure of a population’s sensitivity to natural hazards and its ability to prepare, respond, cope, and recover from a hazard event” (Zhou, Y., 2014, 615). In the future, disaster risk management strategies have still not evolved adequately and continue to be hobbled by a chronic lack of data availability. This future scenario sees no resolution to China’s long-standing system of bias known as the “hukou” system, described by Wenfang Chen as a kind of “economic apartheid” (171). The hukou system greatly limits the mobility of rural farmers, particularly as it applies to their movement into cities, through a series of outright discriminatory measures. A lack of understanding regarding vulnerability to disasters combined with the persistence of programs like the Hukou system, translates into a grim future for China’s rural poor.

Finally, just as the ascension of many European countries in history were met with an equal rise in nationalism, our worst case scenario finds nationalism on the rise in China. As the United States appears to be following many of the signs of declining empire (Roubini, 1 & Regilme, 159), China has the potential to take the number one place as the dominant power in the world, cemented with the successful implementation of the “One Belt One Road” initiative (Layne, C., 101-103). How will China take on this role while simultaneously looking down the barrel of the existential triple threats of climate change, water scarcity, and peak oil? Will nationalism grow in response, as a reaction to a “long list of historical humiliations, including civil war, invasion, poverty, and famine” (Lee, M., 2)? In fact, Michael Lee cites Chinese nationalism as “one of the most important shapers of 21st century global politics” (2). In this scenario, nationalism is appropriated and corralled into the government’s blueprints for global militarism. The fact that China has 34 million more men than women, compounded by years of the One-Child Policy, results in large groups of unmarried men who may be ready, willing, and able to fill the ranks of China’s military (7). With this expansion in military might, China can ramp up its bully-tactics in securing resources at the expense of other countries. These tactics include the further plummeting of Africa’s fisheries; China already robs the West African economy of two billion dollars each year through pilfered fish catches (Jacobs, A., 1). This augmented militarism will embolden China to commit further damming and redirection of shared waterways. As former World Bank vice president Ismail Serageldin said back in 1995, the wars of the 21st century will not be fought over oil, they will be

fought over water (25). China has raised the ire of many neighboring countries (Figure 100) already over its unceremonious damming of shared rivers; the damming of the Brahmaputra River, for example, has stirred a great deal of anger in India and is even described in the original scenarios from 2011 as seen in Appendix D (also Maley, 2011, 15). China may soon find itself embroiled in multiple conflicts over resources, overextending itself to the brink of economic collapse by choosing militarism over cooperation in seeking environmental solutions. This overmilitarization eventually spells the end of China's rise as it did for many empires throughout history.



Figure 100 A google review of the Zangmu dam discovered by the author of this Capstone and initially used in the "SWOT" analysis from 2017 (Maley, 2017, 36).

- (ii) Technological: The RCP_{8.5} scenario (3.2 – 5.4°C increase relative to 1850-1900 levels)
Prediction: Highly unlikely as China has already aligned itself with the best of the three RCP pathways

This scenario does not suffer from complete inertia in terms of technological improvements. Instead, there are “significant” innovations made with “advanced fossil technologies”, specifically the rather spurious benefits of “clean coal” technology as well as various synthetic and coal-to-liquid schemes (Riahi, 45).

Proliferation of non-fossil alternatives is plodding, resulting in fossil fuel technologies remaining “economically more attractive in RCP_{8.5}” (44). This pathway also triggers “some growth for nuclear electricity and hydropower” (45). In fact, by 2100, non-fossil fuel sources for electricity will be derived from biomass and nuclear power in the RCP_{8.5} scenario as seen in Figure 101. An investigation of the author’s 2011 scenarios shows how the RCP_{8.5} more closely lines up with the BAU scenario, particularly in terms of the growth of nuclear power. Even with these modest improvements, the RCP_{8.5} scenario will still be associated with an “almost 10 fold” increase by 2100 of coal utilization and a tripling of overall energy use from current levels as seen in Figure 102 (45).

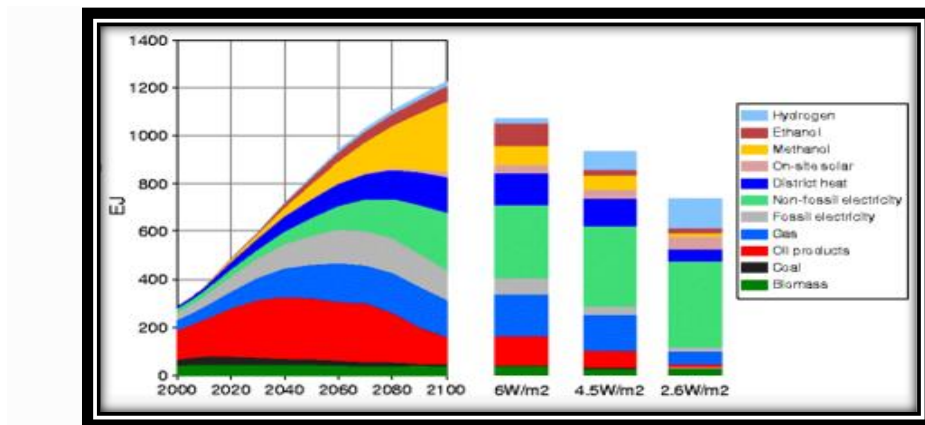


Figure 101 Projection of energy by type to the year 2100, given in exajoules where exa is 10^{18} power. The RCP_{8.5} is featured on the left in comparison to the RCP₆, RCP_{4.5}, and RCP_{2.6} scenarios on the right. Observe that even the RCP_{8.5} scenario has more of its electricity derived from non-fossil than fossil sources by 2100. Source: *Riahi 45*

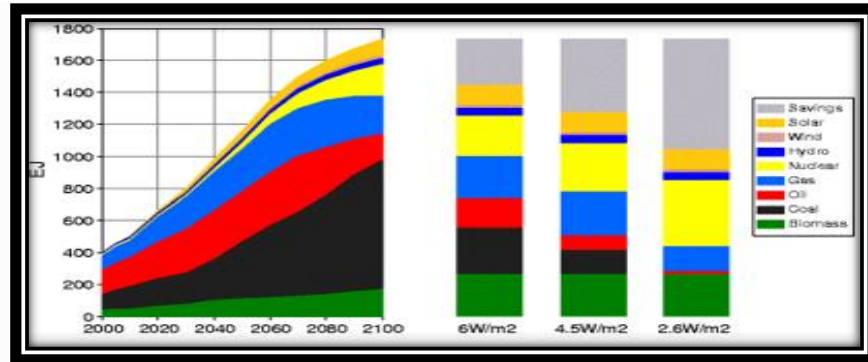


Figure 102 Observe that coal use nearly increases by a factor of ten by 2100 as overall energy use triples from its current level. *Source: Riahi, 44*

As a country that consumes half of the world’s coal despite possessing only 14% of global coal resources, China’s energy security will become increasingly unsustainable as these values continue to diverge over time (Lee, M., 6). In this scenario, whatever inroads made exploring renewable energy options will be hobbled by familiar issues that have gone unaddressed. Some of these issues include a lack of research funding, consequent reliance on imports for parts with “high R&D difficulties”, and overall lack of mastery by Chinese firms of manufacturing, operation, maintenance, and power grid integration (Zhao & Chang, 470).

This scenario has been deemed “highly unlikely” because of how catastrophic it would be to remain stuck in the RCP_{8.5} track. Consider the fact that a 4°C increase approaches the middle of the RCP_{8.5} range of 3.2 – 5.4°C. According to the World Bank, “there is also no certainty that adaptation to a 4°C world is possible” (xviii). This would be a world in which “communities, cities and countries would experience severe disruptions, damage, and dislocation, with many of these risks spread unequally” (xviii). Worldwide, this scenario finds

massive swathes of farmland rendered useless by rising sea levels and an unheralded number of species extinctions. It is important to keep in mind that complex systems preclude any kind of linear relationship suggesting that a 4°C world simply doubles the impacts of a 2°C world. An exponential fallout of impacts is much more likely (New, M., 15).

As an emitter of nearly one-third of the world's carbon emissions (see endnote 59), China remains a major shot caller in terms of what RCP pathway the world will follow as well as how quickly we squander what remains of our carbon budget. The good news is that the continuation of China's renewable commitments and flattening coal use would undermine the projected ten-fold coal increase (Figure 102) associated with the RCP_{8.5} track. There is also a glimmer of hope that humanity overall is moving away from this scenario if, according to Berkeley Earth's Zeke Hausfather, "you look only at pollution from fossil-fuel burning and not from land-use events like deforestation, then humanity's recent record trends closer to RCP_{4.5}" (Meyer, R., 4). That said, while Hausfather remains "skeptical" of late-century figures for an RCP_{8.5} scenario, he muses that "observations to date don't really give us grounds to exclude it" (3).

- (iii) Economic: Free-market Neoliberalism
Prediction: Unlikely due to China's well-established system of authoritarian capitalism with state controls

This 'worst' case scenario finds China moving away from regulations and state intervention once it surpasses the United States as the world's biggest economy. Instead, China models itself after the Chicago-school of neoliberalism that has dominated the United States since the 1970s, marked by privatization,

deregulation, free trade, and austerity. While this scenario is not a return to the “growth-at-any-costs” mindset that typified the thirty-year period starting in 1978, economic growth remains front-and-center. If this economic growth persists for the next ten to fifteen years, China will deal with “a more severe situation of energy consumption, electricity generation, and vehicle population leading to increases in multiple pollutant emissions” (Wang, S., 2). Embracing the free-market trade policies of the west results in the worst possible outcomes of the One Belt One Road initiative, as described in the ‘pessimistic’ sub-section of 2.1(c). The ‘OBOR’ simply devolves into a “globalization 2.0” of Chinese mercantilism where capitalist surpluses and manufacturing are bounced to central Asian countries with less protection for workers and the environment. In this worse-case scenario, China will not step up as a trendsetter by exporting green production to less developed nations. Lei Han’s “EE convergence” is never achieved as central Asia becomes ground zero for China’s most carbon heavy processes, the so-called “black investments” as previously described by John Mathews and Hao Tan.

In this scenario, China’s experimentation with free market liberalism leaves them unprepared to deal with the ongoing trade wars with the United States. As the United States transitions to a net exporter of energy and China remains a net importer of energy, China’s energy security^{li} is placed into serious jeopardy. As China is poised to become the biggest importer of LNG (liquefied natural gas) in the next few years, so too is the United States slated to become LNG’s second largest purveyor. Replacing coal with natural gas is a critical

transitional stepping-stone on the road to renewables in China. However, the trade war with the United States quickly devolves into a zero-sum game of tit-for-tat and escalating tariff measures. Consequently, an important door to the LNG market remains closed for China who now struggles to secure a transitional foothold on the pathway to a renewable energy economy. Further compounding the problem are factors undermining renewable energy development. These factors include poor investment in research and development, particularly basic research (Woetzel & Chen, 94), inadequate salaries discouraging research careers (98), and poor intellectual property rights that dissuade the commercialization of new, innovative products (97). Outside the country, longstanding perceptions of China from global markets continue, as typified by PricewaterhouseCoopers' concerns regarding "ease of doing business, political stability, rule of law, [sic] income equality" (Hawksworth, J., 27). The ongoing trade war with the United States continues to foment China's debt crisis causing the economy to constrict as it sustains itself through debt and inflation of asset prices. The bubble then breaks and people stop spending, while the government attempts to re-stimulate spending through a crisis-prone mechanism similar to the mortgage debacle in the United States. Normally, China was able to avoid the kind of economic bubble that struck Japan in the 1980s and early 1990s due to the fact that "the Chinese government has greater control over the process of debt creation within the Chinese banking system" (24). Unfortunately, China has embraced neoliberal policies in this scenario, which is in lockstep with reckless

bank deregulation, and so the regulatory control to avoid such a bubble no longer exists.

Failing to secure access to LNG markets due to a protracted trade war with the United States, China is unable to achieve a green revolution and must fall back on fossil fuels in order to maintain a sustainable level of growth. The economic impact of this failure results in losses comparable to present losses as detailed in the literature review of section II. Some of these losses are detailed in Table 3. These losses are felt in certain areas more than others since China has

Table 3 A sample of studies revealing economic costs from select environmental impacts

<i>Type of Impact</i>	<i>Cost of Impact</i>	<i>Source</i>
Air Pollution	6.5% of China's <i>annual GDP</i>	<i>Fang, C., 15571</i>
Meteorological Disasters	3-6% GDP loss <i>annually since 1990</i>	<i>Shi, J., 1</i>
Shortages and Quality Deterioration of Water	2.3% " <i>of China's GDP</i> , while the actual costs may be much higher"	<i>Xu, G., 34</i>
Water Pollution	1.71% of China's <i>2004 GDP</i> , used to represent losses from water pollution "calculated to be 286.2 billion yuan"	<i>Zhou & Khu, 1249</i>
Hazardous Drinking Water Sources	2% <i>rural GDP</i> ⁱⁱ loss to health impacts	<i>Zhang, J., 2</i>
Natural Disasters	2.5% GDP was "the <i>annual average</i> direct economic loss"	<i>Wei, Y, 650</i>
Land-based Industrial Pollution	500 million dollars lost <i>annually</i> to marine fisheries	<i>Cao, L., 438</i>

yet to create a progressive redistribution system^{liii} of gross value "rather than leaving local governments to spend what they can borrow or raise through taxes" (Orr, G., 14).

- (iv) Political: China shifts to a western-style electoral democracy
Prediction: Highly unlikely as 'democratic' mechanisms in China differ significantly from expected western standards

The year 2019 has not been a good one for democracy in the western world^{liv}. Two years ago, the Economist's "Economist Intelligence Unit" (EIU) released its annual democracy index, finding that less than half of the countries in the EU are "fully democratic"^{lv}. Meanwhile, charges of "democratic legitimacy" or a "democratic deficit" continue to plague the European Union, as a casual search of the literature on this topic is quick to reveal^{lvi}. In the United States, media outlets continue to cite the devastating "Princeton study" from 2014 suggesting that the U.S. is an oligarchy and not a democracy (Gilens, M., 6, 24). According to Joshua Kurlantzick, a global democratic recession is occurring which flies in the face of predictions by political scientists like Harvard's Samuel Huntington that rising middle classes move a nation inexorably to democracy. In addition to the findings of the ABS (Asian Barometer Study, see endnote 44), both the Afrobarometer and Latinbarometer surveys have found plummeting levels of support for democracy in places like Africa, Central America, and South America. The very middle classes assumed to bring about democracy have instead "ended up supporting military coups or other undemocratic measures" (Kurlantzick, 12-13). Many Asian countries have taken note of China's resilience during the 2008 financial crises as well as the European debt crisis that has persisted since the end of 2009. Impacts incurred by China were partially assuaged by a stimulus package that also helped many nearby Asian countries. Those same countries have observed China's highly regulated banking sector weather the global financial storm. Meanwhile, deregulation in western democracies such as the replacement of Glass-Steagall Act in the United States

with the much weaker Dodd-Frank Act during the Clinton years almost certainly aided and abetted the 2008 crash. This has helped to stoke the “authoritarian nostalgia” currently witnessed in Asian countries professing admiration for China’s current trajectory (Chang, Y., 73). As for China’s own middle class, observers in the west will be searching in vain to find anything resembling the American middle class of the 1960s that was at the forefront of the anti-war and civil rights movements, or even the democratic champions of the Tiananmen protests in 1989. Many researchers such as Jie Chen (see section 4.3(b)i as well as Figure 92) have found that many entering the Chinese middle class are also locked into a cozy relationship of mutual benefits with their authoritarian leaders. While working at the Hoover Institution at Stanford University only ten years after the Tiananmen incident, Suisheng Zhao once stated that “young Chinese, in particular, say they are more concerned with pursuing careers than multiparty democracy, which they see as a distant prospect. Many students now view the 1989 protests as naïve and its leaders as uncompromising”^{lvii}.

The primary reason why a switch to an electoral democracy has been designated as the “worst” scenario is the issue of *time*. Many of China’s environmental tipping points chronicled in this Capstone have turnaround times that include five years, ten years, immediately, and yesterday. Centuries of authoritarian rule have taken a psychic toll on a population, which means that the germination of western-democracy lies far in the future if at all. China’s environment and what remains of the world’s carbon budget will not wait for such a grand social experiment. According to the “carbon clock” found at Berlin’s

Mercator Research Institute on Global Commons and Climate Change^{lviii}, we have 26 years and 8 years left on our carbon budget in order to achieve the much publicized 2°C and 1.5°C climate targets respectively. The emissions from China's cement and energy industries are responsible for 29% of the world's carbon dioxide emissions in 2017^{lix}, "and this trend is expected to continue increasing" (Jiang, K., 477). There is simply no time for a radical reshuffling of the political deck in China. Measures must be taken that are both swift and severe. While writing about the prospects of democracy for China, John Thornton points out (as well as Sheri Berman, 2) that if you include the civil rights act in 1964, then it really took the United States almost two-hundred years to achieve true democracy through universal suffrage (20). Berman goes on to say that Great Britain required "hundreds of years" to "achieve full democracy during the early 20th century" (2); in general "successful democracies are unusual and generally emerge only at the end of a long, arduous process...particularly liberal democracies that protect citizens' rights, enshrine the rule of law, check executive power, and protect civil society" (1). In the case of China, this process would require a wholesale reprogramming of "'Asian values' that privilege group over individual interests, authority over liberty, and duties over rights" (Chang, Y., 69-71). Due to sheer lack of time, a paradigm for effective environmental governance must work within some variant of the *current* system, which is undoubtedly authoritarian in nature. The Chinese people have "embraced authoritarian capitalism^{lx} because it has satisfied the materialistic and spiritual needs of the people" (Ma, L., 9). Authoritarianism has "worked for China, and

regardless of whether one likes it or not, it is likely to stay for a while” (Ma, L., 10).

4.4(c) “Business as Usual” (BAU) Scenario
(S.T.E.P. Analysis (Social, Technological, Economic, and Political))

- (i) Social: Maintaining Control; A System That Expands and Contracts When It Wants To
Prediction: Less likely as the need to maintain a low-carbon economy will require greater concessions to public demands

This social scenario works in tandem with the “BAU” political scenario predicting a classical authoritarian approach. Here we see steps taken from the authoritarian playbook including the shutting down of coal-fired power plants, sudden cuts in steel and aluminum manufacturing, and smaller-scale measures similar to the massive but poorly-orchestrated plan of replacing residential coal-fired boilers with gas-powered units in 2017. However, this scenario does not present us with a “green revolution” in China that is “one of the four upheavals or revolutions in the energy sector” (see Figure 70 and the author’s correspondence with Nobuo Tanaka). This scenario also does not feature the hyper-informed, environmentally engaged population in our ‘best’ case scenario. Therefore, China’s authoritarian measures exact a social cost. The shutting down of coal plants in this scenario is not balanced out by a transformative “green new deal” complete with infrastructure planning and a jobs program. Unemployment climbs as local budgets, now lacking the tax revenue from the coal industry, exacerbate the unemployment program with further cuts to socialized programs.

