How Green Public Procurement Contributes to Sustainable Development in China

EVIDENCE FROM THE IISD GREEN PUBLIC PROCUREMENT MODEL

IISD International Institute for Sustainable Development

MAVA FONDATION POUR LA NATURE

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October 2015
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Any errors or omissions remain the responsibility of the authors.

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Executive Summary

ABOUT THIS PROJECT

The People's Republic of China spent more than CNY 1.6 trillion (USD 252 billion) on procurement in 2013, accounting for 11.7 per cent of all national spending (Ministry of Finance of the People's Republic of China, 2014). In light of these numbers, the potential environmental, social and economic multipliers of greening government purchases become evident. The benefits of a comprehensive and efficient green public procurement (GPP) policy are not limited to the green products and services the public sector buys, but will have a ripple effect that encourages green consumption nationwide. The significant purchasing power of the government will provide the much-needed incentives in order for businesses to invest and innovate in green products and services to meet the government's guaranteed long-term and high-volume demand. Additionally, GPP is in line with China's national plans to pioneer "eco-civilisation" and with the upcoming 13th Five-Year Plan (FYP), which underlines the importance of GPP.

This paper is the second and final component of IISD's contribution to greening public procurement in China. Our discussion paper *Green Public Procurement in China: Quantifying the Benefits*, published in April 2015, analyzed China's GPP landscape, taking a closer look at current practices, actors at different levels of government and the underlying legal framework. In addition, the paper introduced the IISD GPP Model, discussing its potential for quantifying and communicating the benefits of GPP, while providing a high-level overview of the modelling approach used and of the scope of the model envisioned.

Building on the results of the IISD GPP Model, consultations with stakeholders and an extensive literature review, this paper provides targeted recommendations addressing the development areas identified to improve GPP in China. The recommendations follow a multi-phase approach offering more immediate solutions as well as more ambitious, larger-scale overhauls of the GPP framework for the long term.

The results of the IISD GPP Model will be shared for the first time as part of this paper, making the case for green procurement through analyzing five product categories: air conditioners, lighting, cars, paper and cement. These categories were selected because they represent significant financial flows in procurement, have notable environmental impacts and domestic production, and have sufficient data available to facilitate their analysis. A detailed overview of the key elements of the modelling approach will be provided, in addition to an explanation of the model setup and the range of externalities monetised for each product category. Finally, we will look at how to use the model at the different levels of government as well as how its scope can be extended and customised in order to leverage its potential under a wider range of circumstances and areas of procurement.

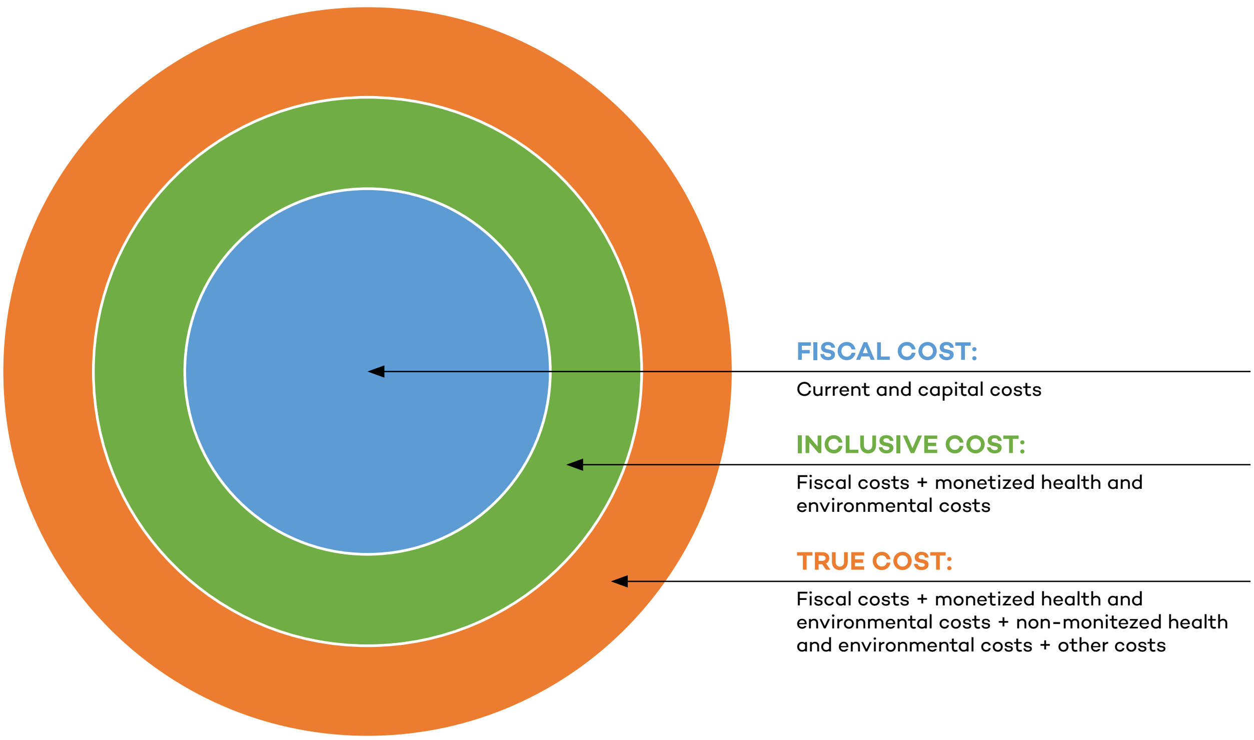
THE IISD GPP MODEL AND ITS FINDINGS IN CHINA

The IISD GPP Model is built using a system dynamics approach. It conducts sensitivity analysis to test how particular modelling choices and assumptions may be driving results, and employs Monte Carlo analysis to create results that are reflective of the degree of uncertainty associated with key model parameters.

The model investigates the impact of GPP in the five product **categories of air conditioners, lighting, cars, paper** and **cement**. Model results are usually presented for the period **2015–2030**. However, in certain cases results until 2050 are presented and discussed.

The model focuses on the **inclusive cost of procurement** by considering both the fiscal and non-fiscal costs associated with government procurement (see Figure 1). Non-fiscal costs included in the model focus on the health and environmental impacts of pollution resulting from the production, use and disposal of products. Monetisation figures for **environmental and health costs** are drawn from the relevant literature on the subject, with China-specific figures used as much as possible. Information on the sources and methods used to estimate this and other model inputs is available in this report's Technical Annex.

Figure 1: The fiscal cost, inclusive cost and true cost of GPP



For each product there are three types of modelled scenarios: **Baseline, Light Green, and Dark Green:**

BASELINE SCENARIO

Uses existing procurement policies and practices to access the current impacts of public procurement in China and how these impacts are expected to evolve

Provides a snapshot of current impacts and serves as the basis for comparison for the Light Green and Dark Green scenario

LIGHT GREEN SCENARIO

Defines an increased level of ambition in GPP, but one that aligns with current standards and for which implementation is believed to be straightforward and realistically achievable

Describes what will happen if China implements GPP using slightly higher standards, or implements it more fully using current standards

DARK GREEN SCENARIO

Models more stringent procurement standards or levels of implementation than are currently practiced or planned, but for which implementation is believed to be feasible

Describes what would happen if China were to increase the stringency and/or ambition of its GPP implementation

Under each scenario, the same estimates and projections for the national aggregate **scale of procurement** in the product category are used, with different levels of GPP ambition and stringency applied in order to assess associated impacts on fiscal, health and environmental costs. The products that are used in the model and their characteristics are based on real goods available in the Chinese marketplace, and the modelled scenarios draw on actual standards and practices in place or planned in China, as well as some international standards. In addition, China-specific data is used to model the present and projected price and emissions intensity of electricity and gasoline in order to produce findings that are rooted in and specific to the Chinese context.

PRODUCT	BASELINE SCENARIO	LIGHT GREEN SCENARIO	DARK GREEN SCENARIO
Air conditioners	Air conditioner procurement is 100% third tier[1]	Air conditioner procurement moves to 100% second tier, over a period of three years	Air conditioner procurement moves to 100% first tier, over a period of three years
Lighting	Lighting procurement is two-thirds compact fluorescent lights (CFL) and one-third LED	Lighting procurement moves to 100% LED, over a period of three years	Lighting procurement moves to 100% LED with smart switches, over a period of three years
Cars	Procurement of hybrid and electric cars remains in line with the broader market average (>99% gasoline)	Procurement of hybrid and electric cars moves to 30% (15% each), over a period of five years (based on gov't policy)	Procurement of hybrid and electric cars moves to 60% (30% each), over a period of five years
Paper	Procurement of recycled paper remains in line with estimates of the broader market average (<1% recycled)	Procurement of recycled paper moves to 20%, over a period of five years	Procurement of recycled paper moves to 40%, over a period of five years
Cement	Cement procurement is 70% from the third tier and 30% from the second tier	Cement procurement moves to 100% second tier, over a period of five years	Cement procurement moves to 100% first tier, over a period of five years

[1] See section 2.2 of the report for more information on the definitions for and characteristics of the products in the model

As presented in the report, many findings and lessons can be drawn from the IISD GPP Model. A summary of model results for the five product categories is provided below. Results are presented for the both the costs presently associated with procurement in China as well as how they are expected to evolve under the modelled GPP scenarios.

The results of the model show that increased GPP ambition and stringency in China have several benefits. These benefits include energy cost savings, avoided health costs and avoided environmental costs, in addition to other non-modelled but notable benefits, such as green innovation, market development and green industry development. Over the model's time horizon, the extra costs associated with realizing these significant benefits only exceed 20 per cent in one instance, and in some cases are even negative—meaning that, for some products, with time, GPP will pay for itself. The model does not speculate about future technologies and product prices, but it is reasonable to expect that ongoing market innovation will lead to further reductions in environmental impact and lower prices, and that therefore the extra fiscal cost associated with GPP for some products is likely to be even smaller than what is presented in the model results.

Figure 2 shows how the costs of procurement break down in China by comparing products' health and environmental costs to their direct fiscal costs. There is considerable variation in terms of how phow these costs compare across products. For example, CNY 1 of procurement spending on cars in China is estimated to lead to CNY 0.87 of health and environmental costs—the highest of all the product categories;However, it should be noted that these costs are expected to fall in 2018 when the new fuel standard introduced in the country significantly lowers the sulphur content of gasoline.[2]

Figure 2: Health and environmental costs associated with CNY 1 of procurement spending (estimate for 2015)

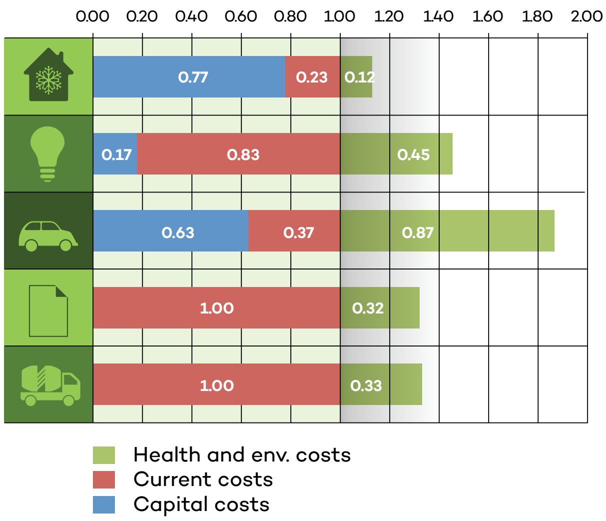


Figure 3 shows the total fiscal versus inclusive absolute cost of procurement in each of the five product categories under the baseline scenario. As seen in the figure, cement has, by far, the largest aggregate cost, mainly due to the extremely large scale of cement procurement in China. This category also has notable health and environmental impacts, which account for approximately 24 per cent of its total inclusive costs. It should be noted that the results seen in this figure are only indicative, since the procurement figures that are used in the model rely on proxy data and assumptions, due the limited reliable data available on aggregate procurement expenditures in China.[3]

[2] The introduction of this standard explains the drop in inclusive costs for cars that is seen in Figure 3 below in the year 2018.

[3] See the Technical Annex for more detail on sources and methods

Figure 3: Total fiscal versus inclusive costs of procurement under the baseline scenario

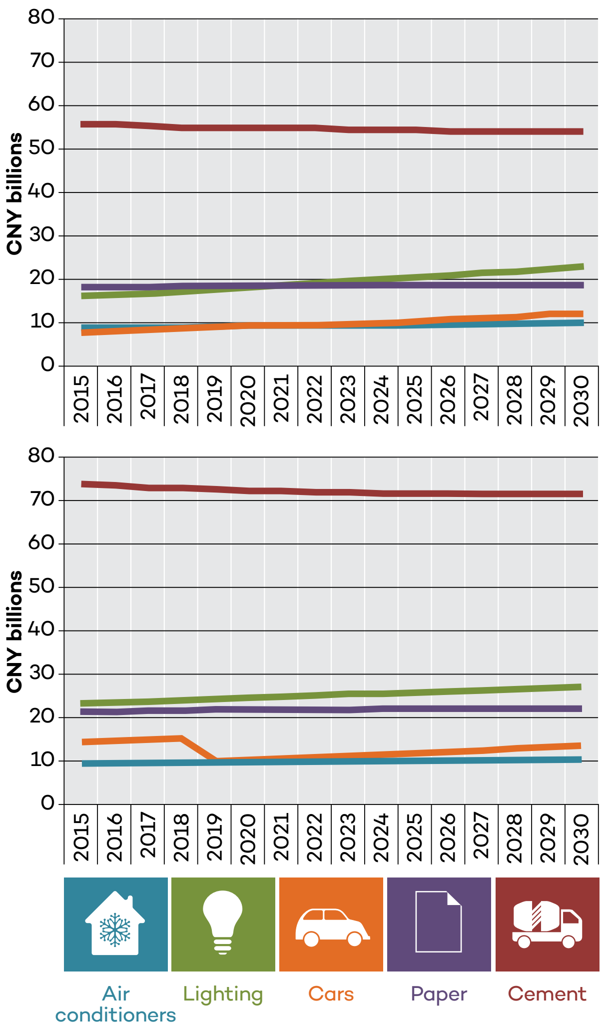


Figure 4 beside provides an overview of the avoided health and environmental costs associated with implementation of the Light Green and Dark Green scenarios. The procurement of more sustainable grades of cement in China would be associated with significant health and environmental cost savings due to the very large scale of procurement in the sector. Other products have comparatively smaller impacts, either because the scale of their procurement is comparatively small (e.g., cars), or because the difference in environmental impacts between the regular good and the green alternative is comparatively small (e.g., air conditioners, which are in fact affected by both drivers).

It should be noted again here that not all types of known environmental impacts could be modelled and that, therefore, some of the values seen in Figure 4 may be underestimated. For example, only the environmental impacts associated with the usage phase were modelled for air conditioners, since production and disposal-phase impacts (which some have estimated to be as high as 30 per cent of total impacts) could not be reliably quantified and monetized.

Figure 4: Total discounted health and environmental costs savings under the Light Green and Dark Green scenarios for the period 2015–2050

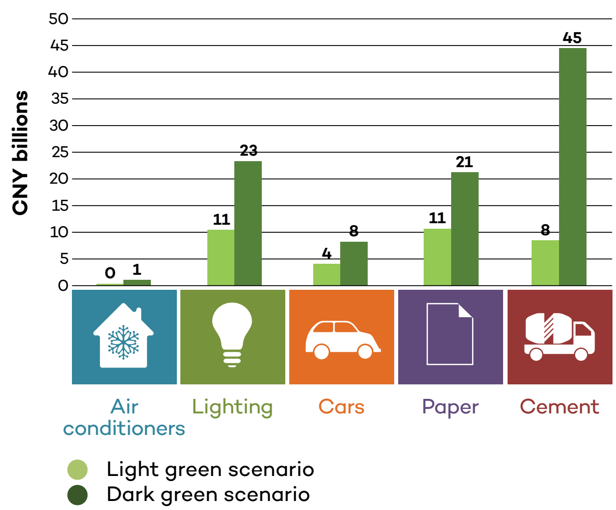


Figure 5 provides additional context to the results seen in Figure 4, showing the cumulative GHG emissions mitigation over the period 2015-2030 that results from increased GPP ambition in each of the product categories. GPP in cement is notable here as well in terms of its potential impacts.

Figure 5: Cumulative GHG emission mitigation associated with the Light Green and Dark Green scenarios for the period 2015-2030

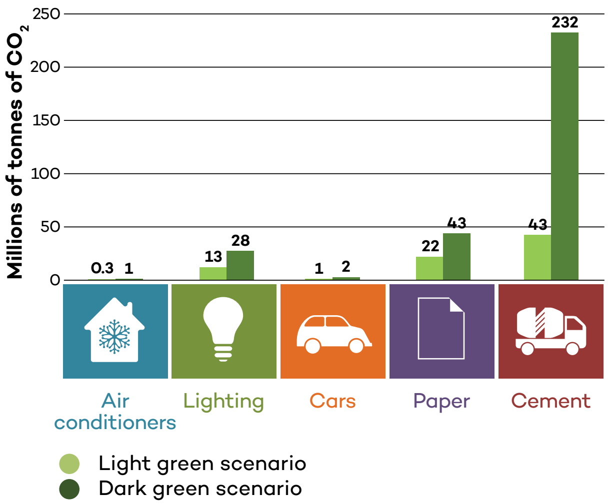


Figure 6 provides a summary of inclusive costs for each of the product categories under the three model scenarios. It uses present value discounting to provide an integrated picture of the total inclusive cost of procurement under each scenario for the period 2015–2050. Figure 7 provides the same information using levelized costs.

Figures 6 and 7 show that, in the product categories of lighting, cars and paper, increasing the level of ambition and stringency in GPP policy and implementation is less expensive from an inclusive cost perspective than employing comparatively less stringent or ambitious GPP practices—in other words, GPP in these product categories pays for itself with time.

On the other hand, for air conditioners and cement, there are increased costs associated with the Light Green and Dark Green scenarios. Therefore, there is a "cost of GPP leadership" in these categories in the sense that increasing the level or stringency of GPP does not pay for itself in the form of energy savings and avoided health and environmental costs, according to the results of the model. Therefore, realizing the benefits that are presented in Figures 6 and 7 for these categories, as well as other benefits such as green innovation, market development and green industry development, will require a degree of investment on the part of government. However, because of the large scale of the private market for air conditioners and its associated impacts, and because of cement's significance as a major contributor to China's national GHG emissions inventory, these product categories are key GPP policy-making spheres. Therefore, GPP leadership in these categories is an important investment and policy action, despite higher fiscal costs. Furthermore, because some types of impacts could not be reliably quantified and monetized in the model, it is likely that the investment required for government to provide leadership in these categories is overestimated, and that the cost of GPP leadership in these will therefore not be as large as it appears in the model results presented below.

Figure 6: Total inclusive discounted cost of procurement under the baseline, Light Green, and Dark Green scenarios for the period 2015–2050

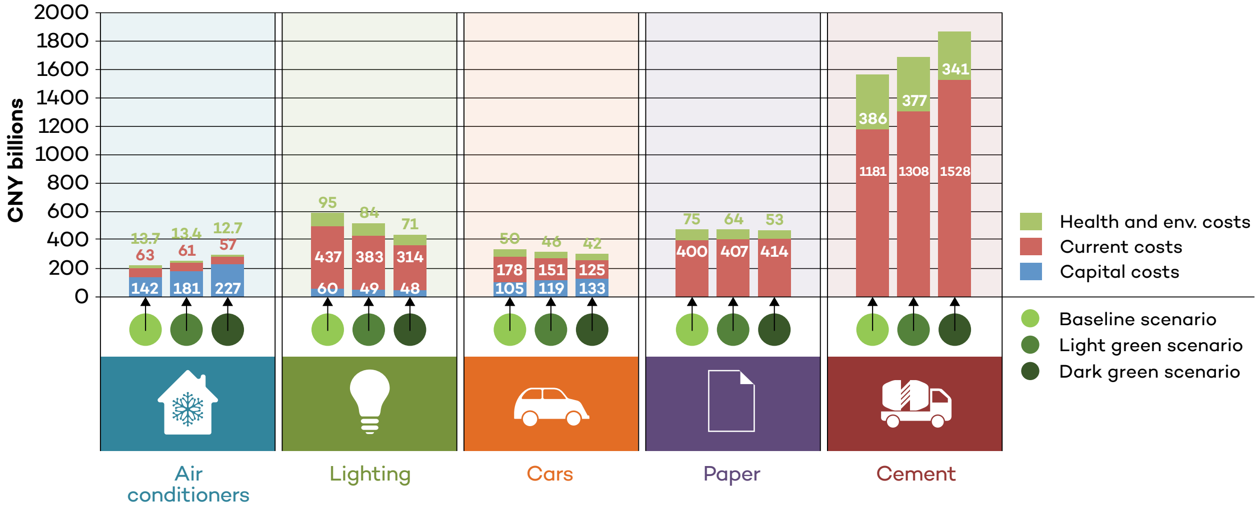
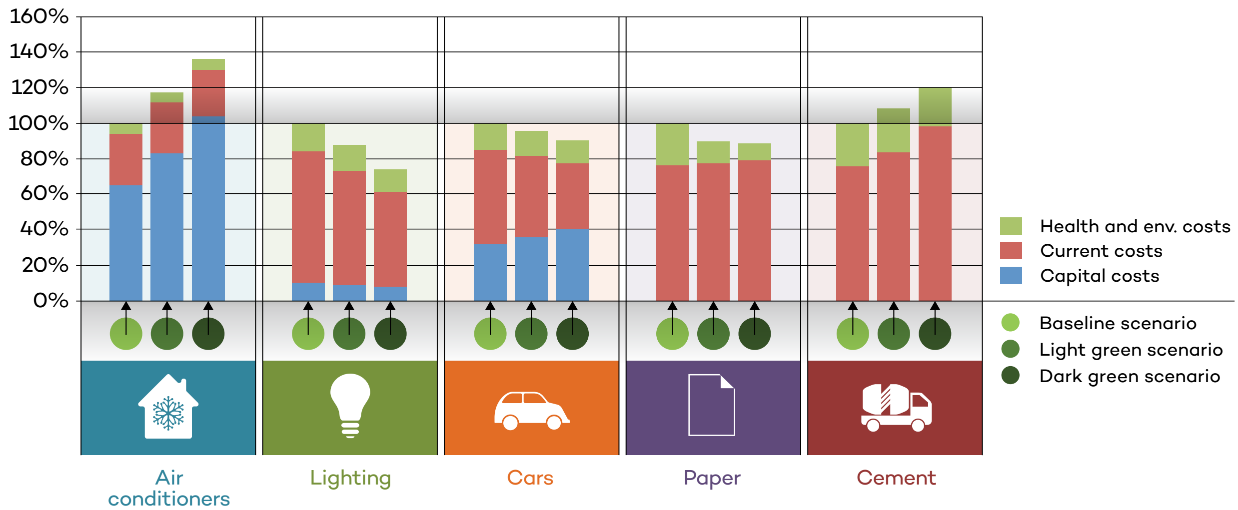


Figure 7: Total inclusive discounted cost of procurement under the baseline, Light Green, and Dark Green scenarios for the period 2015–2050 (levelized costs view)



Enhancing the Implementation of GPP in China Using the Findings of the IISD GPP Model Drawing from the findings of the IISD GPP Model and the knowledge IISD acquired in developing the model and in engaging with policy-makers, businesses and public entities, 13 recommendations on enhancing the implementation of GPP in the immediate term are proposed.

