Air Quality Management in the Jingjinji Region

Formalizing a Collaborative Framework

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Executive Summary

Background

Decision makers in Jingjinji must recognize that air pollution in the region is creating unacceptable health and economic costs- costing China as much as 6.5 percent of their GDP in 2012 (Crane & Mao, 2015) . The problem is multi-sectoral - land use, agriculture, industry, transportation, and energy policy all contribute to air quality problems, and all have a role in creating solutions. The region will have to collaborate on a scale previously unseen in China to make needed progress.

The Jingjinji region comprises three general areas: Beijing, Hebei, and Tianjin. In total, the Jingjinji area has approximately 111 million residents, making it one of the largest and most densely populated urban areas in the world. Air pollution has become a major problem as the region has urbanized and its industries have rapidly grown. In particular, levels of PM2.5 have increased dramatically. PM2.5 is atmospheric particulate matter pollution less than 2.5 µm in diameter. These particles can infiltrate the human lungs and create severe health issues. The World Health Organization standard for PM2.5 is an annual mean of less than 10 $\mu g/m^3$. In 2016, Beijing's PM2.5 annual mean was 46 $\mu g/m^3$, or 360 percent above the international standard for human health.

Recent surveys indicate that 41 percent of residents believe air pollution is a problem. This increased public awareness has led the Chinese government to begin creating policies addressing the air pollution issue. However, collaboration across the Jingjinji region and across various sectors is needed to address the issue. As such, our recommendations focus on a few of the key sectors: land use, industry, transportation, and energy. Collectively these are responsible for a large percentage of air pollution in the Jingjinji region. These recommendations focus on policies, technologies, and collaborative governance to reduce air pollution levels.

Land Use

The utilization of land across the Jingjinji region varies greatly. Beijing is a highly concentrated population of 23 million people. However, the Jingjinji area also encompasses large swaths of suburban and rural areas. Therefore, we have tailored recommendations to each of these three spaces, as they face different challenges. We identified two major urban contributors to air pollution: the waste management process and the lack of air cleaning vegetation in the center city. The suburban areas face the challenge of underdevelopment due to the clustering of low income residents. In rural areas, the agriculture industry contributes to secondary PM 2.5 emissions as ammonia is released from fertilizer. Our recommendations to address these concerns in the JIngjinji region are:

Implement an in-home recycling system in youth communities. Emissions in waste transportation and garbage incineration contribute to urban air pollution. We recommend that a pilot recycling program be implemented in youth communities. This recycling program will ask residents to separate trash into five categories: plastic, paper, glass, compost, and general garbage. These living spaces consist of young professionals working at the top companies in Beijing. We predict this population will already have more knowledge about environmental protection and social responsibility than other communities.

Start green building projects on university campuses. Similar to the Singapore model, plant life would help reduce carbon dioxide in the air. This program would be piloted at Tsinghua University, as it would allow students to have hands-on environmental learning experience. Positive air quality effects would be increased by having many green buildings in a small area, which would be possible on a university campus.

Decrease loan interest rates for homes purchased in suburban areas. We recommend a decrease in the interest rates on housing loans for people who use their housing fund to purchase a residence in suburban areas. This new interest rate will incentivize people to buy homes outside of the city center. We predict this recommendation will attract families and individuals of different income levels, thereby diversifying the socioeconomic breakdown of suburban areas.

Upgrade air pollution monitoring systems to measure ammonia levels. There is currently no measurement of ammonia emissions. This system will augment the enforcement of current laws in the agricultural area surrounding aerosol emissions.

Promote more efficient farming practices for agriculture biomass burning and nitrogen rich fertilizer use in Hebei Province. Biomass burning currently contributes to 5.6 percent of secondary PM2.5 levels. We recommend working with the China Agriculture University to improve farming systems and reduce biomass burning in the agriculture community.

Industry

Industry areas within the Jingjinji region employ a substantial number of people, mainly in manufacturing. Due to their large scale, these industries contribute heavily to air pollution throughout the area. Beijing has passed and enforced strict regulations concerning emissions from these industries, which lead to many manufacturing plants moving to the surrounding areas, which still contribute to pollution in Beijing and the full Jingjinji region. In order to address this concern, the recommendation is split into two sections: industry and government.

Restructure and update industry. Industry needs to transition from manufacturing to a service focus. This can be done by merging or eliminating heavy polluting industry. In order to enforce these enhanced rules, a supervision department should be created to oversee the alignment of environmental initiatives at the regional level. This overarching industrial governing board would ensure compliance with the new regulations. We recommend the implementation of a “Green Industry District”. This area should house eco-friendly industries all in one location. This district could serve as an example to other cities and encourage them to integrate sustainability into their buildings.

Align regional governmental collaboration in economy and environmental incentives. The government should increase the power of a regional agency to enforce and standardize local emission standards as well as enhance regional cooperation. The entire region should adopt Beijing's model of relocation compensation and transfer fee system. This system entails industries being able to sell their original land and move to another province. A downside of this policy is that industries leaving Jingjinji will cause jobs to be eliminated. In order to mitigate this situation, the government should implement a job retraining program.

Transportation

Transportation within the Jingjinji area has poor connectivity which leads to increased emissions. The inefficiency of commercial, public, and individual transportation leads to heavy traffic and greater air pollution. These problems occur within Beijing, between the city and surrounding areas, and in connecting suburban and rural areas. Additionally, although the Beijing lottery system encourages electric vehicles, the city has a poor system of charging stations. Our recommendations center around increasing efficiency and effectiveness in transportation systems. These recommendations are:

Develop multi-modal connectivity to the suburbs for Hebei and Tianjin. This transit system would allow for better connectivity between suburban centers within the Jingjinji region. To maximize the positive effect of this recommendation, the region needs to continue to utilize transit oriented development.

Deploy better transportation demand management strategies. In order to better manage transportation demand, we recommend implementing high occupancy vehicle (HOV) lanes. These lanes encourage carpooling and reduce traffic. Additionally, we recommend adding extra fees on roads during rush hours. This added fee will disincentivize people from taking crowded roads and alleviate traffic during peak times. We recommend the implementation of parking fees based on demand. These fees would help manage peak times of parking congestion by encouraging the use of other forms of transportation.

Improve efficiency and coordination of the freight network. The inefficiency of freight vehicles contributes to many of the emissions causing air pollution. Improving the network would entail the use of low emissions rail transportation as an alternative. This rail network would mitigate both the traffic and the emissions caused by these vehicles.

Expand electrical vehicle use through more convenient charging stations. Beijing lacks adequate and unified charging stations for electric vehicles. We recommend an increase in stations and a unifying plan for charging throughout the city to accommodate electric car users.

Energy

China's energy sector is primarily dependent upon fossil fuels, and the same is true of the Jingjinji region. The primary energy sources are coal and petroleum, both of which are heavy contributors to air pollution.

For the first time China's thirteenth five-year plan set a target cap on the energy consumption of coal. However, even with the coal cap target of 58 percent by 2020, coal will remain a major energy source. Furthermore, even though China appears to have excess capacity of electricity generation, it continues to make investments in new coal plants. Much of the inefficiency in energy planning can be tied to the lack of regional or country-wide coordinated planning and concern over job loss. Our recommendations concerning China's energy sector are to:

Increase collaboration - Regional Energy Certificates and Regional Transmission Organization. This recommendation includes replacing China's grid regions with electricity planning organizations. The United States currently has a similar regional planning model, which provides for regional operations. In addition, the development of a renewable energy trading market would provide an economic incentive to areas capable of developing renewable resources. The regional planning organizations would be the support structure for implementing this renewable market.

Invest in research and development focused on battery storage and nuclear energy. Large-scale battery storage remains a new technology, which is being pursued aggressively by companies like Tesla. The development of large scale battery storage would increase the impact of solar and wind resources by allowing energy to be stored and distributed. This system eliminates the problem of wasted excess capacity. In addition, although nuclear energy has not been utilized on a large scale in China, this is an option capable of providing large amounts of clean energy. If the issues surrounding the cost and design of nuclear generation could be overcome, nuclear energy could be utilized as a replacement for large fossil fuel generation units and the Jingjinji area could be a leader in this type of technology.

Phase out coal plants in Hebei and replace with renewable energy. The accelerated closure of coal plants in the Hebei province would alleviate one of the main air pollution sources from energy production. The closure of coal plants could be paired with increased investment in high-voltage electricity transmission. By expanding the transmission network, Hebei would become more connected with other regions with excess supply. Therefore, Hebei would be able to consume clean energy from surrounding areas, such as Inner Mongolia, as well as benefit from developing capacity to sell clean energy.

Environmental Governance

With the increased focus on air pollution in China, regulations on a national and regional level have been enhanced, including in the Jingjinji region. Despite these efforts, the area will likely not meet its pollution reduction goals for 2017, largely because it has lacked actual mechanisms for coordination. We suggest ways to promote more collaborative environmental governance of the Jingjinji region. Our recommendations are to:

Create an independent regulator for the Jingjinji region. A regulatory body should be modeled after the California Air Resources Board. This would consist of a representative board created from various industries, including both political and non-political members. The board would be given broad powers to cite violations of environmental standards and create needed changes to existing regulations.

Develop a regional air quality grant fund. This grant pool would be funded through taxes, tradable permits or air pollution penalties from all localities in the Jingjinji region. The fund can work in two different ways. It can be used as a reward for local governments actively involved in air quality management. Or the fund can also be used to serve underdeveloped areas where technological upgrades and educational training programs are needed.

Promote open data and government transparency. The Chinese government has not generally followed the open government doctrine of allowing citizens access to documents and proceedings. While the government is becoming more transparent, continued measures need to be implemented to improve public access to information. We recommend the dissemination of more data and information concerning air pollution which will allow for better public understanding as well as increased intersectoral and interdepartmental collaboration. This open data platform could be produced by the government, or with assistance from a third-party.

Build a Jingjinji Regional Air Quality Scenario Planning Tool. The development of a scenario planning tool would allow the impact of air pollution policies to be modeled on a regional and inter sectoral basis. Such a model would allow the user to see air pollution impacts over time based upon different regulation approaches, ultimately allowing for more informed policy decisions.

Conclusion

The Jingjinji region has the opportunity to implement innovative solutions in air quality management. The recommendations in this report provide both short term, easily implementable, suggestions as well as long- term structural change proposals to ameliorate air pollution and improve quality of life within the region. These recommendations, when collectively implemented, can make the Jingjinji region a model of collaboration for air quality management worldwide.

背景介绍

京津冀地区的空气污染严重影响到居民健康，并造成经济成本的增加——人均寿命减少18.5岁，经济损失占GDP的6.5 percent。该地区空气问题源于多个领域——农业、区域土地利用模式、能源政策、交通政策、基础设施投资等。由于这是一个跨领域的问题，京津冀地区需要开展前所未有的大规模合作才能获得进步，然而该地区现有的合作方法却缺少平行合作组织规划框架。因此，我们建议中国采取跨部门、跨层次的政府合作管理创新模式，结合我们所提出的具体政策建议，帮助京津冀地区发展成为世界范围内空气质量管理的领头羊。

京津冀地区包括北京市，天津市和河北省，总人口达到1.11亿，是世界上面积最大，人口最密集的区域。由于京津冀地区城市化的迅猛发展和工业产业的加速化集中，空气污染成为该区域最严重的问题。PM2.5是大气中污染直径小于2.5μm的颗粒物，这些粒子可以直接进入到人体肺部，直接影响居民的身体健康。世界卫生组织的PM2.5标准是年平均量不到10μg / m ^ 3，然而中国2016年的的PM2.5年平均量却是46μg / m ^，是人体可接受范围的4倍以上。因此，该问题得到了多方的高度重视。

近年来，中国政府已经建立了PM2.5数据收集、监测体系。随着数据的透明度提高、社会名人的参与度增加以及污染监测技术的进步，中国居民对空气质量的认识和关注有了明显的提高。近期调查表明，41 percent的居民认为空气污染问题严重，中国政府也设立了相应的治理目标及策略，然而，京津冀地区各行业间的合作却仍然滞后。因此，我们根据空气污染物排放的关键领域，从五个方面提出相关建议，重点关注政策、技术与部门协作，旨在更加有效地降低空气污染水平。这五个方面包括：土地使用、工业、交通、能源和环境治理。

土地使用

京津冀地区在土地规划与利用方面面临很多挑战。北京市总人口2300万，是一个人口高度集中的区域，而河北省却涵盖城市、郊区和农村等不同层次的土地利用类型。由于不同区域面临的问题和挑战不同，我们分别为这三个地区提出了不同的政策建议。我们认为城市存在的主要问题是冗长的废物回收过程和城市中心空气净化植被的缺乏。郊区的主要问题是较低的人均收入和整体发展水平，主要表现为低收入人群的聚集导致经济发展水平缺乏多样性。农村的主要问题则是缺少对重要污染源-氨的监测。我们基于上述问题提出以下建议。

开展一个“始于家庭”的回收利用项目。废物管理运输过程中的排放和垃圾焚烧严重影响了城市的空气质量，因此我们建议在新型青年社区开展一个试点回收计划。生活在这个社区的青年人大多就职于附近的高端大型企业，所以我们预测，这部分人群相较于其它人群，拥有更强的环境保护意识和社会责任感。始于家庭的垃圾回收计划要求居民将垃圾主要分为以下五大类：塑料、纸张、混合物、和普通垃圾。

将农业和植物集中培育在大学校园的建筑物屋顶上。植物将有助于降低空气中的二氧化碳含量。基于新加坡模型，我们建议在清华大学开展试点项目。该项目不仅能够让学生亲身投入环境保护事业，培养社会责任感，还能够将绿色建筑集中于校园区域，增加社会影响力。

提升郊区人口经济背景多样化。我们的建议是大幅度降低在郊区购房的公积金贷款利率，从而提高郊区住房的购置率，增加该地区人口背景的多样性，最终在一定程度上缓解北京的住房拥堵现象。

建立更全面的农业污染物排放监测系统，推行更高效的农业技术。中国目前的农业缺乏对重要农业污染源，即化学元素氨的监测系统及法律监管措施。我们建议在中国农业大学位于河北省的农业实验基地建立培训试点、预估氨排放量，并进行有关生物质研发的相关研究。

工业

京津冀地区的工业，尤其是制造业解决了许多人的就业问题。但同时，工业对京津冀地区的空气严重污染问题也负有主要责任。北京已经通过并实施了严格的行业污染排放规定。这使得很多加工厂计划迁移到周边地区，但由于工业并未完全从该区域中转移，空气中的污染物始终围绕在包括北京在内的京津冀地区。为了解决这个问题，我们的建议分为两部分：工业和政府。

加快产业结构调整和产业升级。京津冀地的产业需要从工业向服务业转型，此转型升级可以通过企业合并重组与污染企业关停两种手段来达成。为了更好的实施升级转型，需要一个区域性的监管部门来确保达成区域间在环境方面的共识与合作，以及确保新规实施的有效性。此外，我们还建议实行一个名为"绿色工业区"的试点项目。将许多的绿色产业都集中在这里，旨在为其他城市树立一个范例，鼓励他们将可持续发展融入城市建设中。

结合政府经济构架和环境激励措施。为了实现这一目标，政府将加强区域机构的权力以严格执行当地的排放标准。整个地区可以采用北京的搬迁补偿和转移费制度的模式，工厂能够出售他们原来的土地，并以此资金搬迁到另一个区域。为了缓解因为企业转移到京津冀以外地区而造成的就业机会损失，政府需推行由政府资助并主导的再就业计划。

交通运输

由于京津冀地区的交通连通性差，商业，公共和个人运输的低效率导致了该区域的污染气体的高排放量。这些问题不仅发生在北京，城市周边以及农村地区也存在着同样的问题。此外，虽然北京鼓励居民使用电动汽车，但该市的充电桩数量也相对较少。我们希望提高交通运输系统的整体效率，我们的建议分别是：

建立郊区、河北和天津之间的综合联运连接。这个交通系统会更好地连接京津冀郊区的中心区域。为了让这个系统更好的发挥作用，京津冀地区需要延续以交通为中心的可持续发展。

在北京的城市中心部署更完善的交通管理战略。为了完成这一挑战，我们建议采用高承载车辆（HOV）车道。HOV车道不仅鼓励拼车出行，同时也减少了交通拥挤。此外，我们建议在高峰时期，增收道路费用。额外的费用会使一些人在高峰时段绕行或避免出行。我们提议根据需求或时段征收停车管理费用，以达到缓解交通和鼓励其他出行方式的目的。