Urban residents are able to take the appropriate countermeasures in this scenario, at least to a degree. The well-heeled denizens of China’s major cities

are able to invest in homegrown programs like CSA's, or "community supported agriculture" which help to partly insulate from the nutrition and safety issues with China's food systems (Krul, K., 12). However, urban residents are not insulated from concerns typically associated with rural areas. A 2013 survey revealed that 40% of rice from city markets registered very high values of cadmium (Hu & Jin, 5828). In our BAU scenario, heavy metal contamination in food supplies, while controlled, are still a clear and present danger.

While the sharp income disparity in the worse-case scenario is not as severe here, the influx of rural workers into the cities in the search for employment remains problematic. However, in the BAU scenario, this "out-migration" becomes a boon for many local villages as returning migrants share their newly-found expertise and knowledge, particularly as it applies to environmental projects. The potential "that returning migrants would bring back to their communities new skills and attitudes" is covered well in the literature (Sjogersten, S., 131). Jinghua Ge chronicles the role many migrants have played in water management projects, with their re-engagement in village life focused "specifically around the activities of a project designed to strengthen agricultural livelihoods and reduce poverty in the village" (134). However, in this scenario, environmental engagement and preparedness still remains a function of wealth, education, and status/social capital. This will remain an ongoing issue for many aspects of the environment including agricultural preparedness (Chen, H., 6 & Sjogersten, S., 131), air pollution (Sun, C., 322), and climate change (Dai, J., 316).

It would be a mistake to find any of the tepid projections in this section to be acceptable. The time for heroic efforts is now and will not be met by any middling half-measures. Michael Lee puts it best when he urged that “if China drifts into a default business-as-usual future, it will risk a chain reaction of system collapses” (7).

- (ii) Technological: RCP_{6.0} and RCP_{4.5} scenarios (2.0 – 3.7°C and 1.7 – 3.2°C relative to pre-industrial levels)
Prediction: Increasingly unlikely for China, increasingly likely for the world

The technological benchmarks associated with our BAU case follow the RCP_{6.0} and RCP_{4.5} scenarios. For this reason, the description of China’s “Green Transition to 2050” from the PBL Netherlands Environmental Assessment Agency functions best for this scenario. In this assessment, the “Green China Plus” pathway is not as ambitious as the 2°C climate target and so matches nicely with our mid-range RCPs. The plan remains rather progressive, but clearly is not as effective as the 2°C climate target (Figure 103). According to the authors, the “Green China Plus” pathway is “insufficient to achieve a 2°C climate target” (Bakkes, J., 11). When this pathway is coupled with current policies, “a doubling of carbon dioxide mitigation is required until 2030 in order to achieve a 2°C warming target” (11). However, this scenario does find coal use dropping by 65% compared to the baseline scenario (represented by the magenta line in Figure 103). It also does an admirable job replacing coal with produced solar and wind power for electricity generation for 2050 (Figure 104).

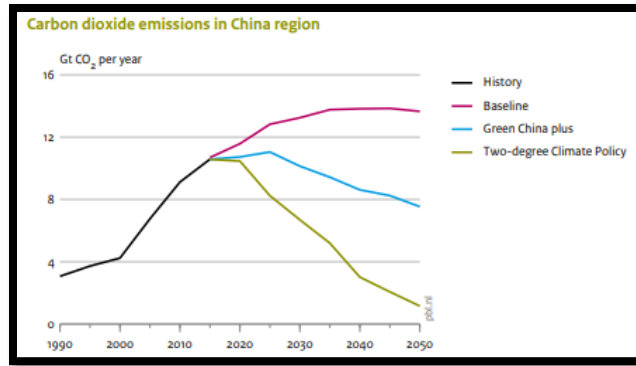


Figure 103 Difference between the “Green Transition Pathway” model and the 2°C climate goal in annual gigatons of carbon dioxide to the year 2050 (Source: Bakkes, J., 10)

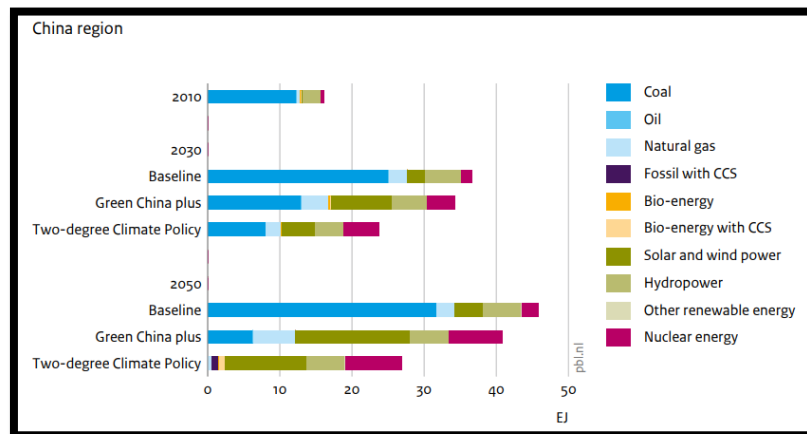


Figure 104 Energy mix for electricity generation in China projected to 2030 and 2050. While the “Green China Plus” scenario is ambitious, only the 2°C model associated with our best case scenario (and with the RCP_{2.6}) manages to eliminate nearly all fossil fuels by the year 2050 (Source: Bakkes, J., 33)

While our BAU scenario moves China along the path towards a renewable energy transformation, the overall program is not driven by the same urgent timeline as our best-case scenario. A phenomenon of delayed implementation therefore typifies our BAU scenario. It translates into a substantial missed opportunity in terms of abatement potential. In a study of China in 2009, Joerss and Woetzel demonstrated that just a five year delay in promoting renewable

technology would “cut the abatement potential by up to 1.5 gigatons of greenhouse gases—over 50 percent of what’s possible”^{lxix}. Issues identified in

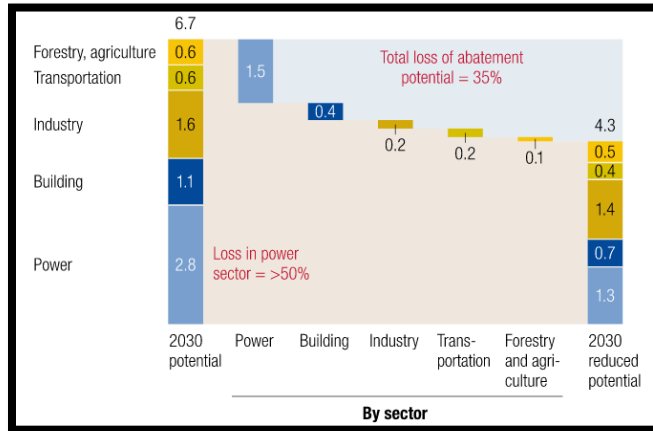


Figure 105 A five year delay of renewable implementation in the power sector means a cut in abatement potential by 1.5 gigatons of carbon dioxide equivalent, representing 50% of the “total potential” (Source: found in Joeress & Woetzel as well as an alternate version found in Woetzel and Joeress, 116)

our worst-case “technological” scenario appear here as well, albeit to a lesser degree. These issues relate to the implementation and maintenance of a wide-scale renewable program and are covered in depth in the literature review of this Capstone (Part II). Curtailment and overcapacity are challenges in the solar and wind industries that see only nominal improvement (Yu & Poon, 1-2, Xu, D., 2, Zhao, Z-Y, 465, etc.). Finally, bad regulatory habits carry over in this BAU-scenario as compensation effects cannot reduce the extrusion effect^{lxxii}, siphoning away money slated for needed green research and development (Hou, J., 1067-8). Perhaps the most unsettling aspect of this scenario is its prediction, by the author of this Capstone, as “increasingly likely” for the *rest* of the world. This designation is the direct result of all of the literature encountered by the author discussing how the world will not reach the 2°C climate target featured in our

“best” scenario. A world that indulges in this scenario does so at our extreme peril. Even the mildest (RCP_{4.5}) of the two RCP scenarios for our BAU will see us “soar” past our targets from the Paris summit into a world where “nearly every coral reef” will meet an untimely end (Meyer, R., 4).

- (iii) Economic: China maintains a system of authoritarian capitalism, with strict controls over economic sectors
Prediction: More likely with hopes of an eventual shift towards a “Nordic Model”

China will soon eclipse the United States as the largest economy in the world. China already surpassed the United States in terms of PPP (purchasing power parity) in 2014 (Figure 106) and is projected to do the same by 2028 in terms of MER (market exchange rate) (Hawksworth, J., 1). However, the move

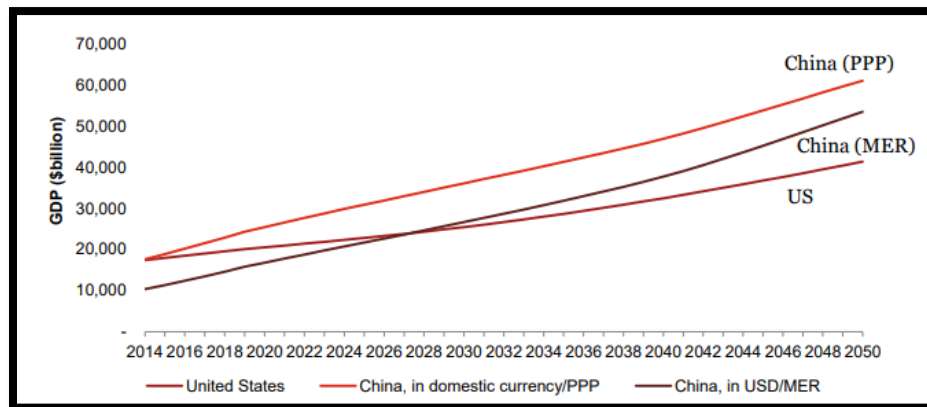


Figure 106 Comparison between China and the United States in terms of purchasing power parity (PPP) and market exchange rate (MER) projected to the year 2050.
 (Source: PricewaterhouseCoopers, Hawksworth, J., 11)

from export-led to consumption-driven forces will cause China’s economy to slow down after 2020 (Figure 107), as expected with the transition into a service economy (Hawksworth, 19). This slowdown will be deepened by a reduced population growth and an aging population (Figure 108) and will require increased productivity and technological innovations. These factors lend

themselves to the establishment of a reliably solid renewable energy market moving forward.

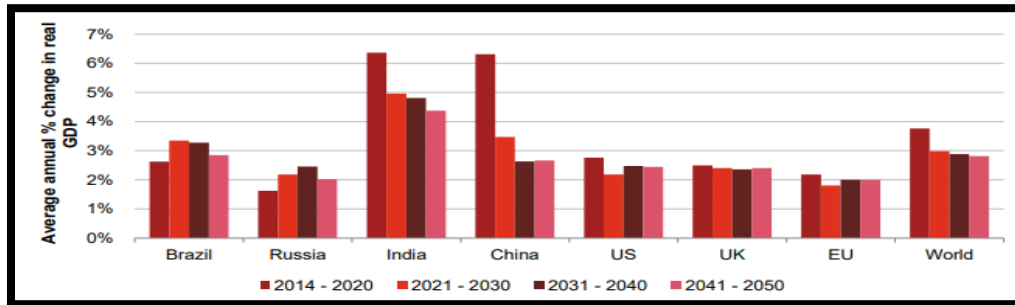


Figure 107 China’s percent GDP change per year to the year 2050 compared with other nations, with clear decline in economic growth after 2020 (Source: PricewaterhouseCoopers, Hawksworth, J., 19)

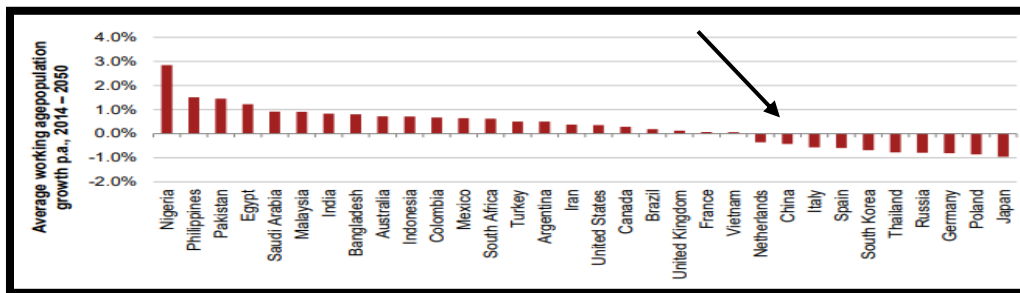


Figure 108 Growth in working age populations by country with respect to an established baseline (Source: PricewaterhouseCoopers, Hawksworth, J., 36) Note: arrow added by author

Unlike the “worst”-case economic scenario of market liberalism, China maintains authoritarian controls over the economy here, marked by mercantilist projects like the OBOR and policies of strategic protectionism applied to key areas. This protectionism is currently reflected in the Xi Jinping era where “greater levels of intervention by the government into business activity spanned almost all aspects of operations” (Orr, G., 8). As seen in Figure 109, “some businesses were discouraged from making international investments; others were strongly encouraged to invest in struggling state-owned enterprises” (8). This level of protectionism is also applied to the world of research, as currently

reflected in attempts to promote homegrown innovation by providing state-oriented researchers with half of all profits associated with notable discoveries^{lxiii}.

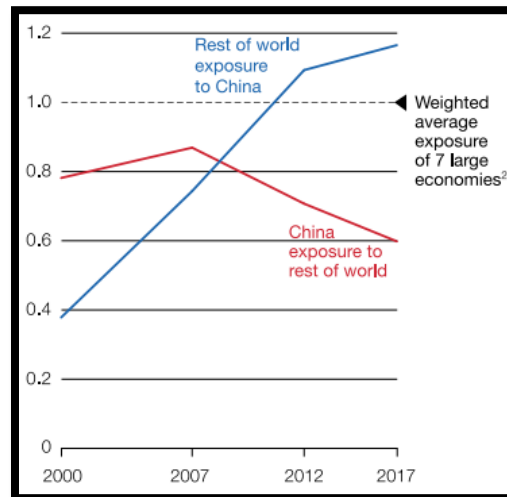


Figure 109 Comparison of world exposure indices with China, including trade, technology, and capital exposure. (Source: Orr, G., 9)

In this scenario, China’s growing green economy is better insulated from a trade war with the west as these policies, while flawed, are “specially tailored for innovation-driven industries—including massive subsidies, forced technology transfer, pilfering of intellectual property, and denial of access to Chinese markets” (Ezell, S., 1). The growth of renewable energy is further boosted “through efficient power markets, and an incentive and taxation system, reflecting the direct and indirect costs of energy supply” and “includes efficient costing of CO₂ emission and other pollutants” (CNREC, 6). In these regulated markets, government interventions negotiate the transition away from fossil fuels to prevent high unemployment numbers (Orr, G.,20). Meanwhile, any fallout from the trade war finds China exploring already established economic ties with Israel, Italy, the United Kingdom, and even Japan (5). In this BAU scenario, despite

calls for China's own softer version of North Korea's "Juche" (self-reliance), enough leeway exists for "corporates, Chinese and non-Chinese, to start to investigate quietly their options for creating separate corporate structures for their China-focused and US-focused operations" (8).

This scenario, while certainly an improvement over the worst-case scenario, remains less than ideal. Deferment to government subsidies and policies can certainly help the kind of engineering-based innovations necessary to achieve a green economy. However, those same subsidies and policies "can also slow the progress of an industry if they protect uncompetitive players" (Woetzel, J., Chen, Y., 79). According to Daniel de Oliveira Vasconcelos, these government supports and policies will "boost the energy transition in the next years" to renewables (3). However, market forces in the BAU scenario still work against this transition, including the temptation of coal power's high profit margin, the "decentralization of the right to approve environmental impact assessments", and the "complex web of cross-subsidization and local protectionism" driving some industries back to fossil fuels (3). Finally, it is also still not cost-prohibitive in this scenario for industries to flaunt environmental law, as cost-benefit analyses reveal that paying polluting fees are preferable to still-overpriced efficiency alternatives.

- (iv) Political: China maintains a classically authoritarian government
Prediction: Less likely with the continued evolution of "consultative authoritarianism" with democratic elements

The growing but limited success that a classically authoritarian approach has had with environmental challenges in China is well documented in research papers encountered by the author of this Capstone. In the strict growth-mindset of a classically authoritarian approach, the PRC has recognized that the current “labor-intensive, low-value-added, export-oriented” structure is not sustainable (Lo, K., 153). A strictly authoritarian system operates on “functionally superior meritocratic principles but that it is actually also more likely to deliver good environmental outcomes than its democratic counterparts as a direct consequence” (Beeson, M., 37). The direct result is that “China’s authoritarian government has been able to mandate the closure of some of the most polluting industries or force their relocation to less politically sensitive regions” (39). In the last five years, this has met with particular success when addressing China’s colossal air pollution challenges. According to Anna Ahlers, air pollution “represents an environmental problem that actually meets the preconditions for ‘authoritarian responses’ better than those previously described in the relevant literature on China” (303). These responses have given China “new momentum on its path towards developing an effective variant of AE” (315). Authors such as Mark Beeson go a step further by stating that the interest in authoritarianism as it pertains to the environment is partly the result of “the failure to deliver on environmental commitments in many of the world’s leading democratic nations” (36).

The current administration under Xi Jinping falls somewhere between our “best” case ‘political’ scenario of an *anocracy* and the strictly *authoritarian* model

proposed here. As explained previously in 4.3(b)iii, China's "consultative" authoritarianism is an Asian construct that makes significant departures from classical authoritarianism in the sense that a uniquely Chinese democratic liberalism exists on the local level. This local 'democracy' exists through the elections of local leaders, a tolerable level of public protests, and the granting of greater journalistic latitudes. (Lorentzen, 3). The result in doing so is to generate "bottom-up pressures against local government malfeasance that complement the existing top-down mechanisms of political control" (3). In the eyes of the government, this is, of course, "not leading to a process of democratization but rather to better governance under the conditions of authoritarianism, which in turn is increasing citizen satisfaction with the regime" (Besson, M., 39).

The "BAU" scenario of classical authoritarianism has been labeled as "less likely" owing to the rapidly expanding degree of public participation allowed for by Beijing in order to achieve a low-carbon growth strategy. The cat is out of the proverbial bag through the breathtaking spread of deliberative polling, DIY activism, and the proliferation of environmental data and education through ICT (Information Communication Technologies). The strides in citizen mobilization in the last five years will ensure a hybrid governmental approach that the author of this Capstone hopes will move China to the best-case scenario of a full-blown anocracy (a mix of authoritarian and democratic systems). There is now no way to roll back any of the public modes of participation that have been allowed for by the central government and hence the BAU-option of a "pure" authoritarian government in China remains unlikely. When speaking at Kent State in 1971,

Dick Gregory used the analogy of an overheated water kettle in a one-room kitchenette when making the argument that “repression is more detrimental to the oppressor than to the oppressed” (Gregory, D., side 2). Gregory pointed out that once you dismiss nature’s warning of a whistling kettle by simply trying to ‘plug up’ and silence it, the kettle will eventually fire steam everywhere and everyone in the kitchenette gets burned. The ruling class in China have seen enough history in Asia to recognize the consequences of an exploding steam kettle quite well and remain hell-bent on maintaining social control and stability. With the removal of Xi Jinping’s term limits, the question for the future will be in locating where exactly China will fall in the spectrum between our two scenarios.