RECOMMENDATION 1: Include GPP in the 13th FYP that covers the period 2016–2020. IISD anticipates that GPP will be prioritized in the 13th FYP and commentators have further suggested that it will be positioned as the solution in the Third Plenum goal on reducing risks related to climate change and the implementation of low-carbon development (National Development and Reform Commission NDRC, 2014).

RECOMMENDATION 2: Make GPP mandatory for state-owned enterprises (SOEs). Given the spending power of these large enterprises, many of which are also global leaders in their respective sectors, the entire global economy stands to gain if these entities would also implement GPP. For example, the IISD GPP Model indicates that if SOEs were mandated to comply with a government procurement goal to transform 30 per cent of public vehicle fleets to low-emission models, the avoided health and environment costs could increase from CNY 200 million to CNY 800 million.

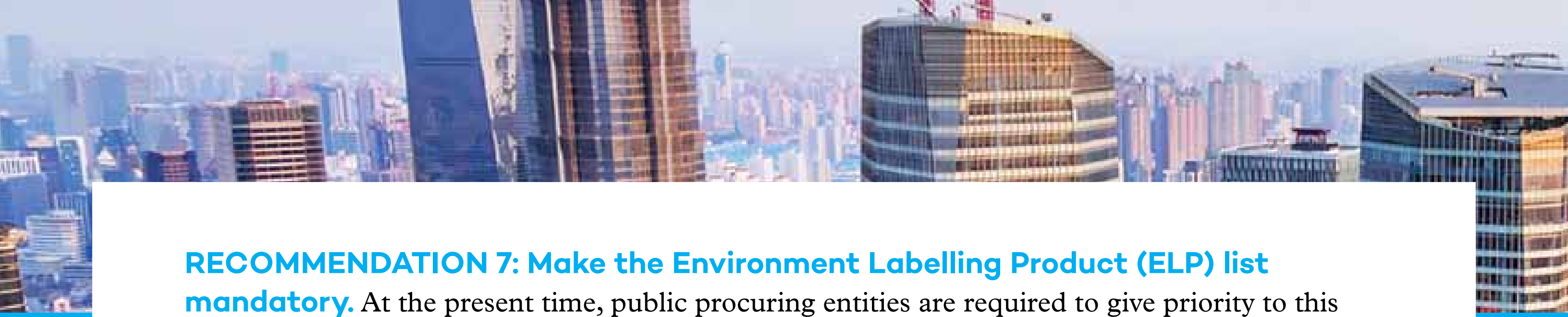
RECOMMENDATION 3: Extend GPP requirements to the commissioning of infrastructure. The Organisation for Economic Co-operation and Development (OECD) estimates that infrastructure spending accounts for at least 3 per cent of a country's GDP and, in China, 59.9 per cent of public procurement is spent on infrastructure. Building materials also have substantial environmental footprints, while the greening of construction will be pivotal in realizing circulate economic growth.

RECOMMENDATION 4: Build on the Synergies Between Green Public Procurement and the Green Credit Guidelines. GCGs could play a valuable role in further upscaling green innovation and investment triggered by the more comprehensive GPP policies recommended in this paper.

RECOMMENDATION 5: Position Green Pubic Procurement as the baseline for expanding markets for Green Infrastructure Bonds. Capital markets should play a bigger role in providing financing to these projects, thereby decreasing the reliance on public funds that could be used more efficiently somewhere else. Bond financing provides a way to access international capital markets and tap a large pool of domestic savings.

RECOMMENDATION 6: Position Green Public Procurement as an priority focus for the Asian Infrastructure Investment Bank.

When structuring sustainable infrastructure projects, there might be a need for some form of credit enhancement to make the deals bankable. AIIB could provide this service in China, especially as the support of sustainable infrastructure development is in line with their mandate of "Lean, Clean and Green." In addition, any deals with AIIB involvement need to meet their high standards for transparency, efficiency and sustainability.



RECOMMENDATION 7: Make the Environment Labelling Product (ELP) list mandatory. At the present time, public procuring entities are required to give priority to this list, which contains 55 product categories. If procurers were legally bound to select from this list, the multiplier gains from GPP could be significantly increased.

RECOMMENDATION 8: Make the already-mandatory Energy Conservation Product list more stringent. The discussion in this report contains evidence that, for photocopiers, refrigerators, panel TVs, washing machines and computer monitors, more than 80 per cent of all available products qualify to be on the Energy Conservation Product list. This indicates that the listing criteria are not co-related with best-in-class energy-efficiency improvements. The IISD GPP Model indicates that if the most energy-efficient models of air conditioners were purchased, the resulting savings in energy efficiency will be CNY 150 million per year.

RECOMMENDATION 9: Make listing requirements and procedures for the Environment Labelling Product list and the Energy Conservation Products reflect best-available technologies. The discussion covers a wide array of evidence to show that the listing and de-listing criteria remain relatively unsophisticated.

RECOMMENDATION 10: Record values and volumes of public procurement as per the categories of major spend. To quote the well-known proverb "You cannot manage what you cannot measure": unless procurers and policy-makers know how much and on what they are spending, they will not be able to assess how GPP optimizes value-for-money. Disaggregated procurement records will also be extremely valuable in increasing accountability and transparency across the public procurement function. Indeed, the largest uncertainties in populating the IISD GPP Model are related to values and volumes of expenditure. IISD finds that there is little reliable information on this in the public and institutional domains.

RECOMMENDATION 11: Job descriptions, terms of reference and performance evaluations of public procurers should contain reference to advancing GPP. If promotions in designation and compensation are linked in part to the practice of implementing GPP, individual procures will have the all-important incentive to proactively seek out greener alternatives.

RECOMMENDATION 12: Position the China Government Procurement Association to lead the debate and implementation of GPP. IISD welcomes the establishment of the association under the auspices of the Ministry of Finance. The association is being positioned as the "voice" of government procurement, to share experience and to enhance the competence of the public procurement profession as a whole. It is therefore suggested that the Association is also positioned to lead the debate and implementation of green public procurement.

RECOMMENDATION 13: Move away from making procurement decisions based on product lists to functional requirements. Basing procurement decisions on product lists encourages procurers to work with a mindset that asks, "What do we want to buy?" rather than "What is the requirement we are seeking to fulfill?" or, indeed, "How can we optimize value-for-money across the product/service life cycle and not purchase the cheapest alternative that will cost more to use and maintain in the longer term?"

THE NEXT STEPS

We have identified certain areas where the IISD GPP Model can be extended in order to improve its output, applicability and coverage of a wider range of public purchases.

1. Improve regional disaggregation – Due to the lack of available data, the model currently uses nationwide averages when monetizing the various externalities. However, the quality of the outputs can be improved if data are available for each relevant region.

2. Extend the scope of externalities – We recognize that other externalities exist that could not be covered in the model at this stage due to the lack of reliable data or difficulties in measuring them. However, various new methodologies are currently being tested by academics as well as non-governmental organizations, providing valuations for a wide range of environmental and social impacts that could be incorporated into future versions of the model.

3. Extend the range of product categories – Making the calculations for a wider range of products could provide a more accurate picture and quantifiable impact of GPP compared to the "business-as-usual" scenario.

Furthermore, the IISD GPP Model is not only an invaluable tool at the procurement level, but it also has a wide range of uses at the national policy-making level. The results of the model could form the basis of new policy initiatives by demonstrating the significance of GPP and providing the necessary arguments for change. At the local level, it also has a wide range of uses, including procurement, capacity building, assessment and reporting.

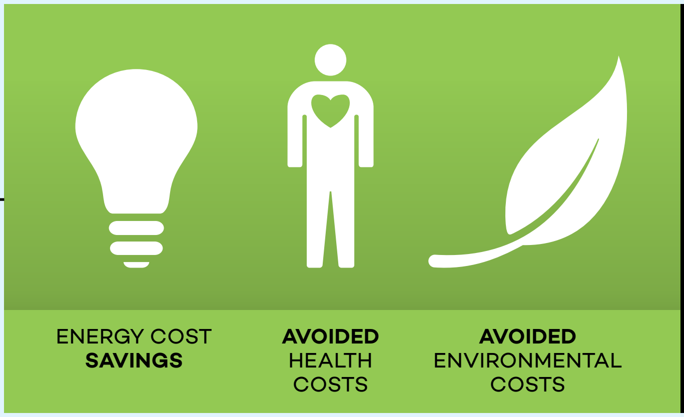
At the time of publication, expectations are high for the upcoming 21st Conference of the Parties (COP 21) in Paris. A universal and legally binding climate agreement is anticipated, focusing on climate change mitigation and adaptation. GPP can significantly contribute to honouring China's commitment to limiting greenhouse gas (GHG) emissions and to upscaling resilient infrastructure development as part of the anticipated COP 21 agreement. The IISD GPP Model gives an accurate picture of the decreased GHG emissions that result from procuring greener products, incorporating emissions data across the product life cycle (i.e. production, use and disposal).

GPP will play an important role in reaching the upcoming Sustainable Development Goals, particularly Target 12.7 to *"Promote public procurement practices that are sustainable, in accordance with national policies and priorities"* and Goal 9 to *"Build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation,"* as they compel countries to implement efficient and stringent GPP policies. By following the recommendations presented in this paper, China will have the necessary policy framework to tackle Goal 9 by extending GPP practices to infrastructure development. In addition, China will have a comprehensive GPP framework in place and can become a leading example of meeting Target 12.7 on promoting sustainable public procurement practices.

Finally, in terms of implementation, it is promising that GPP is expected to be included in China's upcoming 13th FYP, providing the necessary political will to evaluate the current GPP policies and address any potential shortcomings. This significantly increases the chances of implementing some (or all) of our recommendations and highlights the importance of the IISD GPP Model and its findings. Through the 13th FYP, we expect GPP to receive the necessary budgetary support with clear responsibilities assigned for greening procurement processes.

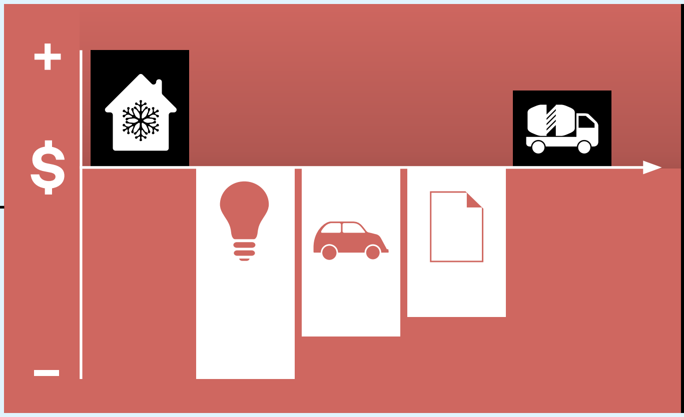
The Benefits of Green Public Procurement (GPP) - Evidence from the IISD GPP model

Benefits



Health and environmental costs, which are not often considered in procurement decision making, can be as high as 30-45% of the fiscal cost of lighting, paper, and cement, and as high as 85-90% of the fiscal cost of cars. In addition to offering energy savings, GPP can help to significantly reduce these costs.

Costs



For many products, GPP pays for itself with time in the form of savings in energy, health and environmental costs

For certain products, increased GPP ambition and stringency involves extra costs (but rarely exceeding 20%), while for others it actually comes at a reduced cost.

The future

As GPP encourages innovation, market development and green industry development, this will lead to further reductions in environmental impact and lower prices. Therefore the environmental benefits of GPP should continue to improve while the costs continue to fall.

Part 1:
How to Enhance the Implementation of Green Public Procurement in China

This project was undertaken by IISD to provide impetus for the more strategic implementation of green public procurement (GPP) in China.

The Government of China began GPP implementation over 10 years ago, recommending that public procurement needs to realize whole-life value in both the Bidding and Tendering Law (1999) and the Government Procurement Law (2002). Public procurers are mandated to select products that have lower-energy footprints by selecting options from the Energy Conservation Products list. In addition, public procurers are advised to purchase products that have smaller environmental footprints using the Environmental Labelling Product list.

IISD believes that if public procurement could be more strategically planned and executed, the government and people of China would stand to gain significantly in terms of lowered and avoided environmental and health costs, increased productivity and assets that bring value-for-money, not just at the point of purchase/commissioning, but across their life cycle. Indeed, as the Government of China seeks to implement green growth and eco-civilisation, it is imperative that public expenditure, equivalent to 59.6 per cent of China's GDP, can be directed to give preference to greener goods, services and infrastructure.

Greening public procurement gains even more significance in light of the upcoming 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), hosted by France in November 2015. The aim of COP 21 is to reach an agreement to fight climate change and lead a transition to climate-resilient societies and economies. GPP, especially with the more stringent and comprehensive policies proposed in this paper, can significantly contribute to honouring China's commitment to limiting greenhouse gas (GHG) emissions and to upscaling resilient infrastructure development as part of the anticipated COP 21 agreement. The IISD GPP Model gives an accurate picture of how GHG emissions can be decreased by procuring green products that incorporate emission data across the product life cycle: production, use and disposal.

To make to case for strategic GPP in China, IISD decided to focus on quantifying the environmental, social and economic gains that can be realized if public expenditure was better directed to environmentally and sustainable goods and services. As a basis for this very complex and data-intensive endeavour, IISD developed a system dynamics model; consulted and engaged with stakeholders on values and volumes of expenditures; and developed scenarios, proxies and assumptions to understand and quantify the gains. Full details of the IISD GPP Model and its outputs for China are presented in Part 2 of this report.

In developing and populating the model and by examining its outputs, IISD developed 13 recommendations on how GPP can be more strategically implemented in China. As with the IISD GPP Model, these recommendations are the result of 18 months of investigation and consultation on the policy and practice of green public procurement. IISD engaged with a wide range of public entities, businesses and commentators. We also held public consultations and expert roundtables in collaboration with the Chongyang Institute for Financial Studies, Renmin University of China, Top 10 China, and Eco Forum Global, in Guiyang across 2014 and 2015.

The 13 recommendations are discussed below. They all aim to enhance the strategic implementation of green public procurement in China in the immediate term.

RECOMMENDATION 1: Position Green Public Procurement in the 13th Five-Year Plan (2016-2020)

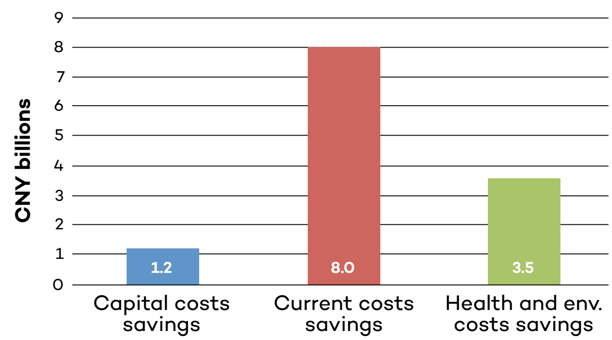
Five-year plans (FYPs) are the blueprints for social and economic development in China. The last two FYPs have witnessed an important shift toward environmentally focused goals—especially regarding energy policies and climate change—and they have provided national targets that demonstrate China's commitment to actively changing its economic paradigm (Yuan & Zuo, 2011). The design of the 13th FYP (2016 to 2020) is ongoing, and commentators expect GPP to be positioned as the mechanism to answer several of the issues identified in the Third Plenum goals related to reducing climate change risks and implementing low-carbon development (National Development and Reform Commission, NDRC, 2014).

IISD welcomes the positioning of GPP in the 13th Five-Year Plan.

Supporting Evidence from the IISD GPP Model

Including GPP in the next FYP could lead to significant energy savings and avoided health and environmental costs. In the lighting category, for example, there are significant savings to be realized in the next five years by expanding GPP, as can be seen in Figure 8 below. Lighting is a particularly strong example, since greater purchase of LED bulbs pays for itself relatively quickly due to longer lifespans and reduced energy consumption. Other products would lead to significant energy savings or avoided health and environmental costs, but would come at a net fiscal cost. Nevertheless, lighting exemplifies that there are real gains to be realized in the next five years by expanding implementation of GPP in the next FYP.

Figure 8: Avoided costs due to expanded GPP of lighting for the period 2016-2020



RECOMMENDATION 2: Make GPP mandatory for State-Owned Enterprises (SOEs)

Current Policy Scenario

Public procurement in China is mainly governed by two sets of laws: the Bidding and Tendering Law (BTL) initiated by the National Development and Reform Commission (NDRC) in 1999, and the Government Procurement Law (GPL) enacted in 2002 by the Ministry of Finance. The BTL regulates specific types of transactions as opposed to regulating the procuring entities themselves (e.g., infrastructure and public utility transactions, projects funded by public fund/foreign loans and aids). In practice, this means that the BTL covers SOE tenders, large-scale infrastructure projects and joint venture projects (e.g., public-private partnerships [PPPs]) (European Union Chamber of Commerce in China, 2011).

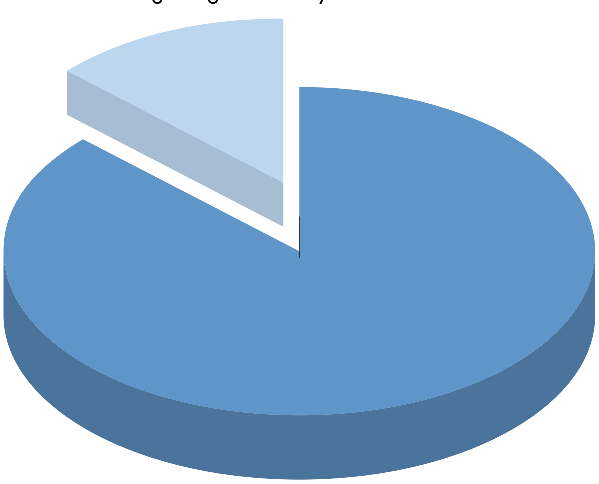
On the other hand, the institutional scope of GPL is more clearly specified, covering all the procurement activities of various government agencies (State Council, Ministries, provincial- and municipal-level governments), public institutions (public entities in education, science, technology, culture and healthcare) and civil society organizations that use public funds for procurement. In other words, GPL regulates the procurement procedure of goods and services that are required for the functioning of the various government-related entities. Currently, the scope of GPP policies in China is tied to the GPL and therefore excludes a significant part of the overall public procurement transactions covered by the BTL.

Challenges

The European Union Chamber of Commerce in China estimates that total public procurement in China was worth CNY 10.56 trillion in 2011 with CNY 9.43 trillion covered by the BTL and only CNY 1.13 trillion by the GPL (2013/14b) as shown on Figure 9 below. This means that environmental and energy conservation considerations only play a role for approximately 10 per cent of all procurement. SOEs currently have no requirement, or any form of incentive, to buy green products and services.

Figure 9

Governement Procurement Law: Public healthcare, governement buildings, IT for governments departments, government office equipment, government car fleet, non-urgent relief work and geological surveys.



Bidding and Tendering Law: Energy, transportation, construction, telecommunications and post, municpal facilities, commercial housing and social welfare projects.
(Estimated at CNY 9.26 trillion by the European Chamber of Commerce)

It is estimated that SOEs represent the majority of transactions covered by the BTL, not only due to their own procurement needs, but also because SOEs are usually the contractors and/or operators of large-scale infrastructure projects. While greening CNY 1 trillion worth of procurement under the GPL is an important priority, the effectiveness and impact of new GPP policy initiatives are significantly limited as it currently excludes 90 per cent of public procurement.

Addressing the Challenges

GPP should be made mandatory for SOEs in order to better leverage the purchasing power of public procurement. For ensuring a smooth transition, the implementation could be done in two phases: first making GPP voluntary for SOEs and then, within a pre-determined time frame, compliance with the new framework would become compulsory.

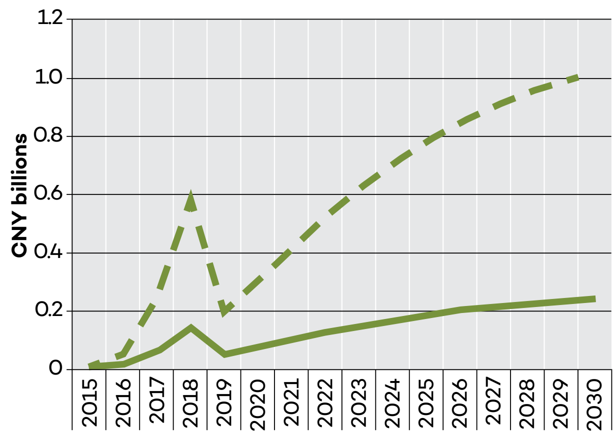
Previous attempts to align the BTL, and consequently the activity of SOEs, with the GPL have failed. While harmonizing the two laws would be welcome and reduce legal uncertainty, it is out of the scope of this recommendation and will only be discussed in detail later in the report. Instead, we propose here that SOEs should be made subject to the GPL, and therefore subject to GPP requirements. This change would not only significantly increase the current scope of GPP, but it would also provide a legal framework for a stricter regulatory oversight of SOEs' procurement activities. As has become evident through the various scandals surrounding SOE purchases, the BTL alone is not sufficient to provide the regulatory basis for a more disciplined and transparent procurement process. By being subject to both the GPL and BTL, SOEs could be held more accountable to value-for-money, and at the same time address any concerns that could potentially arise concerning their use of public funds.

As the overall momentum for GPP increases, manufacturers would have an even stronger incentive to meet the energy-efficiency and environmental standards required for the certifications. Extending the scope of GPP would also improve the economies of scale for these manufacturers. This would enable them to justify the higher R&D costs associated with green technologies and eventually result in lower prices for green products, making them more accessible to the wider public. This policy change would serve as a powerful tool for boosting green consumption in China, not only in the public sector, but also in the whole economy. The government, through public procurement, can play a leading role in this green market transformation and encourage sustainable development.