提高货运网络的协调与效率。低效的车辆使用会大量地产生空气污染物。改进运输网络后，低排放的铁路运输将会取代卡车货运。如此可以在很大程度上减轻交通压力，同时减少排放量。

增加电动汽车充电站的数量以鼓励电动车的使用。北京缺乏足够的电动汽车充电站。所以我们建议增加一些统一的城市充电站来满足充电汽车的需求。

能源

中国能源主要是来自于化石燃料，京津冀地区也是如此。主要能源是煤和石油,这些都是空气污染的主要源头。在“十三五”规划中，中国首次设定了关于碳消耗的目标。目标规定在2020年前要达到炭消耗在中国总能源产量中占比小于58 percent。但即便是这样的目标，在2020年前，煤炭仍然会成为中国能源的最主要来源。此外，中国似乎已经出现了电力产能过剩的情况。而在这个领域，可再生能源和新煤电厂的投资仍在继续。很多低效的电力计划缺乏地区或全国性的协调规划。我们关于中国能源领域的建议是：

增加中国的电力部门间合作。本条建议包括区域内电力规划组织的发展。 美国正在使用相类似的模型，能够支持区域协调规划和操作。此外，中国可再生能源交易市场的发展将为有能力开发可再生资源的地区带来经济刺激。区域规划组织也将成为可再生能源市场的支撑构架。

关注和发展电池存储和核能的研究。大规模电池存储仍是一个新技术，而这种技术主要被像特斯拉这样有先锋意识的公司购买。大型电池存储主要作为太阳能和风能资源发展的辅助，这样可以实现电力在非高峰时段被存储。此外，核能可以提供大量的清洁能源，但因为各种各样的原因没有在中国被大规模的运用。然而，如果关于成本和设计的问题能够被克服，核能就可以作为化石燃料的替代。京津冀地区有机会成为这一能源领域的先锋。

一个更有效的煤炭厂淘汰机制，并以新能源替代。河北省煤炭厂的加速关闭可以缓解由于电力生产所造成的空气污染。中国产能过剩的情况可能是由于对高压电传输和供应明显过剩区域的投资增加造成的。随着传输网络的不断扩大，河北将会出现由于和其它区域的高强连接而产生供应过剩的问题。所以，河北会更加倚重于相邻地区的新能源，并鼓励加快煤炭工厂的关闭。此外，对于在河北的能源投资，如核能、天然气和发电技术，也可加速对煤炭厂的替换。

环境治理

随着人们对空气污染关注度的不断提高，国家和地区层面也颁布了相关的法律法规，例如国家十大措施以及京津冀及周边地区的空气污染行动计划实施细则，这些法规制定了京津冀地区以及整个中国的空气污染标准。根据这些标准，京津冀地区已经做出相应的行动，例如关闭或搬迁高污染厂。然而，京津冀地区仍旧缺乏实际且有效的协调机制。因此我们建议：

在京津冀地区设立独立的监管机构。该监管机构可参照加州的空气资源委员会机制，邀请各行业代表、政治及非政治成员参与其中，他们有权制定环境标准，并根据实际需要进行现行法规的修改。

创建共同基金以改善区域环境质量。该基金会的资金主要来源于京津冀地区的税收、排污权交易和空气污染处罚所得。这个基金将被单独用于京津冀地区的空气质量提升计划。空气质量改善基金可以作为对在减少空气污染有活跃表现的地区的奖励。该基金也可以用于对欠发达地区所需的技术升级和培训项目的补助。

促进政府数据透明度和各部门间的公开合作。中国政府一般情况下不会遵循开放政府信息的原则，也不允许公民查阅政府文件和政策制定的章程。虽然现在政府已经开始逐渐透明化，但一系列的措施仍然需要不断完善以帮助公众更快，更便利地获取官方信息。所以我们建议更多有关于空气污染的数据和报告被公开和传播，这一举措有助于公众更好的了解环境污染的即时信息和政府发布的公共政策，同时也有助于专业的分析。这种开放数据的平台可以由政府或第三方机构协助完成。

建立京津冀区域空气污染的模拟场景模型。模拟情景主要是将有关于空气污染政策对一个区域所带来的影响放入到模型中。这样一个模型有助于公众更好地了解到随着政策的推进，空气污染在时间维度上发生的变化。这个函数跟其他行业的类似模型工具一样，但需要多部门间的协助和共同参与，并且要求着重于京津冀地区。

总结

京津冀地区是一个有潜力实施空气污染管理创新解决方案的地方，我们所推荐的跨部门合作方案也可以为其他城市提供参考。前文所述建议不仅包含短期的快速解决方案，还罗列了长远的方案实施目标，能够在一定程度上缓解京津冀地区的空气污染并提高人民的生活质量，从而促进京津冀地区污染治理水平的提升。

I. Introduction

In 2014, China's President Xi Jinping announced a strategic plan for the collaborative development of the Jingjinji region. Jingjinji encompasses Hebei, the municipality of Beijing, the international port Tianjin, and other major prefectural cities such as Baoding, Shijiazhuang, and Tangshan. The area's permanent population grew from 94 million in 2005 to more than 111 million in 2015 (National Bureau of Statistics, 2016). The Jingjinji plan seeks to connect this rapidly growing region through coordinated economic development and planning, with an emphasis on also managing the area's air pollution problems (Zhang et al., 2016).

In 2013, the State Council published the Jingjinji and Surrounding Area Air Pollution Action Plan Enforcement Regulation which mandated that Beijing, Tianjin, and Hebei reduce their PM 2.5 concentration by 25 percent of the 2012 levels by the end of 2017 (State Council, 2013). This plan also set specific goals and standards for the reduction of coal consumption and carbon dioxide emissions (State Council, 2013). With limited data access, it is unclear exactly how close the region will be to reaching its goal, but predictions by the Clean Air Alliance of China (CAAC) and Tsinghua University indicate that the region will not collectively succeed (CAAC & Tsinghua University, 2014).

According to the CAAC and Tsinghua report (2014), the 2013 average concentration level of PM 2.5 was 88.3 $\mu g/m^3$ for Beijing, 112.7$\mu g/m^3$ for Tianjin, and 112.9$\mu g/m^3$ for Hebei. Even if the Jingjinji region successfully executed all current air quality regulations, the corresponding PM 2.5 average concentration predictions for the end of 2017 are 65.8$\mu g/m^3$, 91.6$\mu g/m^3$, and 96.3$\mu g/m^3$. Thus, in the best case scenario, the reduction percentages would be 25.6 percent for Beijing, 18.7 percent for Tianjin, and 14.7 percent for Hebei (See Figure 1). This indicates that only Beijing will meet the regional reduction goal. While the current regulations have decreased the concentration levels of PM 2.5, they fail to meet the intended reduction objective. To meet future goals, the Jingjinji region must find more effective ways to better manage its air quality beyond Beijing.

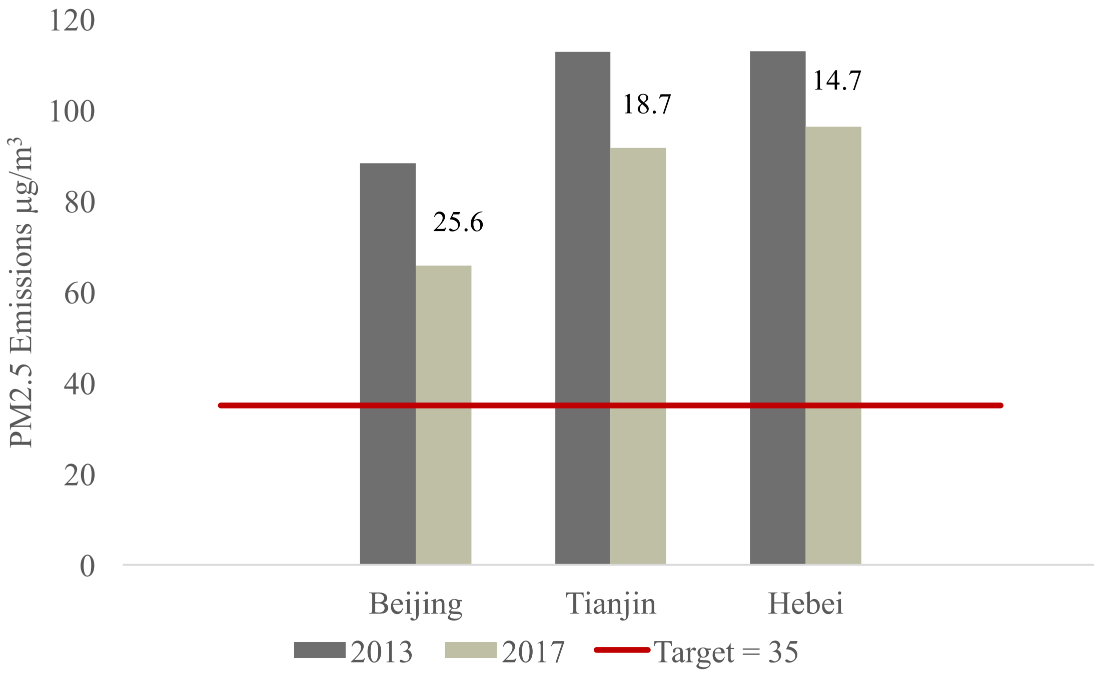

FIGURE 1 ACTUAL 2013 AND PROJECTED 2017 $PM_{2.5}$ EMISSIONS COMPARED TO JINGJINJI PLAN TARGETS; (CAAC & TSINGHUA UNIVERSITY, 2014)

The problem is multi-sectoral - land use, agriculture, industry, transportation, and energy policy all contribute to air quality problems, and all have a role in creating solutions. Decision makers must recognize that air pollution in the Jingjinji region is creating unacceptable health and economic costs, costing China as much as 6.5 percent of their GDP in 2012 (Crane & Mao, 2015). The region will have to collaborate on a scale previously unseen in China to make needed progress. The current Jingjinji approach is still dominated by a planning framework that lacks lateral collaboration. We recommend that the Chinese government consider several governance innovations to increase collaboration across municipalities and provinces, as well as sectors, ministries and governmental levels. We also make several specific policy recommendations that, when collectively implemented, can make the Jingjinji region a centerpiece of air quality management worldwide.

China: South-to-North Water Diversion Project

The South-to- North Water Diversion Projects works to transfer water from The Yangtze river to the north part of China that lacks significant water resources (WRA, 2003). This project was formulated in 1979 and was finally reviewed by the State Council in 2002. It now encompasses a total of 4,350 kilometers of construction divided into three parts based on the different river parts and terrain (WRA, 2003). This dynamic project affects the lives of 438 million people in 7 provinces (WRA,2003). At the time of this report, the middle and east part have been completed (WRA, 2003).

The south-to-north water transfer project construction committee is led by the State Council Vice Premier, Gaoli Zhang (State Council, 2013). This committee also includes members from 20 bureaus and 8 mayors of the affected provinces and cities (State Council, 2013). Water transfer companies in different provinces or cities take responsibility for construction in each province (WRA, 2003). The construction committee coordinates the work of these companies (WRA, 2003).

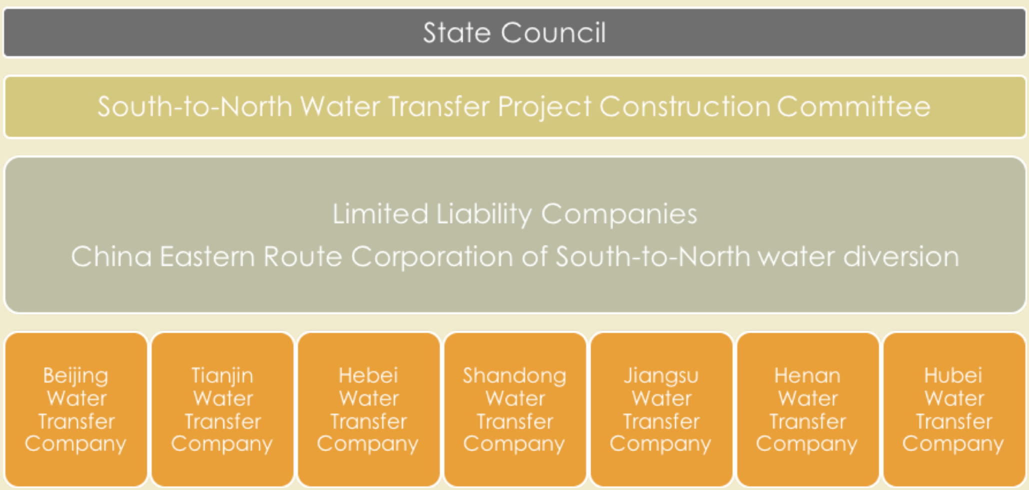

FIGURE 2 RESEARCH PROFILE OF THE SOUTH-NORTH WATER DIVERSION PROJECT CONSTRUCTION AND MANAGEMENT SYSTEM; (WATER RESOURCE ADMINISTRATION, 2003)

The government provided significant funding for the regional companies (WRA, 2003). They also centrally controlled the configuration of water rights and water dispatching based on the regional and seasonal needs (WRA, 2003). As of 2017, 7.66 billion cubic meters of water has been transferred due to this "assembly line" project coordination (Chen, 2017).

II. Background

A. Health Impacts

In China, air pollution contributes to premature death and a variety of health conditions, all of which lead to immense costs for individuals and Chinese society as a whole.

1. Morbidity from Air Pollution

Berkeley researchers estimate that each year in China air pollution contributes to around 1.6 million deaths, about 17 percent of total deaths (Rohde & Muller, 2015). In 2004 researchers found that 45 children per 100,000 under the age of 5 experienced decreased disability adjusted life years (DALYs) due to air pollution (WHO, n.d). These alarming statistics demonstrate that general pollution exposure is detrimental and prevalent in China, but researchers have begun to focus on the particularly negative effects of PM 2.5. In 2013, more than 30,000 people died from premature PM 2.5-related deaths in each of the following cities: Beijing, Baoding, Shijiazhuang, Tianjin, and Handan contributing to more than 150,000 deaths in total (Fang et al., 2016). Figure 2 shows PM 2.5 attributable deaths rose from 2010 to 2015, continuing to be above 1990 premature death rates (Jin et al., 2013).

For many years, researchers have been able to link specific pollutants to resulting health conditions, which vary based on duration of exposure to the pollutant. Table 1 below presents some of the most common health effects, along with their resulting direct health costs.

TABLE 1 COMMON SHORT AND LONG TERM HEALTH IMPACTS OF AIR POLLUTION

	Condition/Disease	*Pollutant*	*Health Costs*
Short Term	Asthma, airway inflammation	$PM_{2.5}$	2005-2007 in California: Asthma admissions accounts for over 410,774,000 RMB of hospital charges. (1 USD = 7.93 RMB average exchange rate between 2005-2007)
Short Term	Acute Bronchitis, a lower respiratory tract inflammation affecting the air tubes of the lungs	NO_2	2005-2007 in California: Acute bronchitis, pneumonia or COPD admission accounted for 1,792,180,000 RMB of hospital charges. (1 USD = 7.93 RMB average exchange rate between 2005-2007)
Long Term	Central nervous system (CNS) disease. Stroke, Alzheimer's and Parkinson's diseases	$PM_{2.5}$	The yearly average monetary cost per person attributable to AD was 108,300RMB. The cost of per AD patient was 107,700RMB for outpatient treatment, 127,900RMB for hospitalized treatment and 75,400 RMB for without treatment.

	Lung Cancer, abnormal and uncontrollable cell growth of lung tissues. Chest pains and blood in cough	$PM_{2.5}$ or smaller sized pollutants	The health expenditure calculated in a study of 195 lung cancer patients in China totaled 144,999.014 RMB per patient in 2014.

2. Productivity Loss of Workers

The societal costs of pollution extend to the workplace as increased levels of pollutants actually decrease workers' productivity (Chang, Zivin, Gross, & Neidell, 2016). Indoor professionals are affected as well as outdoor manual laborers (Chang et al., 2016). One recent study looked at a call center in China's largest travel agency, where a 10-unit increase in the air pollution index (API) decreased the number of daily calls handled by a worker by a statistically significant average of 0.35 percent (Chang et al., 2016). The study shows that productivity generally declines linearly with pollution levels. This pattern seems to be evident in other major cities throughout the world (Chang et al., 2016).