China is a country spanning 3.7 million square miles. Even in our “BAU” scenario, a classically authoritarian approach recognizes the role that citizens and NGOs must play in order to manage environmental enforcement locally over such a large country. On January 1, 2015, China’s revised Environmental Protection Law allowed ENGOs to have the power to bring lawsuits against polluting companies that are in violation of the law. However, in our BAU scenario, the impact of multiple actors remains tightly controlled and limited. Democratic rumblings on the local level are tolerated insofar as they help with top-down directives, but the move to an anocracy is stymied. We may see nominal improvements in this scenario, such as the recent attempt in 2018 to reduce fragmentation and bureaucracy by consolidating several environmental departments into only a few^{lxiv}. The newly-minted “Ministry of Ecological Environment” is now singularly in charge of climate change efforts and water

pollution while the “Ministry of Natural Resources” is tasked with urban planning and land use. However, the future will also see more regressive, knee-jerk authoritarian expressions under Jinping’s leadership such as the “Law of the People’s Republic of China on Administration of Activities of Overseas Nongovernmental Organizations in the Mainland of China”, activated in January 2017. Tantamount to a crackdown on foreign NGOs, this law introduces strict guidelines for many overseas ENGOs including a requirement to register with the Ministry of Public Security (MPS)^{lxv}. Our BAU scenario is therefore best represented by the continued control and reduction of multiple actors, including NGOs, the media, and an engaged citizenry. As a result, many of the elements of environmental governance seen from the period of 2000 to 2010 will persist into the future here by way of data gaps, lack of transparency, and “inconsistencies in China’s baseline official data” (Hsu, A., 2). Without the aid of public monitoring and reporting in this scenario, cities will self-report information that, much like the PM₁₀ data from half of the cities surveyed by Angel Hsu from 2001 to 2010 , “appear to be dubious and show signs of data manipulation” (5). Pollution information of “politically sensitive” topics like soil quality will continue to go underreported (11) along with greenhouse gas-emission data on the local and national level (24). This ensures that the world community’s attempts to reach pre-determined climate targets will be especially onerous.

4.4(d) Best Case Scenario
(S.T.E.P. Analysis (Social, Technological, Economic, and Political))

- (i) Social: Deep public investment in environmental data monitoring, reporting, and accountability

Prediction: Likely due to current trends in transparency, public engagement, and the realization of mutual interests

Our best-case 'social' scenario has significant crossover with the best-case 'political' scenario; both sections should be read in concert. Our best-case scenario finds Chinese citizens following the adage of "praemonitus, praemunitus" meaning "forewarned is forearmed". Our scenario is the logical evolution of what has already been a ballooning arena of public involvement in environmental monitoring and reporting. In the last five years, what started out as a degree of latitude afforded to the public for environmental reporting and collection has spawned into a nation-wide movement. What China's ruling class did *not* anticipate is how the latitude being provided would blossom into "direct action" activism^{xvi}, DIY (do-it-yourself) environmental monitoring schemes, and a transference to the "virtual public sphere" (Xu, J.,1376). This 'virtual public sphere' includes not only cellphones but microblogging which "has been used by many ENGO leaders to publicize their agendas and gain supporters for their work" (1377). There is also the emergence of "new media tools such as Weibo (The Chinese Twitter) and WeChat (The Chinese WhatsApp)", which are "encouraged to be used for public participation" (Zhang, T., 16-17). As far back as 2008, John Thornton notes that "internet and cell phones have started to challenge traditional media by becoming channels for the expressing of citizen outrage, at times forcing the government to take action" (Thornton, J., 16). Since 2008, a transformation of environmental engagement has occurred, moving from "education and volunteering activities to mass protests and civil litigations,

sometimes leading to confrontations with local authorities and large corporations” (Xu, J., 1378). Much of this has occurred in the ‘virtual sphere’ leading Tong Zhang to observe that “with the rapid development and wide use of the Internet and mobile internet in China, information disclosure has made tremendous progress in the last decade” (2). Zhang plotted the number of public complaints regarding environmental protection through “letters, telephones, and networks” from the period of 2011 to 2015. What is abundantly clear from Figure 110 is not only the increase in public engagement, but the shift to a greater use of ICT which has provided “both communities and individuals with a range of new possibilities for communication and public participation” (Xu, J., 1375). Xu further observes that “among Chinese citizens, it is found that extensive use of the smartphone and mobile tweeting were positive predictors of engagement in online civic discourse” (1375). It also helps that these technologies can disseminate large amounts of environmental data instantaneously. ICT in China has the power to facilitate “a collective identity, connecting social actors from diverse groups to address issues of common concern” (1375). The multiple actors that share this identity will soon realize that they share “common concerns, a common enemy, and, typically, a common space” (1375). ENGOs in China have used ICT to build relationships across a spectrum of stakeholders that not only include citizens by way of donors, activists, and volunteers, but also city environmental agencies (1382). Xu provided some excellent examples of this process in action, including the case of Daerwen Nature Quest NGO in Beijing that began posting PM_{2.5} data for public consumption once it was clear that the

government was hesitant in releasing this particular data on their own. The website encouraged the public to “borrow the equipment, learn its use, and to post their ‘air quality diaries’” (1379). An NGO in Wenzhou used microblogging to sell boxes of oranges, ultimately raising over 20,000 yuan (nearly 3,000 dollars) to pay for monitoring equipment (1383). The unyielding resolve and dogged persistence of ENGO leaders is evident in the case of one such individual in Wuhan. This particular individual maintained a diary of air quality conditions “three times a day, in the morning before going to work, in the afternoon before cooking dinner, and before going to sleep at night” and also included “an hour every day in acquisition, data processing, mapping, and publishing” (1381).

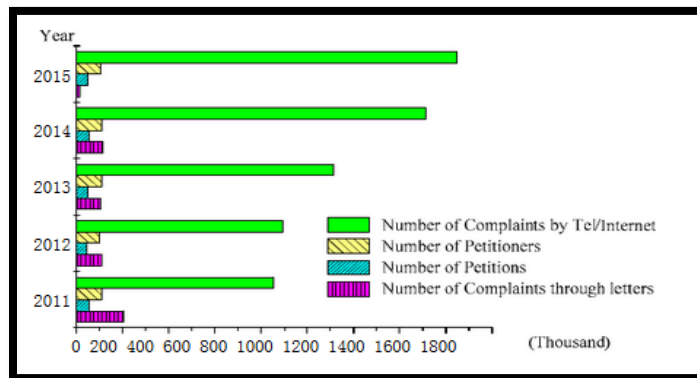


Figure 110 Tong Zhang’s survey of the number of complaints over environmental issues by way of written letters, petitions, and via the cellphone or internet (Source: Zhang, T., 3)

Some of the examples in the previous paragraph chronicled by Holy Family College’s own Janice Hua Xu are randomly distributed point sources that showcase NGO success and persistence. However, in our best-case ‘social’ scenario for the future, these examples do not stand out as uniquely exemplary, but will normalize and reproduce across the mainland. China’s legions of environmental activists, ENGOs, and sympathetic media outlets develop and

grow through greater collaborations with transnational environmental movements. This process recruits an even wider array of stakeholders, as transnational movements tend to include such divergent actors as “local social movements, foundations, media, trade unions, intellectuals, parts of intergovernmental organizations, or even branches of government” (Xie, L., 2008). These global exchanges also allow grassroots environmental movements to expand the scope and depth of their advocacy from single-issue campaigns to even “more global issues of energy, biodiversity protection, and climate change” (219).

In this future scenario, a nationwide “right-to-know” culture is embraced by all, from China’s urban centers to the over one million villages currently in the country. The aforementioned ‘virtual public sphere’ grows into the nation’s de-facto source where public environmental information is collected and shared. In this way, an ‘alternate’ media will emerge from China in much the same way that young people in the United States turn to YouTube for their news, eschewing more establishment sources. The virtual public sphere also evolves into a superlative teaching tool for environmental education that has the capacity to mobilize all demographics in Chinese society. The public recognizes the administration’s need for social order in its pursuit of a low-carbon pathway and uses it as a hammer whenever and wherever. Environmental protection of the public is adopted through a nationalistic lens in much the same way that eco-nationalism appeared in select Soviet republics during the aftermath of the Chernobyl disaster in 1986. People are driven by a sense of ‘romantic

nationalism' that harken back to the days, real or imagined, of China's now despoiled ecological beauty. In the future, this eco-nationalism will buck divide-and-conquer propaganda and bridge the growing divide between China's upwardly mobile urban residents and their analogs in the rural territories.

- (ii) Technological: The RCP2.6 scenario (0.9 – 2.3°C relative to 1850-1900 levels)
Prediction: Likely for China, increasingly less likely for the world

During the Paris Conference, China pledged to achieve an over 20% renewable mix in overall energy use by the year 2030. As mentioned previously, Benjamin Sanderson reported (7137) that this would simply not be enough to reach the 2°C climate target and hence our RCP_{2.6} scenario. However, with the planned addition of 158 gigawatts of nuclear power by 2020, China is seeking to achieve a 30% renewable mix (Woetzel & Chen, 11). According to a September 2018 article from Bloomberg, China is now resolute on increasing this percentage to 35%^{lxvii}. For our best case scenario, China manages to even exceed the 35% commitment.

Our best case scenario closely aligns with the predictions put forth by the Energy Research Institute in their *China 2050 High Renewable Energy Penetration Scenario and Roadmap Study*. The reason the ERI study was chosen to help model this scenario is the fact that their “high renewable energy penetration” model requires that carbon dioxide emissions drop to 3 billion tons by the year 2050 (Figure 111). This is partly accomplished with a substantial increase in solar and wind installation from 2020 to 2040 (Figure 112), with both sources providing “64% of China's total power generation” by 2050 (ERI, 8).

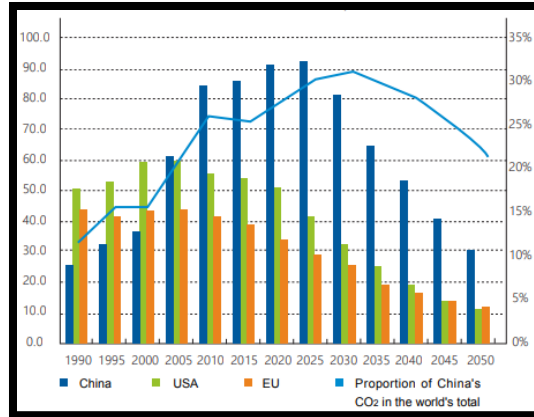


Figure 111 Carbon dioxide emissions of China compared to other nations of the world to the year 2050. Y-axis units are expressed in 100 million tons (Source: ERI, 16/26^{lxviii})

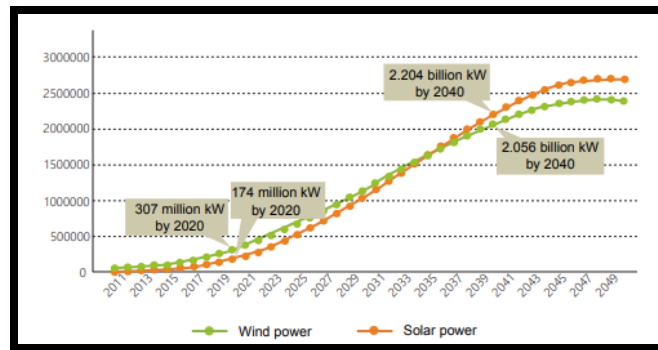


Figure 112 The substantial proliferation of installed solar and wind power for China during the period of 2020-2040. (Source: ERI, 8/14)

As it happens, in order to achieve the 2°C climate goal that characterizes our best-case scenario, emissions for China must peak before 2025, “then reduce to 2.94 billion tons by 2050, representing a 70% emission reduction” (Jiang, K., 481). As seen in Figure 111, the ERI model conforms to these requirements. In fact, the author of this Capstone has deemed this policy to be “increasingly likely” for China because emissions would indeed peak before 2025. The reader may recall from section 1.4(b) that many have predicted an assured “peak in CO₂ emissions between 2020 and 2025” (Green, 19). Kejun Jiang find our 2°C

pathway for China quite possible “because of recent progress in renewable energy development in China” (484). This includes currently competitive power generation costs for wind and solar compared to coal, buttressing of the low-carbon economic model through “rapid GDP growth rate”, and renewables becoming a “key sector for promotion” in terms of government planning and policy (484). Finally, China has the largest investment in renewable energy in the world since 2010, responsible for 24% of “global renewable energy investment” (484). It is therefore likely that our best-case 2°C model will bring about a rapidly changing mix in installed power capacity on the road to 2050 (Figure 113).

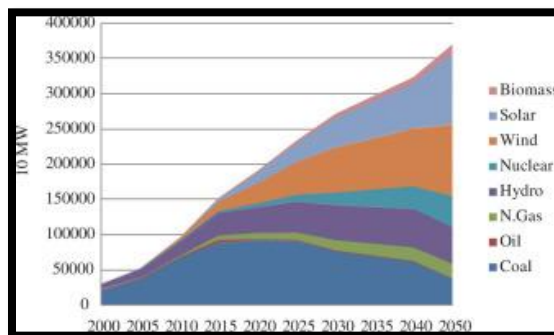


Figure 113 The dominance of various energy sources for China's overall installed power capacity in our best-case 2°C model. Y-axis appears to be in increments of 10 megawatts (Source: Jiang, K., 482)

Our scenario finds longstanding issues of overcapacity and curtailment remedied for the solar and wind industries. China manages to exceed the pledge to spend 360 billion dollars on renewables up to the year 2020, using part of this investment to eliminate the usual suspects of weak innovation (Zhao & Wei, 1414) and the scarcity of skilled technicians and engineers (Joerss & Woetzel, 6). The needed improvements in technical innovation include “the development of low-speed turbines, energy storage technologies, wind-solar hybrid power

supply systems, intelligent electric grids, improvement of PV efficiency, and evaluation of different scale wind resources” (Yang, X.J., 88). Obviously, “reformation of the existing grid system” (Dai, H., 446) will take place to stave off further curtailment and transmission congestion, resulting in a nation-wide distribution system that may look something like the network proposed by the ERI as seen in Figure 114. This “reformation” is nuanced, not only addressing the ultra-high voltage transmission lines, but revamping the overlooked smaller-scale 220kV lines connecting renewable energy sources to the actual grid itself.

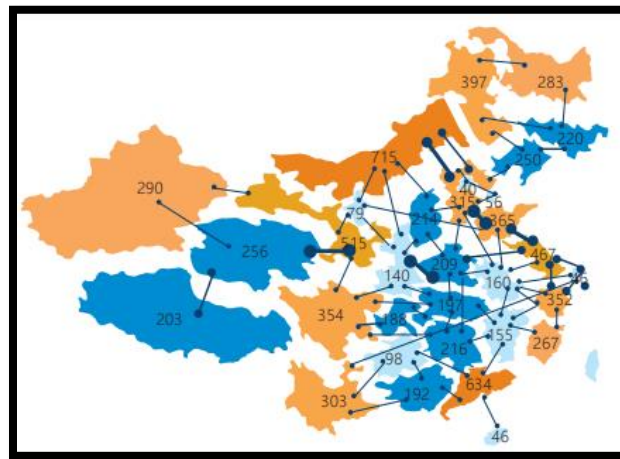


Figure 114 A projection of expanded transmission lines as envisioned by the ERI in order to achieve their “high penetration scenario”. This scenario aligns with our best-case 2°C/RCP_{2.6} model. Installed capacities for each province are given in gigawatts. (Source: ERI, 11/18)

Our scenario also sees a rapid proliferation of other renewables, including hydropower and geothermal energy. China continues to maximize the available resources of geothermal despite geographic challenges (Figure 54). In section 2.3(b) of this Capstone, part ix, Xingcai Liu assessed China’s hydropower potential as falling second only to Russia in 2015 at 2329 Terawatts (Figure 53). Future counterstrategies are developed in anticipation of reduced hydropower

flows due to climate change (3355). Renewable sources are employed in a complementary manner in order to maintain a reliable baseline for the energy grid. This includes the synergistic using of hydropower, which “is abundant in summer and poor in winter” with wind, which is “abundant in spring, autumn, and winter but poor in summer” (Feng, Y., 848). Finally, many “best” case scenarios, when applied to China, tend to eschew use of a comprehensive CCS (Carbon Capture and Storage) regime. However, many authors strongly recommend a “BECCS” approach to achieve an optimal pathway moving forward^{lxix}. This differs from the standard CCS approach in that BECCS (Bio-Energy Carbon Capture and Storage) combines burning plant mass with carbon capture and storage. A global use of BECCS has the potential of doubling our carbon budget and resulting in a net removal of atmospheric CO₂. The process has been described by Birecro’s^{lxx} Henrik Karlsson as “the only technology currently available that can reverse the trend of emissions in the atmosphere – it makes it a moral obligation to deploy it as soon as possible” (McGrath, M., 3). Kejun Jiang cites BECCS as the key ingredient to not only help China reach its 2°C best-case scenario, but even begin to follow a 1.5°C pathway and “achieve negative emissions in the power generation sector by 2050” (482). Unfortunately, at present, BECCS is still regarded as an untested, “Cinderella” technology (McGrath, M., 1).

In conclusion, China has been in the habit of exceeding expectations in the last five years and has been meeting Paris climate goals in advance of their due dates. The author of this Capstone predicts a “likely” outcome for China

achieving, at least, the “technological” part of our best-case scenario. Whether the world achieves the 2°C climate target remains to be seen. Earlier, Benjamin Sanderson was quoted as stating that INDC targets from the Paris summit will be inadequate in reaching a 2°C increase from pre-industrial levels. It appears that a disquieting future lies ahead with even the best-case scenario of a 2°C increase. Economist William Nordhaus stated the following back in 1977: “If there were global temperatures more than 2 or 3°C above the current average temperature, this would take the climate outside of the range of observations which have been made over the last several hundred thousand years” (Lüning, 2).

- (iii) Economic: China Achieves a Mixed “Viking Economy”
Prediction: Less likely although a shift in the direction of this model from the current system of authoritarian capitalism is preferred

“Viking Economics” is a term coined by retired Swarthmore College professor George Lakey in his 2016 book *Viking Economics: How the Scandinavians Got It Right-and How We Can, Too*. Lakey is describing the “Nordic Model” which is the mixed economy of Scandinavian countries that have managed to balance the best elements of socialism and capitalism. The author of this Capstone has chosen this model to be the “best case” scenario for China’s economic future.