Supporting Evidence from the IISD GPP Model

The benefits of GPP demonstrated by the IISD GPP Model can be realized more widely if more public entities were obliged to comply with GPP requirements. Figure 10 shows how the degree to which avoided environmental and health costs would grow in a scenario in which SOEs also complied with government plans to make 30 per cent of its vehicle purchasing low-emission vehicles.[4 5]

Figure 10: The avoided health and environmental costs of SOE compliance with government plans to make 30 per cent of vehicle purchasing low-emission vehicles



RECOMMENDATION 3: Extend Green Public Procurement to cover infrastructure procurement

Current Policy Scenario

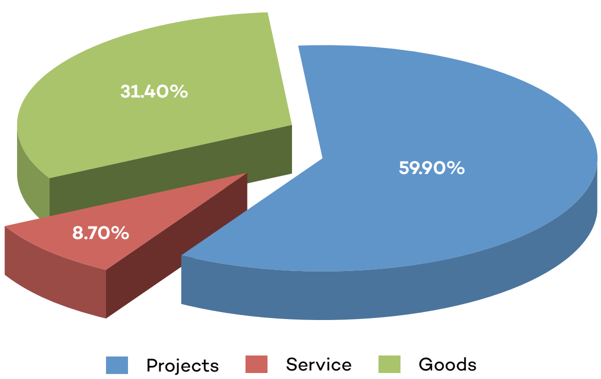
The BTL currently regulates large-scale infrastructure projects. GPP requirements are not applicable to BTL, but are currently limited to the Government Procurement Law (GPL). While infrastructure development has to be compliant with the Environment Protection Law (EPL), there are no specific GPP standards that would require public procurement to integrate more stringent environmental and social considerations for infrastructure. As a matter of fact, even the existing EPL seems to be too difficult to enforce and monitor (CET, 2011), which has resulted in serious breaches with disastrous consequences widely discussed in the press (TGNet, 2013), further damaging the credibility of the EPL for infrastructure development.

4 It has been assumed for the purposes of this example that SOE compared to government's procurement of cars would be in the same proportion as SOEs and government's overall procurement—approximately 4:1

5 The visible drop in costs in 2018 stems from the introduction of a new fuel standard in the country reducing the Sulphur content of gasoline, which leads to reduced associated health and environmental costs.

As shown on Figure 11, infrastructure projects constitute 59.9 per cent of total procurement in China. That implies that a significant portion of public purchases are not covered by the current product certification-based GPP framework, as under the GPL. In addition, infrastructure is the fastest growing part of procurement, with an annual growth of 5.9 per cent over the 10 years prior to 2012, while services have grown only 3.7 per cent and, more importantly, the share of products decreased 5.9 per cent over the same time period.[6] This suggests that goods are no longer necessarily the best focal point to reform procurement to achieve value-for-money.

Figure 11



Challenges

The full potential of Chinese public expenditure cannot be fully leveraged to advance green consumption without including infrastructure projects, as they form an important part of public procurement and give rise to significant environmental and social impacts. However, the current procurement lists are not suitable to be used for infrastructure procurement. The wide range of products used during the construction of an infrastructure project cannot be realistically covered by product categories. This highlights the limitations of the list approach in GPP, underscoring the need for new and more comprehensive ways to green government purchases.

At present, environmental and social standards are not included in the design of Request for Proposals (RfP) and play only a minimal, if any, role in the evaluation of infrastructure bids. That results in procurement decisions that put too much emphasis on the financial costs of infrastructure development, ignoring other important non-financial considerations.

Addressing the Challenges

GPP policies need to go beyond the current product list approach when integrating infrastructure procurement. Environmental and social considerations should be included during the commissioning and procurement of infrastructure. In other words, the tendering and evaluation of bids should not only be based on a financial cost-benefit analysis, but instead a life-cycle approach. Value-for-money across the asset's life cycle, factoring in environmental and social externalities, can provide a much more holistic and accurate picture when commissioning infrastructure projects. This approach embodies the principles of "total cost of ownership" and "whole-life value," facilitating medium- and long-term efficiency gains and cost reductions enabled by sustainable infrastructure.

Procurers need to incorporate environmental and social performance requirements into RfPs. Specifically, technical specifications in RfPs (and subsequent bid evaluations) should cover parameters such as green building standards, bioclimatic features, use of recycled materials, use of green building materials, energy efficiency and emissions, among others.[7]

[6] Hu, B. & Yi, S. (2014). Status report of China's green government procurement

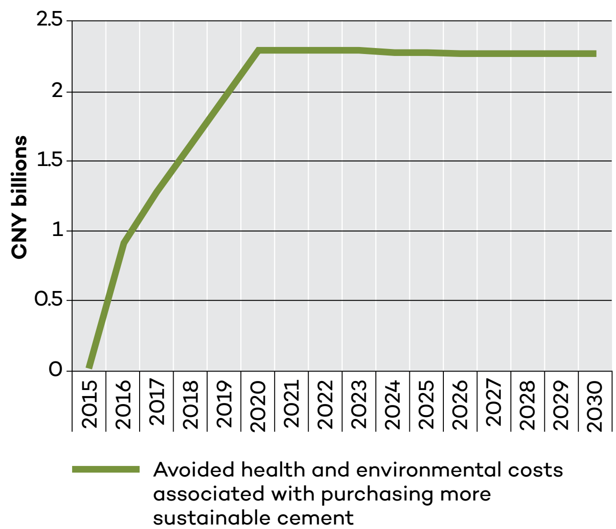
[7] IISD - Value for Money in infrastructure Procurement (2014)

Procurers need to explore new ways to finance green infrastructure, which in many cases involves new technologies with potentially higher capital expenditure at the time of construction. PPPs could be an appealing delivery method, which, besides offering significant efficiency gains, can reduce the financial burden of environmentally sound projects by attracting private financing. In a context of limited reforms, PPPs have the advantage of following different procedures and guidelines than outlined in the standard Chinese procurement laws. However, it is important to recognize that the current regulatory framework in China is not supportive enough of PPP structures. Therefore, relevant policies and procurement laws need to be updated so they can accommodate efficient risk sharing between public and private partners.[8]

Supporting Evidence from the IISD GPP Model

The IISD GPP Model has been used on cement, which is an important construction material for infrastructure. As seen in Figure 12, the results of the model indicate significant avoided health and environmental costs when the government purchases a more sustainable grade of cement. The IISD GPP Model can be further developed to quantify the impacts of greener infrastructure procurement.

Figure 12: Model results for health and environmental costsavings associated with purchase of more sustainable cement by the public sector in China



RECOMMENDATION 4: Build on the Synergies Between Green Public Procurement and the Green Credit Guidelines

As a response to the goals articulated in the 12th FYP, the China Banking Regulatory Commission (CBRC) has issued the Green Credit Guidelines (GCG) in 2012. The primary goal of the GCG is to encourage green lending by requiring financial institutions to incorporate environmental and social criteria in their lending decisions. It is applicable to all policy banks, commercial banks, rural cooperative banks and credit unions, asset management companies and leasing firms regulated by the CBRC.[9] By promoting green credit, the GCG stimulates green economic growth and a more sustainable production and consumption in China.

8 The European Union Chamber of Commerce in China Public Procurement Working Group – European Business in China Position Paper 2013/2014

9 Notice of the CBRC on Issuing the Green Credit Guidelines (2012), accessed at http://www.cbrc.gov.cn/EngdocView.do?docID=3CE646AB629B46B9B533B1D8D9FF8C4A

There are significant synergies to be realized between GCG and GPP. The GCG could play a valuable role in further upscaling green innovation and investment triggered by the more comprehensive GPP policies recommended in this paper. As a result of more public sector purchases of green products, businesses across the value chain will seek out more green solutions and increase their spending on R&D for green technologies.

The long-term and large-scale demand created through GPP cannot realize its full potential in stimulating the green economy, if this growth is not supported by sufficient financing. Through GCG, financial institutions can provide the necessary credit to finance these green investments. In addition, as lenders are also required to price environmental and social considerations in their loan agreements, the interest rates offered to green projects could be more beneficial, but at least in line with other projects, when adjusting for the higher risk associated with these new technologies.

RECOMMENDATION 5:
Position Green Pubic Procurement as the baseline for expanding markets for Green Infrastructure Bonds

Infrastructure projects constitute a large share of public procurement in China. Following Recommendation 3, if the scope of GPP policies is extended to cover infrastructure, it will significantly increase the demand for green financing solutions. Capital markets should play a bigger role in providing financing to these projects, decreasing the reliance on public funds that could be used more efficiently somewhere else. Through bond financing, the large pool of domestic savings can be tapped, and at the same time, it provides a way to access international capital markets.

While China's leaders have expressed their explicit support,[10] currently the green bond market is still in its infancy in China. GPP of infrastructure could ensure a steady and long-term pipeline of new issues, providing a strong signal to market participants of the viability and cost efficiency of green infrastructure bonds. It is worthwhile to note that investors usually demand a higher risk premium for a new asset class with a limited track record. Therefore, the government should leverage its high sovereign credit rating to provide some form of credit enhancement (e.g., partial guarantees) to these bond issues, making them more appealing to investors, and at the same time, decreasing the cost of financing. GPP can give a significant boost to this promising asset class stimulating the wider use of green bonds in China, also outside infrastructure financing.

RECOMMENDATION 6:
Position Green Public Procurement as an priority focus for the Asian Infrastructure Investment Bank

Financing sustainable infrastructure often requires more innovative solutions due to the new technologies used and the higher initial costs associated with these projects. While the environmental, social and economic multipliers of buying green more than compensate for these higher costs for the government and stakeholders (as illustrated through our model at the product level), the bankability of the projects could still be materially affected. As also touched upon earlier, in relation to green infrastructure bonds, in case of private financing, some form of credit enhancement is needed to make the deal appealing enough to investors to commit capital or to ensure that the cost of financing stays within a reasonable range.

[10] Greening China's Financial System (2015), accessed at https://www.iisd.org/publications/greening-chinas-financial-system

As demonstrated by various studies at the international level, credit enhancement, such as partial credit guarantees, is considered a cost-efficient way of government intervention. While the benefits of credit enhancement have been widely recognized, one of the main difficulties of setting up the necessary structure is the lack of suitable financial institutions with high enough credit rating and the capacity to provide guarantees for large-scale projects. Asian Infrastructure Investment Bank (AIIB) could fill this role in China, especially as the support of sustainable infrastructure development is in line with its mandate of "Lean, Clean and Green."

AIIB's support in facilitating GPP of infrastructure in China goes beyond providing credit enhancement solutions. Any form of AIIB support comes with important, positive strings attached. Potential deals to be credit enhanced will be analyzed through an extensive due diligence process, ensuring efficiency and transparency throughout the course of procurement. This includes a requirement for an open and fair tendering process as well as for including environmental and social criteria in the RfPs in line with domestic and international standards. Leveraging the synergy between sustainable infrastructure development as part of GPP and AIIB's mandate in this area, could result in internationally visible flagship infrastructure projects showcasing modern and transparent Chinese public procurement.

RECOMMENDATION 7: Make the Environment Labelling Product (ELP) list mandatory

Current Policy Scenario

In 2004 the People's Republic of China integrated GPP considerations into public procurement by establishing the Energy Conservation Products list. However, IISD has identified significant potential for further extending the scope, volume and stringency of the GPP framework and the underlying green standards. In this and the following recommendations, we discuss IISD's suggestions for upscaling the current GPP policies. They are organized in seven different groups based on the approach and the type of intervention suggested. We recognize that the implementation of some of these recommendations are more ambitious; however, we strongly believe that the expected environmental, social and economic impacts through a more stimulated green consumption in China justifies the effort, and is in line with China's current national goals.

GPP in China is currently based on product certification, which is managed through two separate schemes: Environment Labelling Product (ELP) list and the Energy Conservation Products (ECP) list. Both lists have a range of product categories covering a large number of products that procurers can use to make their purchasing decisions. The lists have different certification procedures, objectives (ECP focusing on energy efficiency, while ELP on wider environmental considerations) and are governed by different government entities. Currently, only some of the ECP list is compulsory, while products on the ELP lists are recommended as the preferred choice for governmental agencies at all levels, institutions and organizations that use public budgets for procurement. The lists specify the name of each product's manufacturer, the registered trademarks and the expiration date of its certification.

Environment Labelling Product (ELP) List

Product list	Bi-annually updated Last updated version is the 14th as of December 2014
Available at	www.ccgp.gov.cn/qyycp/jnhb/jnhbqd/hbqd
Criteria/Standard	China Environmental Labelling
Certification Authority	China Environmental United Certification Center, EDC
Relevant Ministries	MOF, MEP

Energy Conservation Products (ECP) List

Product list	Bi-annually updated Last updated version is the 16th as of December 2014
Available at	www.ccgp.gov.cn/qyycp/jnhb/jnhbqd/hbqd
Criteria/Standard	Energy conservation and water conservartion
Certification Authority	CQC
Relevant Ministries	MOF, NDRC, AQSIQ

The effectiveness of product lists, as a main policy instrument for GPP, is limited by a number of factors. The following recommendations will address some of these limitations and seek to enable the upscaling of GPP in the short and medium terms. However, it is important to highlight that, in the long term, more fundamental changes are needed for greening public sector procurement. Procurers need to move away from using product lists and instead consider procuring integrated services. They could also consider using product service systems and make procurement decisions based on functional requirements as opposed to technical product criteria. Such initiatives will help procurers realize better value-for-money across the product/service life cycle, as procurement decisions will be based on the total cost of ownership.

The ELP list was created in 2006 in the *Recommendations on the Implementation of Environment Labelling Products in Government Procurement* by the State Environment Protection Administration (succeeded by the Ministry of Environmental Protection) and the Ministry of Finance. Products that meet the China Environmental Labelling (CEL) standards are eligible to be included on the list. Procurers must give priority to these products when making purchases that fall within the list's 55 product categories. In other words, the use of the ELP list is voluntary, as opposed to the mandatory approach used for the ECP list. The ELP list is revised twice a year and currently (version 16) contains more than 110,000 products across 1,516 companies (Ministry of Finance of the People's Republic of China, 2015b).

Challenges

The non-mandatory approach of the ELP list leads to lower effectiveness compared to a policy that foresees a legal obligation to purchase from the list, and therefore weakens the implementation of GPP. The Senior Engineer of the Shanghai procurement department, Mr. Ma Zhenghong, also argues that, currently, manufacturers do not have enough incentive to get the CEL certification in the first place, as it might not result in increased sales (ZFCG, 2010). This approach also has a negative impact on the environment, as manufacturers have less incentive to improve the environmental footprint of their products.

Furthermore, the mandatory ECP list only focuses on the energy efficiency of products (and in some cases water efficiency) and does not include other environmental considerations. Greening procurement requires more than just being energy efficient. By relying only on the ECP list, there is no mandatory link being made between purchasing decisions and air pollution, industrial pollution, impacts on ecosystems, water resources, other natural resources and soil degradation, among others.

Addressing the Challenges

IISD recommends that purchasing products from the ELP list be made mandatory, as is currently the case for the ECP list.

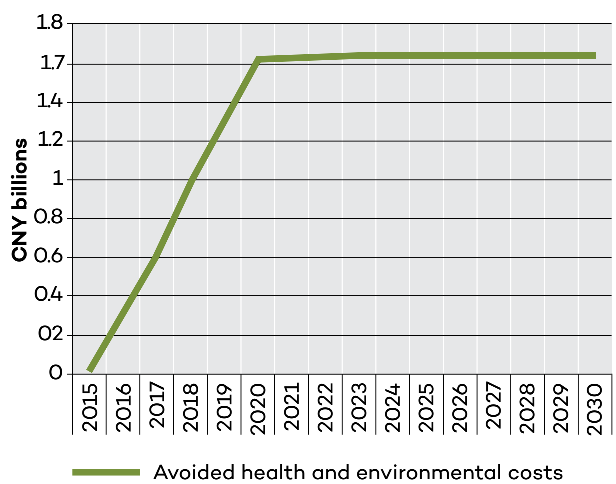
This would broaden the scope of GPP practice in China. Furthermore, this would also incentivize manufacturers to improve the green credentials of their product lines and reward innovation in the form of reliable market demand for green products. The indirect impact on overall green consumption would also be substantial as, this way, the government would demonstrate a vote of confidence for green products, encouraging the market to produce them and the public to switch to them.

It was a prudent decision to initiate the ELP list in 2006 as a voluntary scheme in order to test the new approach, increase the number of products on the list and gather stakeholder feedback; however, almost 10 years later, making it mandatory would be justified, as suppliers have had the lead time to adjust their production practices and obtain certifications. The ECP list has also followed a multi-phased approach: it was created in 2004, including products meeting the Energy Conservation Certification standards, and was made compulsory only three years later, in 2007. IISD recommends a similar progression for the ELP lists.

Supporting Evidence from the IISD GPP Model

IISD GPP Model shows that there are considerable benefits to be gained from making the purchasing of ELP listed products mandatory. As an example, Figure 13 shows what the avoided health and environmental costs would be at the national level as a result of a hypothetical requirement that 50 per cent of the paper purchased by the government must be recycled paper, with a phase-in period of five years.

Figure 13: Model results for the avoided health and environmental costs associated with requiring that 50 per cent of paper procured by government be recycled (with a phase-in period of five years)



RECOMMENDATION 8: Increase stringency of ECP listing requirements

Current Policy Scenario

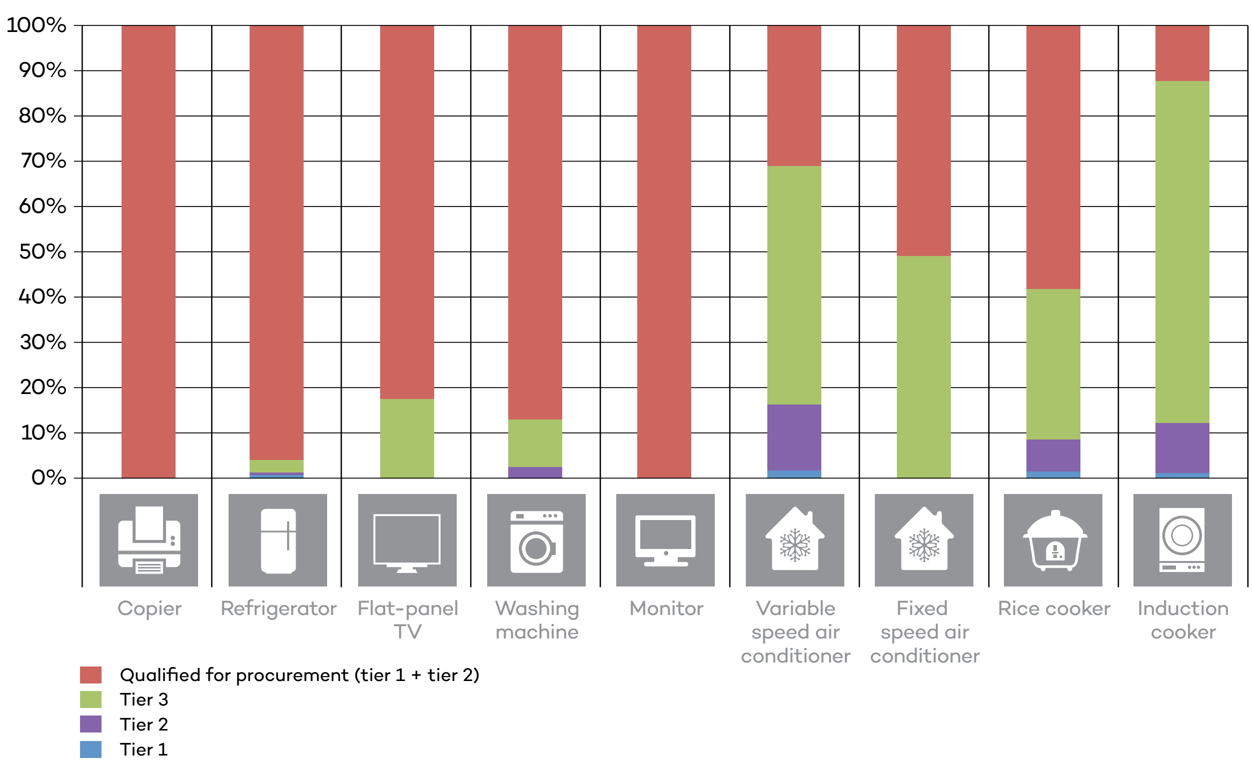
The ECP list was established in 2004 through the publication of the *Circular on Opinion on Implementing Government Procurement of ECPs* by the MOF and NDRC. This document outlined the initial framework requiring procurers to give priority to energy-efficient products. For example, the prevailing Energy Efficiency

Standard (EES) in China distinguishes five levels of energy efficiency classified in Tiers 1 through 5. Products in Tiers 1 and 2 are classified as High-Efficiency Products. They are qualified to receive the Energy Conservation Certification and therefore are eligible to be included in the ECP list. In 2007 the *Circular on Establishing System of Compulsory Government Procurement of ECPs* made the ECP list mandatory for government procurement. However, products on the list, which do not have adequate supply (more than five suppliers) or cannot demonstrate significant energy saving or for any reason not suitable for large-scale procurement, are exempt from the mandatory requirement (The Central People's Government of the People's Republic of China, 2007).

Challenges

Currently, the energy performance requirements for products to be listed on the ECP list are not particularly demanding. Top10 China and CLASP report that, for example, for copiers, refrigerators, panel TVs, washing machines and computer monitors, the total market share of products that qualify to be on the list is higher than 80 per cent (Top10 China & CLASP, 2013). In other words only very few products on the market do not qualify to be procured as GPP. The product distribution across the different energy-efficiency tiers for each category is well illustrated by Figure 14.

Figure 14 (Top 10 China & CLASP, 2013).



This leads to a situation in which the energy performance of products whose procurement qualifies for GPP is almost the same as the overall market for many product categories. This makes it impossible for procurers, or other consumers for that matter, to distinguish between the performance levels of products. The current distribution of the different energy efficiency tiers is also the consequence of lengthy revision processes of the relevant national standards, which usually take two to three years (Top 10 China, 2014). For most manufacturers, it is now a matter of routine to certify their products, rather than a competitive advantage gained by certifying the few highest performing models.

Addressing the Challenges

As a result of the reliance on product certification, the level of impact of Chinese GPP policy depends on the stringency of certifications. The standards for each product category need to be adjusted to achieve a more balanced distribution of the different energy-efficiency tiers. The ones qualified for procurement (i.e., Tiers 1 and 2) need to include products that are leading in energy efficiency in their respective categories. More specifically, Tiers 1 and 2 should include 5–10 per cent of products each, with the rest of the products being evenly distributed among Tiers 3–5. This distribution would give relevance to all tiers and allow procurers as well as consumers to make better-informed decisions.

In order to preserve a fairly even distribution of products across tiers, regular reviews and adjustments of standards are needed. This would ensure that government procurement indeed stays green and meaningful. This approach would also encourage manufacturers to innovate and apply the newest technologies in order to meet the highest certification requirements. This recommendation is in line with the latest international best practise, succesfuly implemented in countries like Canada and Australia.

In addition, policy-makers could consider restricting procurment to only Tier 1 products for certain product categories. However, it is important to ensure that procurers always have a wide range of choices, otherwise manufacturers could adjust their prices to reflect their unique market position.