3. World Health Organization Air Pollutant Standards

In order to provide nations around the world with guidance on limiting these serious health effects of pollution, the World Health Organization (WHO) has set suggested limits for various pollutants. The World Health Organization has listed the following guidelines for air pollution (WHO, 2006):

TABLE 2 WORLD HEALTH ORGANIZATION AIR POLLUTION GUIDELINES; (WORLD HEALTH ORGANIZATION, 2005)

Pollutant	*Annual Mean*	*Hourly Mean*
$PM_{2.5}$	10 μg/m^3	25 μg/m^3 for 24- hour mean
O_3		100 μg/m^2 for 8-hour mean
NO_2	40 μg/m^3	200 μg/m^3 for 1-hour mean
SO_2		20 μg/m^3 for 24-hour mean

Beijing's population-weighted estimated average exposure to PM 2.5 was 46 μg/m^3 (Rohde & Muller, 2015). Based on the WHO's standards for annual mean of particulate matter, in 2014 Beijing's air quality is over 360 percent the recommended annual mean of PM 2.5 (

Table 3).

TABLE 3 WORLD HEALTH ORGANIZATION'S INTERIM TARGETS AND AIR QUALITY GUIDELINES: ANNUAL MEAN CONCENTRATIONS; (WORLD HEALTH ORGANIZATION, 2005)

Annual mean target concentrations	*PM_{10} (μg/m3)*	*$PM_{2.5}$ (μg/m3)*	*Reason for selected level*
Interim Target 1 (IT-1)	70	35	These levels are associated with a 15 percent higher long-term mortality risk relative to the AQG level
Interim Target 2 (IT-2)	50	25	These levels lower the risk of premature mortality by approximately 6 percent relative to the IT-1 level
Interim Target 3 (IT-3)	30	15	These levels reduce the mortality risk by approximately 6 percent relative to the IT-2 level
Air Quality Guideline (AQG)	**20**	**10**	These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase in response to long-term exposure to $PM_{2.5}$

B. Awareness of Air Quality Issues

Growing public concern surrounding air quality is pushing China's leaders to address and manage air quality, particularly in the Jingjinji region.

Before 2012, China's general public had little awareness of the specific pollutant PM2.5, the main contributor to poor air quality. The autumn and winter of 2011 served as a catalyst when Beijing suffered from severe smog. Conversely, the official air quality data remained fair, causing the public to notice this discrepancy (Wong, 2011). The city's residents started to question the accuracy of measurement of air quality from China's government and pressured the central government to address the issue (Zhao & Guan, 2013). Public discussion started to specifically include the harmful impacts of PM2.5 on the human body (YIWUYISHI, 2014). As a result, in 2012, the State Council required the inclusion of PM2.5 into its air quality index (Wang, 2012).

1. Social Media Moments Attract Public Attention

Social media assisted in bringing these air quality issues to the attention of the public. In 2015, internet users in China spent more than half their time on digital media, exceeding traditional media for the first time (China Social Media Report, 2015). Due to the popularity of these outlets, people began to publish information on social media when air quality began to decline in Beijing in 2011. At that time, citizens had limited understanding of PM2.5, and at the beginning of October 2011 there were only 29 WeiBo mentions about PM2.5 (Wong, 2011). However, growing concern was evident when between October 30, 2011 and November 1st, the number of WeiBo mentions related to PM2.5 increased from 583 to 29,552. This increase in public activity and discussion surrounding air quality contributed to the government's stricter air quality actions.

Another example of the internet's influence is the documentary "Under the Dome" by Jing Chai, a former high-profile host of CCTV. She created the film based on a large number of air quality reports published across multiple sectors (Hatton, 2015). The video was released on Youku, a popular video platform, in the morning on February 28, 2015. By 8:13 that evening, the film had been shared across many sites and received 24.76 million views and 42,020 comments (Hatton, 2015). At the same time users of Weibo, Wechat and other social networking platforms were also sharing this documentary, helping the content reach an estimated 100 million views within two days. The speed of social media greatly increased Chinese perception and awareness of the poor air quality throughout the country.

2. Response to International Perception

China is not only being influenced from within, but also by the power of international perception which appears to have affected the Chinese government's air quality management actions. As Zheng and Kahn argued, the central government has a desire to increase the legitimacy and image of China to the international community (Zheng and Kahn, 2013). By committing to strict environmental goals, the central government signals to both constituents and the international community that China is an international leader while improving the quality of life for its citizens.

This desire to improve its image with the international community was evident in the Chinese government's focus on air quality preceding the 2008 Beijing Olympics (He et al., 2016). In the months leading up to the event, the government enforced strict emissions prevention strategies. From vehicle restrictions to closing factories, the government's policies caused dramatic reductions in air pollutants to ensure the Olympic games were comparable to previous host cities (Jin et al., 2016).

3. Public Opinion on Air Quality

A study by the Pew Research Center (Gao, 2015) shows that air quality is of public concern as 75 percent of survey respondents in China indicated that air quality is a problem (Gao, 2015). Of these respondents, 41 percent marked air pollution as a "big" problem and 35 percent as a "very big" problem (Figure 3). While 36 percent of participants believed that an improvement would occur within 5 years; another 34 percent of residents thought the air quality would become worse over time (Gao, 2015).

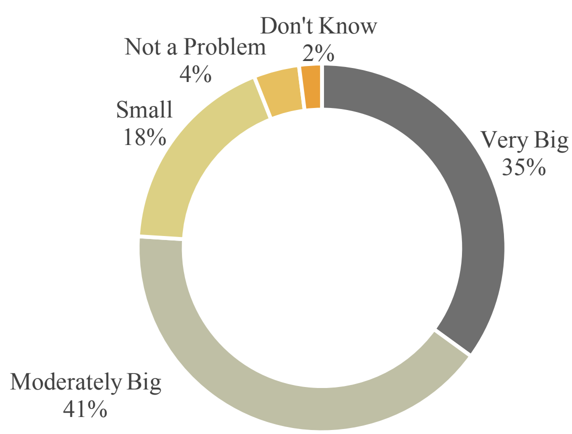

FIGURE 3 CHINESE PUBLIC RESPONSE ON HOW BIG OF A PROBLEM IS AIR POLLUTION IN CHINA; (PEW RESEARCH CENTER, 2015)

According to an investigative report on the environmental consciousness of the Chinese public, 43.2 percent of survey participants knew about “PM 2.5” in 2015. The report noted that over 70 percent of the survey participants believed that the treatment of the air pollution takes time, at least twenty to thirty years (Shanghai Jiaotong University, 2015). Additionally, more than half of interviewees said they wished more information was available to the public concerning air quality (Shanghai Jiaotong University, 2015).

With heightened public pressure, as well as evident health and economic effects, Chinese decision makers are increasingly aware of the need to reform their approach towards air quality management. While the Jingjinji plan has improved air in the region, it has not been able to reach its goals. To assist in reaching future objectives, we suggest considering four main sectors that contribute to air pollution: land use, industry, transportation, energy, and governance regulation in Sections II and III. Finally, we include recommendations for governance innovations that will be necessary to knit together policy activity across these sectors.

III. Land Use

The Jingjinji area uses land in drastically different ways. The land use varies from the urban landscapes of Beijing to rural areas primarily utilized as farmland. Due to these extreme differences in land use, analysis and recommendations are broken up into three sections: urban, suburban, and rural. By dividing suggestion into these categories, recommendations seek to address the specific issues facing each area.

A. Current Land Use Issues

1. Urban concerns related: residential recycling process in Beijing

Currently, Beijing’s trash disposal system consists of 17 sites throughout the city. 14 of these sites are landfills, two are for composting, and one is a garbage incineration site (Lu, 2014). While burning consists of only 2.4 percent of total waste disposal, the Energy Justice Network indicates that “trash incinerators release three times as much NOx as coal plants to produce the same amount of energy” (Energy Justice Network, n.d.; Lu, 2014).

Beijing’s current disposal process consists of four steps (Lu, 2014). First, waste is collected from residential buildings and transported to one of four types garbage storage buildings. The trash is then relocated to one of six transfer stops throughout the city. Of these transfer stops, five service urban areas and one serves the suburbs. Lastly, the garbage is transported to one of the final disposal sites: landfill, composting, or incineration. This four-step transportation process contributes to air pollution due to emissions from standing garbage and materials to be recycled (Lu, 2014). Additionally, these disposal sites do not have adequate capacity to handle the needs of the city. While the sites are built to hold 12,148 tons per day; the actual amount of trash collected is 17,562 tons per day. This overburdened system needs to be reformed (Lu, 2014).

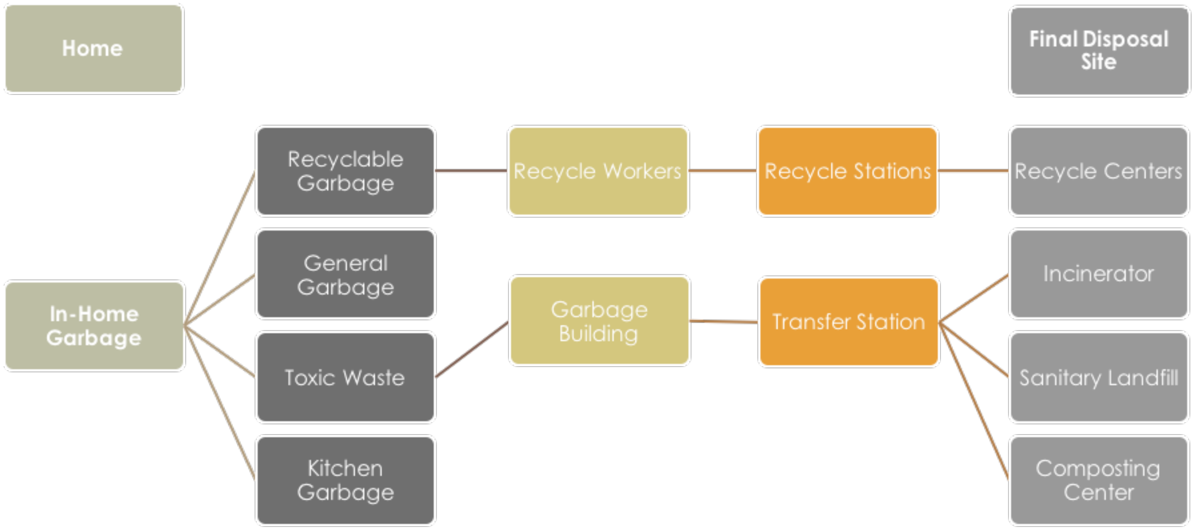

FIGURE 4 DIAGRAM OF CURRENT GARBAGE DISPOSAL SYSTEM IN BEIJING; (LU, Q., 2014)

2. Suburban housing concerns

The socioeconomic diversity of suburban households is a concern for housing development in this area (Dang, 2014). Existing low income housing in the suburban areas is largely found on the outskirts of urban areas where it is disconnected from essential public services like public transportation, education, and green spaces (Dang et al, 2014). Low income housing around Beijing's outer circle has led to concentrated poverty and compounding social issues as shown in Figure 5 below (Dang et al., 2014).

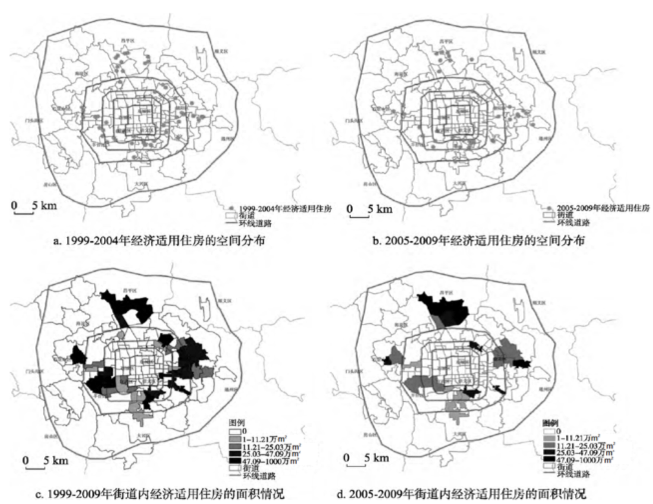

FIGURE 5 SPATIAL DISTRIBUTION OF LOW INCOME HOUSING IN BEIJING; (DANG ET AL., 2014)

3. Rural Agriculture

a. Agricultural Industry Growth and Disparity

Recently, there has been rapid growth of agriculture in the Jingjinji area (Jiang & Jiang, 2014). In 2012, Beijing's total agricultural industry output was 3.957 million RMB, with an annual industry growth rate of 2.9 percent (Jiang & Jiang, 2014). Tianjin's total value of agricultural output reached 3,756 million RMB, with an annual industry growth rate of 3.2 percent (Jiang & Jiang, 2014). Farmers' per capita income in Beijing was 16,476 RMB in 2012 while Hebei farmer's per capita income was 8,081 RMB, around half of the Beijing farmers (Jiang & Jiang, 2014). On average Chinese farming households cultivate two acres of land for farming purposes (*Zhao et al., 2017)*.

b. Agriculture and Creation of Secondary Particulate Matter in the Jingjinji region

The agricultural industry produces excess small anthropogenic particles and ammonia which contributes to particulate matter air pollution in the Jingjinji area. Excess anthropogenic particles are caused by biomass burning aerosols (M*ukai, Nakata, Yasumoto, Sano, & Kokhanovsky, 2015)*. In China, 90 percent of burned biomass is in the form of wood fuel or crop residue *(Zhao et al., 2017)*. China is one of the world's biggest contributors to biomass burning emissions (Zhao et al., 2017) Approximately 90 percent of particles released during biomass burning are PM 2.5 *(Zhao et al., 2017)*. For the Jingjinji area, agriculture biomass burning of excess agricultural waste mainly happens between May and October, peaking in June *(Mukai et al., 2015)*. Pollutants released by this process are carried by the wind, increasing PM 2.5 levels in nearby urban areas *(Mukai et al, 2015).*

Agricultural work also leads to the creation of secondary PM 2.5 when ammonia (NH3) emissions convert from gaseous to particle ammonium (*Wang et al., 2015*). Ammonia is released primarily through nitrogen rich fertilizers (17 percent) and livestock waste (39 percent) (Meng et al., 2011). In order to limit ammonia levels, China passed a 1997 law limiting the number of open field crops and encouraging farmers to use agricultural waste for fertilizer (Yan et al., 2006). However, there is little to no enforcement of these laws, which affects both the immediate rural area and the surrounding environment *(Zhao et al., 2017)*. In Shanghai, 10 percent of PM 2.5 pollution and 22 percent of aerosol pollution was attributable to nearby ammonia conversion from gas to particles *(Wang et al., 2015*; *Zhao et al., 2017)*. Although it is an obvious contributor to secondary particulate air pollution, the central Chinese government does not currently measure atmospheric ammonia levels *(Wang et al., 2015*).

B. Recommendations

1. Implement an in-home recycling system in youth communities

On May 27, the Beijing government announced a commitment to invest 200 million RMB into a recycling system (Beijing Daily, 2017). In conjunction with this effort, we recommend that the World Bank begin a pilot program of an in-home garbage separating and recycling system. This system would require residents to separate waste into five sections: plastic, glass, paper, food, and general trash. Separating recycling in this way emulates Germany, which recycles 65 percent of municipal waste (Wengert, n.d.). This system will eliminate the need of the garbage building and transfer station, therefore simplifying the waste disposal process (shown as below). We predict that this system will streamline the trash separation process and cut down on emissions in the transportation of the garbage. Additionally, air pollution due to stagnant trash will be reduced. Finally, with the increased efficiency of recycling, there will be less trash, reducing the amount that would otherwise be incinerated.