Discussing the “Viking Model” in an online interview with David Pakman, Lakey discusses an economy that “supports entrepreneurs but they just don’t support them at the expense of the common good...it keeps looking out for the well-being of the whole while at the same time it supports creativity and

innovation in the economic realm” (Pakman, D., 2016, 1:00-1:16). In terms of the usual arguments that Scandinavian economic policies are ill-fitted for largely populated and diverse countries such as China, Lakey mentions how a delegation of Chinese economists from Beijing visited Norway. They were asked by Norwegian officials about the reason for their visit to which the delegation replied “our government sent us here to learn what we can” (Pakman, D., 2016, 6:40 – 6:56). The advantage of the Nordic system for China is that it lacks the social and environmental costs associated with the more brutal aspects of U.S. trade policies engendered in our “worst-case” economic scenario. At the same time, the Nordic model is still actively engaged in free trade unlike the authoritarian protectionism of our “BAU” scenario. This balance is achieved due to collective mechanisms for risk sharing “to give some compensation to those suffering from negative effects of structural change” (Andersen, T., 18). Torbin Andersen also points out that this is “the reason why some taxes – say environmental taxes – can be used to steer decisions in a direction which is considered favorable to the society” (Andersen, 94). As Lakey states in his book, this could explain why “Norwegians were among the first in the world to raise the alarm about climate change” (Lakey, G.^{lxxi})

If Nobuo Tanaka’s vision of a ‘green revolution’ is to materialize, China must have unfettered access to foreign trade and outside assistance. The Nordic economic model offers free trade without the same environmental and social costs of U.S.-led globalization. Nordic countries are “wedded to free trade and have, with some sectoral exceptions, been in favor of free trade already for a

very long time” (Andersen, T., 32)^{lxxii}. Access to western companies will not only provide China with needed technical assistance, but also guidance for “corporate governance, fiscal policy, and intellectual property rights protection” in addition to investment in economic and social infrastructure (Hawksworth, J., 5). Such collaborations will provide technical assistance through the “digest and innovate” approach as seen in the “Wind Power Concession Project” where foreign entities established joint ventures in China. This collaboration provided an environment where “domestic players could access global talent and knowledge networks”, thereby allowing the technology gap to close “dramatically” between “foreign and domestic players” (Woetzel, J., Chen, Y., 83). For China, “global and regional collaboration remains as important as ever” (Bakkes, J., 4). In terms of regional collaboration, as China exports its economic role as the world’s factory to nearby Asian countries, “regional collaboration can help prevent, or mitigate, a potential continuation of the associated burden to the global environment” (4). This includes a willingness to recognize that any dalliances with “clean coal” as a so-called “interim option” is “incompatible with agreed international goals” (5).

If one accepts Andersen’s conviction that the Nordic Model “can be used to steer decisions in a direction which is considered favorable to the society”, then this model would surely support the following proposition for China’s renewable transformation. As mentioned previously, air pollution extracts 6.5% of China’s GDP. According to the RAND corporation, that amounts to 535 billion dollars in 2012 (Crane, K., IX). The RAND analysis calculates an annual cost of anywhere from 32 – 52 billion dollars to replace residential and commercial coal

heating with natural gas and a 184 billion dollar cost for replacing half of China's coal-fired power with renewable and/or nuclear power. When also applying the amount of coal saved (around 75 billion dollars), the total possible cost amounts to 140 – 160 billion dollars per year, one-third of what air pollution is robbing from the budget (IX). Similar values have been identified from other studies, including a cost of 150 – 200 billion euros (170.2 billion – 220 billion dollars) each year for the next twenty years in order to achieve a true “green revolution” (Joerss, M., 2 & Woetzel, & Joerss, 11).

Modeling China after the Nordic Model will provide a healthy access to free trade and markets while also providing the government subsidies that “are necessary for the renewable industry to build capacity” as well as the power to “mandate power generation from renewable energy” (Woetzel & Joerss, 118). This will be a flexible and whip-smart model, quick to recognize the massive return on investment for a green revolution. Many studies have already shown that an ‘all hands on deck’ renewable energy plan for China would not have significant impacts on the macro-economy (Dai, H., 446). In fact, an exhaustive study from the Energy Research Institute demonstrates that a “high renewable energy penetration scenario” to the year 2050 would provide massive economic benefits. The cost of scaling up such a program would be offset by “saving the fuel cost of fossil energy” (ERI, 13), while adding over 6.2% GDP (17 trillion RMBs) from the ‘added value’ of renewables^{lxxiii} (14), and also creating over 12 million new jobs in the renewable energy industry (15).

- (iv) Political: China Manages to Achieve an 'Anocracy'
Prediction: Likely, though achieving a 50/50 mix appears less likely

In our best-case political scenario, China has managed to achieve a workable anocracy which is a system governed by both autocratic and democratic mechanisms. As Yale University's James Vreeland defines it, "the basic idea is that anocracies have a mix of institutional characteristics, some democratic and others distinctively authoritarian" (404). Democratic mechanisms operating on the local level have been assessed in this Capstone and continue to grow in their efficacy. Andrew Nathan predicted this eventuality as far back as 1990: "when Chinese democracy begins to take shape, it may turn out to be a mixture of democratic and authoritarian elements, openness and secrecy, idealism and selfishness, turbulence and stability" (208-209). In our "best-case" scenario, democratic rumblings on the ground expand at an exponential rate.

The reader of this Capstone may find it puzzling that the author is advocating for a mixed authoritarian-democratic system while simultaneously expostulating against a western electoral democracy for China. However, it is important to keep in mind that the "Chinese" form of democracy is something decidedly eastern. When asked in 2006 about the Chinese definition of democracy, then premier Wen Jiabao replied that "when we talk about democracy, we usually refer to three key components: elections, judicial independence, and supervision based on checks and balances" (Thornton, J., 6). The elections referred to by Jiabao, which may be a surprise to many western readers, is the ability for citizens to elect local officials. According to John Thornton, for decades "peasants across the country have held ballots to elect

village chiefs” (5). These elections are “not Western-style multiparty elections” per se, “but at least a contest involving a real choice of candidates” (19).

Jiabao’s statement is also a tacit referral to the “deliberative democracy” polling and town hall meetings that have allowed citizens to bring environmentally destructive projects to a standstill. These meetings continue to enable “the compilation of public opinion on environmental issues as a reference for environmental decision making” and that this compilation of public opinion “has affected governmental action relating to environmental governance” (Tang, X., 2). Beeson points to the growing “school of thought among Western observers which argues that sustainable environmental outcomes are more likely in a political context where a form of ‘deliberative democracy’ is central to the process of environmental management” (37). The growing momentum of the “deliberative” phenomenon has been chronicled at various points in this Capstone, including section 2.2c(i) exploring the notion of “Minzhu” (‘people as masters’) as well as the town hall ‘kentan’ (“heart-to-heart discussions”).

Other democratic elements include the “intra-party” democracy exercised within the ranks of government cadres (see section 4.3a(i)) as well as the long-standing tradition of “democratic centralism” that was written in to Article 3 of the Chinese constitution. Under democratic centralism, “the masses would contribute problems, grievances, solutions and related ideas that CPC leadership would work into CPC policies, and the CPC would take these policies back to the masses for critique and then produce a more refined policy based on these further contributions of the masses” (Howland, D., 450).

Therefore, “even though China may not become a Western-style liberal democracy any time soon, some kind of democratic reform is not totally out of the question” (Zhong, Y., 54). China offers a trifecta of three distinctly eastern democratic expressions: intra-party democracy within the party, democratic centralism linking both party and people, and deliberative democracy among citizens. As former president Hu Jintao said “simply copying Western models was not necessarily the answer either” (Thornton, J., 10). Thornton quotes an ‘elder statesman’ who says it best: “they are determined to get it right...but they require patience from the West...please let the Chinese experiment...let us explore.” (20).

For our best-case scenario of an emerging anocracy, we must direct our focus to the third aspect of ‘deliberative democracy’ and the changing landscape of the power of the people. In order to project this scenario to the future, we must recognize that the last five years have been a force of nature in terms of public participation and environmental mobilization. The rising tide of public participation was, admittedly, seen by the regime as simply a tool to enhance their legitimacy in the eyes of the people, a calculated move where “various stakeholders —and potential sources of social unrest—are included in a consultative process” (Beeson, M., 37). Beijing is savvy enough to realize that “public participation promotes environmental governance in China. Public environmental complaints exert significant and positive impacts on the reductions of pollutant emissions” (Zhang, T., 17). However, the ruling elite most certainly did not anticipate many of the ground-up developments detailed in the previous ‘*Social*’ part of our best-

case scenario, particularly the potential for ICT to undermine official environmental statistics from above and provide “both communities and individuals with a range of new possibilities for communication and public participation” (Xu, J.,1375). In our best-case scenario, growing civic engagement results in greater concessions from the central authority of China who realize that social control absolutely must be maintained in order to achieve the low-carbon growth model in the future. The democratic movements by way of grassroots monitoring continue to expand and recruit a more diverse array of stakeholders. ENGOs maintain and even accelerate their proliferation when compared to previous years, with Jinping’s draconian posturing revealed as a temporary blip. Social media continues to play a vital rallying cry, unifying people from different parts of the country under the single banner of environmental protection. Just as the “I gauge air quality for my motherland” slogan appeared on both shirts and in social media (1387), environmental protection will be seen as an issue of national pride and collective action. Dictates from Beijing will be subordinate to a growing environmental nationalism. Due to the falling prices and availability of testing equipment and the broad coordination of environmental information on social media, a taskforce of mobilized and connected citizen activists achieve a nationwide network of real-time environmental monitoring. In our future scenario, the availability of water testing kits as started with Jack Ma’s Alibaba site (Figure 111) in 2014 (see section 4.3(a)vi) has evolved into an affordable and easy-to-use spectrum of kits testing everything from air, soil, and water and promoted through multiple sources on social media. Knowing that all statistics will be

democracy in order to avoid a complete social meltdown. Essential, of course, to this paradigm is the education of China's citizens. Awareness among the economically mobile urban middle-class is easy enough. The challenge will be to promote and inspire environmental awareness within the restless army of China's rural class.

V. Conclusions

5.1 Using S.T.E.P. to Provide Summaries and Recommendations to Key Decision Makers

What follows are a list of recommendations following the S.T.E.P. (Social, Technological, Economic, and Political) format that will help to pull China from the environmental brink.

5.1(a) Social

On June 29, 2019, Foreign Minister Wang Yi met with António Guterres, the United Nations' Secretary-General as well as France's Jean-Yves Le Drian. Among the twelve points addressed, as summarized by the United Nations, is China's continued commitment to a low-carbon economy^{lxxiv}. Of the many motivating factors covered previously for the low-carbon economy transformation, maintaining social order ranks right towards the top. As mentioned in section 4.1(a), the author's email correspondence with Jack Fitzgerald, Senior Analyst at the United States Environmental Protection Agency, revealed that the "Chinese officials have two overarching objectives – economic development and social stability. The latter objective has profound implications for the former". (Maley, 2011, 13). What has emerged is a uniquely Chinese form of "consultative authoritarianism" where everyday people play an increasingly

important role in environmental protection in an increasingly accurate and transparent atmosphere of disseminated environmental data. As stated previously, the “disclosure of pollution source supervision information – a key category of environmental information – saw breakthrough progress between 2017 and 2018” (IPEA, 2018, 1). In section 4.1(a), UCLA law professor Alex Wang recognized this to be a “zone of compatibility” where multiple actors including both the state and citizens find a common ground of mutual benefit, as showcased in Table 2. Here, “disclosure simultaneously enhances environmental performance, facilitates citizen autonomy, and enhances state control and legitimacy” (883).

Public participation is critical to the success of China’s environmental objectives. In terms of achieving a low-carbon pathway, “deep decarbonization will require any country to win the support of its population, not only to achieve passive acceptance but also to gain their support as actors in adopting new daily practices” (Ahlers, 4). Ahlers describes public participation as “crucial for effectively implementing any large-scale program on the ground”, particularly for a comprehensive renewable energy program with any hope of achieving long-standing success (4). The vast expanse of the country will require an integrated network of monitoring that can only be achieved with the help of the public.

When it comes to public participation, China has elected to keep the door tightly shut for many years. The aforementioned progress in transparency and participation has provided citizens with a keyhole through that doorway where the limitations and vagaries of the institutional machine are clearly visible. The public

must strive to break that door down moving into the next decade. The people have already shown a willingness and facility of taking a mile when given an inch. As Janice Hua Xu revealed in our “best case” social scenario, Chinese citizens brought a tidal wave of self-styled ‘do-it-yourself’ and ‘direct action’ activism to the table. Buttressing these efforts is the move into the ‘virtual public sphere’ and the ongoing proliferation of ICT (information communication technologies) as a way to connect people to real-time environmental data. Critical to the success of public participation is the ongoing support from multiple actors. The intersection of interests from multiple players has already yielded compelling results. Public monitoring and reporting was greatly enhanced courtesy of corporate giants like Jack Ma’s Alibaba providing affordable water testing kits for citizens as well as NGOs like Ma Jun’s Institute of Public and Environmental Affairs (IPE) providing real-time monitoring through the “Blue Sky” app. Just as Mao Zedong was fond of using the term ‘paper tiger’ to describe the west, the author predicts that this term will apply to any threat of an authoritarian backlash to this rising tide of activism and mobilization. In this era of a low-carbon pathway, social stability will be the ruling elite’s number one priority. There is also an awareness that this pathway simply cannot be achieved without the cooperation of a population, namely one that is not shell-shocked from habitual disenfranchisement. The government must be increasingly more willing to integrate public involvement as a key factor for achieving a united front for environmental action as well as accuracy and policy uniformity across China’s diverse regions. The framework has already been set with the spread of everything from the ‘deliberative’

democracy of townhall meetings to widespread ICT mobilization. The unyielding resolve of the public could help swing China into an anocratic regime, a governance approach best suited for integrating public participation.

Also critical to China's social objectives is a willingness to find inspiration from beyond its borders. As far back as 2006, the Organization for Economic Co-operation and Development believed that China could learn a great deal by studying the role the public plays in environmental governance among the 36 member states of the OECD. This will help bolster the public's role in narrowing the enforcement gap (OECD, 2006, 6), continuing to help with "non-compliance detection and compliance promotion" (5), and being a part of the regulatory process "at all stages, from drafting environmental legislation to enforcement activities" (7). China also needs to draft environmental policy that is mindful of the vast regional differences across the country, providing nuanced recommendations tailored to the unique social and cultural needs of each province.

Finally, education remains absolutely essential. As mentioned previously by Xiao Tang, of all the various types of pollution besieging the public, citizens were the most engaged with air pollution because it is "the most visible type of pollution" (13). Educating people on the appearance, detection, and reporting of less visible, but potentially more insidious pollution hazards is necessary. Underscoring this point will be the need for the public's ongoing monitoring and protection of groundwater, something that remains "inadequately understood by the public", as China's massive OBOR program extends across central Asia

(Chen, J., 365). Complementing a nationwide education campaign should be improved state methods of risk communication and perception when dealing with the general population. Tangential education can also be achieved by allowing the public to be much more invested in the evaluation process of local cadres. The “fragmented bureaucracy” of centralized environmental directives not being enforced by local officials is frequently cited as a “major factor influencing the implementation of environmental policies” (13). There has been a great deal of progress over recent years, however, in tying local cadre promotion to environmental performance. The growth of the EPPE system in Shenzhen, for instance, was covered earlier in this Capstone as seen in Figure 73. This system can be further improved if the public has a role in the rating process of individual officials based on environmental responsiveness and the “number of environmental petition cases” (14). This will help maintain the public’s increasing role in “policy decision making, implementation, and monitoring following implementation” (13).

5.1 (b) Technological

When considering technological factors, the RCP (representative concentration pathway) scenarios were applied to our model-making for the worst case (RCP_{8.5}), business-as-usual (RCP₆ & RCP_{4.5}), and best case (RCP_{2.6}) scenarios. Differences in the energy mix to the year 2050 for all three RCPs can be seen in Figure 101. The propitious continuation of China’s renewable commitments and flattening coal use would undermine the projected ten-fold coal increase (Figure 102) associated with the RCP_{8.5} track. Maintaining and

expanding current commitments should place China on the right course to achieve the RCP_{2.6} pathway, which aligns with the 2°C climate target (Figure 98). This will handily surpass the RCP pathways associated with the BAU scenario. These mid-range pathways are best modeled with the “Green Transition to 2050” offered by the PBL Netherlands Environmental Assessment Agency functions. While noteworthy, these mid-range pathways will clearly miss the mark of the internationally agreed upon 2°C climate target as seen in Figures 103 & 104. Indeed, China seems to be not only following the 2°C trajectory, but may even achieve the more ideal 1.5°C pathway. 4.1(c)i not only chronicles the breathless ascension in installed renewable capacity, with Figure 67 showcasing the 14.5% growth from 2007 to 2016, but also the untapped potential that remains for particular renewables such as wind (Figure 66).

Benjamin Sanderson cautions that China's Paris pledge of achieving a 20% renewable penetration by 2030 would not be enough to reach the 2°C climate target and hence our RCP_{2.6} scenario (7137). However, many academics predict the achievement of a 30% mix (Woetzel & Chen, 11), a 35% mix, or an even higher value. As of September 2018, China's Renewable Portfolio Standard (RPS) pledges a 35% renewable mix of electricity generation as of 2030. As the largest producer and consumer of renewable energy, China has already exceeded the EU in renewable investment (Figure 69), outperforming “the rest of the world in terms of investment in clean energy” (Mathews and Tan, 9). Our best case scenario closely follows the "high renewable energy penetration" model proposed by the Energy Research Institute which foresees a substantial increase

in both solar and wind capacity in the next twenty years (Figure 112). The ERI model was chosen as the best trajectory to achieve the 2°C climate target because the model requires carbon dioxide emissions to drop to 3 billion tons by the year 2050 (Figure 111). This is an ideal model for the RCP_{2.6} since the 2°C climate goal requires emissions to peak before 2025, and, like the ERI model, “reduce to 2.94 billion tons by 2050, representing a 70% emission reduction” (Jiang, K., 481). China is halfway there due to predictions of an assured “peak in CO₂ emissions between 2020 and 2025” (Green, 19). This has compelled authors like Kejun Jiang to state that China is lining up with the 2°C pathway, “because of recent progress in renewable energy development” (484).

Undoubtedly, a monumental degree of pressure exists to achieve the best-case technological scenario. Between now and 2050, anything vaguely resembling regressive policy must be neutralized. Enervation must not be allowed to set in. All signs seem to suggest that China is lining up well with the 2°C climate target, with even the 1.5°C climate target within reach presuming that CO₂ emissions can fall to 325 million tons by 2050 (Jiang, K.,481). However, implicit in this pathway is the pressure to achieve continual improvement every year. Just as China’s GDP growth over a thirty-year period shocked the world, so must an equally breakneck pace for environmental goal setting exceed all expectations. Heroic efforts to continually ramp up the renewable program in China must happen *now*. The BAU-scenario for technology warns of the looming threat of abatement (Figure 105), as Joerss and Woetzel showed back in 2009 that a reduction in abatement potential of 1.5 gigatons of greenhouse gases

would follow a mere five year delay. Multiple authors urge for China to continue feverishly ramping up renewable capacity if the 2°C or 1.5°C scenarios have any chance of materializing (Dai, H., 446; Jiang, K., 484; Joerss and Woetzel, 8).