As the energy conservation certification becomes more relevant, the inclusion of only top-of-the-line products might result in increased procurement costs, if other environmental and social externalities are not factored in. Also, product availability should always be assessed not only at the national, but also at the local level in order to avoid providing unintended advantages to certain manufacturers.

Supporting Evidence from the IISD GPP Model

Results from the air conditioners category of the IISD GPP Model provide an indication of the potential benefits of stricter listing requirements for the ECP list. The model finds that if the most energy-efficient grade of air conditioners were purchased going forward, this would be associated with over CNY 150 million in annual energy savings by the year 2025, when compared to a situation in which government purchases an above-market average grade, but not best-in-class.

RECOMMENDATION 9: Ensure Environment Labelling Product and Energy Conservation Product lists reflect best-available technology

Current Policy Scenario

The ELP and the ECP lists are both revised twice a year by the Ministry of Finance. There is limited to no information available on the internal revision process. However, the available guidelines specify that products are only eligible for the ELP and ECP lists if they have the Environment Label Certification or the Energy Conservation Certification, respectively. While not an official requirement, local products seem to be preferred and included more frequently on the lists (SINA News, 2015).

As both lists rely on product certification, the relevance and accuracy of their green credentials depend largely on the frequency of the review process and the stringency of the underlying standards used. The revision periods of the standards, for both certifications, are currently only every three years.

The Environment Label Certification distinguishes two types of labelling: Type I is used for products where technical standards already exist, while Type II is based on a self-declaration scheme managed by the CEC. Environmental standards are developed by the Ministry of Environmental Protection (MEP) and its affiliated entities. Similarly, under the Energy Conservation Certification scheme, products can either obtain certification based on existing standards, or alternatively, the CQC can develop the relevant technical specifications. Both the environmental and energy conservation certifications are valid for three years and must be renewed by the manufactures at expiry. Furthermore, a regular annual inspection is conducted to ensure that certified products still meet the required qualifications.

Challenges

Since their inception, both the ELP and ECP lists have grown considerably. For example, the first ECP list only had 1,526 products across 8 categories in 2006, and by 2015 it had increased to more than 160,000 products across 56 categories. While this increase can be viewed as a very positive development for GPP in China (due to a wider range of product categories covered), the reality shows a more mixed picture. A large number of products on the lists represent technologies that have become obsolete and have already been replaced by newer environmental and energy-efficient solutions. As the lists are relying on their respective certification schemes for product selection, the underlying problem seems to be with standards used for these schemes. In short, the quality of the lists can only be as good as that of the certifications.

While the product lists are updated semi-annually, the current revision period of three years for certification standards is not frequent enough to keep up with the current rate of green technological innovation. In addition, any changes to the certification criteria needs to be approved by the Certification and Accreditation Administration of China (CNCA), which usually takes more than half a year (Top 10 China, 2014). Without rigorously delisting unsuitable products at the certification level, procurers are faced with cumbersome lists that may not always point out the alternatives that are the most eco- and cost-efficient.

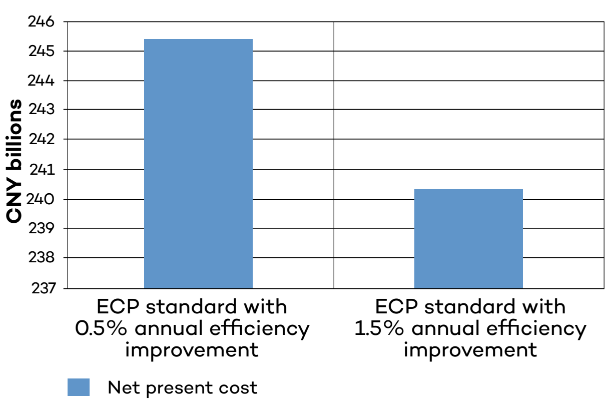
Addressing the Challenges

There has to be a scientific, rigorous and systematic methodology to list and delist products on the ECP and ELP lists based on best available technology in the Chinese market. Consequently, the criteria on which the Environment Label Certification and the Energy Conservation Certification are awarded must keep pace with technological developments of the various product categories. This would make both lists more relevant and of a more manageable size for procurers.

Supporting Evidence from the IISD GPP Model

Keeping up with technological developments is key to realizing maximum value from GPP. Looking again at the air conditioners module of the IISD GPP Model, Figure 15 shows that the net present cost of purchasing efficient air conditioners is CNY 5 billion higher when listing standards only improve at 0.5 per cent per year instead of keeping up with the 1.5 per cent annual energy-efficiency improvements that are expected to be delivered by market innovation.

Figure 15: Net present cost of air conditioners with and without improved procurement standards



RECOMMENDATION 10: Maintain disaggregated records on public spend

Current Policy Scenario

The most challenging task in this project has been accessing public data on the values and volumes of government and public spend. The *Annual China Statistical Yearbook* compiled by the National Bureau of Statistics of China provides a detailed summary of expenditure disaggregated by sector, public services and economic activity. In addition, the *Annual China Government Procurement Yearbook* and the *Annual Financial Yearbook of China* provide further records on government expenditure, aggregated by procuring entity, sector, service and economic activity. Yet few public records appear to be maintained on the disaggregated value and volume of spend.

The major areas of public spend are given in the table below.

Areas of frequent government expenditure		
Products	Services	Infrastructure
Air conditioning	Management consultancy services	Roads
Information communication technologies	IT consultancy services	Water treatment facilities
Vehicles	Software	Airports
Indoor lighting	Servers and data centres	Ports
Outdoor lighting	Electricity	Railroads and stations
Office supplies	Couriers and postal	Buildings
Fuel	Mobility	Sewage plants
Furniture	Waste management	Schools
Apparel	Food and beverage catering	Prisons
Paper	Landscaping	Power plants

Challenges

In order to implement GPP, and indeed to increase the overall efficiency of public procurement more widely, public expenditure needs to be recorded and published in a more disaggregated manner—ideally in directly correlation to the goods, services and assets being procured. Without this information, public procurers and policy-makers are not able to assess if they are spending money wisely and realizing value-for-money.

Indeed, to better implement GPP, sustainable consumption, circular economy and eco-civilisation, the Government of China needs to seek value-for-money, not simply at the time of purchase, but across the life cycle of the asset. This implies that procurers need to move from purchasing the cheapest alternative to purchasing the cheapest alternative across its useful life, taking into consideration the environmental, social and economic externalities related to each product, service or asset. Disaggregated data on expenditures is essential to making such decisions a part of the procurement mindset.

Disaggregated data on the values and volume of spend are also important to provide for the exchange of best practices between municipalities and provinces, since, in the absence of disaggregated data, jurisdictions are not able to contrast and compare their GPP practices and resulting gains.

Addressing the Challenges

Values and volumes of expenditures should be recorded and published as disaggregated at the level of the product, service and asset being procured. This would also greatly enhance transparency and accountability across the public procurement function and greatly facilitates green and efficiency procurement. As the Government of China is already using electronic procurement systems, recalibrating these systems to generate disaggregated information on spend is not likely to be unduly cumbersome.

Supporting Evidence from the China GPP Model

Considerable effort was undertaken to develop accurate estimates of the overall level of government expenditure in the given categories included in this project; however, due to the low level of disaggregated data available in the public domain, the project team was compelled to make assumptions in estimating the value and volume of procurement spending. A high level of uncertainty had to be applied to model inputs in estimating the level of 2015 procurement.

RECOMMENDATION 11: Include performance on GPP in the job descriptions and performance evaluations of public procurers

Current Policy Scenario

Performance on GPP is mostly evaluated based on the extent to which products are selected from the ELP and the ECP lists. Procurers are not assigned direct responsibility nor given additional incentives to implement GPP.

Challenges

To implement GPP in a systematic manner, responsibility needs to be assigned and good performance needs to be rewarded.

Addressing the Challenges

Public procurers need to be made responsible for procuring greener products, services and infrastructure and provide for this. In addition, GPP performance needs to be included in the job descriptions and terms of reference for public procurers.

Similarly, when procurers are practising GPP and, moreover, proactively making purchasing decisions that increase value-for-money across the product and service life cycle, they need to be rewarded. To provide for this, criteria on green procurement should be included in the formal performance evaluations of public procurers. It is only when performance on GPP begins to affect advances in compensation, benefits, designation and responsibility that systematic implementation can be fully achieved.

RECOMMENDATION 12: The China Government Procurement Association could be positioned to lead the debate on GPP

Current Policy Scenario

As reported in the China Government Procurement Newspaper on February 26, 2015, the China Government Procurement Association is currently being established to act as the professional representative organization of the procurement profession. The objectives of this association include:

- Strengthening self-regulation and professional capacities within the profession
- Promoting networking and exchange across the profession
- Educating and training
- Improving the capacities and the calibre of the procurement professionals

Challenges

In light of the above objectives, the China Government Procurement Association may be well placed to lead the debate on GPP, to bring greater policy coherence and to spearhead the more systematic implementation of GPP in the immediate term.

A February 26, 2015 article in the China Government Procurement Newspaper also cites a survey conducted across the public procurement profession in Beijing on the most important mandate for the association. Respondents are reported to have cited "networking and exchange" as the primary mandate and "advocacy on great professionalism and policy positioning" as the second. This increases expectations that the China Government Procurement Association may indeed have the necessary position to increase policy significance and in fact the procurement profession, in deploying large sums of money, can indeed be the change agents for green economic transformation.

Addressing the Challenges

IISD recommends that the China Government Procurement Association be established as a professional association with close ties to both the Ministry of Finance and the Ministry of Environment and Forestry. As such, it will be ideally placed to provide professional representation on the integration of GPP in the overall development agenda of China's economy.

In addition, as the association is expected to represent the public procurement profession and procurement itself is a critical public section function, the association should have a formal seat on relevant inter-ministerial committees.

RECOMMENDATION 13: Move from making procurement decisions based on product lists to functional requirements

Current Policy Scenario

At present, GPP choices are based on the ELP list and the ECP list.

Challenges

The downside of using lists is that procurers' choices are focused on goods and services that are not always representative of best available technologies. For example, when purchasing office electronics from product lists, the decision is likely to be based on a review of equipment that has been on the market for over two years, rather than the most lightweight and efficient alternative that offers better value in terms of software interface, energy efficiency, user-friendliness and improved productivity.

Basing procurement decisions on product lists also encourages procurers to work with a mindset that asks, "What do we want to buy?" rather than "What is the requirement we are seeking to fulfill?" or, indeed, "How can we optimize value-for-money across the product/service life cycle and not purchase the cheapest alternative that will cost more to use and maintain in the longer term?"

While the use of product lists makes procurers' tasks much easier, it encourages procurers to act as bureaucrats and administrators rather than decision-makers that deploy large sums of money. By procuring from lists, procurers and procurement policy leaders lose the opportunity to use their massive purchasing power to lead green economic development, green innovation and green industrialization. Indeed, the social and professional profiling of the entire public procurement profession loses out through the list-based approach, as procurers themselves do not make decisions and therefore they cannot demonstrate how they can increase value-for-money and how they can re-direct markets toward greener growth.

Addressing the Challenges

Instead of purchasing products, procurers need to make procurement decisions based on the functional requirements that need to be fulfilled. For example, do procurers need to procure office electronics or, rather, should they seek to procure services and integrated solutions that will help public entities compute, communicate, telephone, print, photocopy, scan and conference? As such, could not procurers seek to tender an entire e-communication/e-office "service" and invite suppliers (or a consortium of suppliers) to provide the hardware, software, cloud, data and maintenance services in an integrated service offering? In other words, procurers can design tenders based on "functional" requirements, rather than products. Such integrated solutions can bring noteworthy benefits in terms of reduced environmental footprint, resource use efficiency, increase productivity, lower purchasing costs and more.

There are a number of strategies that can be used to make functional efficiency the core determinant of procurement decisions. These include leasing, procuring services, moving to product-service systems and using functional or performance-based specifications. Indeed, public entities in China have already made the first step by leasing vehicles rather than purchasing them outright.

These changes should be undertaken in an incremental manner and be accompanied by continuous training and education to increase the confidence and capacity of public procurers.

Part 2:
How GPP Can Support Sustainable Development: Evidence from the IISD GPP Model

In order to gain an understanding of the quantitative impacts of scaling up GPP, IISD has created the IISD GPP Model. The objective of the model is to estimate the economic, environmental and social impacts of GPP in China, both in their own relative terms and also in monetary terms, in order to create a clear picture of the value proposition that GPP represents. Having an improved understanding of the current and potential impacts of GPP will enable government and civil society to better understand the different trade-offs that are being made in procurement choices, and will allow policy-makers and financial departments to optimize the investment spread over public procurement categories and to realize increased value-for-money.

2.1 Model Description

The following sub-sections describe the modelling approach that is used, detail its scope and set-up, and provide an overview of the model using a causal loop diagram (CLD).

2.1.1 Modelling Approach

The IISD GPP Model has been built from a system dynamics perspective. It conducts sensitivity analysis to test how particular modelling choices and assumptions may be driving results, and employs Monte Carlo analysis to create results that are reflective of the degree of uncertainty associated with key model parameters.

2.1.2 Model Scope and Set-Up

Product Categories

The model investigates the impact of GPP in five product categories: **air conditioners, lighting, cars, paper** and **cement**. These categories were selected for analysis based on a set of factors: the significant financial flow they represent, the notable environmental impacts associated with their production and use, their predominantly domestic production, and the availability of sufficient data to facilitate analysis.

Figure 16: Overview of Key Elements of the Modelling Approach

SYSTEM DYNAMICS (SD) MODELING

The general approach applied in the model is System Dynamics (SD) modeling. SD is a flexible modeling approach that maps out a set of variables, their relationships, and the types of influences they have on each other. The strength of an SD modeling approach is that it helps capture the way that highly complex systems can evolve over time. Improtantly, it also allows for the inclusion of environmental variables that are not always easily captured in certain other types of modeling. Another important distinction is that SD modeling allows for stocks and flows, where where variable inputs accumulate over time—an important feature when trying to assess environmental impacts. It also allows for feedback loops, where one variable's impact on another can itself affect the original variable, an important feature of complex systems.

SENSITIVITY ANALYSIS

Sensitivity analysis is used to assess the significance of different modeling assumptions or input values. Results are re-created with a single change in place so that the degree of influence that it a certain variable or assumption is having on model results can be understood and explored in isolation from other changes.

MONTE CARLO ANALYSIS

In Monte Carlo analysis, probability distributions are applied to variables which have a degree of uncertainty associated with them. The model is then re-run a great number of times, each time sampling within these probability distributions to create a set of results that reflect the uncertainty of key model inputs.

Time Horizon

The model begins in the year 2000, using the period 2000–2014 for calibration and validation, and then continues to project until 2050. Model results are usually presented for the period from **2015–2030**, since the impact of future technologies and trends beyond this horizon is too uncertain. However, in certain cases, results until 2050 are presented and discussed.

Modelled Scenarios

The specific modelled scenarios are described in each product category's respective subsection below, but for each product there are three types of modelled scenarios: **Baseline, Light Green** and **Dark Green**.

Figure 17: The three scenarios used in the IISD GPP Model

Under each scenario, the same estimates and projections for the national aggregate **scale of procurement** in the product category are used. However, as discussed in the previous section, due to insufficient data on national-level procurement in some cases, it was necessary to make assumptions and use proxy data in order to estimate the total scale and composition of procurement. The specific assumptions and methodologies used vary with each product, and are detailed in the Technical Annex. They were corroborated as much as possible using other estimation methods and results and were frequently shared with relevant stakeholders in China for their review and feedback. However, all aggregate procurement figures are essentially estimates, and therefore the model's strength lies not in its assessment of the aggregate levels of impacts under different procurement scenarios, but in its assessment of the relative levels of impacts across scenarios.

Each modelled scenario uses fixed price and efficiency levels for products. An effort was made to incorporate estimates of future **product prices and efficiency levels**, but the evidence base for these projections was deemed too weak for such figures to be meaningfully used in the model. Therefore under each scenario, present-day prices and levels of efficiency are kept constant[11] over the

[11] Hybrid and electric car prices are an exception to this in that they are both modelled to have steadily decreasing prices over the model's time horizon; see section 2.2.3 for more information

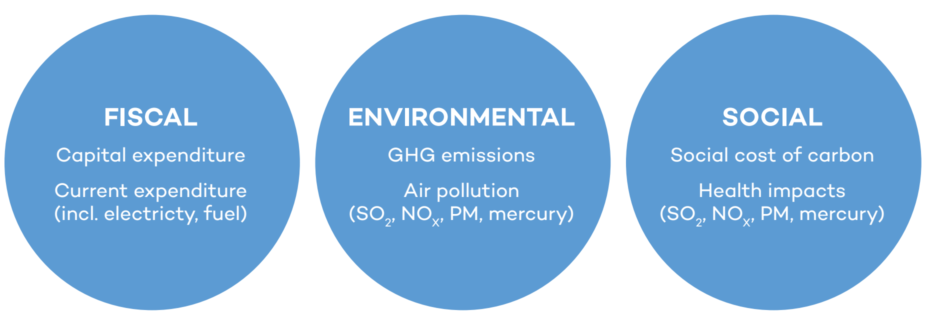
model's 15-year time horizon in order to limit the risk of model results being mainly driven by speculative estimates of future technology and market conditions. However, in cases where changes to prices or efficiency levels are to be expected, sensitivity analysis is conducted to test how robust the model's results are to improving levels of efficiency or falling price differentials.

Impacts

The model focuses on three main types of impacts: fiscal, environmental and social.

- **Fiscal impacts** in the model are broken down into current and capital expenditure. Capital expenditure is the purchase of durable goods, such as air conditioners, lighting and cars, while current expenditure includes the purchase of goods that are consumed or used in the same year they are purchased, such as paper and cement. Current expenditure also includes expenses related to the operation of durable goods, such as expenditure on the electricity or fuel they consume.
- **Environmental impacts** can occur at any point across the life cycle of a product—production, use or disposal. Most products have impacts across all these stages, but some are more notable than others, and therefore the environmental impacts of a product are typically modelled for only one or two of the product's life-cycle phases. In addition, a multitude of types of environmental impact exist, such as impacts on soil quality, biodiversity, deforestation, nutrient cycling, ecosystem service provision, etc. While a number of these impact types may be present for a given product, the model focuses on the impacts that can be reliably understood and quantified using available literature, and focus largely on impacts stemming from emissions of GHGs, sulphur dioxide (SO_2), nitrous oxide (NO_x), particulate matter (PM)[12] and mercury.
- **Social impacts** can take numerous forms, such as impacts on employment, poverty, human capital development and health. However, due to the difficulty of reliably establishing the impacts of public procurement on many of these variables, the focus of the model is strictly on health-related social impacts, which are especially notable in China given the significant health effects of ongoing air, water and soil pollution in the country.

Figure 18: The main types of impacts captured by the IISD GPP Model

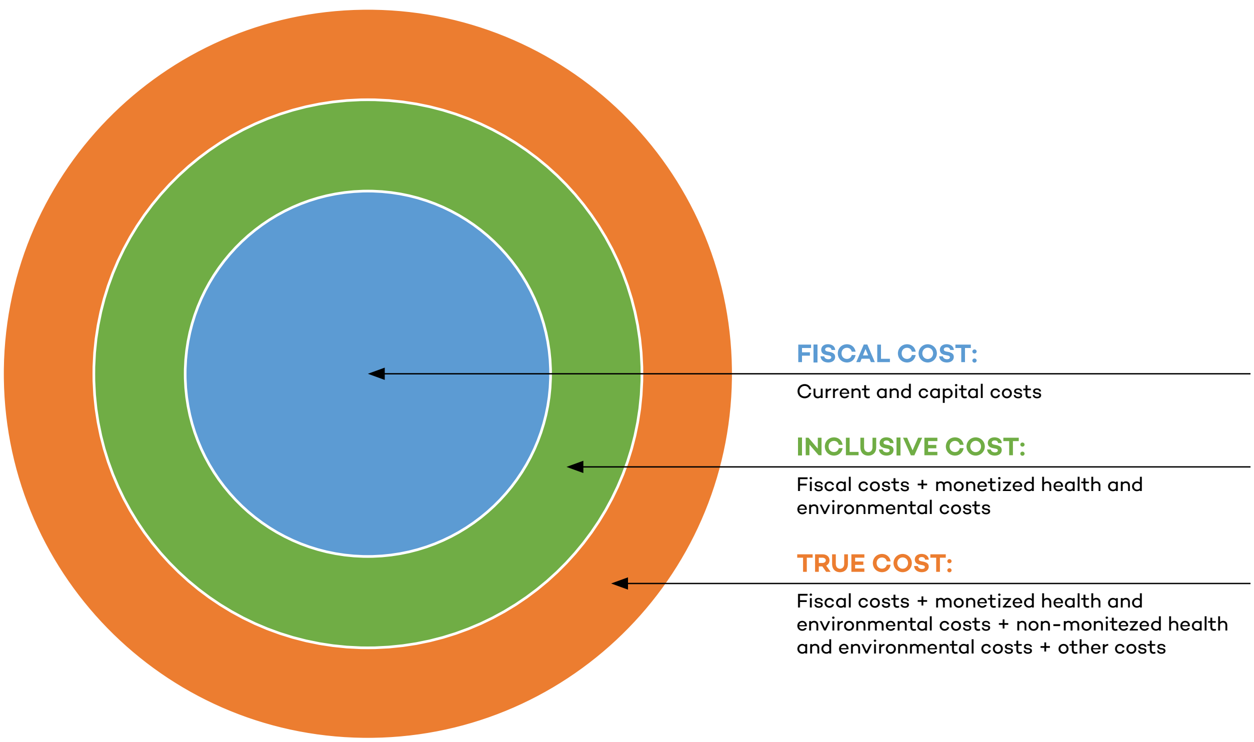


[12] The model focuses on PM10, although where possible inputs were weighted to account for the different respective shares of pollution and contributions to environmental and health costs of both PM_{10} and $PM_{2.5}$.

Monetization

As shown in Figure 19, there are several spheres of GPP costs. First, there is the fiscal cost sphere. These are costs paid by the government and consist of current and capital expenditure. Beyond this, there is the inclusive cost sphere. This includes fiscal costs plus the monetized cost of health and environmental impacts. Lastly, there is the true cost sphere. This consists of the inclusive costs as well as other various types of costs that are real but cannot be measured, monetized, or both. True costs can never be fully quantified. One of the objectives of the IISD GPP Model is to move beyond the traditional fiscal cost view and to quantify inclusive costs, in order to try to paint as clear a picture as possible of true costs.

Figure 19: The fiscal cost, inclusive cost, and true cost of GPP



In order to estimate the inclusive cost of GPP, it is necessary to explicitly model not only the fiscal costs but also the costs of the environmental impacts associated with products' production, use and disposal. However, environmental variables are typically measured in non-monetary units, such as tonnes of timber harvest, grams of pollutant emissions, etc. Therefore, in order to be able to calculate the inclusive cost of GPP, a number of environmental impacts were monetized so that they could be meaningfully accounted for in estimates of the total cost of procurement.