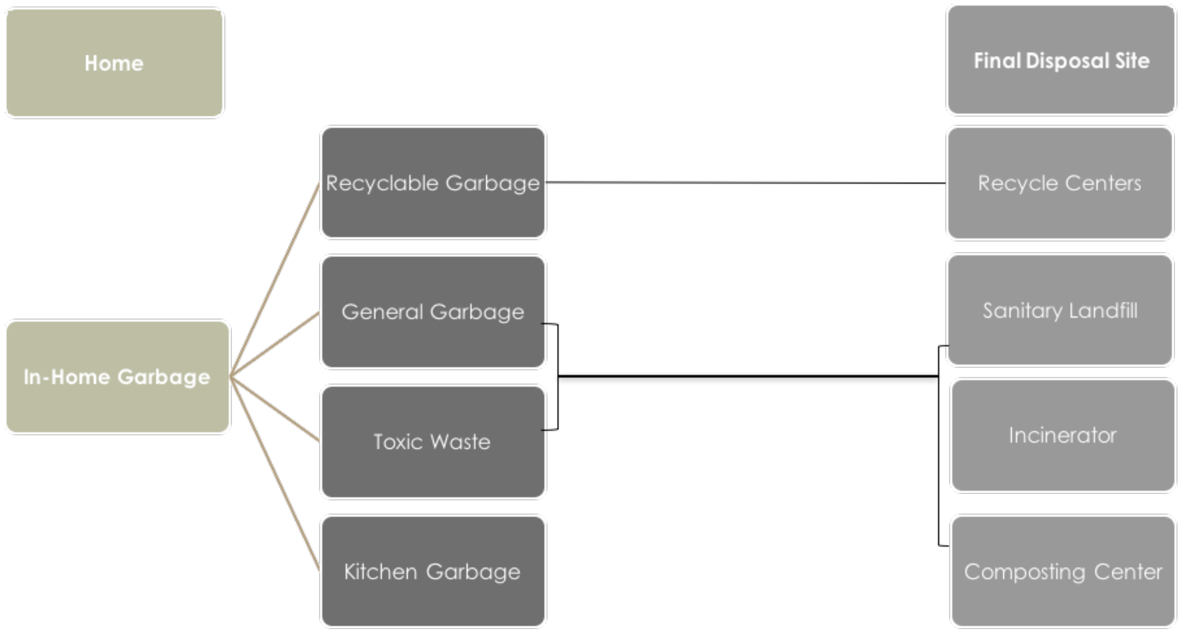

FIGURE 6 RECOMMENDED PILOT GARBAGE DISPOSAL SYSTEM IN BEIJING

The pilot program can be implemented in youth communities, specifically the Apple Youth Community located in CBD Guomao. These buildings are targeted towards young professionals, foreigners, and recent university graduates. These apartment complexes are highly selective and expensive, attracting the best and brightest young adults, often working at the top companies in Beijing. We think this population will be most receptive to implementing a new system because of their sense of social responsibility and their knowledge of environmental problems. Additionally, these buildings create tight knit communities, which could help develop a culture of recycling. Since these complexes are relatively new, they will be more apt to contribute to cooperative social responsibility programs.

2. Start green building projects on university campuses

Green buildings are becoming increasingly popular in urban environmental protection efforts (BCA Green Mar, n.d.). In this context, green building refers to integrating plants and simple agriculture into the structure, especially on the rooftops. According to CAUPD discussion, Beijing has begun implementing these green buildings throughout the city. However, these buildings are still fairly uncommon and spread out, so the city has not observed an impact.

Singapore Green Buildings

Singapore is leading the green building revolution in Asia. Starting in 2006, Singapore launched their first Green Building Master plan and simultaneously, a system for evaluation of sustainability through the Building and Construction Authority (BCA) (BCA Green Mark, n.d.). By 2030, Singapore predicts that 80 percent of buildings will be sustainable, have high water and energy efficiency, which reduces waste, and contain integrated green spaces (BCA, n.d.).

Singapore was able to implement this system through collaboration between the government agency, BCA, and the non-profit organization, Singapore Green Building Council (SGBC), which is a member of the international organization, the World Green Building Council (SGBC, n.d.). There are five major green buildings areas throughout Singapore including: CapitaGreen, Tree House, Nanyang Technological University, Oasia Hotel, and Eco Sanctuary. According to SGBC, the school communities are a feasible starting point for government and non-profit collaboration. The campus created a foundation to deliver the concept of the green building program. BCA is currently working to achieve zero net energy in schools (BCA Green Mark, n.d.).

Following Singapore's green building model, we recommend that the World Bank partner with top universities and the China Green Building Council to implement a pilot program in which they establish 15 green buildings within a 15 km^2 radius. These buildings would have green roofs providing vegetables to be used on site. This would help foster a sense of environmental responsibility amongst students.

Tsinghua University would be a good location for this pilot program due to their emphasis on science and technology. Since the university is a leader in the Chinese educational system, they could encourage other campuses to follow their model. This initiative could attract more visitors to the campus and would provide a venue for students to have hands-on learning in environmental protection and the betterment of air quality.

The long-term goal for this system would be to noticeably reduce carbon dioxide in the area and educate future generations. The secondary goal would be to decrease the number of agricultural products being delivered from outside sources, cutting transportation emissions throughout the city.

3. Decrease loan interest rates for homes purchased in suburban areas

Integrating suburban areas into urban development through the Housing Fund can increase the socioeconomic diversity of housing in suburban areas. Additionally, diversifying the area would also incentivize the construction of public infrastructure and community building.

The Housing Fund in China was created in 1999 to allow employees to put aside a percentage of their income into an account from which money can only be taken out for a down payment, to obtain a loan to purchase a house, or construction and remodeling (Tonini, 2015). Employers match the employee's contribution between 5 percent and 25 percent of the employee's average monthly income from the previous year (Tonini, 2015). The percentage differs between cities and provinces and the employee's contribution is determined by the previous year's average wage and the statutory contribution ratio (Tonini, 2015).

The housing fund policy is intended to provide social welfare for residents, but due to the high housing price of urban housing in Jingjinji region, this housing fund is not enough for urban middle and low income class to afford a house in the urban city. Since the suburban area has lower housing prices, incentives for suburban house purchasing can address the issues of a centralized megacity while diversifying the residents in the suburban area. Housing funding can serve as a potential government tool to incentivize such actions. Thus, our recommendation is to decrease the loan interest rate for people who want to buy house in the suburban area. This will create additional incentives for people to move out from the centralized downtown area with higher housing prices.

4. Upgrade air pollution monitoring systems to measure ammonia levels.

Currently, the Chinese government's air pollution monitoring system does not monitor ammonia levels (China National Environmental Monitoring Centre, 2017). The monitoring of ammonia levels is essential to better understand the creation of secondary PM 2.5, but this data is not currently collected by the Chinese government and is missing from the Air Quality Index. Ammonia's conversion process is affected by temperature and humidity but little is known about how ammonia caused by agriculture contributes to Jingjinji's air pollution *(Mukai et al., 2015)*. Monitoring and collecting comprehensive data will help understand ammonia conversion in the Jingjinji region.

In the United States, the National Air Emissions Monitoring Study (NAEMS) was conducted with Purdue University in 2006 through a voluntary Air Compliance Agreement by the United States Environmental Protection Agency (EPA) and offers a model of how to study and monitor atmospheric ammonia (EPA, 2016). Through the study, 24 sites at animal feeding operations (AFO) were monitored in 9 states for a period of 2 years (EPA, 2016). The study offered analysis on the effect that AFOs had on air pollution in the United States (Purdue University, 2006). Prior to the study, AFOs had not complied with EPA air quality regulations but could not be completely regulated because of the lack of data (Purdue University, 2006).

5. Promote more efficient farming practices for agriculture biomass burning and nitrogen rich fertilizer use in Hebei Province.

Agricultural biomass burning happens when farmers use open field burning techniques to clear agricultural waste. Open field burning in China is done on a small scale and for a short period of time making the extent of agricultural biomass burning's effect on air pollution unknown. Alternatives to open field burning and regulation of these new management systems need to be offered and enforced.

We recommend to start a pilot educational program in the agriculture experimental base of China Agriculture University, which located near Baoding, Hebei province. Covering an area of 21,600 mu, this experimental base serves as one of the most important hi-tech agriculture incubators, providing advanced agriculture facilities, professional agriculture knowledges and young agriculture expertise into nearby agricultural communities (Lu, 2014). By adding a new project aimed at introducing ammonia detection techniques and open field burning systems, farming techniques can be improved in an effective way.

IV. Industry

High-polluting industries are relied upon in the Jingjinji region for economic growth. Industry, as referred to in this report, means "one that employs a large personnel and capital especially in manufacturing" (APCG, 2017). This section looks at the current industries and regulations in the individual provinces of Jingjinji to then develop recommendations on how to best shift to greener, low-emitting industries.

A. Existing Industry Situation

Since the reform and opening-up, China's industry has greatly shifted and agglomerated in the areas surrounding the capital. According to China's second and third industrial census data (Guo & Shen, 2011). Chinese manufacturing sectors are highly concentrated in the eastern coastal areas. However, strong economic growth in these regions has resulted in poor air quality (Guo & Shen, 2011).

From 1998 to 2008, China's industrial sectors experienced large change because of China's economic transition which transferred gradually to a more open, market-based economy (Guo & Shen, 2011). At the same time, China implemented the "Fifteen" plan, the "11th Five-Year' plan and the "95" plan. During this period, the actual industrial added value increased from 803.841 billion yuan in 1998 to 51,052.78 trillion yuan (Guo & Shen, 2011). On the other hand, SO2 emissions also increased from 12.4773 million tons in 1998 to 16.663 million tons in 2008, a growth of 33.5 percent (Guo & Shen, 2011).

1. Beijing

According to the industrial census data in 1995, Beijing's total industrial land was 265 square kilometers, accounting for 17 percent of the total area of Beijing city planning (1560 square kilometers) (Commission, 2012). In 2011, Beijing's regional GDP was 1.60004 trillion yuan, an increase of 8.1 percent over the previous year, and the total industrial output value was 303.9 billion yuan, an increase of 7.4 percent compared to the previous year, Industry accounts for 19 percent of Beijing's GDP (Commission, 2012).

From the founding of the PRC to the end of 1950, the government established the industrial division of Beijing - the eastern suburbs for the cotton textile industry, the northeast suburbs for the electronic industry, the southeast suburbs for the machinery and chemical industry and the western suburbs for the metallurgy and mechanical heavy industry zone (Commission, 2012). Having all the industries surrounding the capital allowed for self-reliance and high employment (Commission, 2012). However, this also led to suburban and urban fringe sprawl as industries moved outward looking for more space (Commission, 2012). Furthermore, it contributed to high levels of pollution in the region (Commission, 2012).

Beginning in 2000, the government began to relocate large enterprises with a goal of alleviating air quality issues (Yang, 2006). In 2008 august, the government accelerated the relocation of enterprises that currently exist within the city center, with a goal of relocating all industrial enterprises located within in the fourth ring road in the next three to five years (Yang, 2006). Under that relocation plan, it is estimated that Beijing city will reclaim 8 million square meters of land for other functions and the proportion of land allocated to industry will drop to 7 percent (Yang, 2006).

a. Regulation

A primary regulation in Beijing surrounding greening of the industry is the requirement that relocated factories must implement environmentally-friendly retrofits that aim to conserve water and energy as well as reduce emissions (Beijing Municipal Commission of Economy and Information Technology, 2015). Removed enterprises must strictly implement environmental protection, labor protection, industrial hygiene, fire control, water conservation, energy conservation and greening, and never allow pollution to be transferred to new location (Beijing Municipal Commission of Economy and Information Technology, 2015). The site selection of the new plant must be to the industrial land as stipulated in the master plan of Beijing. The new use of the original site must also conform to the urban planning and environmental requirements (Beijing Municipal Commission of Economy and Information Technology, 2015).

If these environmental changes are not met, then the company must pay back their transfer fees (the relocation compensation enterprises receive for moving) to the government (Beijing Municipal Commission of Economy and Information Technology, 2015).

2. Tianjin

Tianjin is the largest coastal city in northern China and the biggest port in the region (Li, 2008). Coastal advantages have brought the prosperity of commerce and the rapid development of industry. In 2006, the city achieved an industrial added value of 220.081 billion yuan, an increase of 17.7 percent from the previous year, and an industrial output value of 890.745 billion yuan, an increase of 25.1 percent (Li, 2008). Tianjin industry has become the main supporter of the city's sustainable development. As of 2008, 50 percent of Tianjin's GDP, 60 percent of taxes, 70 percent of foreign investment, and more than 80 percent of exports came from industry (Li, 2008). The primary industries in Tianjin are electronic information, automobile, petrochemical and marine chemical industry, petroleum pipe, and new energy sources, such as photovoltaic power (Li, 2008).

a. Regulation

In November 14, 2005, the Tianjin government announced measures for the management of polluting enterprises (Municipality, 2005):

- For some chemical industry that are banned by the State Council, the environmental protection departments have the right to stop production once they are found producing, and put forward proposals for closure. Then need to ask the local government to provide the final approval for closure (Municipality, 2005).

- Small chemical enterprises in violation of environmental laws and regulations, causing serious pollution to water, soil, oceans, atmosphere, shall be forced to close directly by the environmental protection departments or in coordination with another department (Municipality, 2005). The shutdown decision must be approved by the same level of government as these departments. No economic compensation is provided to these small polluting companies when they are forced to close (Municipality, 2005).

- Closed chemical enterprises can apply for appropriate subsidies if they take the initiative to implement relocation, and meet environmental protection requirements. The specific measures of this agreement shall be formulated by the municipal environmental protection department (Municipality, 2005).

When the government has decided to close enterprises, an oversight group guides the closure of the enterprises in accordance with the law (Municipality, 2005). The oversight group is currently composed of the departments in charge of industrial economy, environmental protection and industry administration, amongst others (Municipality, 2005).

3. Hebei

Hebei relies heavily on industry (manufacturing) and high energy consuming industries comprise a major part of the overall industrial sector in the province (BMBS, 2014). Sulfur dioxide from industry was 92.4 percent of the total sulfur dioxide emission in Hebei in 2012 and dust from industry was 85.4 percent of the total dust production, the highest percentage in the Jingjinji region (BMBS, 2014; Figure 7).

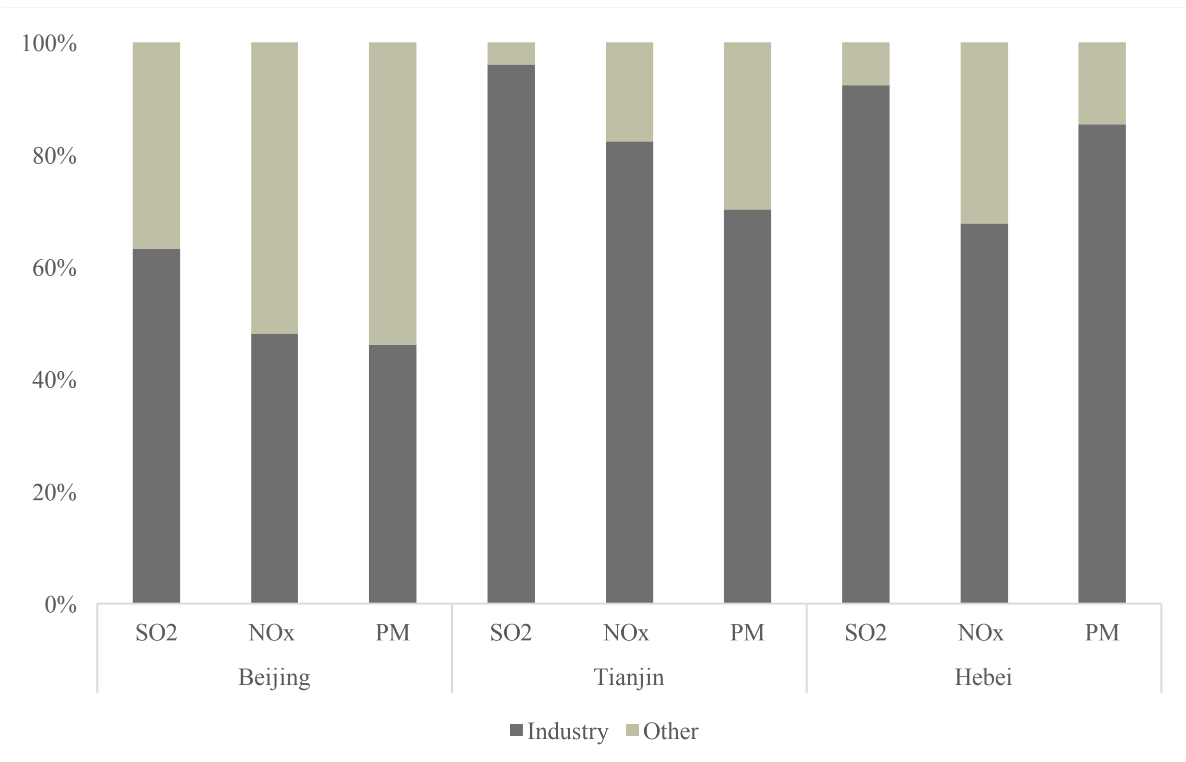

FIGURE 7 PERCENT OF AIR POLLUTION FROM INDUSTRY IN THE JINGJINJI REGION 2012; (BMBS, 2014)

The consumption of coal in Hebei in 2012 made up 88.8 percent of its total energy consumption, which was higher than Beijing (25.4 percent) and Tianjin (59.6 percent), The consumption of coal generates sulfur dioxide, a major pollutants of air quality (BMBS., 2014). Hebei had the worst situation the Jingjinji area since sulfur dioxide emission in Hebei made up 80.8 percent of the total emission in Jingjinji area (BMBS, 2014).

a. Regulation

In order to mitigate the air pollution caused by industry emissions, the National Air Pollution Prevention and Coordination Group wrote a “Briefing on prevention and control of air pollution” for Hebei province in May 2017, noting the progress that has been made to ensure that industry emissions reach the standard they have set up, as well as the future plan (National Air, 2017). As of 2017 779 companies in Hebei including in steel, coal, cement, thermal power, pharmaceutical, sewage treatment and garbage disposal have reached the standard. It is estimated that the emissions levels of the main pollutants will decrease by another 15 percent by 2020 from the current 2017 numbers (National Air, 2017).