If left unaddressed, familiar issues will present major stumbling blocks to the scenarios detailed above. A lack of trained engineers and technicians (Joerss & Woetzel, 6), a lack of research funding, and a lack of innovation (Zhao & Wei, 1414) are persistent deficiencies that should be redressed by at least some of the hundreds of billions of dollars injected into China's "ecological civilization". Other previous issues cited in this Capstone regarding renewables are an overreliance on imported parts with "high R&D difficulties", and a lackluster command of manufacturing, operation, maintenance, and power grid integration by Chinese companies (Zhao & Chang, 470).

Two of the most notorious obstacles in China's renewable development are overproduction and curtailment. The importance of these two issues warrant the frequent coverage received in this Capstone. The former can be assuaged through sophisticated economic measures, which include a more nuanced approach to subsidy distribution. The latter is considered one of the biggest technical challenges associated with China's wind and solar industry. The 15% curtailment of wind power in 2015 resulted in a cost of 1.4 billion dollars. The remarkable proliferation of UHV power lines across the country is slowly remedying this problem, though this expanding transmission network is still outpaced by solar and wind installation capacity. China should study the power distribution network proposed by the ERI (Figure 114) whose "high penetration

scenario” is commensurate with the 2°C climate target. China continues to focus on the ultra-high voltage power networks, while giving short shrift to the lower voltage (220 kilovolt) subnetworks that transfer the power to the grid.

China must be willing to gamble with cutting-edge, progressive technology, thereby stepping up as a trendsetter for the world community. This includes technologies detailed in this Capstone that, if implemented properly, could yield massive returns. This includes the use of ACC (Air-cooled power plants) and comprehensive desalination programs as described in section 4.3(a)v. When compared to wet-cooling systems (Figure 79), the Union of Concerned Scientists found that dry-cooling systems save 90% on overall water consumption (2). Meanwhile, one of the largest desalination companies in the world (IDE) determined that China will “eclipse the Gulf market within two decades” (Wong, G., 4). Other very promising technologies as featured in section 4.3(a)vi offer a unique approach to reducing China’s air pollution. These include the SALCS (solar-assisted large-scale cleaning systems) seen in Figure 87 which is a variation of the ‘solar chimney’ system the author encountered while attending a global warming conference in Istanbul in 2008. There are also the MOFs (metal-organic frameworks) which, as seen in Figure 90, have the ability to capture PM_{2.5} particles, storing ten times more pollutants than regular filters.

Finally, we are discussing a country that has some of the richest biodiversity on Earth and contains all of the ecosystems “outlined in the global ecosystem” (Bai, 349). Such diversity could offer a staging ground for the kind of visionary projects that would support Tanaka’s “green revolution”. One idea

proposed by the author in 2011 drew on the findings of the landmark “Aquatic Species Program” by the National Renewable Energy Laboratory. By equating algal oil yields by acre with UNEP estimates for the total number of cars in China by 2050, the author calculated that the conversion of 5% of the Gobi Desert to an algae farm could meet all of China’s auto fuel needs (Maley, 2011, 17-18). This is just an example provided to the reader, as to the kind of break from orthodoxy China will need in terms of vision and technological innovations. The path to 2050 must be unconventional, unprecedented, and uncompromising.

5.1 (c) Economic

China's continual shift from an export-led to a consumption-driven, service economy will result in an even greater economic slowdown after 2020 than what has been experienced in the last few years, as seen in Figure 107. China's areas of strategic protectionism are reminiscent of the state planning and mercantilism of the United States in the 19th century. However, unlike the west, China's economic model will unlikely morph into western neoliberal policymaking. An overarching interest in social order precludes the use of a system that would further disenfranchise China's vast proletariat. China will maintain authoritarian capitalism with strict control and the maintenance of state-controlled enterprises, seeking to “engage the global system of capitalism while keeping intact its primary domestic focus of state-led development” (Horesh and Lim, 23).

China is urged to consider moving away from a strict platform of authoritarian capitalism to an adapted 'Nordic Model' in the coming decades. This will allow China to engage in the necessary free trade to achieve environmental

objectives without the social and transferred environmental costs associated with U.S.-led globalization. China must achieve greater access to technical assistance as well as guidance for "corporate governance, fiscal policy, and intellectual property rights protection" in addition to investment in economic and social infrastructure (Hawksworth, J., 5). Collaborations with foreign firms have a proven track record of success by way of a "digest and innovate" approach which closes technological gaps across China's borders. China must also step up as a leader and not allow the transference of its manufacturing sector to nearby Asian countries without insisting that China's past environmental mistakes are not repeated. The Nordic economic model will provide access to foreign markets while still maintaining enough state control to maintain government subsidies "necessary for the renewable industry to build capacity" as well as the power to "mandate power generation from renewable energy" (Woetzel & Joerss, 118).

However, China must learn from the lessons of the past when applying subsidies and wielding the power to "mandate power generation from renewable energy". Progress has been made in reducing the number of technocrats in office, as seen in section 2.2(c)ii. This reduction marked a shift away from supply-side solutions to much needed demand-sided strategies. "Mandates" for grandiose building projects like the Three Gorges Dam and the South-To-North Water Transfer Project must be replaced by phenomenal efforts to promote demand-based measures of efficiency and pricing.

Smarter subsidies must replace the previously reckless use of subsidies to strong-arm world markets, which led to the overcapacity crisis in wind and solar

energy. The reassuring trend of recent legislation addressing this issue must continue to grow and evolve. Some of these measures include the RPS (“Renewable Portfolio Standard”) which sets penalties for not reaching renewable energy targets. Also of note is the Renewable Energy Certificate Program in 2017 allowing subsidies to be tradable between solar and wind producers and state-owned and private companies. Ideally, considering China's heterogeneous landscape, subsidies should be strategically assigned to promote enough innovation to make the "Porter Hypothesis" (see 4.3(a)iv) applicable nationwide.

Both Green and Stern also proposed strong pricing recommendations for China by way of increasing coal taxes, an emissions trading scheme, and appropriately set carbon prices. China has risen to the challenge with the release of the “Environmental Protection Tax Law” on January 1, 2018, providing an update to the formerly problematic “Pollution Discharge Fee”. China’s recent Emissions Trading Scheme (ETS) has also been described as “a powerful signal about the country’s mitigation commitment” (Swartz, J., 8). Success at the Paris Summit will provide China with the opportunity to improve the recent ETS by comparing it with similar ETS systems in effect within the European Union since 2005. Moving forward, the Environmental Protection Tax Law still leaves room for improvement. Affording far too much autonomy to provinces may cause the assignment of environmental standards that vary by location, creating as Jian Wu suggests, a network of pollution ‘havens’. Most concerning is the fact that carbon dioxide emissions are currently exempt from taxation.

Smart pricing, particularly as it applies to water, is also desperately needed in China. China's water issues have been covered extensively in this Capstone. With 20% of the world's population, but only 6% of the water, the dwindling supplies that *are* available are constantly under siege. In a previous paper, the author urged for a "market-approach of environmental taxes, draconian volume-based fees for water pollution, water-pricing mechanisms, and quotas" (Maley, 2014, 14). Such measures should not be geared towards residential water use necessarily, but by the primary offenders in the agricultural and industrial sector. The ultimate goal is for industrial water recycling rates to achieve, according to the World Bank, the 75-85% levels of developed nations as opposed to the currently abysmal 40% rates (Xie, J., 26). Meanwhile, moving away from unitary pricing structures to volumetric pricing will provide the incentive to conserve water and graduate to water-saving techniques in the agricultural sector.

Additionally, enough funding should be earmarked for city coffers to address an issue raised by Stefan Brehm. According to Brehm, "fiscal capacity emerges as a crucial factor" in terms of a city's ability to achieve enforcement and transparency of environmental laws (490). Steps must also be taken to make sure that penalties for violating environmental laws are not dwarfed by the cost of reaching compliance efficiency standards. Finally, a system of monetary incentives could also be integrated into this paradigm to promote good behavior among firms.

Other economic recommendations include the need for more spending in research and development, particularly considering that only 5% of R&D is currently earmarked for basic research, resulting in lagging quality of Chinese output (Woetzel & Chen, 97). Finally, most studies have demonstrated that a switch to a deeply-entrenched renewable energy scenario is quite affordable. Extensive analysis from the Energy Research Institute reveals that the cost of a “high renewable energy penetration scenario” to the year 2050 would be offset by “saving the fuel cost of fossil energy” (ERI, 13), while creating over 12 million new jobs in the renewable energy industry (15), and adding over 6.2% GDP (17 trillion RMBs) from the ‘added value’ of renewables (14). An analysis from the RAND corporation shows that replacing residential and commercial coal heating with natural gas coupled with the replacement of half of China’s coal-fired power with renewable and/or nuclear power will cost a mere third of the amount air pollution plunders from the annual budget. Similar figures have been derived by other authors (Joerss, M., 2 & Woetzel, & Joerss, 11). In fact, Hancheng Dai concludes that a radical restructuring to a renewable economy would have minimal impact on the macro-economy, but will instead insure a windfall of profits and subsequent job growth (4.12 million jobs by 2050) (435).

5.1(d) Political

Max Weber’s modernization theory, first introduced in section 2.2c(i), equates China’s rapidly ascending middle class with an eventual shift towards western democratization. Some economists and armchair pundits from the west

foresee an emerging westernized electoral democracy as the staging ground for China's environmental deliverance. However, this is considered an unlikely prospect for China, as addressed in section 4.3(b)i. This section includes Chen and Lu's polling as featured in Figure 92 with a subsequent defense provided in footnote 44. It is much more likely that China will eschew a "unilateral" approach and follow Jie Chen's "contingent" approach as is typical for late-developing countries. China's authoritarian system is likely to persist, although this uniquely eastern construct does not conform to the attributes of classical authoritarianism, per se. It is, in fact, a "mixture of authoritarian and democratic features" (Ahlers, 316). In the literature, this system has alternately been described as a form of "responsive", consultative", or "adaptive" authoritarianism. Out of this system has emerged a distinct brand of authoritarian environmentalism (AE) as described in section 4.3(b)ii which the author of this Capstone posits is a viable system to confront China's substantial environmental challenges. Upon initial inspection, it may be surprising to many western readers that such a system has become synonymous with a "remarkable environmental policy change" and "mushrooming civil engagement" (316). For many on the outside looking in, AE may appear "highly authoritarian", however "the situation on the ground is much more ambiguous, displaying a mixture of authoritarian and liberal features" (Lo, K., 158). For these same outsiders, one other consideration: a cursory perusal of sections I and II quickly acclimates the reader to not only the intensity of China's environmental challenges, but the narrow timeline available to address them adequately. As argued in section 4.3(b)iii, there is simply not enough time for

China to engage in any grand experiments with western democracy when the current system has shown the ability to take strict and needed action in a manner that is swift and severe.

The point cannot be overemphasized that support for China's AE system is not support for classical authoritarianism. In China, a cord exists that connects classical command-and-control authoritarian systems to a burgeoning trifecta of democratic ideals. This includes the democratic centralism between the people and the party, intra-party democracy within the party, and most importantly, deliberative democracy among citizens. Deliberative democracy has been covered on various occasions in this Capstone and has provided an essential pathway for the public to not only express discontent over environmentally destructive projects, but to also pressure officials into taking action.

In terms of the aforementioned 'cord' connecting authoritarianism and Chinese-style democratic mechanisms, the goal between now and 2050 is to move the country as much as possible away from the former and towards the latter along that cord. In the last five years, there has seen major strides in citizen mobilization regarding the environment, including a DIY-network of data collection that demands greater and greater governmental accuracy and transparency. It will be a fool's errand to attempt to roll back public modes of participation regarding the environment, as afforded by the government. The hyper-focus in the following decades of maintaining a sustainable economy through a low-carbon growth model will require a greater toleration and implementation of people power. It is the hope of the author that the move along

that cord is great enough for China to achieve an authentic anocracy, mixing both democratic and authoritative processes in order to best expedite a full environmental recovery.

The future success of this distinct form of environmental governance rests on one essential factor. As mentioned in section 4.3(b)ii, this system presumes that there is a core of incorruptible, hyper-informed “*eco-elites*” at the helm of government who are whole-heartedly invested in the Chinese concept of meritocracy. However, the “governmental considerations” featured in section 2.2 of this Capstone address recurring institutional shortcomings that are now well-known. Environmental governance in China has been historically thwarted by needless bureaucratic complexity, challenges in transparency and accuracy, and poor enforcement at the local level. Failure to address this collection of shortcomings adequately will mean an easy slide into all four of the ‘worst case’ scenarios for S.T.E.P. However, this Capstone details some of the significant improvements in these areas for the last five years.

A contributing factor to China’s bureaucratic fragmentation was the dizzying collection of governmental ministries, administrations, and bureaus as shown in Figures 33 and 34. This has led to “discrepancies due to lack of coordination among reporting ministries” (Hsu, 8). Many efforts have been made during the Jinping era to obviate needless bureaucratic complexity. As highlighted in the “BAU” political scenario in the previous section, a large departmental consolidation in 2018 created the “Ministry of Ecological

Environment” to address climate change efforts and water pollution and the “Ministry of Natural Resources” for urban planning and land use.

Immediately following poor governmental organization is the issue of transparency. As explored in the latter half of section 4.1(a), transparency has increased significantly, with the period between 2011 and 2012 generally regarded as a turning point due to public outrage over PM_{2.5} levels. To assuage public pressure, real-time monitoring of pollution levels was provided by the MEP. Transparency continues to rise in lockstep with greater citizen mobilization, leading the Institute of Public and Environmental Affairs to suggest that transparency has achieved “breakthrough progress between 2017 and 2018” (1).

Section 1.3(b) presents a timeline of China’s “rising environmental laws”. These laws have improved in leaps and bounds in recent years and have worked in concert with the “more explicitly” top-down style of leadership from Xi Jinping and Premier Keqiang (Chen and Lees, 225), closing the gap between environmental enforcement and economic growth. Identified as one of the greatest barriers to environmental governance, poor enforcement by local officials has been roundly addressed by the current administration. As discussed in 4.3(a)ii, the 2014 “Evaluation Method of the Implementation of Atmospheric Pollution Prevention and Control Action Plan” (Liu, L., 656) tied the evaluation of local officials to particular environmental targets. The spread of “EPPE” (Environmental Protection Performance Evaluation) mechanisms continue to gain ground as demonstrated quite dramatically in Figure 73. The Environmental Protection Law in 2014 (see section 2.2(b)ii) monitors local governments to make

sure that they fall in line with the central government's environmental objectives, and provides the right to sanction or detain the property of enterprises that are not in environmental compliance (Chen and Lees, 222). Article 67 also allows for top-down spot inspections and the promise of draconian sanctions for violating "the behavior of the law"^{lxxv}. The "Deepening Reform Leadership Small Group" helped to strengthen these measures even further in 2015 (222). Finally, the "National Guidelines of New Urbanization, 2014–2020" further sought to reduce fragmentation by requiring subordinate organizations to defer to higher entities to "coordinate various department in the governance system" (221). The implementation of many of these policies "reverses the trend towards what many China scholars have called fragmented authoritarianism" (225).

The current administration has made admirable strides through recent legislation to promote an "ecological civilization" for China. However, many concerns still remain. The most formidable of these claims, by far, is how China will approach the One Belt One Road initiative. Despite poor coverage in the western media, the OBOR promises to be one of the most landmark moments in recent Chinese history once it is fully realized. Section 2.1(c) outlines pessimistic (i), optimistic (ii), and neutral (iii) viewpoints with regards to this project. However, will the government use the colossal OBOR project to just export capitalist surpluses to poorer countries with weaker environmental protection? Will China's "globalization 2.0" duplicate the original western system of externalized costs, and pass the cost of extraction, production, and disposal to more vulnerable countries in central Asia and around the world? It is concerning there is such a

paucity of environmental references in governmental policies regarding the OBOR. As mentioned previously, the 2015 policy document *Vision and Actions on Jointly Building the Silk Road Economic Belt and 21st-Century Maritime Silk Road* only mentions environmental protection in a section called “unimpeded trade”.

The PRC must strive to ensure that green investments supersede Mathews and Tan’s “black investments”. The OBOR must make heroic efforts to achieve Lei Han’s “EE” convergence where shared integration with high efficiency countries allows energy convergence to occur among low efficiency “lagging countries” (112-3). If China adopts the “Nordic Economy” presented in our best-case economic scenario, the Scandinavian “consensual policy deliberation approach” (Tracy, 61) could be exported to more vulnerable developing countries as a conditionality of membership into the OBOR initiative. China must also create a system patterned after the NEPA policy act in the United States requiring environmental impact statements for all further projects associated with the OBOR. These impact statements (what Ascensao refers to as “SESAs” (Strategic Environmental and Social Assessment)) should be open to public review and subject to an interorganizational system of checks and balances just as NEPA requires a ‘comment’ letter from the Environmental Protection Act and oversight from the White House Council for Environmental Quality. All of the progress in environmental governance detailed in this Capstone will be undermined if China uses globalization schemes to simply export dirty energy to someone else’s backyard.

5.2 Final Thoughts

In Section 1.6, the reader will find the sobering, now famous assessment made by former director of the International Energy Agency, Nobuo Tanaka In 2010. Standing before a group of nettled officials in Beijing, Tanaka stated that the world would not reach essential climate targets by 2050 unless China's CO₂ emissions peaked by 2020. As we scramble to forestall the consumption of our remaining carbon budget, all eyes are on China, who, by some accounts, is responsible for one-third of global carbon emissions (see footnote 59). There is no need in these closing sections to remind the reader of China's many environmental trials and tribulations. An exhaustive exploration of these statistics appear in the first 120 pages of this Capstone, as seen in the Introduction (Section I) and the Literature Review (Section II).

However, in May of 2018, an email exchange between Tanaka and the author of this Capstone revealed a very different position, eight years on. Tanaka was certain that China's CO₂ emissions would peak "by even 2025" and assigned China's "green revolution" as one of the four "upheavals or revolutions in the energy sector" (Figure 70). A remarkable change has occurred in the last nine years, in a country with a three-thousand-year history that is used to unexpectedly contracted and intense changes. Following Xi Jinping's "New Normal" speech in 2014, a willful and systematic shrinking of China's economic growth followed. Gone was the breakneck annual GDP growth of nearly 10% from 1979 to 2014 (Morrison, 2). Declarations of an "ecological civilization" have

led many scholars to declare a new Chinese era of “post-coal” growth. Notable authors have observed a recent peak of China’s coal use, as addressed in section 1.4(b), as well as a decoupling of coal from economic growth as seen in Figure 18. Respected economists such as the London School of Economics’ Fergus Green and Nicholas Stern have interpreted the coal peak as an assurance of a “peak in CO₂ emissions between 2020 and 2025” (Green, 19). This would not only find China meeting and exceeding the INDC Paris pledge of a 2030 peak, but also the 2°C climate target requiring China emissions to peak before 2025, “then reduce to 2.94 billion tons by 2050, representing a 70% emission reduction” (Jiang, K., 481). China’s pledges during the Paris summit remain ambitious (see Appendix C) while the environmental evolution of the FYP’s (Five Year Plans) from the 11th and 12th (see Appendix A) to the current 13th FYP covering 2016-2020 (see Appendix B) is substantial. China also remains the world’s largest producer and consumer of renewable energy, pledging in 2017 to invest 360 billion dollars in renewable energy by 2020. China has also achieved an installed capacity growth for solar and wind energy that has been staggering in the last fifteen years.