A great deal of literature exists on establishing the monetary costs of different types of pollution. A large literature review was undertaken to identify high-quality studies that monetize the costs of relevant types of pollution (mainly GHG, SO_2, NO_x, PM, and mercury emissions). As much as possible, China-specific studies and figures were employed, but where necessary findings from other contexts were used and appropriately adjusted to make them suitable to the Chinese context. The costs of pollution were separated into **environmental costs** and **health costs**, except in the case of GHGs where a "social cost of carbon" was used that combines environmental and health impacts. The monetization figures used in the model are summarized in Table 1[13].

Table 1: Monetized environmental and health costs of pollutant emissions

Pollutant	Environmental cost	Health cost
GHG	0.13242 CNY/kg CO_2	
SO_2	0.001923 CNY/g	0.05748 CNY/g
NO_x	0.03946 CNY/g	0.03879 CNY/g
PM	0.05926 CNY/g	0.04099 CNY/g
Mercury	No estimate	0.005534 CNY/mg

Sources: Various; see Technical Annex for more information

It should be noted that in most cases, these costs are likely underestimates, since they focus only on the impacts of pollution that could be quantified and monetized. This is particularly true of SO_2 emissions, which are monetized based on the damage to crops done by acid rain, which is only one of much large number of environmental impacts known to be associated with acid rain.

Present Value Discounting

When weighing the trade-offs involved in different GPP implementation choices, it is necessary to consider the value that future energy savings and future avoided environmental and health impacts represent. However, it would not be accurate to equally weight present and future benefits or costs. Their values have a time dimension in the sense that the same monetary amount does not have the same value later that it does now. To account for this time value of money, discounting is applied. Discounting can be essentially thought of as a reverse interest rate, where the value of future benefits or costs is discounted based on an annualized discount rate. In practice, it

13 See the Technical Annex for more information on sources and methods used in the monetisation of the environmental and health impacts of pollution

means that the further off the cost is, the more it is discounted, so that the cumulative cost of GPP over the time horizon can be summed in a way that gives lesser weight to more long-term costs. **A discount rate of 3 per cent is applied** in this model, a standard figure in cost-benefit analysis studies that weigh public investment choices.[14]

Electricity and Fuel

When assessing the fiscal costs and environmental impacts of energy-consuming products, it is important to have detailed and accurate information on the price and characteristics of the electricity or fuel that is being consumed. A considerable effort was undertaken to include electricity and fuel parameters in the model that evolved with time and that were specific to China.

For electricity, the model uses a 2015 electricity price of **CNY 0.85 per kilowatt-hour**. It assumes an annual growth rate of 2.5 per cent based on figures found in the 12th FYP Research Report.

To estimate electricity emission intensity, figures for the present mix of generation sources being used in China were taken from International Energy Agency (IEA) data, and projections were based on figures from China's **National Renewable Energy Centre(CNREC)**. The CNREC figures used are drawn from its **High Renewable Energy Penetration Scenario and Roadmap Study Brochure** for electricity generation, which takes an optimistic view of the pace at which renewable sources of electricity generation will come online, and is broadly in line with international pledges that China has made regarding the future of its electricity sector. Using this CNREC generation projection scenario limits the risk of the model being biased by the use of pessimistic generation mix projections; however, sensitivity analysis is also done in the model to show how the results would be affected by a slower renewable energy deployment timetable. Table 2 provides an overview of the projected generation mix used in the model.

Table 2: Electricity generation mix used in IISD GPP Model

Generation source	2015	2020	2025	2030
Nuclear power	5%	4%	4%	4%
Natural gas	4%	6%	6%	5%
Coal	68%	60%	49%	38%
Hydropower	16%	15%	16%	15%
Solar energy	1%	3%	7%	13%
Wind energy	4%	9%	15%	22%
Other renewables	2%	3%	3%	3%

Source: International Energy Agency (IEA), China's National Energy Board (NEB)

Finally, in order to produce figures for the average GHG, SO_2, NO_x and PM emission intensity of electricity for each year covered in the model's time horizon, China-specific figures for the average emissions intensities of different electricity generation sources were weighted by each source's share in the overall generation mix.[15]

[14] Three per cent is consistent with values seen in the economics literature and is the value used in the United States Office of Management and Budget (OMB) circular A-4 guidance for the consumption rate of interest

[15] See the Technical Annex for more information on sources and methods used in the modelling of electricity.

For fuel, the model uses a 2015 gasoline price of **CNY 7.2 per litre**. It assumes an **annual growth rate of 5.8 per cent** based on estimates for future global oil prices found in the **International Energy Agency's** 2015 ***Medium-Term Oil Market Report***.

For fuel emission intensity, the SO_2, NO_x and PM intensity of gasoline consumption was modelled based on the standards found in ***Limits and Measurement Methods for Emissions from Light-duty Vehicles***, published by the **Department of Environmental Protection** and the **State Administration of Quality Supervision, Inspection and Quarantine**. Stages 4 and 5 of the fuel quality standard were used to describe the emission intensity of gasoline combustion for the periods 2015–2018 and 2018–2030, respectively. In some cases, additional complementary sources were used in order to fill gaps in the data and to adjust variables' units for input into the model. A standard CO_2 intensity of 2.375 kg/L was applied throughout the model period.[16]

Table 3: Gasoline emissions intensities used in the IISD GPP Model

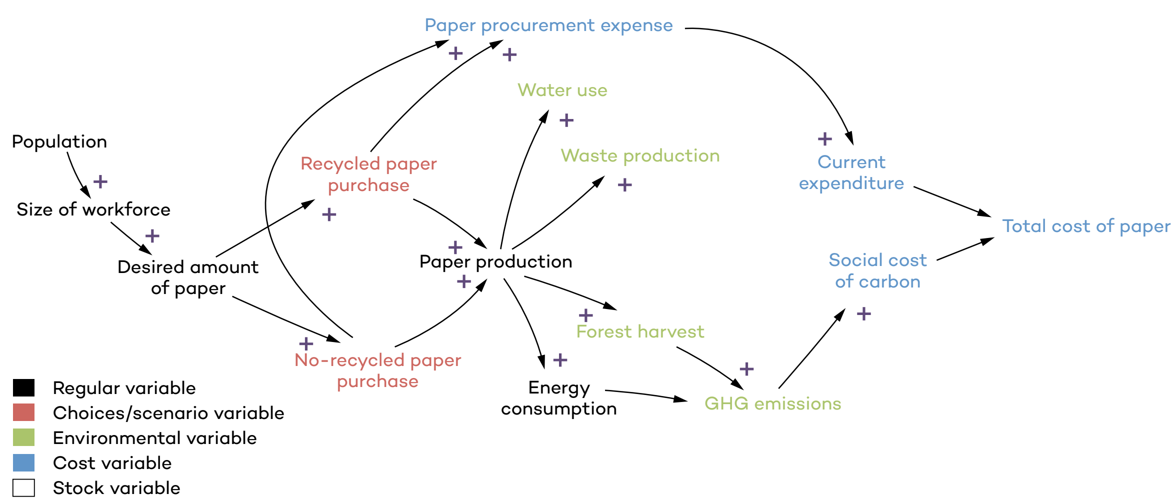
Pollutant	Units	Fuel standard 4 (effective Jan. 2014)	Fuel standard 5 (effective Jan. 2018)
SO_2	Grams/ kilogram of gasoline	<0.05	<0.01
NO_x	Grams/ kilometre driven	<0.08	<0.06
PM	Grams/ kilometre driven	<0.0237	<0.0045

Source: Department of Environmental Protection and the State Administration of Quality Supervision

2.1.3 Causal Loop Diagram (CLD)

A causal loop diagram (CLD) is a visual representation of a system dynamics model. It provides a schematic overview of the model's key variables and how they interact. It is an oversimplification of the model (the real IISD GPP Model in fact includes over 600 variables) intended to provide a summary view of the model's set-up and dynamics for stakeholders and users. Figures 20 and 21 offer partial CLDs of the IISD GPP Model, while Figure 22 summarizes the whole model.

Figure 20: CLD for a current good (using paper as an example)



[16] See the Technical Annex for more information on sources and methods used in the modelling of fuel.

Figure 21: CLD for a capital good (using lighting as an example)

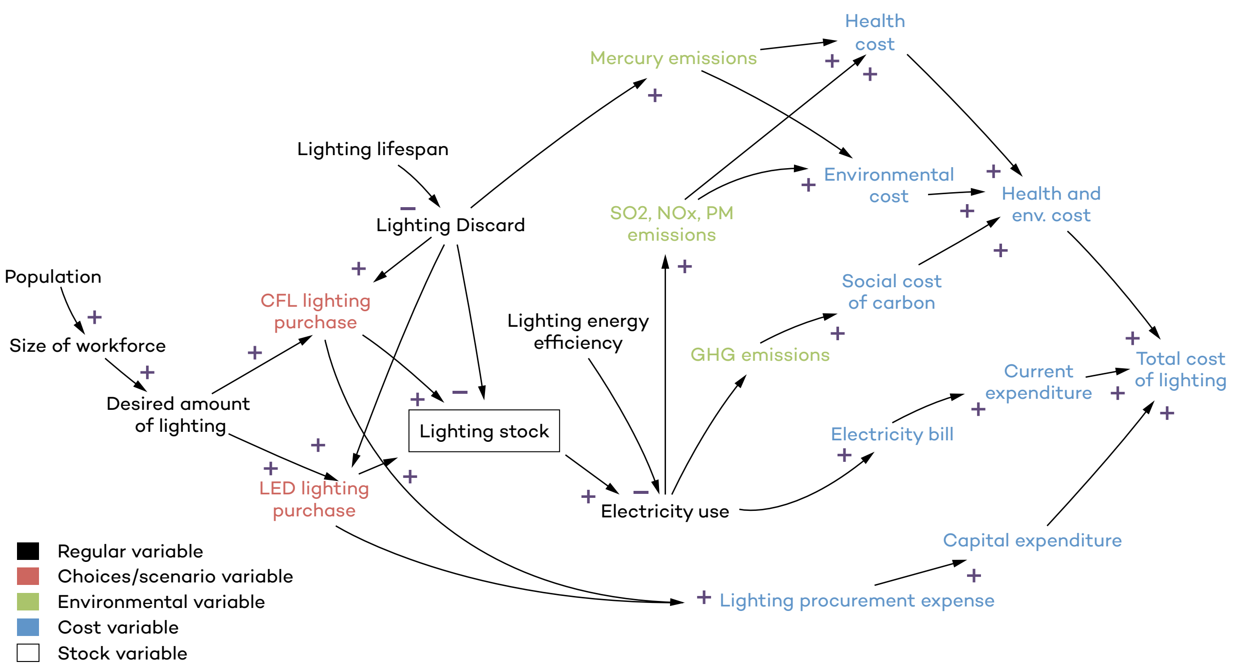
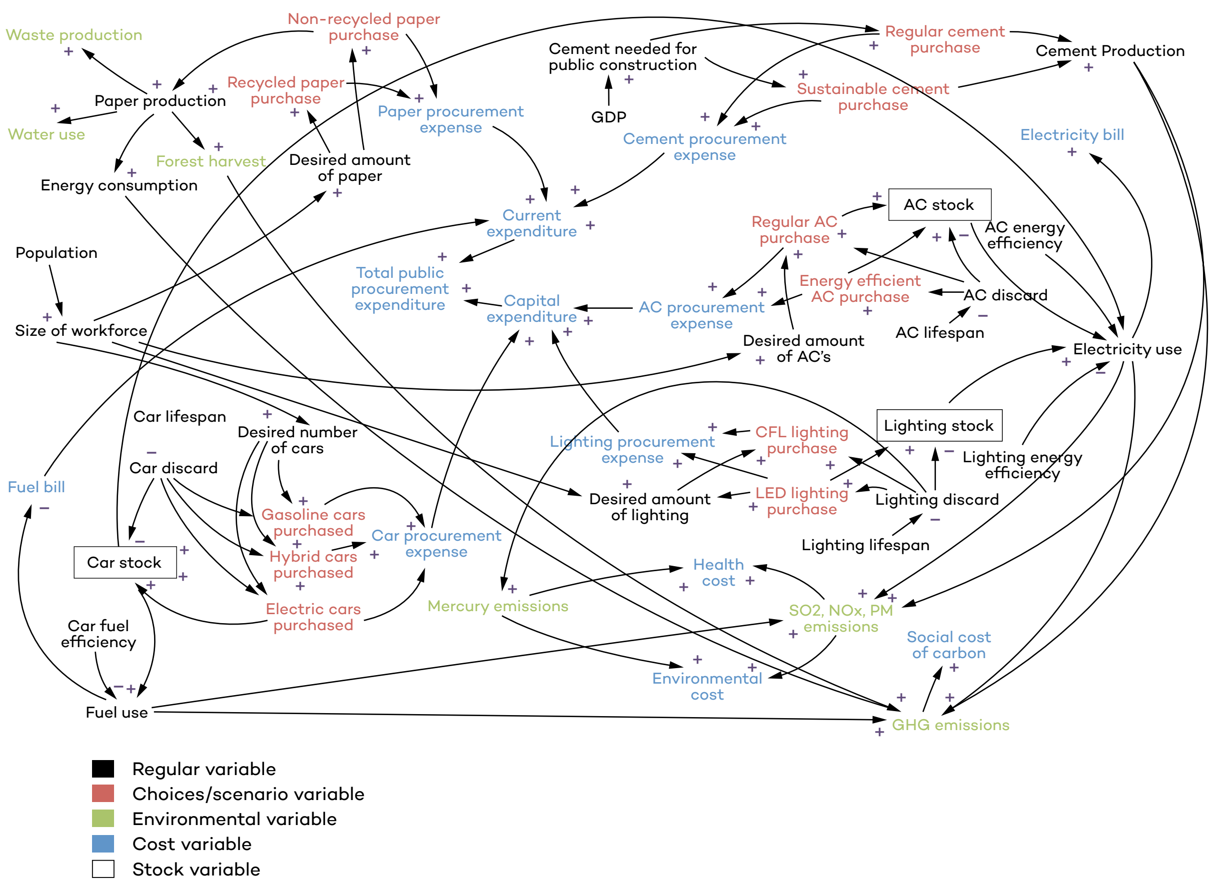


Figure 22: CLD overview of the IISD GPP Model



2.2 Modelling the Impact of GPP in China

The sections below present the modelling results for each of the five product categories analyzed—air conditioners, lighting, cars, paper, and cement. Summary results are provided in the following section.

2.2.1 Air Conditioners

Scope and Set-Up

- Three different tiers of air conditioners are modelled, differing with respect to their levels of energy efficiency and prices.
- Each tier of air conditioner describes a "representative" air conditioner available in the Chinese market, and is defined by the average prices and efficiency levels of small- and large-sized and fixed- and variable-speed air conditioners at each tier, weighted by their respective market shares.
- Procurement of air conditioners is assumed to follow projections for the size of the public workforce; disposal occurs after a period of 10 years.
- Environmental impacts occur during the use phase, stemming from air conditioners' electricity consumption.

Scenario Definitions

BASELINE SCENARIO
Air conditioner procurement is 100% from the third tier

LIGHT GREEN SCENARIO
Air conditioner procurement moves to 100% second tier, over a period of three years

DARK GREEN SCENARIO
Air conditioner procurement moves to 100% first tier, over a period of three years

Key Input Values[17]

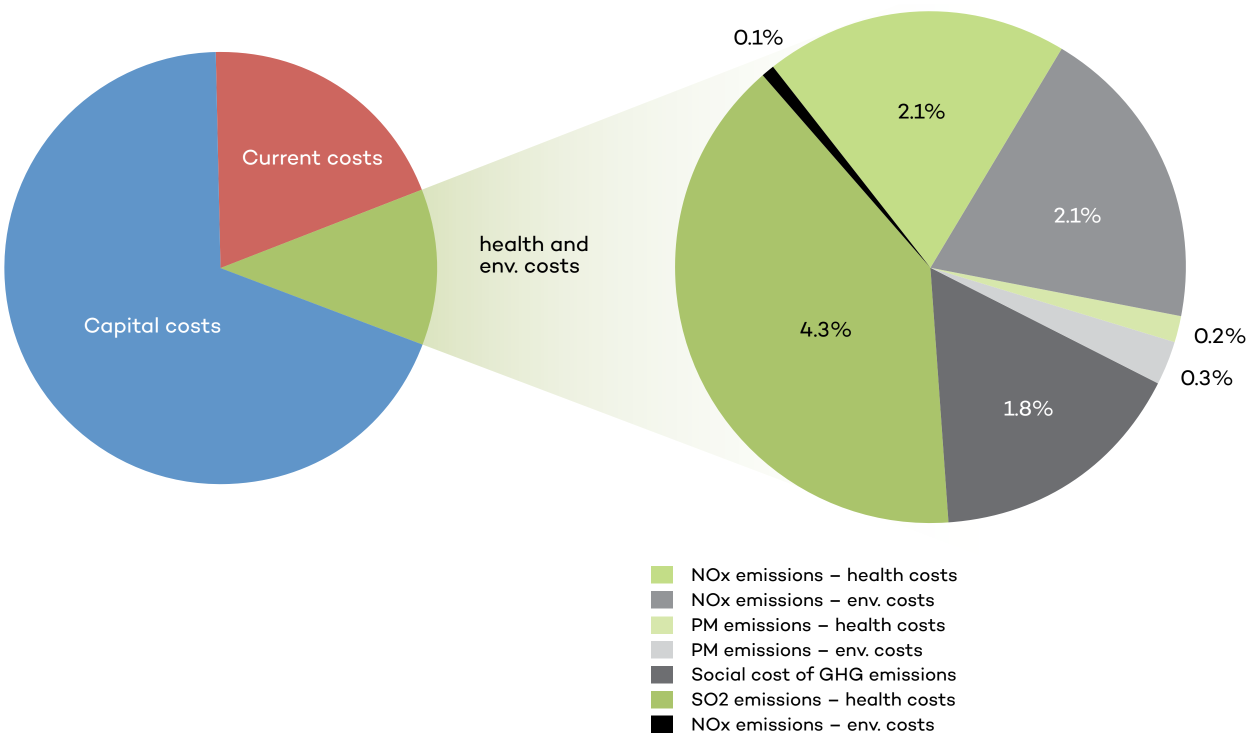
Variable		Units	Input value
Total stock (2015)		Air conditioners	16.3 million
Annual procurement (2015)		Air conditioners	1.63 million
Energy consumption	Tier 3	Kilowatts	980.18
	Tier 2	Kilowatts	941.25
	Tier 1	Kilowatts	856.11
Price	Tier 3	CNY	3,538
	Tier 2	CNY	4,585
	Tier 1	CNY	5,834
Annual usage		Hours	1,136
Lifetime		Years	10

[17] See the Technical Annex for a full explanation of sources and methods

Results

Before presenting scenario results for air conditioners, it is instructive to examine the current situation. It is estimated that the current total inclusive annual cost of public air conditioners in China totals CNY 9.3 billion . As seen in Figure 23 below, most of the fiscal costs stem from capital expenditure on air conditioners; current costs (from electricity consumption) make up a relatively smaller share. A large share of the health and environmental costs from air conditioners stem from the health costs of SO_2 emissions associated with their electricity consumption[18].

Figure 23: Cost components of air conditioner procurement in China (estimate for 2015)



With respect to scenario outputs, as seen in Figure 24, the total inclusive cost of the Light Green and Dark Green scenarios exceeds that of the baseline scenario, due to more efficient air conditioners' higher capital costs. This means that the energy savings and avoided health and environmental costs do not fully offset the higher purchasing costs. However, a consideration of the environmental and social impacts of air conditioner's electricity consumption lowers the effective cost of more efficient air conditioner models—the extra cost of the Light Green and Dark Green scenarios are 18.1 per cent and 38.9 per cent from a purely fiscal view, but only 16.9 per cent and 36 per cent when health and environmental costs are also considered.

[18] It is important to remember when interpreting results that some health and environmental cost components are likely underestimated, as discussed in Section 2.1.2 above.

Figure 24: Total inclusive cost of air conditioners under the baseline, Light Green, and Dark Green scenarios

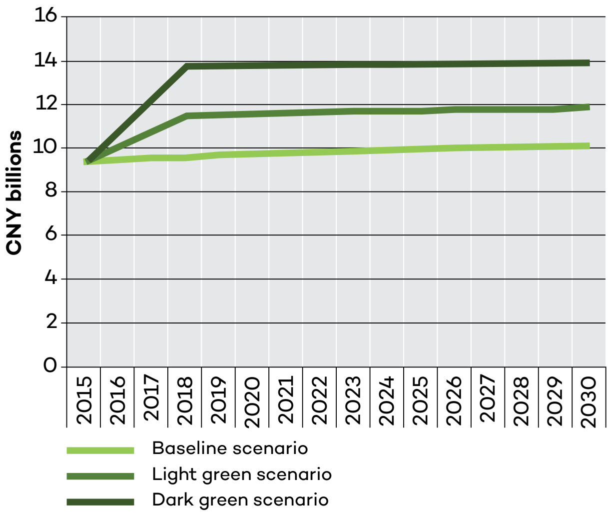
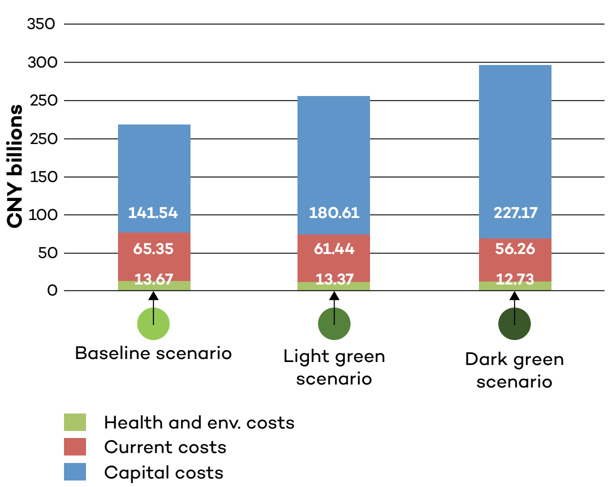


Figure 25 provides a comparison of aggregate costs for each scenario for the years 2015–2050 using present value discounting, and underscores the importance of capital costs as a determinant of air conditioners' total inclusive cost.