The Briefing includes the “1+18” Act which sought to replace enterprises with high Volatile Organic Compounds (VOCs) with low VOCs materials and to update companies with clean energy. It is estimated that the total emission of VOCs will be decreased about 20 percent by 2020 (from 2015 levels), and will reach the target of emission reduction-- at least 195,000 tons (National Air, 2017).

The Act also made specific plans for factories to take turns for production during the winter based on municipal progress in emission control (National Air, 2017). The Act specifies that cities with steel-oriented industry, including Shijiazhuang, Tangshan and Handan, can only produce at 50 percent of their annual production capacity. The coking industry will have to limit its production to about 30 percent of its annual capacity. Finally, pharmaceutical companies with high VOCs will have to be closed during the winter (heating season) (National Air, 2017).

4. National regulations that impact the region

Following the worldwide trend of cap-and-trade, China set up seven pilot cities beginning in 2011(Daily, 2015). The pilot programs in Beijing and Tianjin were initiated at the end of 2013, after testing for half a year, the trading volume in Beijing was 297,000 tons, which is worth about 15.889 million RMB, and it was 121,000 tons in Tianjin, equivalent to 3.58 million RMB (Daily, 2015).

Although the pilot programs have made progress, they are still facing several challenges (Daily, 2015). Regional cooperation was initially limited since the volume of cap-and-trade could not be transferred from one city to another, which weakened the efficiency of carbon emission reduction. In order to maximize cap-and-trade benefits, Jingjinji has been set up as the first cross-region cap-and-trade market, which enables the area to utilize different advantages they have in each city. For example, they are able to take advantage of the Free Trade Zone in Tianjin to import advanced carbon reduction technology from overseas; utilizing the lowest cost of carbon reduction among three regions to activate the cap-and-trade market (Protection, 2016).

B. Recommendations

1. Restructure and upgrade industry

As discussed, the governments in the region have begun to require the retrofitting and updating of factories to meet environmental standards (National Air, 2017). It is not realistic to eliminate all polluting industries from the area. In particular, Hebei relies on industry to generate revenue. However, new plans must acknowledge that as China becomes a consumer society, industry may naturally move or merge with competitive enterprises. Therefore, the government in the region can prepare by incentivizing the service sectors and providing job re-training programs for workers to qualify for new jobs.

Pittsburgh, PA Steel Industry

Pittsburgh began encountering air pollution problems in 1700 when bituminous coal was used in the steel industry (Davidson,1979). Industries expanded quickly in late eighteenth and nineteenth centuries. The air pollution worsened over time as the steel industry was the main economic generator in Pittsburgh (Streitfeld, 2009). The air pollution grew along with the steel industry. Smoke abatement officially launched in 1890. However, the effectiveness of smoke control did not appear until a smoke control ordinance was implemented in 1946.

"The key to successful enforcement was that the method of reducing smoke was realistic and achievable without disastrous economic consequences". The ordinance required: 1) "use smokeless fuels, such as anthracite coal, natural gas, or fuel oil" or 2) "incorporation of mechanically-fired stokers rather than manual firing if bituminous coal were used" (Davidson, 1979, pg.1039). The first method was favored by the industry which resulted in a net economic benefit.

One way in which the Jingjinji Region may attract green industries is by creating a pilot "Green Industry District" in Hebei that relies on eco-friendly industries, renewable energy and incubates clean technology development, which encourage economic growth in a positive way. This may be wrapped into relocation plans to see if certain industries can convert to low or zero emissions. In creating this special district, the government can test technology and ideas that allow economic growth without harming air quality.

2. Align regional and governmental collaboration in economic and environmental incentives

One of the main barriers to cleaner industry in the Jingjinji Region is uncoordinated and regulation that is motivated by economic growth competition rather than environmental protection(Wu,2016). A mandate that gives a regional agency power to enforce local emission standards could set strict and specific standards of state-owned factories; enforce implementation of the standards; and create a supervision office, which can be composed of multiple sectors, including governmental agencies, enterprises, and the general public (non-governmental organizations) and led by the Ministry of Environmental Protection. This body could enforce the adoption of Beijing's model of relocation compensation and transfer fee system to the other urban centers in the Jingjinji area.

NO_X Budget Trading Program

The NO_X Budget Trading Program provides a good example of regional cooperation. A standard of Reasonably Available Control Technology (RACT) for sources within non-attainment areas was made under the 1990 Clean Air Act Amendments. To attain the National Ambient Air Quality Standard, thirteen Northeastern and Mid-Atlantic states and District of Columbia formed the NOx Budget Program against ozone in the Northeastern United States. This is a regional program, involving multiple states which led to a negotiation.

Having a "Phase by phase" plan also helps to make progress as well as adjust the long-term vision. "The Memorandum of Understanding in 1994 that established a three-phase program of control of NO_X emissions from electric utility and large industrial boilers" (Denny, 2006). Phase I aimed to relabel RACT standards and later discovered that greater NOx Emission reductions were necessary to attain the standard. Phase II and III focused on imposing tight cap and trade program for eleven jurisdictions from May to September (ozone season). Phase IV expanded the program to cover states that located east of the Mississippi River.

From EPA compliance reports (2007), ozone season NO_X emissions had decreased 74 percent below 1990 baseline. Phase II successfully completed 30 percent of the reduction. The NO_X emissions in 2007 is 5 percent below the emissions cap and 60 percent lower than the emission before implementation of the program. However, some states refused to participate in the program. Virginia did not sign the Memorandum because it had already achieved the emission level standard. Thus, it is crucial to figure out a universal standard that can be compliance with different states.

Beyond creating a new oversight or regulatory body, the Jingjinji Region could enhance the implementation of its own cap-and-trade system. For example, in the United States, cap-and-trade systems have typically involved single states or regional collaboration across states (Upton, 2015). Cap-and-trade is a way to ensure companies internalize the negative externalities of pollution.

V. Transportation

Vehicular congestion and inefficient multi-modal connectivity in the Jingjinji Region are causing high emissions. As the region continues to grow and integrate, examining the transportation system is key to ensuring environmentally-friendly development. This section examines personal vehicle use, public transit connectivity and freight transportation networks to understand the transportation system in the Jingjinji Region and the ways in which the transportation system can be optimized for improved air quality management.

A. Current Conditions

1. Personal Vehicle Use

Beijing had a total of 5.61 million vehicles in 2016, emitting 700 thousand tons of criteria pollutants into the air every year, making traffic congestion one of the main sources of $PM_{2.5}$ (Gu, 2016). In the first half of 2014, vehicle emission accounted for 31.1 percent of total $PM_{2.5}$ emissions in Beijing (Gu, 2016).

According to the Urban Transportation Analysis Report published by Amap, Beijing experiences the most serious traffic congestion between 7:00 to 9:00 AM and 5:00 PM to 7:00 PM (Amap, 2015). Beijing road users are on the road an average of 2.56 times longer during rush hour than during off-peak times, which is the highest among 45 cities in China (Amap, 2015). This high amount of congestion in the Beijing urban area causes vehicle emissions that could be avoided with improved traffic demand management.

a. Existing Vehicle Emission Reduction Policies

Major measures to control vehicle emissions in the Jingjinji region include restrictions on vehicle use, a license plate lottery and elimination of Yellow-Label and Outdated Vehicles. Table 4 below outlines major vehicle emission reducing policies implemented in Beijing, Tianjin and Hebei.

TABLE 4 VEHICLE EMISSION REDUCTION POLICIES IN THE JINGJINJI REGION

Policy	*Description by Province/City*	*Year*
Vehicle Use Restrictions	**Beijing:** No vehicles from other cities during rush hours 1/5 of vehicle are prohibited to use one day a week. Odd-even traffic ban during Red Alert Weather and big events.	2008
	Tianjin: Same as Beijing	2014
	Shijiazhuang: No vehicles from other cities during rush hours within central area Other cities: Odd-even number traffic ban on Red or Orange Alert Weather	2014
License Plate Lottery	**Beijing:** Growth of vehicles in Beijing is controlled in 150,000 annually and by lottery only. 90,000 gasoline vehicles and 60000 EVs.	2011
	Tianjin: Combination of lottery and auction for 60,000 license annually.	2015
	Hebei: No restriction on vehicle registration	

Yellow-label Vehicles	**Beijing:** Eliminated yellow-label vehicles in the whole city	2015
	Tianjin: Eliminated yellow-label vehicles in the whole city	2015
	Hebei: Major cities in Hebei have restriction on use of yellow-label vehicles.	2014

Electronic vehicle (EV) ownership is growing because the Beijing government has incentivized demand by increasing the odds of receiving a license plate with an EV. Although Beijing has 14 percent of China's total charging stations, those stations were unsystematically distributed causing inconvenience for EV owners (Figure 8, Qiu, 2016). Four major companies and hundreds of small companies operate charging station now, but the city still suffers from uncoordinated distribution (Qiu, 2016).

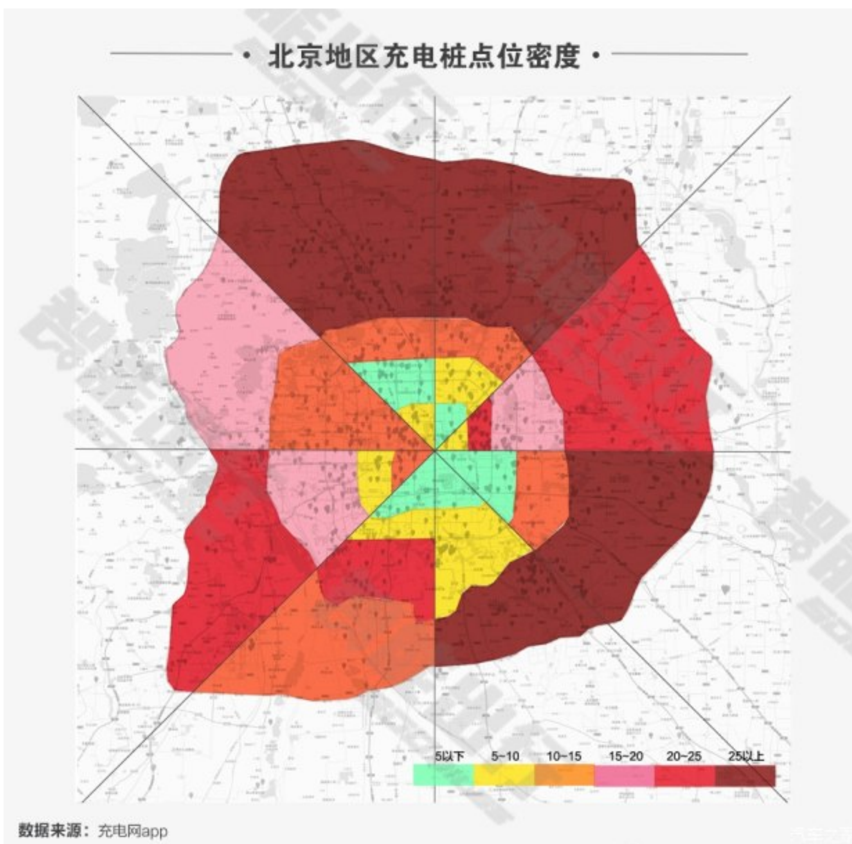

FIGURE 8 DENSITY OF CHARGING STATIONS IN BEIJING; (QIU, 2016)

Poor and underpriced parking management is also an issue in the urban centers of the Jingjinji region, particularly Beijing. According to a news report (Gu, 2015), large-scale, district-own companies own the rights of operation for 35 percent of total parking lots in Beijing, 30 percent of parking lots are owned by large-scale private companies, and others are owned by hundreds of small companies (Wang, 2013). Improved parking management, as seen in the San Francisco case study, could save time and fuel by providing real-time information on parking availability. Beijing may want to explore a system similar to San Francisco to prevent emissions and congestion caused by vehicles circling for parking.

San Francisco Parking Demand Management

Providing free (or undercharged) parking in a dense city results in lost revenue and wasted time and fuel for those looking for available parking spaces. Beginning in the summer of 2010, the San Francisco Municipal Transportation Agency in San Francisco, CA, piloted a robust, technology-driven parking demand management system called SFpark. Through the use of SFpark, the city hoped to increase parking reliability and convenience; reduce vehicle emissions; and improve economic activity by providing easy to access information on parking availability and adjusting parking price that is responsive to demand (SFpark, 2017).

The system monitors metered on-street parking and public parking garages for real-time availability through sensors. SFPark tracks and analyzes the sensor data to create real-time variable pricing by time of day and location. Residents of San Francisco can then check on the SFpark mobile phone application or website to check the price of and reserve an open parking space.

SFpark was successful in re-distributing parking across the city between overcrowded and under-utilized blocks, improving the city's overall parking occupancy rate (Pierce & Shoup, 2013). Additionally, the program provided drivers real-time information, improving decision-making and reducing an individual's time to look for an available parking space by 50 percent (Millard-Ball, Weinberger, & Hampshire, 2014). Although San Francisco achieved positive results in better managing its parking, several limitations exist that must be acknowledged before the JJJ Region considers a variable parking pricing scheme:

- Operating time: SFpark only manages parking spaces until 6 PM. By extending hours, the city could increase its revenue generation and improve its occupancy rates (Pierce & Shoup, 2013).
- Abuse of Disabled Placards: Drivers with disabled placards are allowed to park for free for an unlimited time, therefore SFpark staff noted that widespread abuse of disabled placards resulted in imperfect demand response to price changes (Pierce & Shoup, 2013). Policies that address this abuse and strengthen violations again placard abuse should be considered.
- Pilot Funding: Funding for SFpark was initially provided by a grant through the U.S. Department of Transportation. If Beijing would like to fund a program like this, the city would require sufficient funds for installing smart meters; developing smart phone and web-based applications; and creating a data management system.

2. Passenger Transportation

The railway network of the Jingjinji area is extensive; it leads the country in both length and density. However, there are two types of rail transit that the area is lacking: 1) rail transit to the suburbs of the metropolitan area; and 2) inter-city rail transportation.

As Figure 9 displays, railway passenger transportation accounts for 11 percent of passenger trips in the Jingjinji (Beijing Transportation Research Center, 2016). While the region has a dense railway network, there is little railway that efficiently connects the suburban with the urban area in the Jingjinji Region. Use of inter-city rail is low because there are only two existing inter-cities railway which cover less than 300 total kilometers (Beijing Transportation Research Center, 2016). As a result, residents choose to use highway transportation for inter-city trips, which increases traffic and negatively impacts the environment.