The world community’s reaction to these transformative efforts still remains measured and reticent, and for good reason. For starters, China’s achievement in the last nine years has been laudatory, but is still not enough. Much still needs to be done, particularly if China has any chance of achieving the much more preferable 1.5°C pathway. Consistently upping the ante of environmental achievements and milestones must be a year-to-year

commitment. Inertia of any kind cannot be tolerated. The 2019 ranking of global risks by the World Economic Forum places environmental threats as responsible for seven of the ten top risks facing humanity^{lxxvi}. China will continue to wield a significant influence on the world's environmental vector for decades to come. The stakes are far too high now for any backsliding by the PRC into the type of institutional shortcomings and flirtations with disaster detailed in this Capstone.

As a country responsible for the invention of both the rudder and the compass, it shouldn't be surprising that China's innovations over the course of history have set the direction for the rest of the world to follow. Without Chinese mastery of paper and papermaking, for example, how would knowledge have travelled from region to region during the Islamic Renaissance and later to the Western Renaissance through to the Enlightenment? One of the towering figures of the Enlightenment was Isaac Newton who is credited with formulating the law of inertia. The law of inertia states that *an object will remain at rest or move at a constant speed unless an outside force acts on it*. The nation of China has understood inertia and its dangers for many years. The Chinese philosopher Mozi even intuited the law of inertia around two thousand years before Newton. It is time once again for China to set a direction for others to follow and be that 'outside force' that is antithetical to inertia in all its forms. This Capstone has offered many current developments suggesting that Tanaka's "green revolution" could and should happen for China. Executing and maintaining a sustainable pathway to the year 2050 will require a fiendish level of commitment and vigilance from leadership. Lesser alternatives slip the country into scenarios far

too hair-raising to fathom. Consider China, with all of its vast complexity and protracted intensity of challenges. If a nation such as this could deliver itself from the environmental brink of no return, then surely any nation could. The author of this Capstone remains steadfast in the belief that it is not a question of 'if' but 'when'.

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VII. Appendices

Appendix A

(Table originally featured in earlier academic work by the author in 2017 (Maley, J., 14))

<p>10th Five Year Plan (2001-2005)</p> <ul style="list-style-type: none"> • "Greening" of urban areas up to 35% • Increase forest cover to 18.2% <p><i>Statistics from Sayer (182)</i></p>	<p>11th Five Year Plan (2006-2010)</p> <ul style="list-style-type: none"> • Reduce energy and water consumption by 20% and 30% respectively • Reduce discharge of total pollutants by 10% • Increase forest cover from 18.2% in 2005 to 20% in 2010 <p><i>Statistics from Cao (6)</i></p>	<p>12th Five Year Plan (2011-2015)</p> <ul style="list-style-type: none"> • Increase total energy consumption from non-fossil fuels to 11.4% • Energy consumption per unit of GDP and CO₂ per unit of GDP will decrease by 16% and 17% respectively • Decrease in CODs and SO₂ will be 8% • Decrease in Ammonia Nitrogen and Nitrous Oxides will be 10% • Increase forest cover from 20.36% in 2010 to 21.66% in 2015 <p><i>Statistics from Casey (18-19) as well as from full on-line transcript</i></p>
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Appendix B

(Table originally featured in earlier academic work by the author in 2017 (Maley, J., 16))

Table 3 Notable environmental goals within the 13th Five-Year Plan

<p><i><u>For Non-Renewables:</u></i> "National upgrades of coal-fired power units to achieve ultra-low emissions and energy efficiency"</p>	<p><i>Source: Central Committee, 86</i></p>
<p><i><u>For Renewables:</u></i> "improve supportive policies for power generation from wind, solar, and biomass energy" and "coordinate the development of hydropower with ecological conservation"</p>	<p><i>Source: Central Committee, 84</i></p>
<p><i><u>For GHG Emissions:</u></i> "bring carbon emissions in power, steel, building materials, chemical, and other major carbon-emitting industries under effective control, and promote low-carbon development"</p>	<p><i>Source: Central Committee, 137</i></p>
<p><i><u>For Air Pollution:</u></i></p>	<p><i>Source: Central Committee, 109</i></p>

<p>“better coordinate efforts to prevent and control air pollution, implement gasification projects in key areas of heavy air pollution, and ensure that the concentration of fine particulate matter is reduced by at least 25%</p>	
<p><u>For Water Pollution:</u> increase Grade III^{lxxvii} (or better) water to more than 70% while decreasing “Worse than Grade V” to less than 5% by 2020</p>	<p>Source: Central Committee, 9</p>
<p><u>For Water Use and Availability:</u> “China’s total water usage stays below 670 billion cubic meters” (CCCP, 123)</p> <p>Chapter 3’s “Major Objectives” commits to a 23% water use reduction per 10,000 Yuan of GDP</p>	<p>Source: Central Committee, 123</p> <p>Source: Central Committee, 18</p>
<p><u>For Oceans and Fisheries:</u> “strictly control the intensity of fishing and enforce a fishing prohibition period”</p>	<p>Source: Central Committee, 117</p>
<p><u>For Natural Disasters/Disturbances:</u> “improving disaster investigation, assessment, monitoring, early warning, prevention, and emergency response systems”</p>	<p>Source: Central Committee, 204</p>
<p><u>For Ecosystems:</u> Achieve by 2020:</p> <ul style="list-style-type: none"> • a 23.04% forest coverage • a 56% increase in grassland vegetation coverage • a 53.33 million hectare total area of wetlands 	<p>Source: Central Committee, 19</p> <p>Source: Central Committee, 133</p> <p>Source: Central Committee, 136</p>
<p><u>For Agriculture:</u> Achieve by 2020:</p> <ul style="list-style-type: none"> • a 70% mechanization rate for agriculture • increase “high efficiency water conserving irrigation” by 6.7 million hectares • “aiming for the completion” of 67 million hectares of “high-quality farmland” 	<p>Source: Central Committee, 57-58</p>

Appendix C

(Table originally featured in earlier academic work by the author in 2017 (Maley, J., 15))

Table 2 Overview of Significant Environmental Goals Appearing in China’s Intended Nationally Determined Contributions (INDC’s) in Advance of COP 21.

<p>1. Achieve “agricultural modernization” by achieving:</p> <ul style="list-style-type: none"> • “zero growth of fertilizer and pesticides utilization by 2020” • controlling “methane emissions from rice fields and nitrous oxide emissions from farmland” • constructing “a recyclable agriculture system” 	<p><i>Source: UNFCCC, Chapter I Enhanced Actions on Climate Change, Page 4</i></p> <p><i>Source: UNFCCC, Chapter II Policies and Measures to Implement Enhanced Actions on Climate Change, Page 9</i></p>
<p>2. “Increase the share of non-fossil fuels in primary energy consumption to around 20%”</p>	<p><i>Source: UNFCCC, Chapter I Enhanced Actions on Climate Change, Page 5</i></p>
<p>3. “Achieve the peaking of carbon dioxide emissions around 2030”</p>	<p><i>Source: UNFCCC, Chapter I Enhanced Actions on Climate Change, Page 5</i></p>
<p>4. “Increase the forest stock volume by around 4.5 billion cubic meters on the 2005 level”</p>	<p><i>Source: UNFCCC, Chapter I Enhanced Actions on Climate Change, Page 5</i></p>
<p>5. “Effectively defend against climate change risks in key areas such as agriculture, forestry, and water resources” and also “further strengthen the work on statistics of climate change”</p>	<p><i>Source: UNFCCC, Chapter I Enhanced Actions on Climate Change, Page 5</i></p> <p><i>Source: UNFCCC, Chapter II Policies and Measures to Implement Enhanced Actions on Climate Change, Page 14</i></p>
<p>6. “Enhancing Overall Climate Resilience”</p> <ul style="list-style-type: none"> • “to improve safe operation of infrastructure for water conservancy” • “to properly develop and optimize the allocation of water resources, implementing the strictest water management regulation” • “to improve the construction of water conservation facilities for farmlands” • “to strengthen R&D on technologies for water saving and desalination of sea water” 	<p><i>Source: UNFCCC, Chapter II Policies and Measures to Implement Enhanced Actions on Climate Change, Page 11</i></p> <p><i>Source: UNFCCC, Chapter II Policies and Measures to Implement Enhanced Actions on Climate Change, Page 13</i></p>
<p>7. “Strengthen the development of disaster reduction and relief management system” (UNFCC, 12).</p>	<p><i>Source: UNFCCC, Chapter II Policies and Measures to Implement Enhanced Actions on Climate Change, Page 12</i></p>

Appendix D

(Scenarios originally created by the author during previous academic work in 2011 (Maley, J., 2011, 14-20))

Scenario #1: Economic Growth at all costs

In this disaster scenario, the PRC places economic growth and GDP above everything else with a complete disregard for the environment. No attempt is made to decouple economic growth and environmental degradation, as the turning point on the environmental Kuznets curve is never reached. Earlier efforts to develop a “green GDP” within the verbiage of the communist party are forgotten as a

Deng Xiaoping-era raw growth mindset is maintained as environmental considerations are determined to be bereft of practical, monetary value.

- In the process of maintaining a coal-powered economy, great amounts of energy and resources are expended as the 90% of China's coal located in inland provinces¹³ must be shipped out to meet exponential demands in the more urbanized coastal regions. In an attempt to avoid this, some people begin to utilize more 'local' coal sources which are lower grade and less efficient.
- China's lack of renewable development and insistence on using water-hungry and inefficient processes of coal production has greatly increased desertification in China which at present is increasing at a rate of 1000 m² per year. Sandstorms attack urban areas, bringing economic activity to a standstill. The FAO has estimated that 400 million people in China are affected by desertification – this number will greatly increase with our current scenario. In northwestern locations like Ningxia, people begin to die from starvation and lack of water.
- Food supplies are imperiled by the aforementioned onslaught of desertification. China, with 20% of the world's population, but only 7% of the arable land, continues to see more farmland lost to desertification every year. Wealthier groups in urban areas try to hoard food supplies as massive migrations of people, in an attempt to escape the prospect of starvation, flee rural areas.
- China's answer to satiate growing demand for automobiles (predicted to reach 200 million by 2020) among the growing urban population is to implement a disastrous country-wide coal-to-liquid program based on current designs by Sasol Ltd. and the China Shenhua group^{lxxviii}. This process of converting coal to fuel has been shown to release twice the amount of carbon than diesel engines and would also consume huge amounts of water for cooling during the conversion process, further exacerbating China's profound water shortages¹.
- China, long identified as having "some of the most extreme water shortages in the world"^{lxxix}, wages war with India after diverting the flow of the Brahmaputra river² in a desperate attempt to secure more water. The military is stretched thin, deployed to both fight India and other potential adversaries who China has been impacting over the years with its river damming practices as well as in its own civil war at home due to desperate fights for survival among its poor population.

¹ According to Alex Farrell and Adam Brandt at the University of California, processes like this could be a "significant source of additional carbon dioxide".

² This is not a stretch of the imagination here – this river has already been a source of controversy between China and India and has been called "the biggest potential point of contention between the two Asian giants". Check out "*UPI Asia Online: China's future war with India*".

- China's war with India results in a battle with India's navy at the Strait of Malacca where China gets 4/5 of its oil to feed the demands of its 200 million cars by 2020. In the ensuing chaos, Taiwan finally declares its sovereignty, now endangering China's access to the Taiwan Strait as well.
- China's carbon intensive path augments the force of climate change beyond what scientists had anticipated as various heat waves claim the lives of record numbers of people in China. Previous estimates from 2010 of 400000 premature deaths from lung disease now seem, in retrospect, quite low as large numbers of people die from various respiratory-related ailments.
- China still continues to play a 'low-value' export role in the globalized economy, continuing its role as the world's factory – most renewable technology, once built, continues to leave the country.
- Faith in the ruling party deteriorates as party members become increasingly corrupt and ineffective. The effect of their failure to address China's environmental woes galvanizes people's resentment, particularly in the hardest hit rural parts and also fosters a more militant environmental movement in the country. The government's reaction is swift and severe, serving to only embolden rebellion and further rioting in the country. Civil war ensues, stoked by a climate of environmental desperation. Corruption still reigns as the reaction of some in the government during this meltdown is a 'pay-to-play' system rife with bribery where basic items needed to survive can be had at the right price.
- In the 'past', environmental damage exacted anywhere from 7% to 20% of GDP annually – in this scenario, the percentage has risen much higher. Further social and environmental costs therefore lead to economic collapse for China as it reverts to a third-world country.

Scenario #2: Business-as-usual

In this scenario, China is relegated only to energy technologies that exist today or in the very near future, with a few leapfrogging sparks of true innovation sprouting up here and there. China is generally able to meet its 12th environmental five-year plan (figure 36) as it almost did with its 11th year goal, with over 11% of its energy from renewable installations. In this scenario, the more renewably-minded policy-making in the last five years is maintained and commitments are met though without a radical 'green' transformation of said policies. The development strategy of China, started by the likes of Hu Jintao and Wen Jaibao has been to move away from 'at-all-costs' GDP growth to "environmental concerns and the need for social harmony"^{100x}. In short: good but not great.

- Pollution-control policies continue to be implemented to deal with the dominance of fossil fuels. Inefficient, smaller power plants continue to be shut down and are replaced by larger, more

efficient substitutes. Coal gasification technology is perfected but not as widespread as it could be to drastically reduce carbon emissions from coal-fired power plants. Various methods of carbon capture and sequestration via underground tanks are used but due to lackluster attempts in education and outreach by the Chinese government, sequestration plans encounter great public opposition due to fears of a 'Lake Nyos'-type disaster³.

- Energy efficiency is promoted strongly and continues to increase in building construction, appliances, and industry. Note, however, that in this scenario, there is a linear amount of improvement – no fundamental transformations at work.
- The domestic economy continues to grow in strength as renewable production stays more and more 'in-country'. However, fossil fuels remain the mainstream form of energy in the world, particularly coal for China, until 2030. Many baseline scenarios then see oil and coal consumptions stabilizing after 2030 with more and more reliance after 2030 on natural gas and renewables. In this baseline scenario, China meets its 12th five-year plan renewable energy goal with the lion's share of energy provided by hydroelectric (table 2), and a continually rapid growth of wind, though solar energy, one of the resources with the 'highest potential'²⁹ is not maximized.
- Nuclear power grows considerably in this scenario in an attempt to offset carbon emissions. China must continually import uranium from places like Namibia and Kazakhstan in the face of international criticism, troubled relations with export countries, and the looming prospect of peak uranium.
- Subsidies for hydrogen fuel cells, electric vehicles, and hybrids are maintained in China. China honors its promise to produce 500000 electric and hybrid cars by the end of 2011^{lxxxix}. Hydrogen cars, in particular, come to the foreground, riding a trend of popularity based on the appearance of hydrogen buses at the 2008 Olympics. They are also seen as helping to obviate several environmental concerns as well (figure 26)^{lxxxii}. Unfortunately, in the BAU scenario, China adopts a technique similar to the United States where 95% of hydrogen is obtained through the steam reformation of fossil fuels. Despite China successfully maintaining the downward trend since the 1990's (table 3) of using less and less platinum catalyst, the world supply of platinum continues to fall. As for the electric vehicles, China still uses an inordinate amount of coal for electricity production in the BAU scenario while the continued counterfeiting and overall expense of lithium-ion batteries continue to be an issue. Finally, while electric cars in the BAU scenario are certainly better than the coal-to-liquid scheme in our previous scenario, *it is still no substitute for a sustainable urban planning mechanism that fundamentally moves away from auto-centric lifestyles.*

My Impressions:

³ The 1986 Lake Nyos disaster in Cameroon was the result of a natural release of 2 million metric tons of CO₂ resulting in the death of over 1700 people due to asphyxiation.

While the first scenario is clearly a non-option, our BAU scenario will not work either. While our next ‘ideal’ scenario will detail innovations and ideas that may, in part, be challenging to implement, a strict BAU scenario such as the one that I’ve crafted here or in similarly tepid ‘baseline’ scenarios in other papers that also rely on current technology will not allow China to “achieve its economic development aspirations over the next 50 years while simultaneously meeting energy-security and local air-pollution reduction goals¹⁶”. The choice to commit to a more progressive, visionary scenario versus a BAU-model translates into a serious reduction of fossil fuels by 2030 (figure 27).

Scenario #3 – A Green Revolution!

Some of the forecasts that we analyzed previously made projections to 2050 without factoring in a radical transformation of renewable technology save improvements in efficiency and greater proliferation of current advances. Even with the progressive ‘AIS’ scenario from LBNL, we’ve discussed how total installed renewable capacity by 2050 could still fall short of what China, and by default, the rest of the world, needs. Our third scenario, however, presumes that China will use technologies that, while not commercially available in a complete form at the present, could conceivably achieve widespread use with significant drive and willpower. I would like to discuss what some of these ideas are and why China would benefit from them.

Due to full nationwide implementation of carbon capture and storage technology coupled with a revolutionary transformation of renewables, nuclear energy may not be necessary in this scenario. Other studies have seconded this motion in their own ‘advanced’ technology scenarios as well: “Little or no contribution from nuclear power is needed to achieve energy-security and air pollution reduction goals if an advanced-technology strategy is pursued¹⁶”.

The following are some ideas that I feel could potentially be used to help China achieve a ‘Green Revolution’ marked by a transformative evolution of renewable technology:

Idea #1 – Automotive biodiesel from algae

While a marked improvement over traditional gasoline engines, the possible proliferation of electric vehicles (EV’s) and hydrogen-based fuel cell and internal combustion engine vehicles (HFC’s and ICE’s) in the BAU scenario is still not without environmental costs. Our best scenario for China’s

automotive sector would not only require a radical departure from any of the current paths being proposed for China’s automotive future, but a Herculean amount of national willpower to successfully implement. That said, the conclusions that can be made by running the numbers on this idea is simply too compelling to ignore.