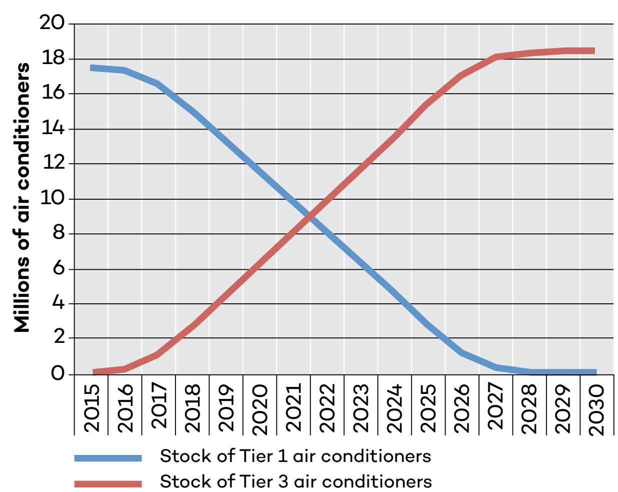
Figure 25: Total inclusive discounted cost of air conditioners for the period 2015-2050 under the baseline, Light Green, and Dark Green scenarios



Discussion

In analyzing the above results, it is important to remember the stock dynamics that are at play. Because air conditioners have a lifetime of ten years and because procurement of more efficient air conditioners is phased in over three years, it takes over 13 years before the less efficient air conditioners are completely phased out, as seen in Figure 26. GPP in air conditioners cannot offer immediate or significant offsetting cost savings, and therefore there is a cost of GPP leadership in the procurement of air conditioners. This "cost of leadership" is the difference between the costs seen under the baseline and the Light Green and Dark Green scenarios.In practice, that means that if government wishes to help drive the market toward the development and production of more efficient air conditioners by acting as a reliable buyer, it comes at an extra cost.

Figure 26: Air conditioner stock dynamics under the Dark Green scenario



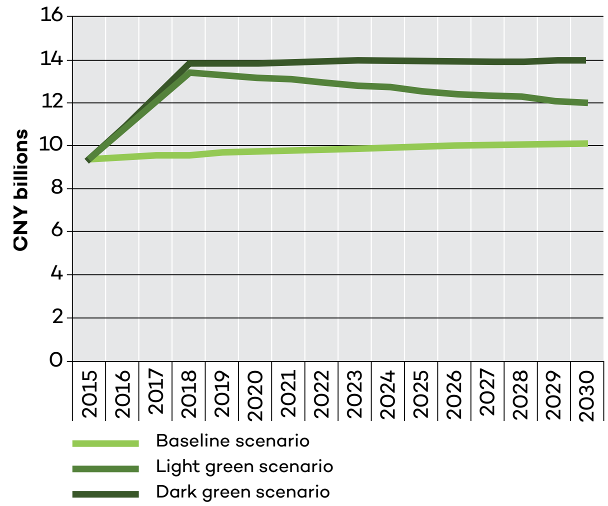
An additional point is that, even though modelling of their health and environmental impacts was focused on their use phase, air conditioners can be relatively emission-intensive at the production and disposal phases as well. A life-cycle analysis study of air conditioners commissioned by the European Commission found that production and disposal-phase environmental impacts could constitute as much as 30 per cent of total impacts (Philippe, Arimines & France, 2012). Production- and disposal-phase impacts of air conditioners in China were not modelled due to a lack of reliable data, but they certainly form part of the cost picture, and would help to further close the cost gap between the baseline and the Light Green and Dark Green scenarios seen above.

Sensitivity Analysis

Two sensitivity tests were conducted for air conditioners—falling prices for energy-efficient air conditioners, and a more pessimistic renewable energy deployment timetable for the electricity sector.

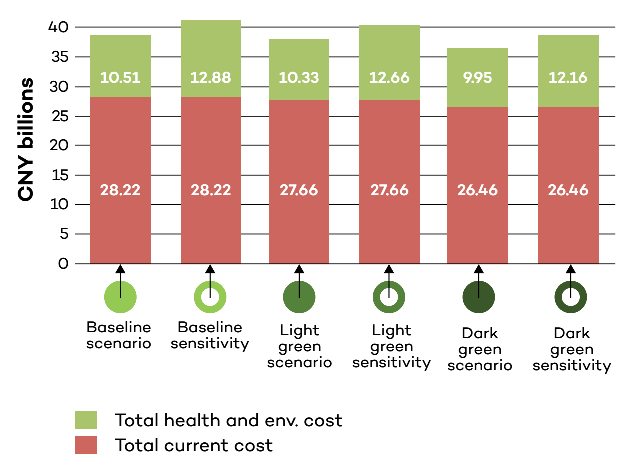
Figure 27 tests an alternative pricing assumption for air conditioners where the price difference between Tier 3 and Tier 1 air conditioners falls linearly between 2015 and 2030 to half of its current level. As seen in Figure 27, this leads to declining inclusive costs relative to the baseline scenario, but inclusive costs still remain higher overall due to the significant capital costs of Tier 1 air conditioners.

Figure 27: Sensitivity analysis on total inclusive costs of air conditioners, given falling prices for Tier 1 air conditioners



Results were also tested for their sensitivity to alternative emission factors for the electricity grid, using a more pessimistic view of the timetable for renewable energy deployment in the country than the NEB's High Renewable Energy Penetration Scenario.[19] As seen in Figure 28, using different projections for the electricity sector leads to notable differences in current costs and health and environmental costs.

Figure 28: Sensitivity analysis on current and health and environmental costs of air conditioners under a more pessimistic renewable energy deployment timetable



[19] See the Technical Annex for details on both electricity emissions intensity scenarios

Monte Carlo Analysis

In order to assess the potential impacts of model inputs' uncertainty, the following input variables were given an uncertainty rating of low, medium or high. A normal distribution was applied to these variables with a respective standard deviation of 5 per cent, 10 per cent or 25 per cent of their input value. The model was then re-run 1,000 times, sampling within these distributions and producing a set of results that reflected uncertainty in model inputs.

- **Current and projected levels of procurement** – <u>medium</u> level of uncertainty
- **Energy efficiency** – <u>low</u> level of uncertainty
- **Product prices** – <u>low</u> level of uncertainty
- **Annual usage** – <u>medium</u> level of uncertainty
- **Current electricity price** – <u>low</u> level of uncertainty
- **Projected electricity price** – <u>high</u> level of uncertainty
- **Electricity emissions intensity** – <u>high</u> level of uncertainty
- **Monetization values** – <u>high</u> level of uncertainty, right-skewed[20]

Figures 29 through 31 provide Monte Carlo analysis results for air conditioners, visualizing the degree of uncertainty associated with model results as a result of inputs variable uncertainty.

Figure 29: Monte Carlo analysis for total inclusive cost of air conditioners - baseline scenario

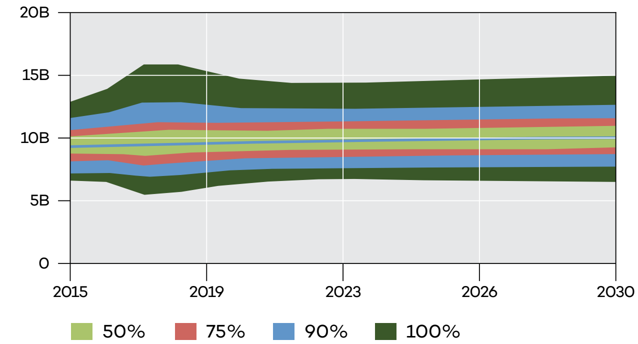


Figure 30: Monte Carlo analysis for total inclusive cost of air conditioners – Light Green scenario

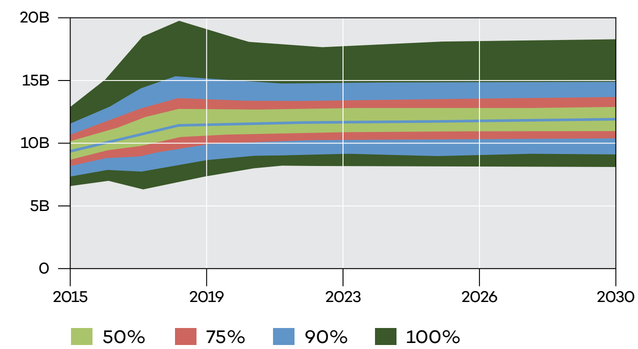
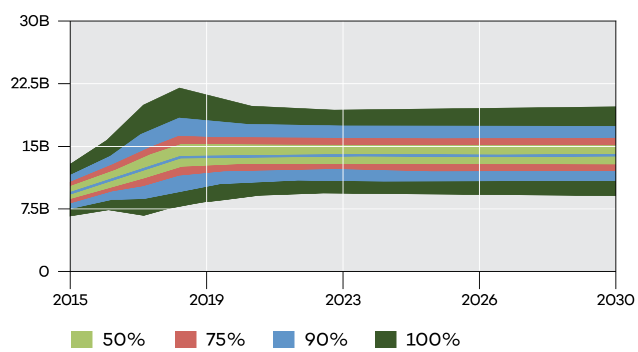


Figure 31: Monte Carlo analysis for total inclusive cost of air conditioners – Dark Green scenario



[20] Monetisation variables' probability distributions were right skewed to account for the fact that they are likely underestimates

2.2.2 Lighting

- Two different types of lighting are modelled: compact fluorescent lights (CFL) and light-emitting diodes (LED).[21]
- Modelled CFL and LED bulbs provide the same amount of light (775 lumens, equivalent to a 60W incandescent bulb), but differ in prices, levels of energy consumption and lifetimes.
- The installation of energy-conserving "smart" switches is also modelled, which affects the annual usage (and thereby the lifetime) of lighting.
- Procurement of lighting is assumed to follow projections for the size of the public workforce; disposal occurs when a bulb reaches the end of its expected lifetime.
- Environmental impacts occur during the use and disposal phases, with use-phase impacts stemming from electricity consumption and disposal from mercury emissions.

Scenario Definitions

BASELINE SCENARIO

Lighting procurement is two-thirds CFL and one-third LED

LIGHT GREEN SCENARIO

Lighting procurement moves to 100% LED, over a period of three years

DARK GREEN SCENARIO

Lighting procurement moves to 100% LED *with smart switches*, over a period of three years

Key Input Values[22]

Variable		Units	Input value
Total stock (2015)		Bulbs	263.9 million
Annual procurement (2015)		Bulbs	100.3 million
Energy consumption	CFL	Watts per bulb	14
	LED	Watts per bulb	10
Mercury emissions from disposal	CFL	Milligrams per bulb	2.97
	LED	Milligrams per bulb	0
Price	CFL	CNY per bulb	21.46
	LED	CNY per bulb	37.71
	Smart switch	CNY per bulb	20.2
Annual usage	Without smart switch	Hours	4680
	With smart switch	Hours	3744
Lifetime	CFL	Years	1.7
	LED without smart switch	Years	5.3
	LED with smart switch	Years	6.68

[21] Incandescent lighting was not modelled since research showed that its government procurement has already been largely phased out in China.

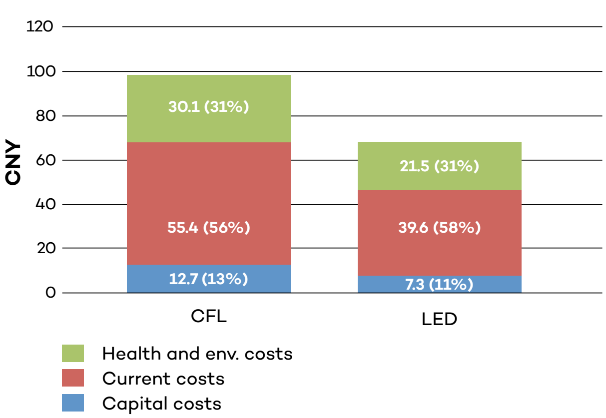
[22] See the Technical Annex for a full explanation of sources and methods.

Results

It is estimated that the total annual inclusive cost of government lighting procurement in China is CNY 23 billion, with the majority of this being driven by current expenditure (from lights' electricity consumption). Figure 32 gives the estimated average annual per-bulb costs of CFL and LED lighting, and shows that the current costs form over half of the total cost of each type of lighting.

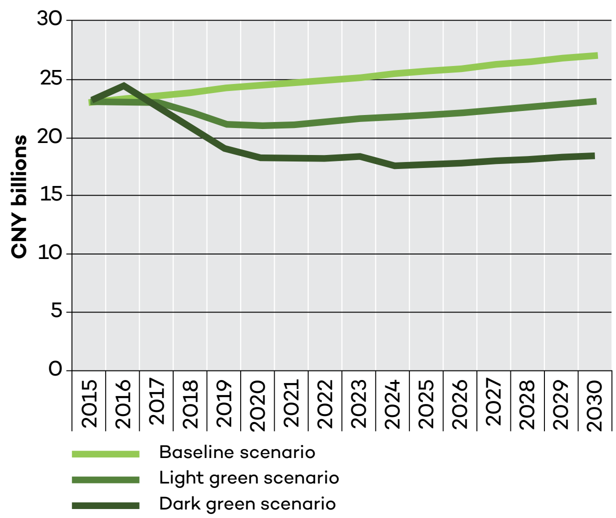
A very significant model result seen in Figure 32 is that CFLs are found to be more expensive than LEDs on an annualized basis. This means that when accounting for the fact that CFLs need to be replaced more often, the cost of ownership for an LED bulb is actually less than that of a CFL bulb, despite LED bulbs' higher purchase price. An additional notable finding is that, for both types of lighting, the health and environmental costs associated with electricity consumption form a more significant share of total costs than capital costs do. This means that the health and environmental costs associated with light bulbs' use is actually greater than the cost of buying them.

Figure 32: Per-bulb costs of CFL and LED lighting procurement in China (estimate for 2015)[23]



The scenario outputs for lighting, as seen in Figure 33, show that it is cheaper overall to buy LED lighting and smart switch-enabled LED lighting, despite their higher purchase prices. Costs are higher under the baseline scenario, where two thirds of lighting procurement is CFL, than under the Light Green and Dark Green scenarios, where 100 per cent of procurement moves to being LED (with and without smart switches, respectively).

Figure 33: Total inclusive cost of lighting under the baseline, Light Green, and Dark Green scenarios



An additional, powerful finding is that the purchase of LEDs proves to be cheaper overall, even when health and environmental costs are ignored and only fiscal costs are considered, as seen in Figure 34. The Light Green and Dark Green scenarios are respectively 13.2 per cent and 27.1 per cent cheaper than the baseline scenario when health and environmental costs are considered, but are still 12.9 per cent and 26.7 per cent cheaper when only fiscal costs are considered.

[32] Capital costs are annualised in this figure, meaning they are spread over the lifetime of each bulb type.

Figure 34: Total fiscal cost of lighting under the baseline, Light Green, and Dark Green scenarios

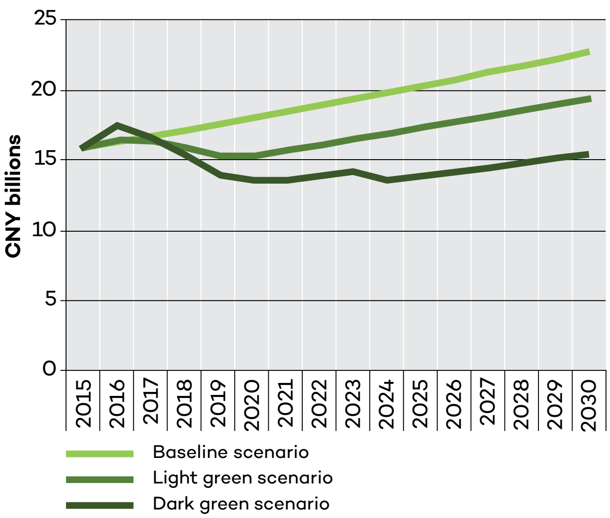
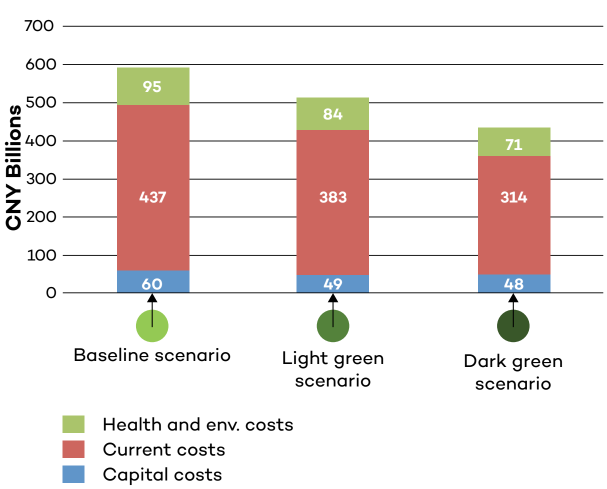


Figure 35 provides a comparison of each scenario's aggregate cost for years 2015 to 2050 using present value discounting. Here we again see that current costs (from expenditure on electricity) are the most significant component of overall costs for lighting, followed by health and environmental costs.

Figure 35: Total inclusive discounted cost of lighting for the period 2015-2050 under the baseline, Light Green, and Dark Green scenarios



Discussion

It is important to note that, as with air conditioners, the effects of GPP in lighting may take time to be realized because of stock turnover—even once procurement has moved to 100 per cent LED, it takes a number of years for CFL bulbs to be fully phased out. However, stock turnover in lighting does not take as long as in air conditioners due to comparatively shorter lifetimes. Indeed, in Figure 33 one can see that the cost savings realized in the Light Green scenario have been mostly realized by 2020.

Stock turnover is in fact one of the features that help keep the capital expenditure on LEDs low in the Light Green and Dark Green scenarios. LED bulbs are typically expected to last 25,000 hours compared to CFLs' 8,000. This means they need to be replaced much less often; along with their greater energy efficiency, that is one of the main reasons that costs in the Light Green scenario are lower than in the baseline scenario.

The installation of smart switches extends bulbs' lifetimes as well, since they turn off lights when they are not needed, extending the expected lifespan of LED bulbs by over a year. With time, this leads to reduced capital expenditure. Another advantage of smart switches is that they only need to be installed once, so although they raise the effective price paid for a bulb, the increase is only temporary. This is the reason for the dip in costs seen in 2023 in Figure 33's Dark Green scenario—at that point, all bulbs have been equipped with smart switches and the effective price paid per bulb declines.

A final point concerns the mercury content of CFL bulbs. A CFL bulb typically contains 2.97 milligrams of mercury (LED bulbs do not contain mercury). Mercury is a dangerous neurotoxin, and exposure can have major impacts on human health. The release of mercury from CFL bulbs at the disposal stage and their consequent health costs are modelled; however, monetized impacts from mercury were not a significant contributor to the total inclusive cost of CFL bulbs. This may be because the monetization figures for mercury focus on general environmental accumulation, whereas with CFL there is a risk that mercury will end up concentrated in particular locations, for example sites where e-waste is processed, and that health impacts in these areas will therefore be much more pronounced. At the production end, there is strong anecdotal evidence of notable health impacts from CFL mercury in China (Barratt, 2010), as well as evidence that the production and disposal-phase impacts can reach as high as 15 per cent of total impacts from a life-cycle perspective (International Energy Agency, 2014). Therefore, while this model does not project notable costs from mercury emissions, this finding deserves closer examination in future studies.

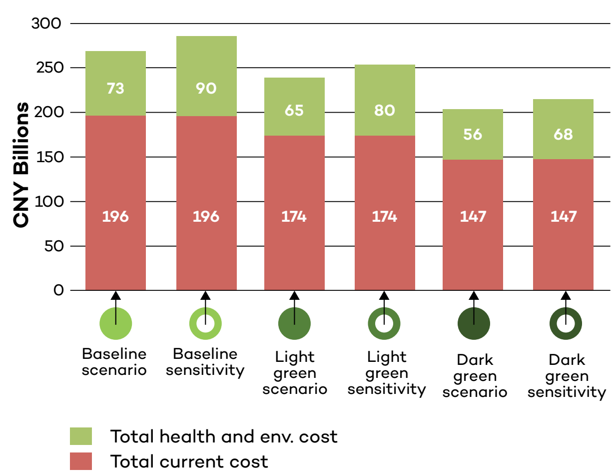
Sensitivity Analysis

Two sensitivity tests are done for lighting: an alternative, higher price for smart switches and the more pessimistic renewable energy deployment timetable for the electricity sector.

Smart switch prices used in the model are based on market research in China. However, estimates of their installation cost are based simply on the assumption that they are equal to the market price. However, it is possible that installation costs will be even higher than this. To test how higher smart switch costs might affect model results, an installation cost of three times the purchase price was tested, which amounts to doubling the price used in the Dark Green scenario presented above. As seen in Figure 36, a higher smart switch cost raises the costs of the Dark Green scenario and delays the point at which smart switches become more cost effective by approximately a year, but overall it still remains cost-effective to buy smart switches. This means that the model results are robust to higher smart switch installation costs.

The effect of the more pessimistic scenario for renewable energy deployment is also tested. As seen in Figure 36, a more emission-intensive electricity sector would lead to notably higher current costs and health and environmental costs.

Figure 36: Sensitivity analysis on current and health and environmental costs of lighting under a more pessimistic renewable energy deployment timetable



Monte Carlo Analysis

In order to assess the potential impacts of model inputs' uncertainty, the following input variables were given an uncertainty rating of low, medium or high. A normal distribution was applied to these variables with a respective standard deviation of 5 per cent, 10 per cent or 25 per cent of their input value. The model was then re-run 1,000 times, sampling within these distributions and producing a set of results that reflected uncertainty in model inputs.

- **Current and projected levels of procurement** – medium level of uncertainty
- **Energy efficiency** – low level of uncertainty
- **Product prices** – low level of uncertainty
- **Annual usage** – medium level of uncertainty
- **Current electricity price** – low level of uncertainty
- **Projected electricity price** – high level of uncertainty
- **Electricity emissions intensity** – high level of uncertainty
- **Monetization values** – high level of uncertainty, right-skewed[24]

Figures 37 through 39 provide Monte Carlo analysis results for lighting, visualizing the degree of uncertainty associated with model results as a result of inputs variable uncertainty.