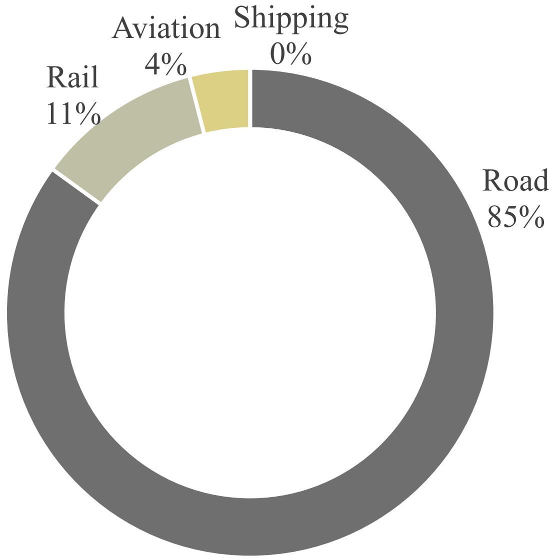

FIGURE 9 PASSENGER TRANSPORTATION MODE SHARE IN THE JINGJINJI REGION; (BEIJING TRANSPORTATION RESEARCH CENTER, 2016)

According to iFeng (2016), the Jingjinji area is planning to build 24 inter-city railways by 2030, with a total length of 3,400 kilometers. Recently, plans to build nine high speed railways, which will connect Beijing and Tianjin, Beijing and Shijiazhuang, Beijing and Tangshan and other inter-city railways was approved by the National Development and Reform Commission (NDRC) (iFeng, 2016).

Regional Transit Financing: Washington Metropolitan Area Transit Authority

The Washington Metropolitan Area Transit Authority (WMATA) is successful in providing standardized and well-connected regional transit service for the Washington, D.C. metropolitan area, which includes parts of Virginia and Maryland (AECOM, 2011).

Although initially financially sustainable, WMATA does not have a dedicated tax revenue source and relies heavily on federal appropriations and annual, negotiated allocations from the participating local governments to fund operations (Schlickman, Snow, Smith, Zelalem, & Bothen, 2015). As federal transportation funding diminished and local resources became tight, WMATA's deferred maintenance backlog grew. Although, WMATA seeks alternative sources of revenue to capital and rehabilitation projects through public-private partnership, this example stresses the need for dedicated and reliable sources of revenue for cross-jurisdictional transit projects.

As the Jingjinji Region begins to plan and design these new stations, decision-makers must consider the placement of transit stations as well as commute patterns requiring transfers. The Jingjinji area lacks convenient transfer and connectivity hubs between major transportation points such as railway stations, highway passenger stations and airports (BTRC, 2016). Newly built stations lack transportation connections to old stations (BTRC, 2016). Large-scale passenger hubs such as airports and main railway stations rely heavily on vehicle transportation, causing traffic congestion around these passenger hubs (BTRC, 2016). As new lines are being built, efficient connectivity and density surrounding stations will be necessary to reduce the number of unnecessary trips and transfers an individual makes as well as increase the practicality of using public transit.

a. Beijing is the region's only transportation hub

Since Beijing is the capital of China, railway, highway and airports are all centered and agglomerated in Beijing. As a result, Beijing is most often the transfer station for passenger and freight rails. This situation adds pressure to the transportation system in Beijing while isolating and disadvantaging Tianjin and Hebei. Beijing started the task of "relocating non-capital functions" in 2015 (Mao, 2017). Under this initiative, general manufacturing industry, regional logistics, regional wholesale markets and some educational and medical institutes will be moved out of Beijing. This project will reduce some pressure on Beijing and defer more transfers and trips to the surrounding areas.

3. Freight Transportation

Significant amounts of emissions result from inefficient freight systems. The freight transportation network in the Jingjinji Region also heavily relies on utilizing Beijing as a major transfer hub (Baokui, 2017). The Jingjinji Plan seeks to divert more freight traffic to Tianjin to leverage the port, which will make freight connectivity more efficient with the added benefit of potentially strengthening the city's logistics industry (The Economist Corporate Network, 2016).

a. Freight Network

It is important for the Jingjinji Region to examine how goods are moved and to determine the freight network's capacity in order to understand freight's impacts on future emissions. As Figure 10 shows, freight volume experienced a steady increase over the last ten years and is expected to continue increasing in the future. The forecast was calculated by the Beijing Transportation Research Center using consumption, industrial output and population data (Beijing Transportation Research Center, 2016).

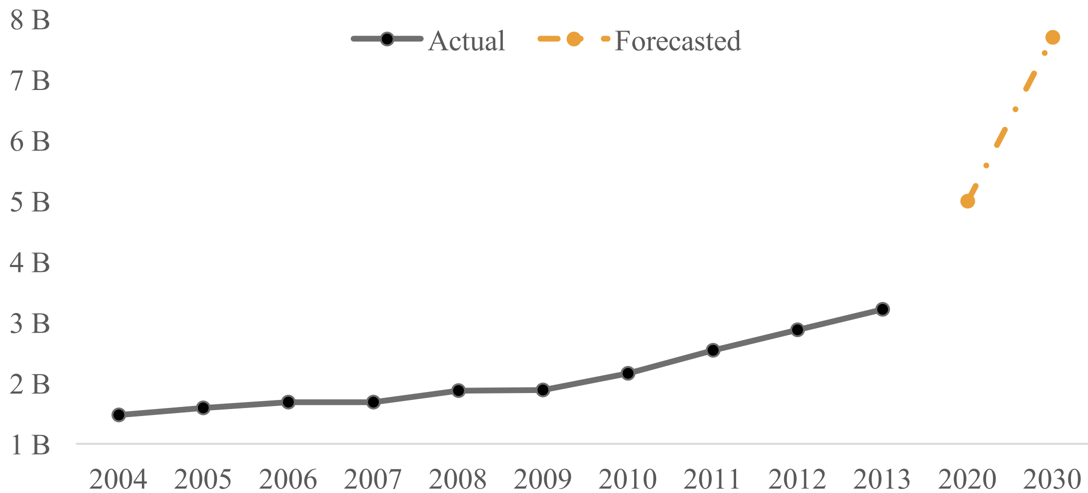

FIGURE 10 ACTUAL AND FORECASTED TOTAL FREIGHT VOLUME IN THE JJJ REGION (IN BILLIONS OF TONS); (BEIJING TRANSPORTATION RESEARCH CENTER, 2016)

As seen in Figure 11, majority (87 percent) of freight was transported via highways in 2013 (Beijing Transportation Research Center, 2016). The World Bank and China's Ministry of Environmental Protection estimate freight trucks accounted for 36 percent of carbon monoxide, 60 percent of nitrogen oxides, and 76 percent of particulate matter emissions nationwide (World Bank - Ministry of Environmental Protection, 2012). With a dominant majority of freight being transported by high-emission trucks, it will be important that a greater proportion of future freight volume be accommodated via railways.

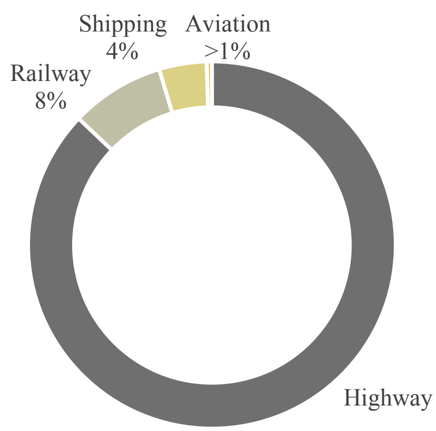

FIGURE 11 PERCENTAGE OF FREIGHT VOLUME BY TRANSPORT MODE IN THE JJJ REGION IN 2013; (BEIJING TRANSPORTATION RESEARCH CENTER, 2016)

In an effort to shift its intercity and regional freight volume to rail, the Jingjinji Regional Plan proposes extensions to its intercity rail and high speed rail (HSR) networks. The new railway will seek to increase freight flow efficiency and make it a more competitive, low cost mode against the use of highways (Beijing Transportation Research Center, 2016). Additionally, the new track will make use of Tianjin as a freight and logistics hub, diverting goods away from the Beijing area (Figure 12).

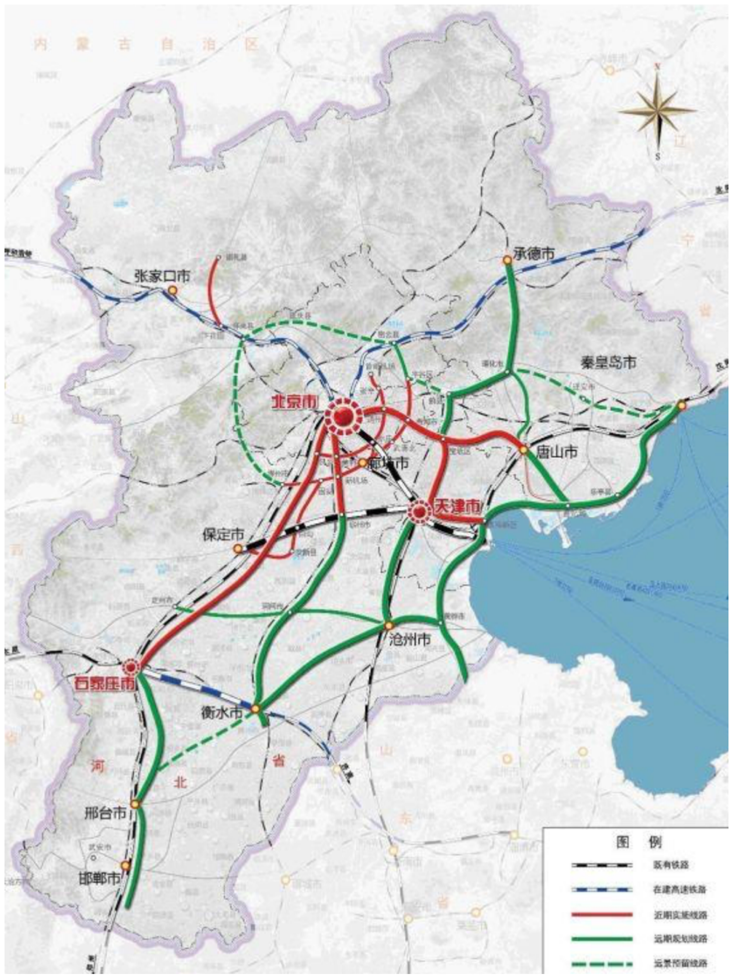

FIGURE 12 MAP OF EXISTING AND PROPOSED JINGJINJI REGION INTERCITY AND HIGH SPEED RAIL LINES; (BAOKUI, 2017)

b. Port of Tianjin

The Port of Tianjin is the largest in northern China, receiving 14.36 million twenty-foot equivalent unit (TEU) and has seen an average annual growth rate of 16 percent since 2003 (Beijing Transportation Research Center, 2016). With a high amount of activity, it is important that the Jingjinji region's air quality management system consider emissions from this industrialized area.

In 2015, the Chinese central government required cities with ports to set policies and targets for controlling and preventing port emissions between 2015 to 2020 (Clean Air Asia, 2016). The following measures were adopted in the Jingjinji region:

- *Regional Coordination:* Tianjin, working with Hebei and Shandong Provinces, will lead research and inventory of emissions from the port and associated vessels (Clean Air Asia, 2016).

- *Vessel Emission Control:* As of January 1, 2017, the sulfur content of fuel can be no more than 0.5 percent for vessels entering emission control areas along the coast of Tianjin. By January 1, 2019, the emission control area will expand to include any vessels within 12 nautical miles of the shore (Freda & Zhixi, 2017).

- *Specific Port Pollution Control:* Pilot clean energy use projects for harbor boats, machinery and charging facilities in the port area (Clean Air Asia, 2016).

With recently enacted regulations on port emissions, it is still unclear how the Ministry of Environmental Protection and Ministry of Transport will coordinate to enforce these standards and ensure they are continued in the long-run. To make Tianjin the new primary freight hub, the region will need thoughtful planning and further development of efficient and connected infrastructure as well as city services, such as healthcare and education, to attract and retain businesses and high-skilled residents.

B. Recommendations

The following are recommendations to address the criteria pollutant emissions from the transportation sector in the Jingjinji Region:

1. Develop multi-modal connectivity to the Beijing suburbs, Hebei and Tianjin.

As discussed above, the Jingjinji Plan includes the building of several new and expanded intercity and suburban rail lines which will address a major limitation of the existing transit system. These new tracks will improve multi-modal connectivity for the entire region, providing greater travel choices for residents in the area.

One major consideration for multi-jurisdictional rail development is long-term, sustainable financing for operations and maintenance. As the Washington Metro Area Transit Authority (WMATA) experienced, a financial model that relies upon individual jurisdictions contributing unfixed amounts does not work for long-term sustainability (see case study). The World Bank in partnership with the National Development and Reform Commission may want to study and forecast potential fare box recovery of the new transit lines to see if that may partially fund operations and maintenance into the future. We also suggest that the World Bank and the National Development and Reform Commission study sustainable financing approaches for operating costs in the event that fares do not cover needed operating and maintenance costs.

A second area of concern in planning these new transit lines is ensuring the stations are in high-density, multi-use areas. The city and national governments will want to continue to ensure transit-oriented development (TOD) is prioritized as it plans and designs transit stations. Additionally, these stations should provide easily accessible bike share bicycles to help with first and last mile problems or park-andride facilities for residents who must connect to these stations. TOD is an important way to increase the convenience of using transit and reduce the number of trips individuals must take.

2. Deploy better transportation demand management strategies.

To improve traffic demand management in Beijing and other urban areas in the Jingjinji Region, the following strategies are recommended for study and piloting:

a. *Implementation of high-occupancy vehicle lanes*

High-occupancy vehicle (HOV) lanes are a management tool transportation agencies may implement to reduce high levels of congestion by incentivizing carpooling, ridesharing or public transit use (U.S. Department of Transportation, 2015). HOV lanes only allow vehicles with two or more passengers to use the lane, typically during peak traffic periods.

As seen in the sidebar, Chengdu recently implemented HOV lanes which may serve as a valuable model for implementation of a pilot project in the Jingjinji Region. As a large share of commuters currently use highways, HOV lanes may motivate drivers to carpool or rideshare which will reduce vehicle miles traveled and therefore emissions as well.

Chengdu High Occupancy Vehicle Lanes

The city of Chengdu created two high occupancy vehicle (HOV) lanes in January 2017. Vehicles with two or more passengers (not including children under 12) are permitted to drive in the designated HOV lanes during rush hour periods, 7:30 – 9:00 AM and 5:00 – 7:00 PM (Go Chengdu, 2017). Any drivers caught in violation of the HOV lane rules will be fined either 100 RMB, or 200 RMB and 3-point deduction on their driver license. Chengdu

Results are yet to be seen as the lanes were recently implemented, however, this example is provided to display the use of HOV lanes by a Chinese city government. The National Development and Reform Commission may want to evaluate the HOV lanes in Chengdu to see if its application will result in congestion reduction in the JJJ Region.

b. *Congestion-based fee*

The Beijing Transport Institute has a robust data management system that could be utilized to implement a congestion-based fee during rush hours on its existing toll roads. This strategy is shown to reduce travel demand using private vehicles and reallocate travel to off-peak periods (Eliasson et al., 2013). The largest benefits from congestion-based pricing are seen when tolls are applied systematically, thereby reducing unpredictable revenues and sprawl due to varied traffic patterns attempting to avoid paying the fee (Litman, 2017). The Jingjinji Region will want to ensure sufficient transit alternatives are provided for those unable or unwilling to pay the higher toll. The Jingjinji region many also want to combine congestion pricing or toll roads on HOV lanes if the HOV lanes have excess peak hour capacity.

c. *Demand-responsive parking fee*

As seen in the SFpark case study, creating a variable parking price system based on demand results in time and fuel savings, revenue generation, and more efficient use of parking spaces. A pilot demand-responsive parking system could be implemented in Beijing by working with private parking management companies and installing curbside parking meters within the second ring road.

3. Improve efficiency and coordination of the freight network.

The clean port initiatives and expanded rail network will assist in creating a low-emissions freight network in the Jingjinji Region. With thorough plans to ensure that future freight volume can be transported via rail, the Jingjinji Region will want to make sure that Tianjin is prepared to handle greater traffic as well as serve a larger population as logistics companies move to the area.