The National Renewable Energy Laboratory’s Aquatic Species Program^{lxxxiii} was a nearly twenty-year landmark study from 1978-1996 investigating the use of algae as a source of biofuel for America’s vehicular fleet (figure 28). The study, resulting in the comprehensive analysis of over 3000 strains of candidate algae, determined that roughly 500,000 acres of land could cultivate one ‘quad’ of algae-based biodiesel, or roughly 7.5 billion gallons. Based on this statistic, Michael Briggs at the University of New Hampshire’s biodiesel group calculated that the annual needs of America’s vehicular fleet could be met by 19 quads of biodiesel, obtainable by converting 12.5% of the Sonoran Desert’s total land area into an algae farm. These results, unsurprising when one considers the stark difference in oil yields between algae and the much more touted alternatives (table 4)^{lxxxiv}, seems to go a long way in deflating much of the criticism suggesting that biodiesel cultivation would take up far too much land. It is estimated by UNEP that by 2050, China could have anywhere from “486-662 million highway vehicles...based on business-as-usual vehicle growth”^{lxxxv}. This would translate to “12-20 million barrels of oil per day”. With 1 barrel equal to 42 gallons, this is roughly the same as 504 – 840 million gallons of oil per day. Running the numbers for an algae-based biodiesel economy, we will take the midpoint of 672 million gallons/day. Keep in mind that diesel-based engines are over 35% more efficient than gas combustion engines, so technically we would need nearly 1/3 less gallons/day, but will keep the current statistic anyway: (calculations are mine)

$672 \text{ million gallons/day} \times 365 = 245.3 \text{ billion gallons/yr}$
$1 \text{ quad} = 7.5 \text{ billion gallons of biodiesel} = 500,000 \text{ acres}$
$245.3/7.5 = 32.7 \text{ quads of biodiesel to meet China's automotive 2050 fuel needs}$
$32.7 \text{ quads} = 16,353,333.33 \text{ acres} = 25,552.08 \text{ square miles (640 acres} = 1 \text{ sq. mile)}$
$\text{Gobi Desert (500,002 sq. mi)} / 25,552.08 \text{ sq. miles}$
<i>Result: conversion of around 5% of Gobi Desert to algae farm will meet Chinese auto fuel needs in 2050.</i>

My impressions:

As a disclaimer, I am aware of how difficult it would be to logistically get a program like this off of the ground in China by 2050. However, there are so many aspects of this alternative that are attractive. Yearly costs to maintain a program like this (\$40,000 per hectare^{lxxxvi} for initial costs, operating costs of \$12,000/hectare per year) would roughly be around 79 billion dollars a year. It seems highly unlikely by

2050 that the amount that China would need to spend on oil for gasoline would be nearly as cheap as this. A homegrown algae-based biodiesel program would also keep all of China's money right at home, without having to continually rely on importation from volatile countries. Imagine, too, the possible benefit a program like this would have for the people of rural China. Algae farming could go a long way in helping to address what is promising to be an ever-increasing income and quality-of-life disparity between China's coastal cities and its rural poor. **Also, consider this: I read^{lxxxvii} about one Chinese firm that is already proposing to use microalgae as a means to absorb carbon dioxide in carbon capture-technology for coal plants – why not apply this on a large scale and kill two birds with one stone? Carbon emissions from coal plants can be absorbed and, in turn, will be used to make algae grow which can then be used to make fuel!**

...by the way, the large-scale algae farming in China that will be needed to get my biodiesel program off the ground will need a lot of sugarcane to produce the biodiesel through the process of transesterification. Normally, the waste products of sugarcane, bagasse, needs to be disposed of and is frequently burned. However, the creation of bagasse as a by-product of the biodiesel process takes me to my second idea for China:

Idea #2 – Making Charcoal Briquettes out of Sugarcane

MIT's process of creating charcoal briquettes out of the bagasse from sugarcane is a simple alternative to creating it from wood or mining it in its fossil fuel form, and is a great idea for coal-hungry China. If a biodiesel program gets off the ground, there will be no shortage of bagasse for making the briquettes. In figure 29, we see villagers in El Roblar, Nicaragua, burning sugarcane bagasse to make charcoal briquettes. In general, 3 kg of bagasse can produce 1 kilogram of coal – not bad when you consider how energy-intensive other forms of coal production are! I spoke with Ji Ping Chang, a professor at Shanghai Institute of Visual Arts who joined up with our school during our trip to China who mentioned her plans to use this process to help rural farmers in China and sent me a copy of an article detailing how it all works (link provided earlier in methodology section).

Idea #3 – Generation of power in the Gobi and Taklimakan deserts using Solar Chimneys.

One of the more fascinating presentations I encountered at the global warming conference my school sent me to was a proposal to use solar chimneys in northern Africa by a Libyan engineer named Muftah Elarbash^{lxxxviii}. A prototype for one of these devices was built in Madrid, Spain in the 1980's and the design itself is elegant in its simplicity (figure 30). Tedlar sheeting is used around a very tall chimney to trap

in the heat – since hot air rises, it seeks the only way out from underneath the sheeting – up the chimney, where the subsequent gush of wind turns a turbine at the base of the chimney. Elarbash suggested that the desert areas in northern Africa with their high retention of heat would be ideal to power a network of chimneys. This also strikes me as a wonderful idea for providing local power for increasingly desertified, off-grid regions throughout China as well.

Idea #4 – Ocean sequestration of carbon

I discussed in my previous baseline scenario the use of carbon capture and storage technology. I also mentioned how public concern over this process may arise for fear of a “Lake Nyos”-type incident in the event that storage beds underground might somehow rupture. In our ideal scenario, I have decided to include ocean sequestration processes to store carbon from coal-powered plants as a way to remedy this problem. I contacted Dr. Ian S.F. Jones (who I also saw speak at the aforementioned global warming conference) who sees it as “one of the important components in a solution to the climate change threat”. I can’t say I’m not a little wary of this process however – ocean sequestration of carbon must have an effect on the delicate balance which is our carbon cycle, while further ocean acidification would only lead to the further degradation of corals and other organisms. Dr. Jones shared with me one of his most recent, as of yet unpublished papers regarding ocean sequestration where he proposed a direct injection technique that may circumvent this problem by “placing the pH change deep and away from much of the biological activity of interest to humans” (figure 31).

Idea #5 – Hydrogen from thermo-chemical water decomposition

I expressed in the previous scenario why hydrogen fuel cell cars, which are currently gaining a lot of attention in China, may not be the best idea if China adopts our policy of obtaining the hydrogen from the steam reformation of fossil fuels. I always thought the other option is electrolysis which I’ve always would not work on a large scale. According to Marc Rosen from the University of Ontario^{lxxxix}, hydrogen can also be obtained through the thermo-chemical splitting of water. This process is possible at high temperatures of 800 to 1200 degrees Celsius - temperatures achievable in nuclear reactors and certain solar assemblies like the 100 kilowatts Hydrosol-2 plant in Spain. Through this process, Rosen feels that “for China, hydrogen is likely to be a beneficial energy carrier, as it facilitates widespread use of ‘non-fossil fuel energy options’, thereby producing a clean energy carrier”. It would also promote more solar panel construction along the lines of the Hydrosol-2 plant for the purposes of water splitting.

Idea #6 – Maglev wind turbine

This was a really compelling idea that would put to rout a lot of the criticisms made regarding low power yield from wind turbines. The maglev wind turbine design involves a vertical axis (vawt) wind turbine that uses neodymium magnets to suspend the blade assembly thereby eliminating energy loss by friction via ball bearings. With China's wind potential slated to be upwards of 1667% , various models currently being designed in China have a lot of promise (figure 32). (Disclaimer: watch out for the so-called maglev "mega-turbine" advertised on a Chinese website that will produce "1 gigawatts" and "power 750,000 homes" – this has been widely debunked as a hoax!).

VIII. Endnotes

ⁱ These reforms produced a host of significant social consequences for rural farmers as engendered by the three rural problems (*sannong wenti*) of “agriculture, countryside, and peasantry”

ⁱⁱ Table showcasing GDP agricultural growth rate from the years 1980 to 2014. *Source: Huang, J., 121*

	Pre-reform period 1970–78	Reform period						1978–2014 Average
		1979–84	1985–95	1996–00	2001–05	2006–10	2011–14	
Agri. GDP	2.7	7.1	4.0	3.4	4.3	4.5	4.1	4.6
Grain	2.8	4.7	1.7	-0.7	1.1	2.5	2.0	1.9
Cotton	-0.4	19.3	-0.3	-1.9	5.3	-0.9	-2.1	3.2
Edible oils	2.1	8.9	17.2	8.0	2.0	-2.7	9.8	8.8
Fruits	6.6	8.0	12.5	8.2	29.2	6.0	12.8	12.6
Meat	4.4	8.5	10.0	7.3	5.1	-3.1	7.7	6.6
Fishery	5	7.4	12.6	6.8	3.9	3.6	11.0	8.3
Population	1.80	1.40	1.37	0.91	0.63	0.51	0.50	1.0
Per capita GDP	3.1	7.4	8.3	7.2	9.0	10.6	7.5	8.3

ⁱⁱⁱ This is detailed on the government website for the Ministry of Ecology and Environment and can be found here:

http://english.sepa.gov.cn/Events/Special_Topics/AGM_1/1997agm/meetingdoc97/201605/t20160524_345135.shtml

^{iv} For context, McKinsey Quarterly defined the Chinese middle class as those with developing consumer habits who spend less than 50% of their income on necessities (Barton, 1). Upper middle class command salaries up to 229,000 RMB (\$34,000 a year) and “mass” middle class up to 106,000 RMB (\$16,000 a year). For comparison, the 6.5% of people in China living in poverty are defined as those making less than 60,000 RMB (\$9000 a year). The affluent generally are associated with wage earners making more than 229,000 RMB per year. (3)

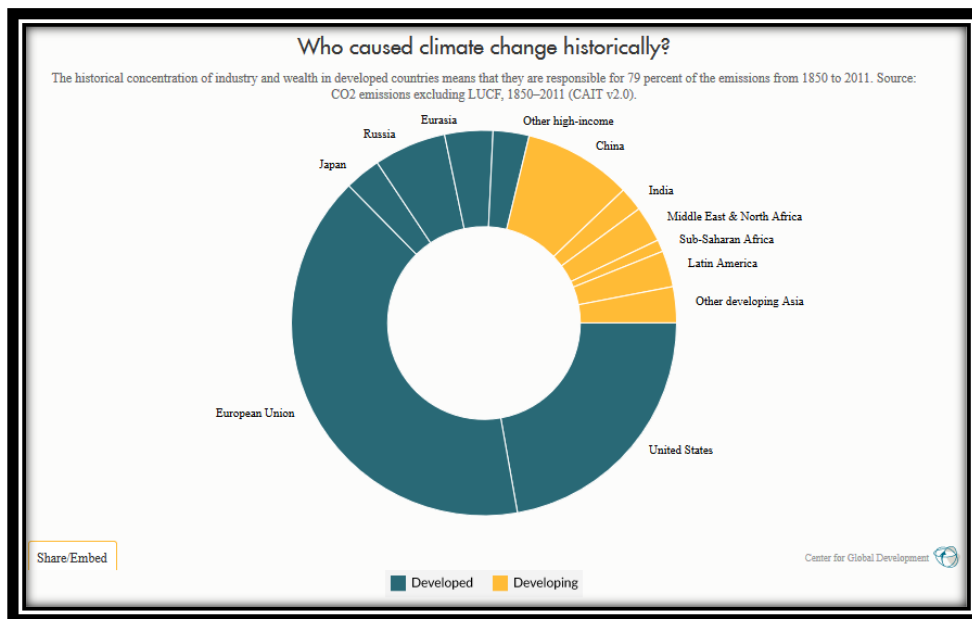
^v As seen on page 4: <https://epi.envirocenter.yale.edu/downloads/epi2018policymakerssummaryv01.pdf>

^{vi} The Environmental Performance Index (EPI) is a joint effort between the World Economic Forum and both Yale and Columbia University.

^{vii} This is mentioned on Carnegie Mellon’s website here:

https://www.cmu.edu/news/archive/2008/July/july29_chinaclimate.shtml

^{viii} The Center for Global Development is a Washington-based think tank. The pie chart created by the CGD reveals the level of responsibility from *each* of the developed nations since 1850. This can be found at <https://www.cgdev.org/media/who-caused-climate-change-historically> and is also pictured below:



Source: <https://www.cgdev.org/media/who-caused-climate-change-historically>

^{ix} Some authors go so far as to question the efficacy of the entire notion of the Environmental Kuznets Curve itself. In *The Rise and Fall of the Environmental Kuznets Curve*, David Stern suggests that “EKC results have a very flimsy statistical foundation” (1419)

^x Admittedly, Wang and Zhang’s per-sector application and interpretation of the Kuznets curve is unique as most authors invoke the Kuznets curve when considering the *totality* of a country’s environmental performance. That said, there are other examples in the literature where the environmental Kuznets curve is applied to a very particular area similar to our aforementioned authors. One example that comes to mind is David Katz’s application of the EKC to water use only. However, Katz concluded that his findings were “consistent with other EKC studies which found the curves to be poor predictors of individual national level patterns” (213). Even as far back as 1997, authors have questioned whether the so-called EKC ‘turning points’ in the curve were really the result of responses to a distinct “historical exogenous shock” as opposed to an overall trend (Moomaw, 19). In fact, the unique EKC shape may not be “universally true for all wealthy countries” (3) and that an “N-shaped curve” (4) is more accurate.

^{xi} <https://www.bbc.com/news/blogs-china-blog-34674395>

^{xii} <http://www.worldwatch.org/node/6247>

^{xiii} <https://www.chinadialogue.net/article/show/single/en/1962-Your-right-to-know-a-historic-moment>

^{xiv} <https://law.ucla.edu/faculty/faculty-profiles/alex-wang/>

^{xv} <https://www.theguardian.com/environment/2009/dec/18/copenhagen-deal>

^{xvi} <https://www.theguardian.com/environment/2009/dec/22/copenhagen-climate-change-mark-lynas>

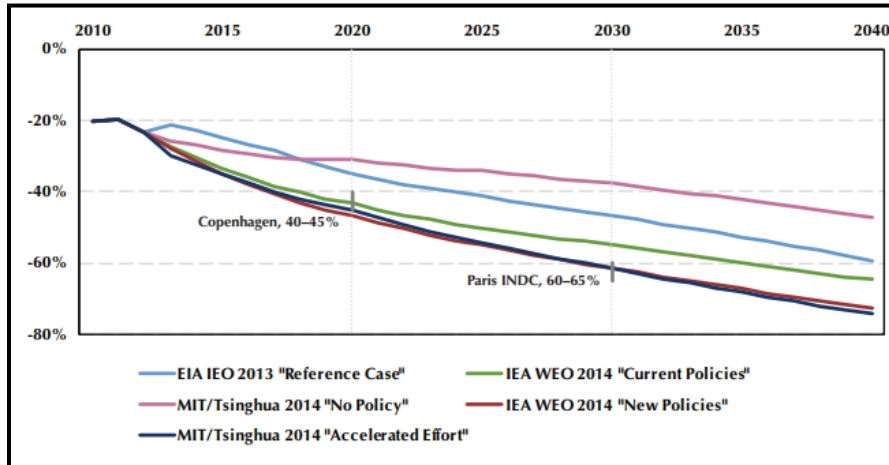
^{xvii} All 165 submissions can be found here:

<http://www4.unfccc.int/Submissions/INDC/Submission%20Pages/submissions.aspx>

^{xviii} Originally utilized in a previous independent study by the author, this figure is taken from CCES (2) and reveals how the 60-65% reduction pledge from the INDC is “significantly more ambitious than the best BAU scenario” (Maley, 2017, 29).

Modeling from the Massachusetts Institute of Technology, Tsinghua University, International Energy Agency, and the United States Energy Information Administration forecasting the lowering of carbon emissions per unit of GDP to the year 2040 relative to 2005 levels.

BAU predictions are shown in the “reference case” (blue), “current policies” (green), and “no policy” (purple). “Accelerated efforts” (dark blue) and “new policies” (red) are commensurate with the INDC pledge.



Source: Center for Climate and Energy Solutions. (2015). *China's contribution to the Paris climate agreement*

^{xix} Some of the details of this plan can be seen here:

https://ec.europa.eu/energy/sites/ener/files/documents/workplan_2017-2018_of_the_eu-china_roadmap_on_energy_cooperation.pdf

^{xx} Of course, achievement of 100% wind power requires an idealized scenario that is currently not possible and equally unlikely by 2030 due to China's many issues with wind curtailment, overproduction, and high failure rate, all of which are covered in this Capstone. For pictures of actual wind turbine failure in action, please see Figures 74 & 75. While the authors did not include the cost necessary to connect the new wind grid to the electricity network, McElroy and his colleagues came up with a figure of 900 billion dollars from the 20 year period of 2009 to 2029. This figure would achieve the 640 gigawatts of installed wind capacity that will allow China to reach this goal. McElroy is quite emphatic that this could be done, pointing out at the end of the paper that "this is a large but not unreasonable investment given the present size of the Chinese economy (annual GDP of about 26 trillion RMB)" (1380). 26 trillion RMB is about 3.75 trillion dollars – the 900 billion dollar estimate would be about 24% of this total.

^{xxi} <https://cleantechnica.com/2018/11/06/china-may-increase-its-2020-solar-target-to-200-gigawatts-or-higher/> as well as Mathews and Tan, 4

^{xxii} <https://www.thebalance.com/u-s-military-budget-components-challenges-growth-3306320>

^{xxiii} <https://www.weforum.org/agenda/2018/04/for-every-1-the-us-spent-on-clean-energy-in-2017-china-spent-3/>

^{xxiv} In one instance, the author of this Capstone was excited to hear back from Peter Gleick of the Pacific Institute and even persuaded Dr. Gleick to consider a skype session for the water scarcity course that the author worked on during an independent study.

^{xxv} Here is the full e-mail correspondence with Nobuo Tanaka:

JAMISON MALEY <jmaley@sas.upenn.edu>

May 26, 2018, 5:16 PM



to nobuo-tanaka ▾

Hello Mr. Tanaka,

My name is Jamison Maley and I am currently enrolled as a Masters of Environmental Studies student at the University of Pennsylvania. I also am a full-time high school teacher, teaching a course on environmental ethics and policy at The Haverford School for boys in Haverford, PA.

To date, three of my final research papers at Penn have addressed China's environmental policy and future. In every case, I have quoted your statement in 2010 about the need for China's carbon dioxide emissions to peak by 2020 if the world is to reach its 2050 climate goals.

I will be detailing China's environmental future once again while writing my final capstone project this summer. Many things have happened in the last eight years since your 2010 statement (e.g., China's latest Five-Year Plan, the announcement of the "new normal" economy, the aftermath of the Paris agreement, the One Belt One Road initiative, etc.). Mr. Tanaka, I would be very interested in any impressions or feedback you would be willing to give regarding China's *current path* since your initial statement eight years ago.

Thank you for taking the time to read this and for considering my request!

Sincerely,

Jamison Maley

The Haverford School

田中 伸男 <nobuo-tanaka@spf.or.jp>

May 27, 2018, 6:51 PM



to me ▾

Dear Maley San,

Thanks for quoting me for years.

I now think China will peak its CO2 emission by even 2025. Its new five year plan is ambitious.

The IEA's recent WEO 2017 said there are four upheavals or revolutions in the energy sector and one is China's green revolution. Others are US shale revolution, Solar PV revolution and Electrification. Three of four are led by China.

Cheap solar and wind with nation wide power grid connections help China to generate clean electricity for EVs and digitalization of the economy. It reduces dependency on oil and gas from the Middle East, Russia or the US. This is the geopolitical strategy and industrial competitiveness policy of China.