Figure 37: Monte Carlo analysis for total inclusive cost of lighting - baseline scenario

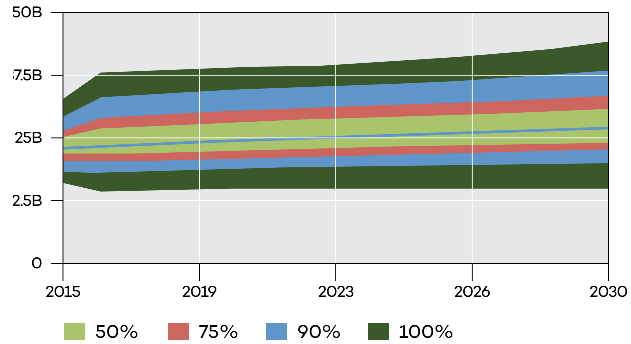


Figure 38: Monte Carlo analysis for total inclusive cost of lighting - Light Green scenario

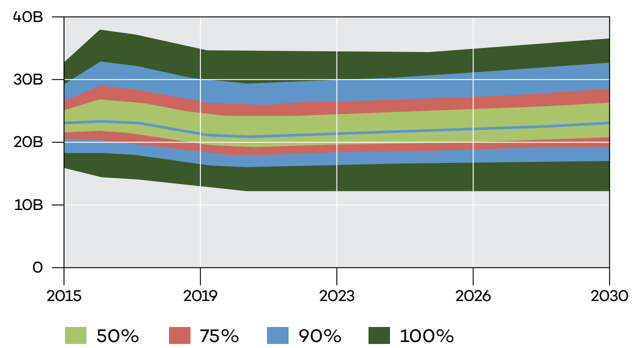
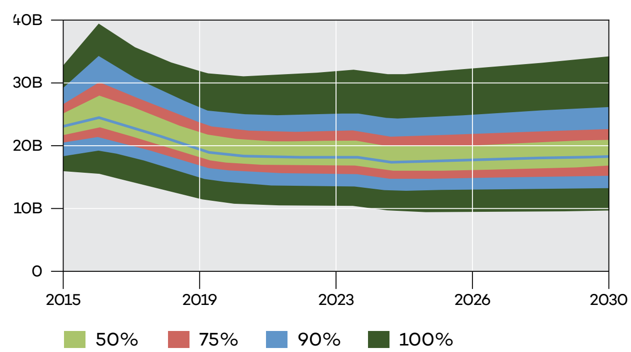


Figure 39: Monte Carlo analysis for total inclusive cost of lighting – Dark Green scenario



[24] Monetisation variables' probability distributions were right skewed to account for the fact that they are likely underestimates

2.2.3 Cars

Scope and Set-Up

- Three different types of cars are modelled: gasoline, hybrid and electric, differing with respect to their prices and levels of energy efficiency.
- Cars’ prices and energy efficiency are based on averages seen in the Chinese market; any differences with respect to engine size are weighted by market share.
- To account for the fact that hybrid and electric cars can be reasonably expected to fall in price going forward, the price difference between them and gasoline cars is assumed to fall linearly between 2015 and 2030, to one third of its current level.
- Procurement of cars is assumed to follow projections for the size of the public workforce; disposal occurs after eight years.
- Environmental impacts are modelled to occur entirely during the use phase, stemming from environmental and health impacts associated with cars’ fuel consumption.

Scenario Definitions

BASELINE SCENARIO
Procurement of hybrid and electric cars remains in line with the braoder market average (>99% gasoline)

LIGHT GREEN SCENARIO
Procurement of hybrid and electric cars moves to 30% (15% each), over a period of 5 years (based on gov’t policy)

DARK GREEN SCENARIO
Procurement of hybrid and electric cars moves to 60% (30% each), over a period of 5 years

Key Input Values[25]

Variable		Units	Input value
Total stock (2015)		Cars	318,400
Annual procurement (2015)		Cars	39,800
Energy consumption	Gasoline car	Litres per kilometre	0.0772
	Hybrid car	Litres per kilometre	0.0551
	Electric car	Kilowatt hours per kilometre	0.15625
Price[26]	Gasoline car	CNY	106,000
	Hybrid car (initial price)	CNY	144,000
	Electric car (initial price)	CNY	306,000
Annual usage		Kilometres per year	15,183
Lifetime		Years	8

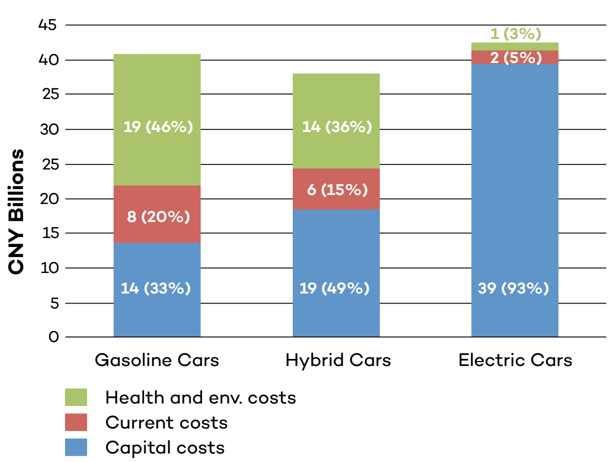
[25] See the Technical Annex for a full explanation of sources and methods.

[26] Prices for hybrids and electrics reflect plans to waive the 10 per cent purchasing tax in cases of government procurement (5pp).

Results

The different types of cars in the IISD GPP Model differ significantly in terms of how their costs break down. Figure 40 provides annualized per-car costs for each type of car. As seen in the figure, hybrid and electric cars have much higher capital costs due to their significantly higher purchase prices. However, they also have significantly smaller current costs and health and environmental costs due to their greater energy efficiency. Overall, under current prices, hybrid cars appear to be the most cost-effective option from an inclusive cost perspective. And electric cars, despite their much higher capital costs, are only 4.1 per cent more expensive than gasoline cars from an inclusive cost perspective due to their much smaller fuel consumption and associated health and environmental costs.

Figure 40: Per-car costs of gasoline, hybrid, and electric car procurement in China (estimate for 2015)



The three types of cars also break down quite differently with respect to their health and environmental costs. Because of the relatively high sulphur content of gasoline in China, hybrid and gasoline cars have most of their health and environmental costs stemming from the health impacts of SO_2, as seen in Figure 41, while as seen in Figure 42, electric cars' health and environmental costs are more in line with other electricity consuming products such as air conditioners and lighting, both presented in the sections above.

Figure 41: Health and environmental cost components of gasoline and hybrid cars' gasoline consumption in China (estimate for 2015)

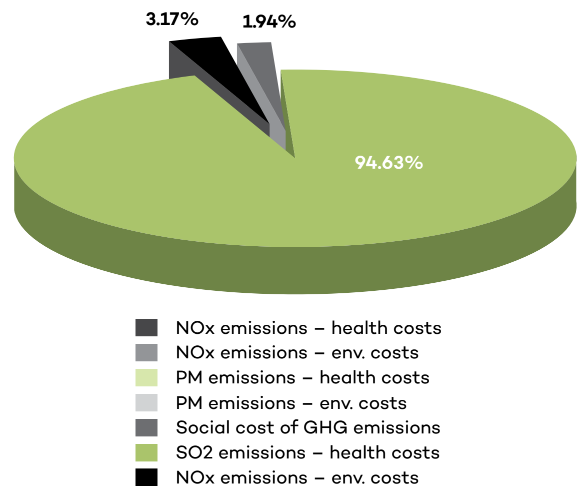
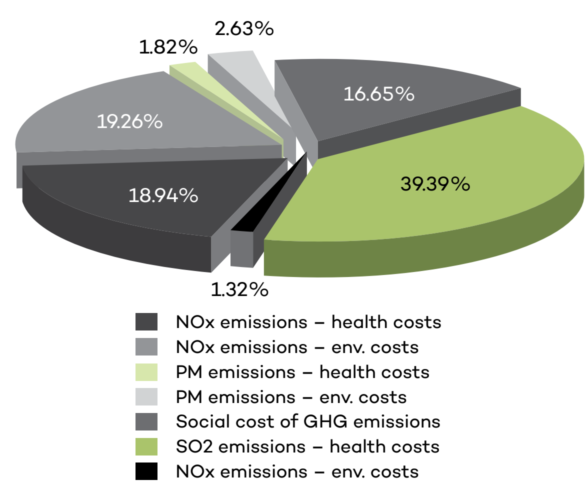


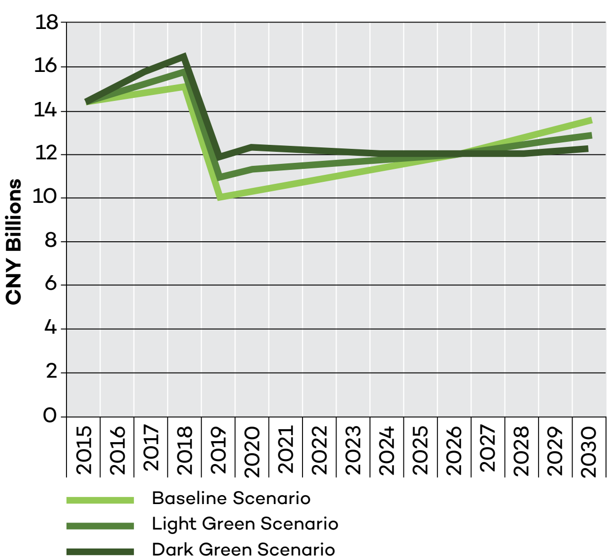
Figure 42: Health and environmental cost components of electric cars' electricity consumption in China (estimate for 2015)



[27] Capital costs are annualized in this figure, meaning they are spread over the lifetime of each car type (assumed to be 8 years for each)

With respect to scenario results for cars, as seen in Figure 43, total inclusive costs are higher under the Light Green and Dark Green scenarios for at least the next ten years. This is due entirely to the significantly higher purchase price of hybrid and electric cars. However, as more and more gasoline cars reach the end of their assumed eight-year lifespan and are replaced with hybrid and electric cars (which are modelled to steadily decrease in price between 2015 and 2030), the effect of reduced fuel consumption and reduced health and environmental impacts becomes more pronounced, and the Light Green and Dark Green scenarios become more cost-effective relative to the baseline scenario. This means that there is a significant up-front investment associated with hybrid and electric cars, and that it takes some time for this investment to pay off—an intuitive result.

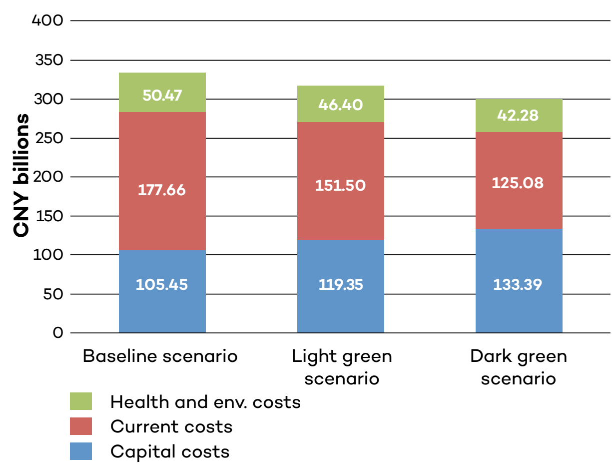
Figure 43: Total inclusive cost of cars under the baseline, Light Green, and Dark Green scenarios



It should be noted that the drop in costs seen in the year 2018 across all scenarios in the figure above is explained by the introduction that year of Fuel Standard 5, which requires that the sulphur content of gasoline fall to one fifth of its current level.[28] Other future possible improvements to the country's fuel standard were not modelled, but would similarly lead to a fall in total inclusive costs if instituted.

Figure 44 provides a comparison of each scenario's aggregate cost for years 2015–2050 using present value discounting. It shows that, despite higher capital costs, the greater expenditure associated with the increased purchase of hybrid and electric cars eventually comes to pay for itself (and more) in the form of energy savings and reduced health and environmental costs.

Figure 44: Total inclusive discounted cost of cars for the period 2015-2050 under the baseline, Light Green, and Dark Green scenarios



[28] It was assumed that this change takes effect in the year 2018, but in fact it may be the case that sulphur levels begin to fall in advance of 2018 as fuel refiners and distributors prepare for the policy change.

Discussion

Before discussing the results seen above in detail it is necessary to say a few words about the choice of cars as one of the products analyzed in the IISD GPP Model. Interviews with in-country stakeholders revealed that cars are decreasingly being directly procured by government in China. Instead, government is using more rental cars and other types of car service providers. However, despite this, cars were chosen for analysis in the IISD GPP Model for two reasons—their importance as a product category, and the possibility of government pursuing GPP indirectly.

First, cars were selected for analysis because they are an important GPP product. China's national vehicle fleet is massive and growing, and the energy efficiency of cars that consumers purchase will have a dramatic effect on GHG emissions, air pollution, and associated health costs in the country. However, as in other countries, the uptake of hybrid and electric cars is quite small. Therefore, cars are an important area in which government can signal to the market that it is a reliable buyer, encouraging companies to invest in production capacity and R&D. This will hopefully in time lead to lower prices for consumers and greater uptake of hybrids and electrics.

Second, cars were selected because of the possibility of indirect GPP. Government may be purchasing less and less cars itself, but if it signals to its service providers that it would like a certain share of the cars it uses to be hybrids or electrics, this can be a valuable indirect way of pursuing GPP in this key product category. For these two reasons, cars were selected as a key category for analysis of GPP policy impacts.

As with air conditioners, important stock dynamics are at play in the results seen for cars. Due to their modelled lifetime of eight years and the fact that GPP implementation is phased in over a period of five years in the Light Green and Dark Green scenarios, the stock of cars does not reach the 15 per cent hybrids and 15 per cent electrics in the Light Green scenario or 30 per cent hybrids and 30 per cent electrics in the Dark Green scenario for a full thirteen years. This means that the benefit of GPP in cars (in the form of energy savings and avoided health and environmental costs) takes time to be realized.

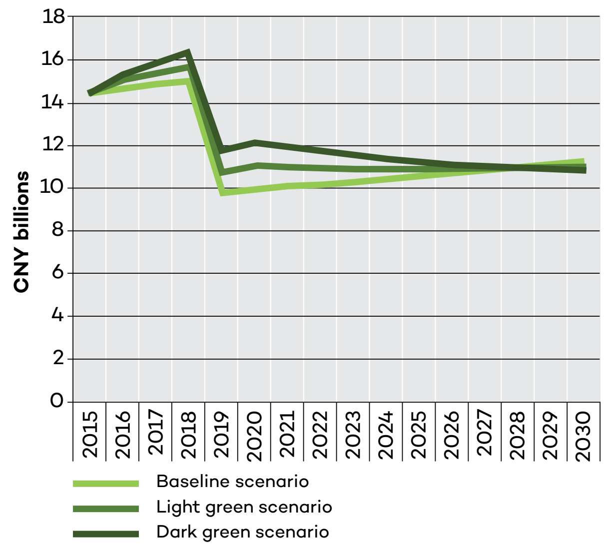
Cars' relatively long lifetimes and slow stock turnover is one of the reasons that the results show such a significant up-front investment cost for GPP in cars. The other major important driver is the high cost of hybrid and electric cars. This high up-front cost is a form of GPP leadership cost—if government wishes to provide support to the fledgling sector by being a reliable buyer of hybrid and electric cars, it requires that it pay higher costs. However, the model results for cars are different than for air conditioners in that owning and operating hybrid and electric cars eventually becomes cheaper than gasoline cars. This means that the cost of GPP leadership in this product category is only a temporary one. Given the importance of the sector in terms of its GHG, health, and environmental impacts, as well as the important economic opportunity it represents in terms of potential export to international markets, GPP in cars represents a wise policy. Indeed, this is already realized by government. Its policy of waiving the 10 per cent purchasing tax on hybrids and electrics in cases of government procurement (Fleming, 2014) helps to lower the price premium that government buyers face in purchasing these types of cars, incentivizing their purchase and signalling to producers that government intends to be a reliable buyer of their products.

Sensitivity Analysis

Estimates of future fuel prices in the model are based on IEA projections for the global price of oil. A growth rate from the 2015 price of 5.8 per cent per year is predicted, but given the historically low price of oil being experienced in the past year, and uncertainty over how fast and to what degree is might rise in the future, it is important to test the sensitivity of model results to the model's fuel price growth assumptions.

An alternative fuel price growth rate of 2.9 per cent (half the rate used normally in the model) was used to test the sensitivity of results to this change. The results of this sensitivity test, seen in Figure 45 below, show that while the absolute level of costs is affected (see Figure 43 above to compare), the relative difference between the scenarios is largely unchanged. The main difference is that it now takes two years longer to reach the point at which the Light Green and Dark Green scenarios become cheaper than the baseline scenarios. This makes intuitive sense—if gasoline prices aren't as high, reduced fuel consumption will not lead to the same degree of fiscal savings, and it will take longer for the investment in hybrid and electric cars to pay off. Broadly speaking, the results presented in the section above are robust to the possibility of a slower growth rate in the price of gasoline.

Figure 45: Sensitivity analysis on total inclusive costs of cars, given a slower rate of increase in fuel prices



Monte Carlo Analysis

In order to assess the potential impacts of model inputs' uncertainty, the following input variables were given an uncertainty rating of low, medium or high. A normal distribution was applied to these variables with a respective standard deviation of 5 per cent, 10 per cent or 25 per cent of their input value. The model was then re-run one thousand times, sampling within these distributions and producing a set of results that reflected uncertainty in model inputs.

- **Current and projected levels of procurement** – medium level of uncertainty
- **Energy efficiency** – medium level of uncertainty
- **Product prices** – medium level of uncertainty
- **Annual usage** – medium level of uncertainty
- **Car lifetime** – high level of uncertainty
- **Current fuel price** – low level of uncertainty

- **Projected fuel price** – high level of uncertainty
- **Fuel emissions intensity** – medium level of uncertainty
- **Current electricity price** – low level of uncertainty
- **Projected electricity price** – high level of uncertainty
- **Electricity emissions intensity** – high level of uncertainty
- **Monetization values** – high level of uncertainty, right-skewed[29]

Figures 46 through 48 provide Monte Carlo analysis results for cars, visualizing the degree of uncertainty associated with model results as a result of inputs variable uncertainty.

Figure 46: Monte Carlo analysis for total inclusive cost of cars - baseline scenario

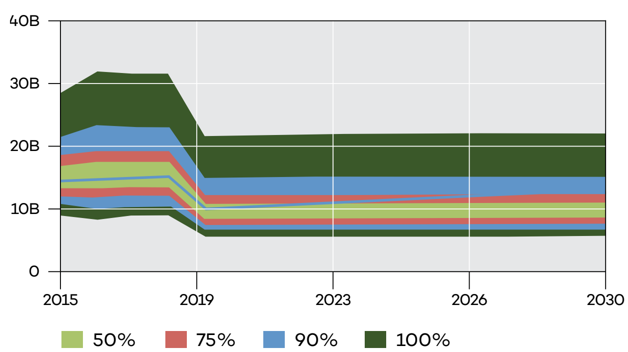


Figure 47: Monte Carlo analysis for total inclusive cost of cars - Light Green scenario

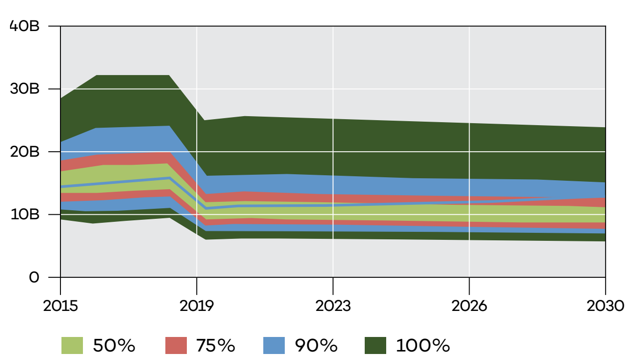
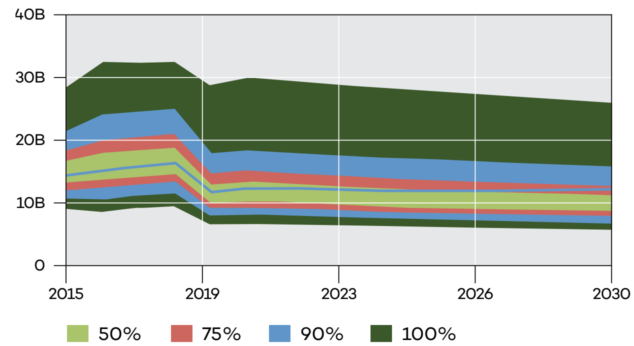


Figure 48: Monte Carlo analysis for total inclusive cost of cars – Dark Green scenario



2.2.4 Paper

Scope and Set-Up

- Two different types of paper are modelled—recycled and non-recycled, differing with respect to their price and their material and emission intensity.
- Procurement of paper is assumed to follow projections for the size of the public workforce; it is assumed that all paper is produced in the year it is purchased.
- Environmental impacts occur entirely during the production phase (the extent and impact of government's recycling of the paper it uses was not modelled due to data constraints).
- Only GHG emissions (which stem from both energy and wood use) are monetized, other environmental impacts such as water use and waste production are quantified in the model but are not monetized.

[29] Monetisation variables' probability distributions were right skewed to account for the fact that they are likely underestimates.

Scenario Definitions

BASELINE SCENARIO
Procurement of recycled paper remains in line with estimates of the broader market average (<1% recycled)

LIGHT GREEN SCENARIO
Procurement of recycled paper moves to 20%, over a period of five years

DARK GREEN SCENARIO
Procurement of recycled paper moves to 40%, over a period of five years

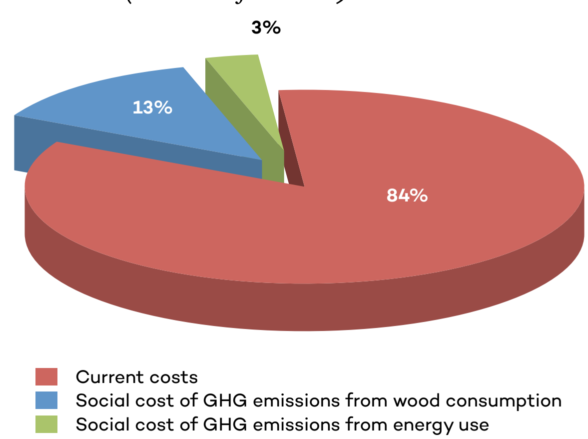
Key input values[30]

Variable		Units	Input value
Annual procurement (2015)		Tonnes of paper	3.6 million
Energy requirement	Non-recycled paper	Kilowatt hours per tonne	9,600
	Recycled paper	Kilowatt hours per tonne	3,600
Wood requirement	Non-recycled paper	Tonnes per tonne	2.9626
	Recycled paper	Tonnes per tonne	0.14813
GHG intensity	Non-recycled paper	Kilograms CO_2 per tonne	2,800
	Recycled paper	Kilograms CO_2 per tonne	554
Water use	Non-recycled paper	Cubic metres per tonne	15
	Recycled paper	Cubic metres per tonne	8
Waste production	Non-recycled paper	Kilograms per tonne	1,500
	Recycled paper	Kilograms per tonne	100
Price	Non-recycled paper	CNY per tonn	4,967
	Recycled paper	CNY per tonn	5,478

Results

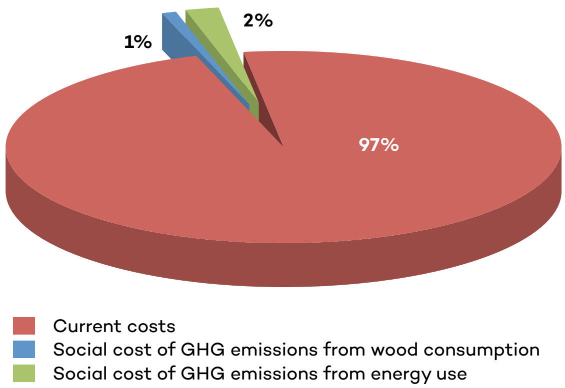
It is estimated that the total annual cost of government procurement of paper in China is CNY 21.2 billion when the cost of associated GHG emissions is included. The costs for recycled paper and non-recycled paper break down quite differently, as seen in figures 49 and 50. Non-recycled paper, because of its greater energy use and far greater use of virgin wood pulp, has much higher GHG emissions costs than does recycled paper. And even though recycled paper is more expensive than non-recycled paper, fiscal expenditure makes up a lower share of its cost due to its less significant energy and virgin pulp requirements (which are on average less than 5 per cent).