4. Expand electrical vehicle use through more convenient charging stations

Growing EV ownership in China, particularly the Jingjinji Region, will require greater installation of EV charging stations. To ensure systematic distribution, the city code could potentially require new apartment, business buildings and gas stations to provide a set proportion of EV stations in parking lots. Governments in this region should also explore the creation of a single smart phone application where EV owners can locate charging stations and potentially integrate a payment system. It is important to note that greater EV use will only be as clean as the grid in which the vehicle is receiving electricity. The expansion of EVs as a means to improve air quality is heavily reliant on simultaneous policies to provide clean electricity generation in the region.

VI. Energy

For years, the Jingjinji's energy structure was heavily dependent on coal. Currently, the three Jingjinji provinces are pursuing the move towards cleaner energy with differing levels of intensity. Lack of collaboration and economic incentives to keep coal factories open have slowed development of clean energy in this region. Policy recommendations are aimed at increasing collaboration and switching to clean energy while addressing the economic tradeoffs.

A. Existing Concerns Related to Energy Structure

1. Current Energy Structure

As the population of the Jingjinji region continues to grow, demand for energy has risen. From 2001 to 2015, the total energy consumption in Beijing increased 138 percent (Beijing Municipal Bureau of Statistics, 2016). In addition, Hebei ranked second for total energy consumption in China (Chen & Feng, 2016). Tianjin's energy supply is dependent on other provinces such as Shanxi, Inner Mongolia and Hebei, which are the area's main suppliers of coal (Sun, Qu, & Zhang, 2016). As the Jingjinji region grows, energy policies should meet China's energy demand, increase sustainability, and minimize adverse effects on the environment.

With the rising demand for energy, low costs historically made coal the primary type of energy consumed as well as a source of economic growth. Beijing has made strides to improve this reliance on coal as a primary source of energy. From 2010-2015, the percent of coal as part of Beijing's total energy consumption dropped from 29.6 percent to 13.7 percent (Beijing Municipal Bureau of Statistics, 2016).

Subsequently, the portion of natural gas in Beijing doubled from 14.6 percent to 29 percent from 2010-2015 (Beijing Municipal Bureau of Statistics, 2016).

In contrast to Beijing's progress, and as a result of central governmental policy, neighboring Hebei remains one of China's largest consumers of coal in the country. From 2005-2012, the percent of coal in Hebei's total energy consumption reduced slightly by 2.92 percent (Chen & Fung, 2016). Similarly, the percentage of natural gas only increased from 0. 61 percent to 1.87 percent, suggesting the switch from coal to cleaner forms of energy is happening more slowly in Hebei province than in Beijing (Chen & Fung, 2016).

China recently implemented several policy actions aimed at reducing air pollution by switching to cleaner energy sources. The thirteenth five-year plan, issued in December 2016, set the first target for reducing coal's percentage of total energy production from 65 percent (2015) to 58 percent by 2020 (Lin, 2017). This plan set a target to increase non-fossil energy production to 15 percent by 2020 (Lin, 2017). In addition, China is focused on the development of renewable energy, specifically solar energy, with China now having the largest amount of installed solar capacity in the world (Martin, 2016).

2. Barriers to Clean Energy

One of the primary factors slowing the development of clean energy in the Jingjinji area is lack of regional collaboration for the switch to cleaner energy in all three provinces. Progress remains inconsistent between provinces as areas pursue a cleaner energy structure with differing levels of intensity. In 2017, Beijing became the first city in China to shut down all major coal plants replacing them with four natural gas-fired stations with capacity to supply 2.6 times more electricity than the coal plants (Brown, 2017). However, Dongxianpo, located in rural Hebei, was also approved to build a new coal plant in 2015 with 700 megawatts of power at a cost of 580 million dollars (Wong, 2015). Hebei faces problems switching from coal to cleaner energy due to the high proportion of energy used by industries supplying the city's economic development. In 2011, secondary industry made up 81.3 percent of Hebei's total energy consumption (Chen & Fung, 2016).

As a result of the lack of effective cooperation between the regions, unused energy capacity from one region is not currently being transferred to other areas. According to the China Wind Energy Development Report, 20 percent of wind energy produced was wasted (Zeng et al., 2014). The total unused wind energy from 2014 to 2016 is equal to the total electricity consumption of Beijing in 2015 (China Industry Investigation, 2017). Similarly, 12.6 percent of solar energy is wasted every year due to lack of dispatch across provinces (Photovoltaic Industry Annual Report, 2017). There is great potential for energy structure transformation in Jingjinji area. The full capacity of these resources is not effectively shared across provinces (Li et al, 2015). Hebei has the second largest capacity to produce wind energy at 11 percent of China's total wind power capacity ranking right after Inner Mongolia (Zeng et al., 2014). Additionally, in 2014, Hebei only exploited 20 percent of total geothermal energy reserves (Li et al., 2015).

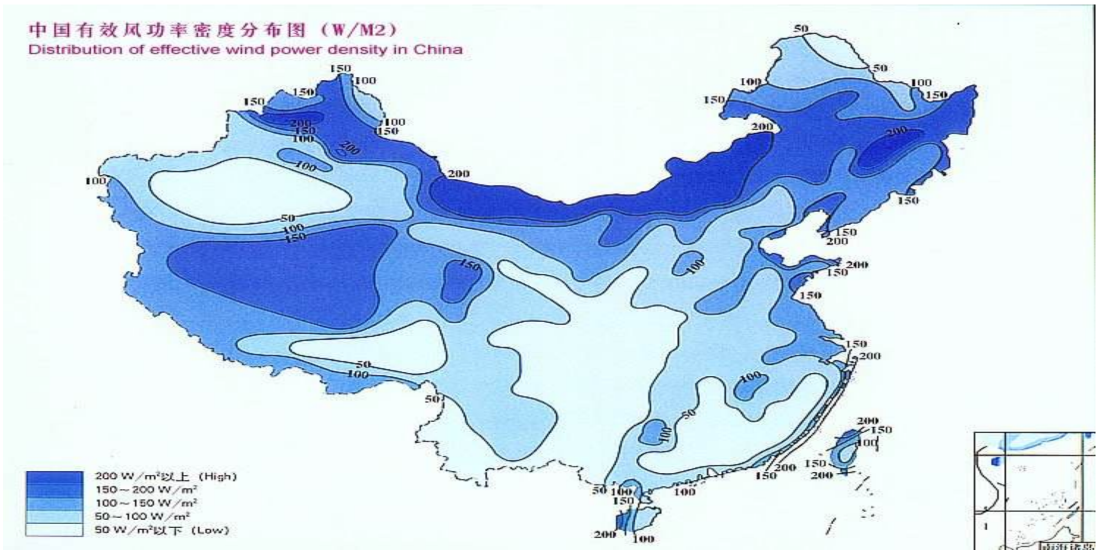

FIGURE 13 DISTRIBUTION OF EFFECTIVE WIND POWER DENSITY IN CHINA; (WWW.TECH-DOMAIN.COM)

China's dependency on coal factories for economic growth is an obstacle that future energy policies must address. The way China's state-owned economy is currently structured encourages provinces to internally manage their own energy resources to create jobs and stimulate economic growth (Wong, 2015.) Therefore, economic stability reduces the attractiveness of switching to clean energy in provinces, such as Hebei, that are dependent on coal to maintain employment rates.

B. Recommendations

Due to the complexity and magnitude of Jingjinji's energy and pollution crisis, multiple recommendations should be implemented to accelerate the switch to cleaner energy. Implementation of these recommendations should not be mutually exclusive.

1. Increase Collaboration- REC and RTO

A collaboration system between provinces to incentivize making the switch to cleaner energy should be implemented. The Jingjinji region should create a Regional Transmission Organization (RTO) potentially modeled after similar programs in the United States. The RTO would be an independent governing entity that controls and monitors the electric grid in China's northern provinces including the Jingjinji and Inner Mongolia. Incorporating Inner Mongolia in the Regional Transmission Organization would help the Jingjinji exploit excess wind energy available in northern China（Zeng et al., 2014). The RTO would be in charge of managing the distribution of resources in these four areas ensuring available clean energy capacity is maximized by consolidating control into one governing entity. This option would require regional collaboration through the RTO to build a high-voltage electric transmission system with large scale transmission lines connected to regions with an excess supply of energy generation.

U.S. Regional Transmission Organization

In the United States, the Federal Energy Regulatory Commission issued an order allowing the creation of Independent System Operators ("ISO") and Regional Transmission Organizations ("RTO") (FERC, 2017). These groups are given authority to regulate and control assigned areas of electrical transmission and/or generation resources (FERC, 2017).

One example of an RTO in the United States is the Pennsylvania New Jersey Maryland RTO known as PJM, which controls the power grid in thirteen states (PJM, 2017). PJM is the primary system operator, controlling the dispatch of generation resources, operating an active energy market, and planning transmission of resources on a multi-state basis (PJM, 2017). Since 1997, when PJM became the first Federal Energy Regulation Commission approved RTO, PJM has grown from three states to utilities in thirteen states (PJM, 2017.). Through PJM, states operate their energy systems in a coordinated effort achieving significant cost savings through a combination of measures such as more efficient use of investment in generation, energy cost savings, and energy reliability savings. PJM estimates annual savings at approximately $3 billion, (PJM, 2017).

PJM, and other RTOs, have worked well to achieve a more efficient electric grid since their inception. Despite this, there are some drawbacks of an RTO. One of the primary drawbacks of an RTO is that individual states or utility companies must cede some control of its resources. Additionally, since PJM is the primary system planner, decisions on approved projects such as the location may have local economic impacts compared to an individual state's preference.

Additionally, an RTO-style model would provide a platform for the use of renewable energy certificates in China similar to the Renewable Energy Certificate (REC) system used in the United States. The RTO should set standards for clean energy use in the region and the REC system to track each region's progress toward clean energy standards. Renewable Energy Certificates ("RECs") refer to a marketable instrument that conveys an attribute of being cleanly produced. These attributes are documented in a numbered certificate that can be bought or sold. RECs allow the "clean" attribute of energy to be separated from the physical energy (United States Environmental Protection Agency, n.d.). RECs enable areas with few clean energy resources or development to purchase attributes from other regions. This would be a particular benefit to the Jingjinji region because Tianjin is energy dependent while nearby Hebei and Inner Mongolia have an excess of wind and solar capacity. China can learn from the United States REC case study by implementing REC tracking uniformly across the region, clearly defining clean energy sources and their weights when measuring progress.

U.S. Renewable Energy Markets

In the United States, the Renewable Energy Certificate (REC) system has successfully aided in motivating the switch to cleaner energy and tracking regional progress. A REC is generated for each MWh of energy produced from defined clean energy sources (solar, wind, hydro, etc.). These attributes are documented in a numbered certificate that can be bought or sold. RECs allow the "clean" attribute of energy to be separated from the physical energy (United States Environmental Protection Agency). RECs enable states with few clean energy resources to purchase clean energy attributes from other areas of the country (O'Shaughnessy et al., 2016).

To supplement the REC system, states created mandatory Renewable Portfolio Standards (RPS). Twenty-nine states have existing RPS, with more than half of clean energy generation since 2000 attributable to an RPS (Barbos, 2016). These standards set the state's goal for how much electricity generation comes from clean energy sources (Barbos, 2016). RECs are the underlying method used to monitor and track RPS compliance, as well as the method energy companies use to meet compliance either by generating their own clean energy and/or buying RECs. In 2015, about 42.5 million MWhs of RECs were sold, up from 20 million in 2010 (O'Shaughnessy et. al, 2016).

While the United States REC system increased the use of clean energy sources, a few issues still exist. Some states have not created a REC system and have no Renewable Portfolio Standards. Each state implements its RPS differently. For instance, certain technology, such as hydro, counts as a clean energy in one state but not another (Barbos, 2016). As a result, clean energy in the United States is developing non-uniformly, though this coordination could be improved through progressive energy policy creation.

2. Invest in research and development focused on battery storage and nuclear energy.

Another recommendation is to invest in the research and development of new green energy technologies. Two areas of clean energy stand out as markets where China has the opportunity to become a leader in development and production: nuclear and energy storage.

For nuclear energy, high initial costs, concerns over safety, and waste management are primary factors preventing development in the United States (Bullis, 2013). Currently, China is set to overtake the United States as the country with the largest nuclear power capacity, signaling the optimal time to invest in nuclear energy in the Jingjinji region (Stapczynski, 2017). Selling the surplus of energy would help offset the slowdown in Jingjinji's economy due to coal factory closings. The China General Nuclear Power Corporation plans to export nuclear technology and sell the surplus of energy (Stapczynski, 2017). Building a nuclear power plant would use 3,500 employees during the construction period and would require a supply of resources already available in the region such as steel (The Nuclear Energy Institute, n.d.). A downside to this option is the jobs created by developing a nuclear plant would not be enough to offset the trade-off between closing coal plants and job loss; progress would also have to be made on this elsewhere.

Another research and development recommendation is to build large storage facilities to transmit and share excess energy across provinces. Jingjinji and surrounding areas have the capacity to become leaders in the clean energy movement. This option would need to be implemented in tandem with an RTO to designate a governmental entity to oversee regional energy distribution.

One example of an energy storage facility is the technology being pursued by Tesla.
In a recent interview during "TED 2017" global seminar held in Vancouver, CEO Elon Musk announced Tesla's plan to build four more giga-factories to supply their projected supply demand of lithium ion batteries. Bringing a Tesla factory to the Jingjinji region has the potential to employ ten thousand workers based on the number of employees in Tesla's Nevada factory with the possibility to employ more (Etherington, 2017). The Chinese government should attract Tesla to build a new factory in Hebei province helping to upgrade the current industry and create thousands of jobs for the local citizens offsetting the economic loss from shutting down coal plants.

Tesla Energy Storage System

Tesla Motors Inc. and Southern California Edison unveiled one of the world's largest energy storage facilities, a 20MW, 80MWh battery storage system, part of a massive deployment of grid-connected batteries that regulators hail as key to helping keep Southern California's lights on and reducing fossil-fuel reliance (Cardwell, 2017).

The project is a response to mandates by regulators for utilities in Southern California to secure energy storage to compensate for the troubled Aliso Canyon Natural Gas Storage Facility, which leaked methane for four months beginning in October 2015. The leak forced thousands of residents in the nearby Porter Ranch community from their homes, complaining about headaches, nosebleeds, and other ailments (Penn,2017).

The facility at the utility's Mira Loma substation in Ontario contains 398 Tesla PowerPack units on a 1.5-acre site, which can store enough energy to power 2,500 homes for a day or 15,000 homes for four hours (Penn, 2017). The utility will use a collection of lithium-ion batteries to gather electricity at night and other off-peak hours enabling the electrons to be injected back into the grid when power use jumps (Penn, 2017).

Ravi Manghani, director of energy storage for Boston-based GTM Research, said the delivery of the battery systems in a matter of months highlights that energy storage, which continues to drop in price, can be a reliable alternative source of energy during times of high electricity consumption to natural gas peaker plants, which contribute to pollution (Penn, 2017). However, "peaker" plants, which are tapped during high-demand periods, can take two to three years to get through the permitting and building process (Penn, 2017).

In addition to the Tesla-Edison project, storage facilities of similar size are also being rolled out in Southern California by San Diego Gas & Electric with AES Energy Storage. The Escondido system consists of 24 containers hiding nearly 20,000 modules that hold 20 batteries each (Geuss, 2017). A 30MW battery system is capable of storing 120MWh of energy and can serve 20,000 customers for four hours (Geuss, 2017). SDG&E hopes increase energy storage 330 MW by 2030 (Geuss, 2017).

California legislation seeks to ensure that 50 percent of its electricity comes from clean energy sources by 2030 and that greenhouse gas emissions are reduced to 80 percent below 1990 levels by 2050. One of the key issues has been energy storage because solar and wind produce electricity only at certain times. Previously, there was no cost-effective way to retain excess power. However, as demand and competition increase with new development of new technology, energy storage is a clear area of potential for China become a leader in production (Global Climate Leadership Memorandum of Understanding, 2015).

3. **Phase out coal plants in Hebei and replace with renewable energy.**

While Beijing made progress towards switching to cleaner energy by closing coal plants, Hebei's coal production still adversely affecting the region. Building on the recommendation to invest in clean energy technology, Hebei should accelerate their approach to closing coal generation plants. A phased closing of coal generation plants in Hebei would be supplemented by the first two recommendations: increased collaboration to share excess energy and development of new technology such as nuclear energy and energy storage system.