Sincerely,

Nobuo TANAKA

Chairman, the Sasakawa Peace Foundation (SPF)

Former Executive Director of the IEA

JAMISON MALEY <jmaley@sas.upenn.edu>

May 29, 2018, 6:07 PM



to 田中 ▾

Mr. Tanaka,

This is excellent information, thank you. It was an honor to have the opportunity to contact you.



Sincerely,

Jamison Maley

The Haverford School

^{xxvi} Grams of Coal Equivalent

^{xxvii} <https://www.nytimes.com/2018/03/12/upshot/china-pollution-environment-longer-lives.html>

^{xxviii} Paraphrasing the title of Qiang Wang's 2017 paper

^{xxix} Demand Resources Energy Analysis Model and the Long-range Energy Alternatives Planning platform,

respectively

^{xxx} https://link.springer.com/chapter/10.1007/978-94-017-8691-1_3

^{xxxi} A brief video of Jack Ma making these statements at the WEF can be seen here:

<https://www.youtube.com/watch?v=lgE87UhhC60>

^{xxxii} Performance Evaluation System

^{xxxiii} McCarthy is a self-described “political ecologist” and can be seen making interesting points here:

<https://vimeo.com/142319389>

^{xxxiv} Here is a basic framework for how the REC subsidy system works in China. This diagram was taken from the Global Environmental Institute, A Beijing-based NGO founded in 2004.



^{xxxv} Future projections of China’s renewable energy policy from established organizations like the Energy Research Institute do, in fact, account for drivers like population growth and affluence. Working in conjunction with the China National Renewable Energy Centre (CNREC), the ERI modeled China’s current “stated policy” scenario as outlined at the Paris summit as well as an improved “below 2°C” scenario to the year 2050. The report concludes that “all the criteria for the future energy system is greatly improved both in the stated policy scenario and the below 2°C scenario” (CNREC, 20). The report considers both affluence (116) as well as population. It should be noted that concerns about population growth, as it applies to China, *may* be overstated. China’s population is expected to *decrease* after 2030 and roughly be equal in number to the *current* population of 1.38 billion by 2050 (7). This population estimate for 2050 is also corroborated by the United Nations (24).

^{xxxvi} This is best explained in Maley, 2014: “The answer is best understood when one realizes that the generation of steam to turn a turbine is only *one* of the many uses of water in a coal-fired power plant: the process of cooling thermoelectric power systems, washing coal to remove trace elements like sulfur before its burned for power, transport of coal to power plants by way of a slurry pipeline, the use of water and limestone in scrubbers to remove pollutants – all of these are highly water-intensive processes” (4)

xxxvii http://europe.chinadaily.com.cn/business/2010-12/28/content_11834692.htm

xxxviii

JAMISON MALEY <jmaley@sas.upenn.edu>
to ma.jun, Ryan.mckenna ▾

Thu, Dec 6, 6:09 PM ☆ ↶ ⋮

Mr. Jun,

My name is Jamison Maley and I am currently a Masters of Environmental Studies student at the University of Pennsylvania. I am also a full time high school science teacher at the Haverford School, teaching a course on Environmental Ethics with China's environmental challenges featured as a major unit in my course.

I am currently writing my thesis on China's environmental future and have identified it at the outset as a "wicked problem" due to the highly complex interaction of factors associated with this issue. I am in the process of writing my "analysis" section and am detailing all of the social, cultural, economic, and political considerations that need to be assessed in order to arrive at realistic solutions.

I have written about China, particular regarding issues of water quantity and quality, for my final research papers for two separate classes preceding my thesis. In the process, I have learned a great deal watching videos featuring your excellent analysis and have even quoted you on more than one occasion.

Would you mind if I asked you a question, Mr. Jun? I'd be honored if you would take the time to offer a few sentences in response. I was just wondering what you believed to be the most important change that needs to be made if China is to avoid irreversible environmental fallout. In my thesis, I have pointed to a multitude of encouraging 'signs' such as the supposed 2014 coal peak, the possible growth of 'deliberative' democracy, declining numbers of technocrats in the PRC, etc., but would be curious to know your thoughts on this matter. I'd also be curious to know whether you see China's surging middle class as a net positive or negative development in terms of environmental impacts.

Thank you for taking the time to read this and for considering my request.

Sincerely,
Jamison Maley
The Haverford School

xxxix <https://www.forbes.com/sites/jeffmcmahon/2017/11/17/how-an-app-is-stopping-pollution-in-china/#504300da288c>

xl <https://www.scmp.com/news/china/policies-politics/article/2123959/app-thats-naming-and-shaming-chinas-polluters>

xli http://www.nea.gov.cn/2017-09/25/c_136636910.htm

xlii and in the trappings of Mol's "Ecological Modernization"

xliiii According to Chen, this is true for many Asian countries, including Malaysia, Indonesia, and even to some degree in Taiwan and South Korea (711)

xliv It is understandable for the reader to dismiss Chen and Lu's polling regarding Chinese attitudes towards democracy as simple distortion courtesy of the long arm of the state. Both authors (Chen at Shanghai Jiao Tong University and Lu at the China University of Political Science and Law) are on the 'inside' and so some readers may assume that the fixing or 'blue-penciling' of data has transpired to fit some government narrative. However, the aversion to western-style democracy, particularly by the rising middle classes in China, is a fairly established fact, covered extensively by sources both inside and outside the country. A Pew Research Center poll of 3,232 people in China back in 2008 found that 86% of the people polled were "content with the country's direction" (Ma, L., 7). University of Western Australia's Mark Beeson posits, "...there is no shortage of successful capitalists in 'communist' China, but they are not pushing for political liberalism. On the contrary, the most striking feature of the growing capitalist class in China is that it is perfectly happy to work closely with the CCP, as long as it is free to make money" (35). Finally, the ABS (Asian Barometer Study) is a self-described 'cross-national survey project' based in Taiwan. The ABS conducted an extensive survey of eight 'first-wave' countries including China and thirteen 'second-wave' countries including Taiwan and Indonesia. The ABS findings suggest that "East Asian citizens feel ambivalent about democracy, and that the region's new democracies have seen their popular legitimacy stay flat or even drop slightly" (Chang, Y., 71). Chang points out that there are fundamental eastern values that draw a "sharp line between East Asia and the West, and make the former less prone to embrace liberal democracy" (71). In his article for the New Republic called "The Great Democracy Meltdown", Joshua Kurlantzick also references the ABS findings and mentions that nearby Asian countries even show signs of "authoritarian nostalgia" based on China's success and the economic failures of notable democracies like Japan (3).

xlv Gilley notes that 74% of Chinese respondents in a poll conducted by Horizon Research felt that the government "should play the leading role in responding to climate change" (293)

xlvi During a school trip to China in 2009, one of my students asked our tour guide about "the events that happened twenty years ago" while we walked through Tiananmen Square. Our young guide looked

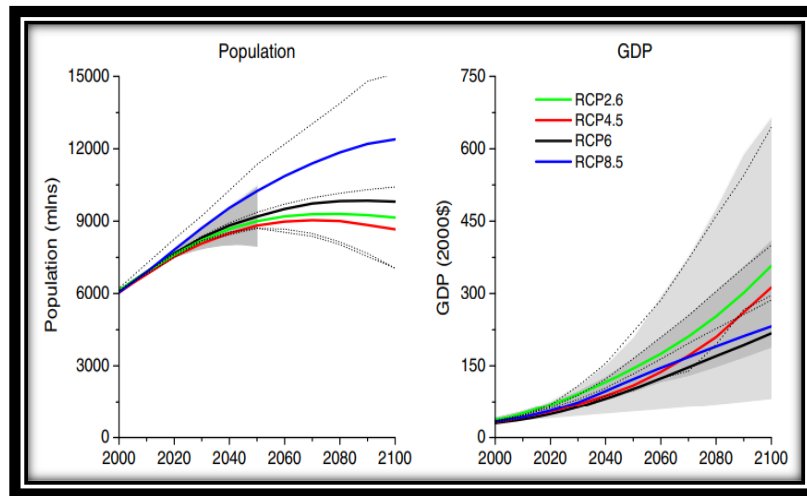
around nervously and said “I cannot answer that at this time” while in the distance an armada of surveillance cameras whirred along the tops of street lamps.

^{xlvii} Mark Beeson would disagree with this, stating that “others conclude that NGOs have become important parts of environmental management that influence the policymaking process (Tan 2014), a process that is being actively reinforced by a more environmentally aware media and a concomitant raise in public consciousness in environmental issues (Steinhardt & Wu 2016)” (40). It is worth noting that the number of ENGOs in China had already risen to 8000 by 2012 (source: https://www.wilsoncenter.org/sites/default/files/wu_haoliang_he_yi_institute.pdf & http://press-files.anu.edu.au/downloads/press/p319971/pdf/04_Fei.pdf)

^{xlviii} Engels also states that “because deep decarbonization over time must take place at local (e.g., city) levels and involves wide-ranging structural changes, the adoption of new daily practices, mobility patterns etc., there is no method of achieving this goal without massive support by the public” (5).

^{xlix} <https://www.theguardian.com/environment/2008/jun/30/pollution.olympicgames2008>

^l The connection made by Van Vuuren between the RCP scenarios and population growth (as well as GDP) can be seen here (17). Of particular interest is how the most carbon-intensive scenarios do not lend themselves to higher GDP rates as one might expect.



^{li} <https://www.scmp.com/economy/china-economy/article/3012315/us-china-trade-war-energy-deal-may-not-be-easy-win-it-appears>

^{lii} Zhang took this figure from the following World Bank report, page xiv:

<http://documents.worldbank.org/curated/en/782171468027560055/pdf/392360CHA0Cost1of1Pollution01PUBLIC1.pdf>

^{liii} As an example, Orr mentions the British system, which redistributes 7% of London and southeast England’s gross value to the rest of the country (Orr, G, 14).

^{liv} The reader is challenged to use google scholar and peruse the academic literature regarding the future of democracy. Much of it is decidedly grim. One exception appears courtesy of Garry Jacobs in the Cadmus Journal. Jacobs recognizes that democracy is under threat worldwide. However, Jacobs believes the 4th Industrial Revolution (a term introduced by a member of the World Economic Forum in 2015 referring to the growth of artificial intelligence, nanotechnology, 3-d printing, etc.) could help save democracy by creating inclusivity for all people across the globe. Jacobs is specifically referring to the phenomenon of “blockchain”. Blockchain is a global platform that could totally subvert the banking system, allow for tamper-proof voting platforms, track political funding, and much more. In short, “blockchain has the potential to usher in a whole new age of participative democracy” (Jacobs, G., 29)

^{lv} <https://www.euronews.com/2018/02/01/less-than-half-of-eu-countries-are-fully-democratic-report>

^{lvi} <https://www.bloomberg.com/opinion/articles/2018-02-09/the-eu-doesn-t-want-to-be-more-democratic>

^{lvii} <http://www.cnn.com/SPECIALS/1999/china.50/50.beyond/democracy.zhao/#bio>

^{lviii} <https://www.mcc-berlin.net/en/research/co2-budget.html>

^{lix} One source places China's emission at one-third the total volume:

<https://arstechnica.com/science/2015/11/global-carbon-emissions-slowed-for-third-straight-year-to-near-stall/>

while the Union of Concerned Scientists place China at 28% of the total:

<https://www.ucsusa.org/global-warming/science-and-impacts/science/each-countrys-share-of-co2.html>

^{lx} A review of urban geographer Laurence Ma's publications reveals a diverse coverage of topics and doesn't suggest that a preponderance of his work involves commentary on governmental ideology:

https://www.researchgate.net/scientific-contributions/2031618277_Laurence_J_C_Ma

^{lxi} Other issues related to abatement apply here as well, such as the "lag effect on carbon emissions reduction" owing to poor "governmental environmental regulatory and guiding policies" (Zhang & Peng, 26). However, this would be more appropriate for our "political" section.

^{lxii} The extrusion effect is defined by Qi-Yun Zhou in the following way: "carbon emission regulations of developed countries affect the R&D investment of enterprises in developing countries that participate in intra-product specialization. This is because the implementation of carbon emission regulations from developed countries will increase the production cost of the enterprises that participate in intra-product specialization, and erode their profits, causing the latter's investment that can be used for research and development be extruded." (669)

^{lxiii} This was covered in an article by Mandy Zuo for the South China Morning Post and can be read here:

<https://www.scmp.com/news/china/policies-politics/article/1947190/spur-innovation-beijing-offers-state-backed-researchers>

^{lxiv} http://www.xinhuanet.com/english/2018-03/13/c_137035291.htm

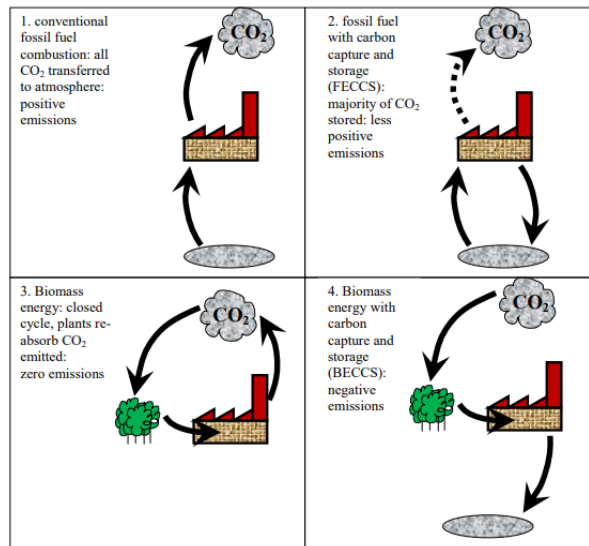
^{lxv} <http://www.chinafile.com/ngo/latest/fact-sheet-chinas-foreign-ngo-law>

^{lxvi} This form of activism has roots in the IWW (International Workers of the World) movement at the turn of the 20th century and beyond.

^{lxvii} <https://www.bloomberg.com/news/articles/2018-09-26/china-sets-out-new-clean-energy-goals-penalties-in-revised-plan>

^{lxviii} The dual page numbers are the result of ERI having two nearly identical publications of this article online. I had a hardcopy of an alternate version, but when I went online to extract some of the images, a slightly different version with different page numbers was featured.

^{lxix} BECCS (seen as #4 on the bottom right part of the diagram below) is gaining more momentum as "the accepted target of limiting the increase in post-industrial temperatures to 2°C is looking increasingly challenging" (Gough, C., 2011, 1). This rather simplistic diagram provides the standard case on the top left of coal burning and the consequent transference of CO₂ to the air. The top right features the well-known approach of carbon capture and storage, which still raises serious questions as mentioned in Maley, 2011, 16 with samples from that paper found in "idea #4" in Appendix D. The third option on the bottom left introduces biomass in the picture, but subtracts the element of carbon capture. The ultimate goal in the third case is to achieve a net zero emission based on CO₂ emitted and CO₂ absorbed by the biomass. The fourth scenario is our BECCS scenario where carbon capture and storage *and* biomass work together synergistically. In this case, the combination of both processes could achieve net negative emissions. As Gough states, "linking large scale biomass energy to CCS (BECCS) has been proposed as a potential response to abrupt climate change and a means of achieving negative emissions" (2). At issue is the fact that carbon capture and storage remains a large part of BECCS. CCS remains an expensive and generally unproven technology with the real potential of leaking into groundwater, oceans, or other sensitive areas.



Source: Image taken from Gough, C., 2010, 5

lxxx A Swedish firm whose work on BECCS can be found here: http://biorecro.com/?page=beccs_projects

lxxxi This book excerpt was taken from an online version where page numbers were not visible

lxxxii This is because “free trade is a must for small countries with a narrow resource base and peripheral location” (Andersen, T., 32).

lxxxiii In addition to what is being offset by GDP loss from fossil fuel use – recall the 6.5% GDP loss due to air pollution.

lxxxiv <https://www.un.org/sg/en/content/sg/note-correspondents/2019-06-29/press-statement-climate-change-following-the-meeting-between-the-state-councilor-and-foreign-minister-of-china-foreign-minister-of-france-and-the-united>

lxxxv These articles can be read in an English-language version seen here:

<https://www.chinadialogue.net/Environmental-Protection-Law-2014-eversion.pdf>

lxxxvi <https://www.unpri.org/news-and-press/the-global-risks-report-2019-what-does-it-tell-pri-signatories/3970.article>

lxxxvii From Han (1227):

The “Environmental Quality Standards” for water quality, assessed by the Ministry of Environmental Protection, are represented by six “grades”

Table 2. Surface water quality standard 6-class rating system.

Grade	Classification/applicable uses
I	Pristine water sources (e.g. river headwaters and protected natural catchment areas)
II	Class A water source protection areas for centralized drinking supply
III	Class B water source protection areas for drinking supply and recreation
IV	Industrial water supply and recreational water with no direct human contact
V	Limited agricultural water supply
VI	Essentially useless

Source: Ministry of Environmental Protection (2002).

Source: Han, D., Currell, M. J., & Cao, G. (2016). *Deep challenges for china's war on water pollution. Environmental Pollution*

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- ^{lxxxviii} *Sasol and Shenhua's coal-to-fuel plant wins Chinese environmental award*, Bloomberg News, March 7, 2011
- ^{lxxxix} *China's health and environment: water scarcity, water pollution, and health*, World Resources Institute, <http://www.wri.org/print/8414>
- ^{lxxx} *China in the year 2020: three political scenarios*, Cheng Li, Asia Policy, number 4 (July 2007), 17-29
- ^{lxxxix} *China views to be world's leader in electric cars*, Keith Bradsher
- ^{lxxxii} *Hydrogen-fuel cell vehicle development in China*, Lun Jingguang, GEF-UNDP-China Cooperation Project
- ^{lxxxiii} *A Look Back at the U.S. Department of Energy's Aquatic Species Program: Biodiesel from Algae*
<http://www.nrel.gov/docs/legosti/fy98/24190.pdf>
- ^{lxxxiv} <http://www.greenchipstocks.com/articles/investing-algae-biofuel/253>
- ^{lxxxv} *The Chinese Automotive Fuel Economy Policy*,
http://www.unep.org/transport/gfei/autotoool/case_studies/apacific/china/CHINA%20CASE%20STUDY.pdf
- ^{lxxxvi} *The Controlled Eutrophication Process: Using Microalgae for CO2 Utilization and Agricultural Fertilizer Recycling*,
Agricultural & Biological Engineering Dept., Clemson University, J.R. Benemann, J.C. Van Olst, M.J. Massingill,
J.C. Weissman and D.E. Brune
- ^{lxxxvii} *China recruits algae to combat climate change*, Jonathan Watts, The Guardian, June 29, 2009
- ^{lxxxviii} *Global warming: Desert Heat Collection and conversion into electricity*, Muftah Elarbash, Proceedings of the
Global Conference on Global Warming-2008 (GCGW-08), 6-10 July 2008, Istanbul, Turkey Paper No. 421 389
- ^{lxxxix} *Combating global warming via non-fossil fuel energy options*, Marc A. Rosen, Proceedings of the
Global Conference on Global Warming-2008 (GCGW-08) 6-10 July 2008, Istanbul, Turkey