VII. Environmental Governance

The historical focus on "assembly-line" collaboration for multi-region projects in China will not work for long-term successful air quality management. Despite the intent to use a different collaboration model for the Jingjinji region, the current plan does not clearly specify the necessary governance mechanisms to support the achievement of regional air quality goals.

A. Current Status of Jingjinji Air Pollution Governance

Rapid population and industrial growth made air pollution a serious problem in Jingjinji region contributing to adverse effects on health and the overall development of the area (Zhang, Liu, & Li , 2014). In order to address this problem, the State Council published the Jingjinji and Surrounding Area Air Pollution Action Plan Enforcement Regulation in 2013 which mandated that Beijing-Tianjin-Hebei reduce their 2012 levels of $PM_{2.5}$ by 25 percent by 2017. The plan also set reduction goals for other regions in the same air basin area, including 20 percent for Shanxi-Shandong , and 10 percent for inner Mongolia (State Council, 2013). Further goals stipulate that by 2020 total consumption of primary energy should be reduced to less than 5 billion tons of standard coal, carbon dioxide emissions per unit of GDP should be reduced by 40-45 percent and all small coal-fired boilers shall be eliminated (State Council, 2013).

FIGURE 14 STRUCTURE OF JINGJINJI AIR POLLUTION CONTROL GROUP

The central government set up the Jingjinji Air Pollution Control Group In order to monitor the air quality management actions and improve the collaboration of different sectors (ZGYJGL, 2016). This group is run by the mayor of Beijing, Guo Jinlong, and is composed of seven provinces and municipalities (Beijing, Tianjin, Hebei, Shanxi, Shandong, Henan, and inner Mongolia province) and nine ministry departments (agriculture, transportation, environmental protection, industry and information, housing, rural and urban development, and national reform and development commission, national meteorological administration and china energy administration)(Huanqiu, 2015). The board has four standing committee members, the mayors of: Beijing, Tianjin, Hebei, and the minister of MEP (Huanqiu, 2015).

This board is tasked with unified air pollution regulation. It seeks to promote industrial upgrading and accelerate green technology development as well as improve the legal framework, implementation, and enforcement to reach the region's air quality goals (Huanqiu, 2015). To begin to meet these goals, the Jingjinji Coordinated Development Group has taken action by shutting down or moving 1,300 highly polluting factories and inefficient factories (MEP, 2017). Despite this effort, Beijing is the only area in the region on track to meet the required 25 percent reduction set by the State Council.

B. United States: California Air Quality Management

The state of California has suffered from significant pollution, which it must continue to manage. Improvements over the last decades can be largely attributed to horizontal coordination and efforts to remove political influence on regulators, providing a potential model for Jingjinji collaboration.

1. The Environmental Protection Agency and the Clean Air Act

California operates under the federal Environmental Protection Agency (EPA) which manages air quality through the enforcement of national ambient air quality standards (NAAQS) for stationary and mobile sources (EPA, 2017). The EPA's ability to set NAAQs was established by the Clean Air Act of 1970, which specified which pollutants should be monitored based on their impact on health outcomes (EPA, 2017). Ozone, particulate matter (PM), carbon monoxide (CO), inhaled lead, nitrogen dioxide (NO2) and sulfur dioxide (SO2) have been continually monitored under this justification, but standards have been updated since the bill's original passage due to evolving research on their health effects (Howitt & Altshuler, 1999).

Under the Clean Air Act, states must adopt individual state implementation plans to reach or maintain the federally designated NAAQS by specific deadlines (EPA, 2017). The 1977 Clean Air Act amendment adjusted deadlines and sought to address initial state resistance to these measures by threatening to cut large swaths of federal highway funding if states did not adopt inspection programs (Howitt and Altshuler, 1999). Now states submit plans to be reviewed by the EPA. Upon approval, this plan becomes enforceable, meaning that enforcement actions can be taken against violators by either the EPA or the state (EPA, 2017). Civil actions can be taken in the form of a notice of violation or an order, or in court, through a formal civil lawsuit (EPA, 2017). These actions can result in settlements, penalty payments or injunctive relief. Furthermore, criminal charges can be pressed against violators, resulting in penalty payments or even incarceration (EPA, 2017).

2. State of California Air Quality Management

California environmental policy is overseen by the California Environmental Protection Agency (CalEPA). Established in 1991, the CalEPA consists of six offices/departments, of which the Air Resources Board (ARB) is most relevant for this report (CalEPA, n.d.). The ARB sets California air quality standards, going beyond the national standards, and stimulates the development of new technology for industrial facilities and motor vehicles (ARB, n.d.). There are 14 board members on the ARB, six of them are elected officials who represent regional air pollution control agencies, including the South Coast Air Quality Management District (discussed below). The six other members are appointed by the governor and are experts in automotive engineering, science, agriculture, health and air pollution control. Two additional members are appointed by the Legislature, one each from the Senate and the Assembly (ARB, n.d.). Members serve staggered six year terms, but can serve more than one term if approved by the appointing body.

The board holds monthly meetings that are open to members of the public who may also testify on items of interest. Furthermore, full meetings are broadcasted and transcripts are made available on the website (ARB, n.d.). The easily accessible records provide the public with a transparent view of what the ARB has accomplished and what efforts it continues to make.

This board oversees the activities of 35 local and regional air pollution control districts in California. These agencies regulate industrial pollution sources, issue permits and develop local plans to ensure the industries in the area adhere to the air quality mandates (ARB, n.d.).

a. Local Level Coordination: Southern California Air Quality Management

Los Angeles, and Southern California more broadly, has struggled with air pollution issues since the early 1900s partially because its geography makes it particularly vulnerable to trapped air (AQMD, 1997). However, the problem worsened when World War II increased industry in the area, accompanied by an increase in population and cars. In 1947, Los Angeles created the first air pollution control program in the country, but a lack of coordination prevented extensive progress (AQMD, 1997).

This problem was eventually addressed in legislation passed in 1977, when the California state legislature created the South Coast Air Quality Management District (SCAQMD), bringing Los Angeles and three nearby counties (San Bernardino, Orange and Riverside) together for air quality management purposes (AQMD, 1997). The SCAQMD coordinates efforts through a diverse board, of thirteen representatives (three appointees and ten elected officials from the area) (AQMD, 2017). The representatives work to prepare the Southern California region's section of the State Implementation Plan (AQMD, 2017). Again, this diversification of members is intended to reduce political pressure on the regulatory body.

Through this regulatory structure, California's economy continues to expand as it leads the way on environmental innovation in the United States. Between 1990 to 2015, California's population increased by 29 percent, registered vehicles increased by 32 percent and the economy grew by 83 percent (CAPCOA, 2015). During the same time span, statewide emissions of smog-forming pollutants decreased by over 50 percent. In addition, emissions of toxic air contaminants and the resulting cancer risk to residents have been cut by 80 percent since 1990 (CAPCOA, 2015). Challenges remain, particularly in Southern California, where the SCAQMD continues to struggle to meet federal standards. Still, air quality has generally improved each year (Figure 15).

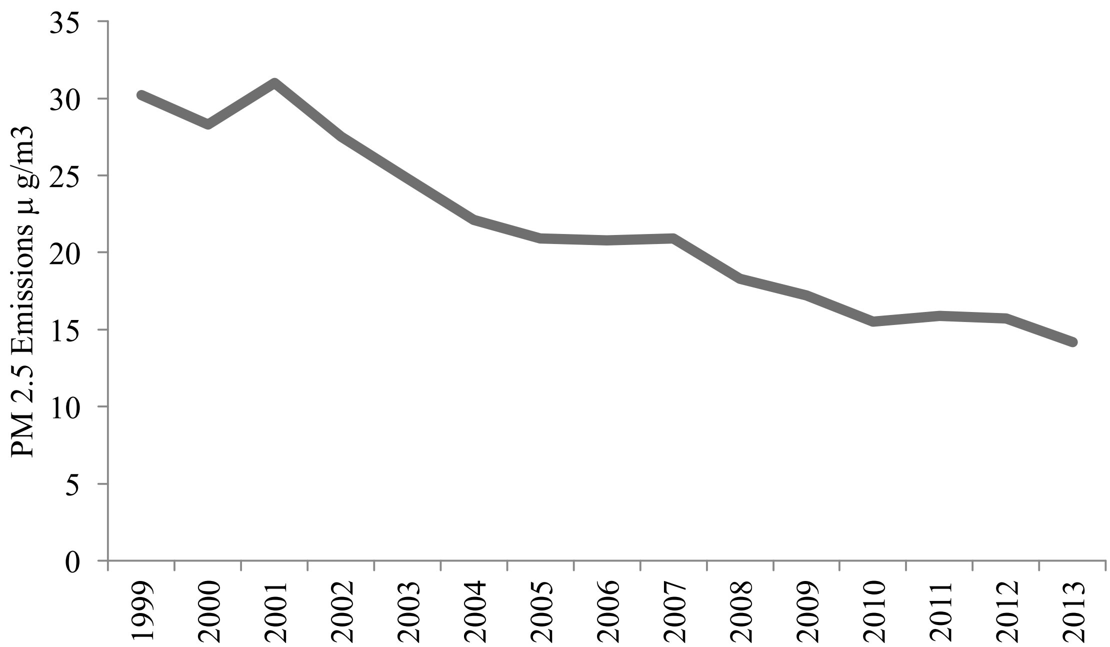

FIGURE 15 SOUTH COAST MAXIMUM ANNUAL AVERAGE OF $PM_{2.5}$ EMISSIONS; (CALIFORNIA AIR POLLUTION CONTROL OFFICER' ASSOCIATION, 2014)

C. Recommendations

The Jingjinji Plan sets progressive environmental standards for the region and seeks to link provinces together to meet the goals. However, the plan seems to lack the actual coordination mechanisms to ensure its success. Using the models of the previously analyzed cases, some best practices can be implemented to ensure cooperation between not only the regions but the central governmental bureaus that work on environmental issues.

1. Create an Independent Regulator for the region

The Jingjinji Plan sets progressive environmental standards for the region and seeks to link provinces together to meet the goals. However, the plan seems to lack the actual coordination mechanisms to ensure its success.

The state of California provides a valuable example of possible structure improvements to ensure successful environmental regulation in the Jingjinji region. Much like in China, California's general standards are set by the EPA at the federal level, largely under the structure created by the Clean Air Act of 1970 and its subsequent amendments. As previously mentioned, under this law, California is permitted to set stricter standards that go beyond those of the federal government.

This structure is valuable, but would be ineffective without the specific bodies that California employs to make sure that regulations are met. The most important of these bodies in regards to air pollution is the Air Resources Control Board. As, appointments to this body are distributed to ensure its independent nature, meaning that it cannot be swayed by any one specific political party or pressure. It is this board that ensures that the state meets its federal and state obligations.

It is recommended that China create what would be a regulatory body similar to the previously mentioned Air Resources Board of California. This independent structure would be incredibly unusual for China, but would ensure that enforcement could not be swayed. The breakdown of board membership could be varied based on decision makers' preferences, but should likely include government members and public representatives, as well as scholars within public health, transportation, urban design and the environment. If necessary, this body could include a limited number of party leaders, though this would create political pressure that seems antithetical to the model. Regardless of its composition, this body must be empowered to cite violations of environmental standards and push changes. Furthermore, their meeting conversations and decisions should be shared publicly to promote greater government transparency.

2. Develop a Regional Air Quality Grant Fund

The Jingjinji region currently operates under a structured top-down chain of command by the state council, but with poor cross-regional horizontal coordination. We think that minor changes in the structuring of cross-regional goals can help local governments, and the region as a whole, meet their targets.

One recommendation would be to set up a grant pool for environmental projects, the funds for which would be derived from all provinces and municipalities in the Jingjinji cooperative region. We propose that the source of revenue would come from land tax, tradable permits or penalties from polluting industries. The mutual fund can work in two different ways. It can be used as a reward to the local government actively involved in air quality management. Or the fund can also be used to serve underdeveloped areas where technological upgrades and educational training programs are needed. These initial suggestions require further research into the model of best fit for the Jingjinji region.

3. Promote open data and government transparency

Open government is the doctrine which holds that citizens have the right to access the documents and proceedings of the government to allow for effective public oversight (Lathrop, 2010). This has not been the approach of the Chinese government, but they have made a recent effort to share more data. In 2015, the State Council released the Big Data Development Action Plan, which explicitly recognizes that this sharing could promote economic and governance improvements (Ma, 2017). The Plan has yet to lead to any major changes, though the Ministry of Environmental Protection has begun to share more freely (Ma, 2017). Still, this current open data effort, amongst others, continues to suffer from low quantity, low value, and low machine readability, as well as infrequent updating (Zheng & Gao, 2016). Furthermore, convenient channels for data accessibility and convenient, timely, effective and open interaction with users is low (Zheng & Gao, 2016).

Data needs to be made more widely accessible to researchers and the public, providing for analysis and understanding of important policy issues. Most importantly for air quality regulation, opening up data will facilitate coordination between relevant agencies, municipalities, and regions that need to first understand the problem before they can work together on applicable solutions.

If a governmental open data platform is not possible, we recommend that third parties, specifically universities, and perhaps other NPOs, can assist in creating a platform for sharing and disseminating environmental data. The World Bank has long sought to provide open data through its platform and could perhaps be a supporting body in this effort.

4. Build a Jingjinji Regional Air Quality Scenario Planning Tool

Building a scenario planning tool would help decision makers better account for the uncertainty of future environmental conditions and policy contexts in the Jingjinji region and beyond. Urban Footprint and other similar tools have been utilized by many governmental bodies throughout the world, including by a number of agencies in California, including the Air Resources Board.

This type of tool can be especially useful in meetings with stakeholders from different sectors, encouraging discussion and collaboration and ultimately allowing all participants to see possible outcomes in real time. While these tools currently exist for specific sectors, we recommend the creation of a new option tailored to the specific needs of the Jingjinji region. It should allow for the linkage of data for land use, energy, industry, and transportation policies and allow scenarios to encompass multiple sectors and municipalities. The Clean Air Alliance of China is currently using the USEPA Community Multiscale Air Quality model for the emission prediction and could perhaps be a valuable partner on this initiative. The World Bank could also be instrumental in setting up this tool for use throughout China, enabling cross-sectoral and cross-regional collaboration.

The Urban Footprint Scenario Planning Tool in California

The San Joaquin Valley in central California has successfully used scenario analysis to seeks improvements to its air pollution levels. It is one of the largest contiguous regions in the US continuously violating annual average NAAQS PM 2.5. With the population expected to double over the next 25-50 years (Hixon et al., 2010). This leads to changes in patterns associated with transportation, energy, and industry which can potentially lead to a rise in air pollution (Hixson et al., 2010). A summary of the region's scenario analysis can be seen below (Figure 16).

Scenario 1 "Population Growth"	Scenario 2 "Compact Growth"	Scenario 3 Urban Sprawl	Scenario 4 "Planned Growth"
• Moderate population density; no land use change • Existing roadway network; no high speed rail • No new emission controls	• Highest population density with tight land use restrictions • High speed rail • Additional emission controls	• Sparse population density with unrestricted land use • No high speed rail • No new emission controls	• Moderate population density with planned land use changes only • 2030 roadway network; high speed rail • Planned emission controls only

FIGURE 16 GENERAL ASSUMPTIONS OF SAN JOAQUIN VALLEY'S SCENARIO PLANNING TOOL; (HIXSON ET AL., 2010)

Hixson et al. (2010) described each scenario:

Scenario 1 reflects existing land use patterns and transportation infrastructure but with population growth and employment growth.

Scenario 2 is a case defined by compact urban footprints including a redevelopment of existing urban centers to increase population density. This includes investments in infrastructures such as high-speed rail, and adoption of clean technology/policies that can lead to reduced emissions.

Scenario 3 allows sprawling developments in the SJV and all planned investments in highways with little adoption of new technologies or policies to reduce emissions.

Scenario 4 reflects existing land use and transportation plans as well as policies related to technology change that are likely to be adopted.

This scenario analysis helps decision makers conclude that compact, high-density urban development combined with rigorous pollution control measures at the local level could significantly reduce regional PM concentrations. The tight restrictions policies on land use and high-speed rail adoption led to the reduction of PM 2.5 concentrations (Hixson et al., 2010).

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