Figure 49: Cost components of non-recycled paper in China (estimate for 2015)



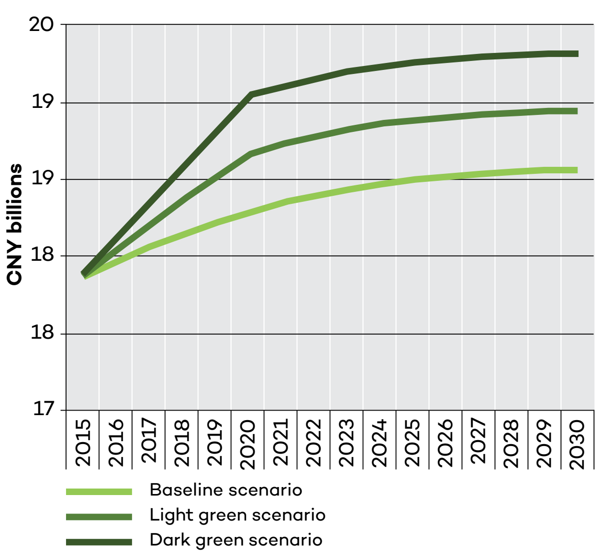
[30] See the Technical Annex for a full explanation of sources and methods.

Figure 50: Cost components of recycled paper in China (estimate for 2015)



In terms of scenario results, the present tendency toward purchase of non-recycled paper seen in the baseline scenario is cheaper from a fiscal perspective, as seen in Figure 51.

Figure 51: Total fiscal cost of paper under the baseline, Light Green, and Dark Green scenarios



However, as Figure 52 shows, when the cost of associated GHG emissions are accounted for, the greater purchase of recycled paper seen in the Light Green and Dark Green scenarios becomes the cheaper option. This means that from an inclusive cost perspective, the model finds that procurement of recycled paper is more cost-effective.

Figure 52: Total inclusive cost of paper under the baseline, Light Green, and Dark Green scenarios

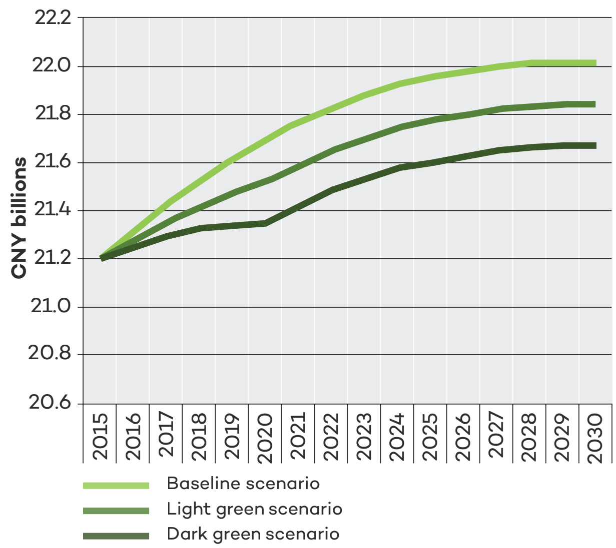
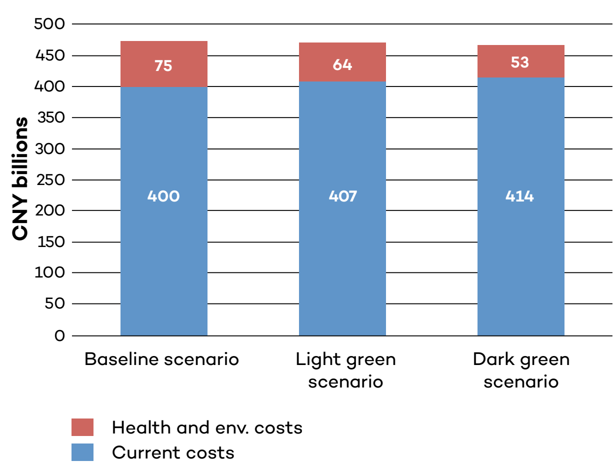


Figure 53 provides each scenario's aggregate cost for years 2015–2050 using present value discounting, and shows that there is a lower overall cost associated with buying recycled paper when non-fiscal costs are accounted for.

Figure 53: Total inclusive discounted cost of paper for the period 2015–2050 under the baseline, Light Green, and Dark Green scenarios



Discussion

While the model's findings about the merits of buying recycled versus non-recycled paper are compelling, the environmental costs represented are probably an underestimate. While not monetized in the model due to difficulty in establishing their value, water use and waste production are quantified in the model, and their impacts across the three scenarios are notable, as seen in Figures 54 and 55. These and other known environmental impacts, while not monetized, further support the results seen above.

Figure 54: Total water use due to paper production under the baseline, Light Green, and Dark Green scenarios

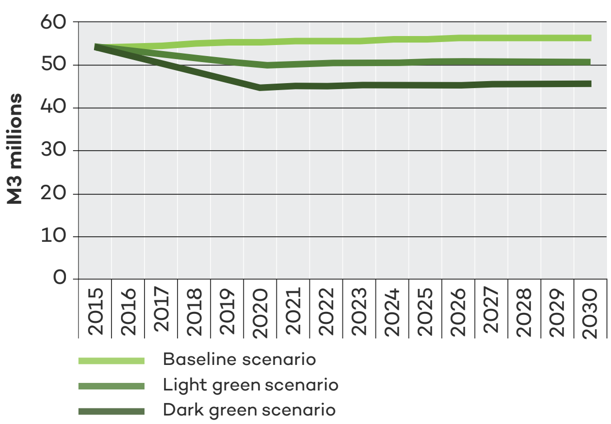
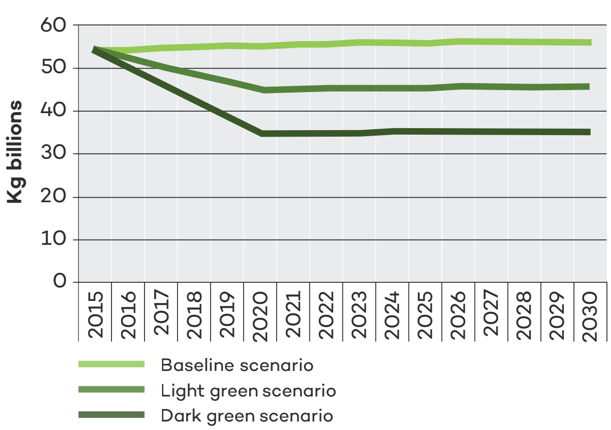


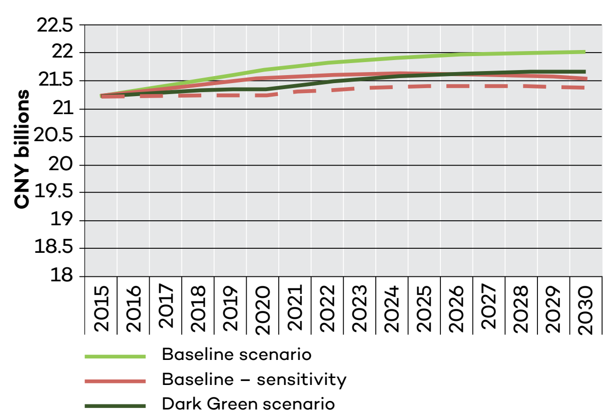
Figure 55: Total waste production due to paper production under the baseline, Light Green, and Dark Green scenarios



Sensitivity Analysis

It is possible that due to technological innovation and improved timber harvest methods and practices, the energy and materials intensity of non-recycled paper production may improve with time, thereby limiting the differences between the scenarios. The results' sensitivity to improvements in the energy and materials intensity of non-recycled paper were therefore tested using a 1 per cent annual efficiency improvement during the model period. As seen in Figure 56, such an outcome would affect the results seen above, but would not make purchase of non-recycled paper the preferred choice.

Figure 56: Sensitivity analysis on total inclusive costs of paper, given annual improvements in the materials and energy efficiency of non-recycled paper production



Monte Carlo Analysis

In order to assess the potential impacts of model inputs' uncertainty, the following input variables were given an uncertainty rating of low, medium or high. A normal distribution was applied to these variables with a respective standard deviation of 5 per cent, 10 per cent or 25 per cent of their input value. The model was then re-run one thousand times, sampling within these distributions and producing a set of results that reflected uncertainty in model inputs.

- **Current and projected levels of procurement** – medium level of uncertainty
- **Wood requirement** – high level of uncertainty
- **Energy requirement** – medium level of uncertainty
- **GHG emissions intensity** – medium level of uncertainty
- **Product prices** – low level of uncertainty
- **Monetization values** – high level of uncertainty, right-skewed[31]

Figures 57 through 59 provide Monte Carlo analysis results for paper, visualizing the degree of uncertainty associated with model results as a result of inputs variable uncertainty. The baseline and Light Green scenarios have a higher degree of variability overall due to the greater proportion of non-recycled paper procurement—non-recycled paper, due to its greater wood requirement and the uncertainty in this variable, has more uncertain impacts overall.

Figure 57: Monte Carlo analysis for total inclusive cost of cars - baseline scenario

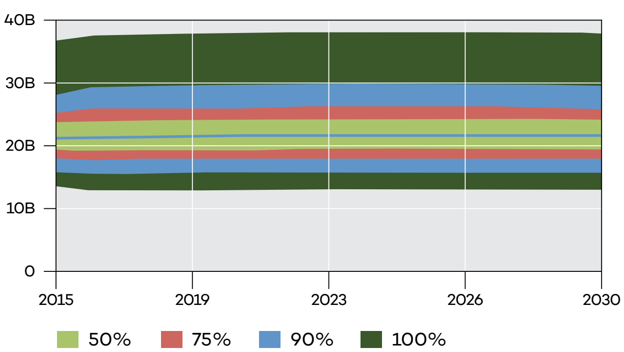


Figure 58: Monte Carlo analysis for total inclusive cost of cars - Light Green scenario

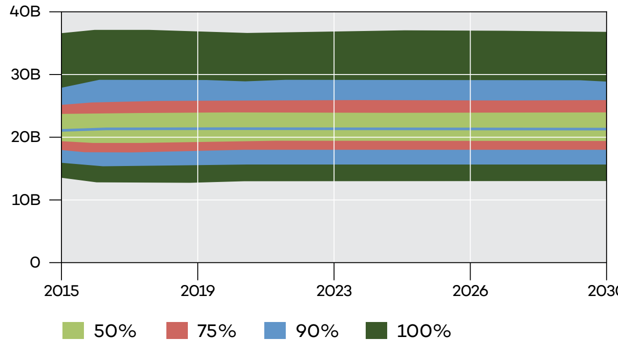
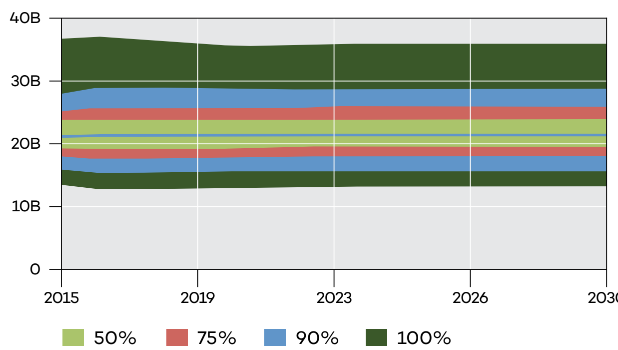


Figure 59: Monte Carlo analysis for total inclusive cost of cars – Dark Green scenario



2.2.5 Cement

Scope and Set-Up

- Three different tiers of cement are modelled, differing with respect to their levels of emissions intensity and price.
- All three tiers describe various types of Portland cement, the most common type of cement; differences in emissions intensity between tiers relate mainly to the various levels of energy consumption associated with different production techniques.

[31] Monetisation variables' probability distributions were right skewed to account for the fact that they are likely underestimates.

- The three tiers are respectively defined by the Chinese market average, by Chinese standards for sustainable cement, and by developed country sustainable cement standards.
- Government procurement of cement is assumed to follow projections for Chinese Gross Domestic Product (GDP); it is assumed that all cement is produced in the year it is purchased.
- Environmental impacts occur entirely during the production phase.

Scenario Definitions

BASELINE SCENARIO
Cement procurement is 70% from the third tier and 30% from the second tier

LIGHT GREEN SCENARIO
Cement procurement moves to 100% second tier, over a period of five years

DARK GREEN SCENARIO
Cement procurement moves to 100% first tier, over a period of five years

Key input values[32]

Water		Units	Input value
Annual procurement (2015)		Tonnes of cement	159 million
GHG intensity	Tier 3	Kilograms CO_2 per tonne	877.23
	Tier 2	Kilograms CO_2 per tonne	846.92
	Tier 1	Kilograms CO_2 per tonne	757.02
SO_2 intensity	Tier 3	Milligrams per tonne	531.21
	Tier 2	Milligrams per tonne	332.00
	Tier 1	Milligrams per tonne	207.49
NO_x intensity	Tier 3	Milligrams per tonne	531.21
	Tier 2	Milligrams per tonne	411.68
	Tier 1	Milligrams per tonne	332.00
PM intensity	Tier 3	Milligrams per tonne	79.68
	Tier 2	Milligrams per tonne	46.48
	Tier 1	Milligrams per tonne	19.92
Price	Tier 3	CNY per tonne	334
	Tier 2	CNY per tonne	395
	Tier 1	CNY per tonne	466

32 See the Technical Annex for a full explanation of sources and methods

Results

Before presenting scenario results for cement it is instructive to examine the current situation. It is estimated that the current total inclusive annual cost of public cement procurement in China is 74 billion CNY—a sum higher than any of the other products, due to the massive scale of cement production and use in China. This sum may even be an underestimate, since it assumes only 6 per cent of all cement consumed in China was for public projects.[33]

As seen in Figures 60 and 61 below, GHG costs are the largest non-fiscal contributor to the inclusive cost of cement. And of the two types of cement modelled for China (Tier 3, based on market averages, and Tier 2, based on CEC standards for cement production[34]), Tier 2 has notably smaller GHG emissions, but higher current costs due to the higher price of this type of cement.

Figure 60: Cost components of Tier 3 cement in China (estimate for 2015)

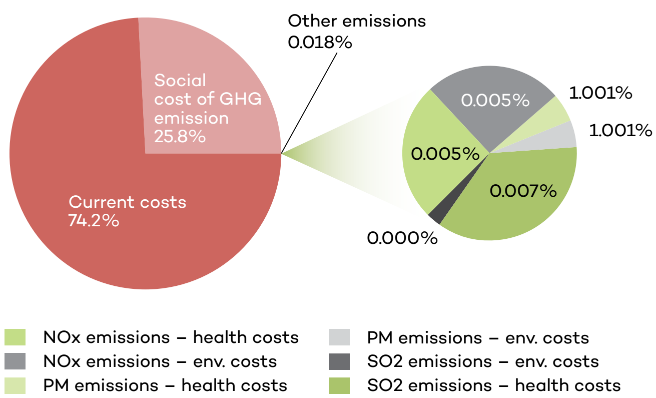
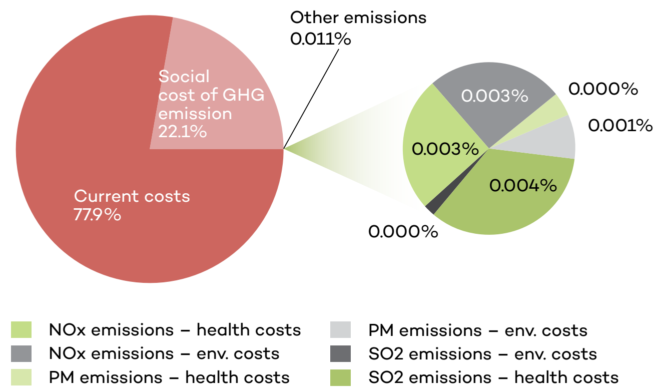
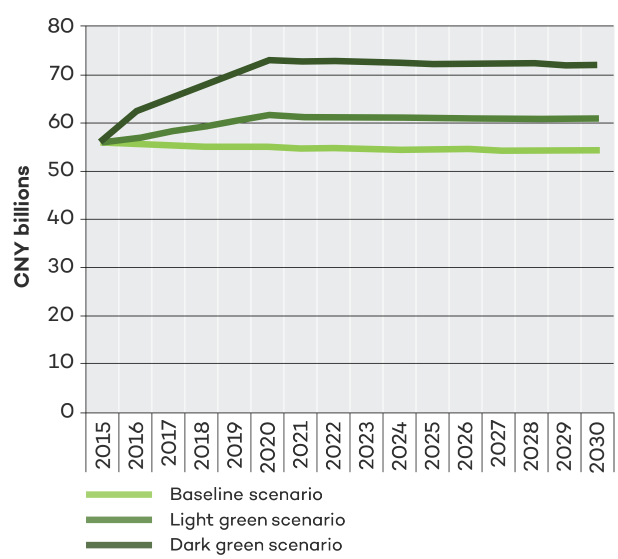


Figure 61: Cost components of Tier 2 cement in China (estimate for 2015)



With respect to scenario results, when considering only fiscal costs (as seen in Figure 62), the model unsurprisingly finds that the shift toward purchase of Tier 2 and Tier 1 cement seen under the Light Green and Dark Green scenarios leads to significantly higher costs, due to the higher purchase prices of Tier 2 and Tier 1 cement.

Figure 62: Total fiscal cost of cement under the baseline, Light Green, and Dark Green scenarios



[33] The public sector's expenditure on construction was 6 per cent of the national total so this same share was used to estimate government's share of cement purchase; see the Technical Annex for more information.

[34] Tier 1 was of course also modelled but current consumption of it by government was estimated at zero.

However, when the health and environmental costs of cement production are included (as seen in Figure 63), the proportional gap between the scenarios shrinks. This means that when health and environmental costs (mainly stemming from GHG emissions) are considered, the effective cost of more sustainable grades of cement is lowered. Indeed, the extra cost of the Light Green and Dark Green scenarios are 9.7 per cent and 26.7 per cent from a purely fiscal view, but only 6.8 per cent and 17.6 per cent when health and environmental costs are also considered. Still, total costs are higher under the Light Green and Dark Green scenarios, and therefore there is a cost of GPP leadership in this product category.

Figure 63: Total inclusive cost of cement under the baseline, Light Green, and Dark Green scenarios

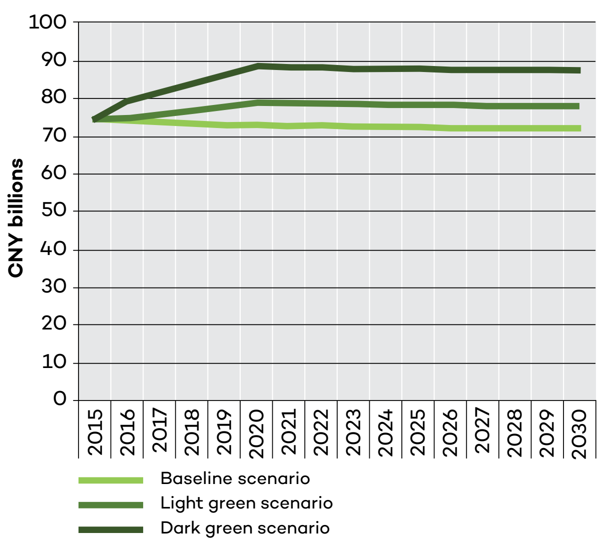
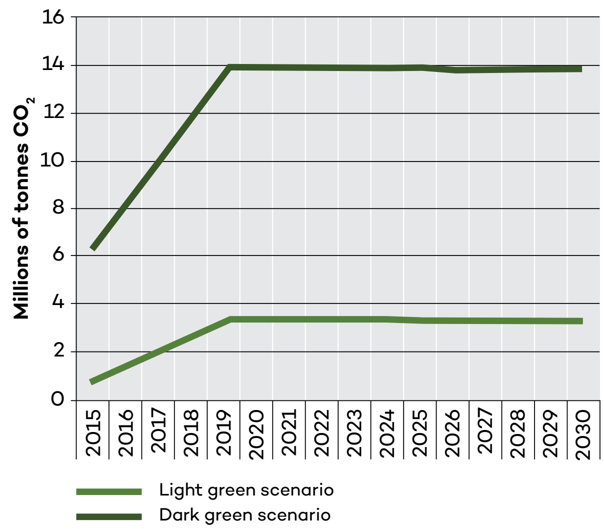


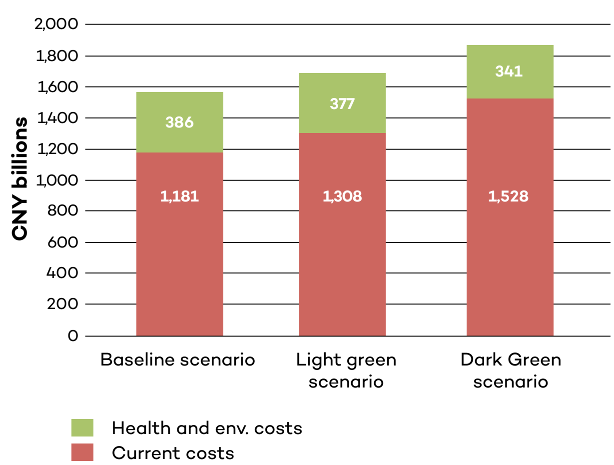
Figure 64 provides further context to the results seen in Figure 63 above, by showing the level of annual GHG mitigation achieved under the Light Green and Dark Green scenarios.

Figure 64: Avoided GHG emissions in the cement sector under the Light Green and Dark Green scenarios



Finally, Figure 65 provides each scenario's aggregate cost for years 2015-2050 using present value discounting, showing the declining environmental impacts but rising fiscal costs under the Light Green and Dark Green scenarios.

Figure 65: Total inclusive discounted cost of cement for the period 2015-2050 under the baseline, Light Green, and Dark Green scenarios



Discussion

Before a detailed discussion on the results above, the inclusion of cement as a GPP category should be defended. Cement is not a typical product category in GPP policy-making since it is not necessarily directly purchased by government—often, it is purchased by the company or contractor that the government has hired to construct a building or unit of infrastructure. However, by stipulating in requests for proposals (RFPs) that bids should include the use of more sustainable grades of cement, government has the ability to indirectly influence procurement in this category, making it an important GPP policy-making sphere. Because of this, as well as the massive scale of cement production and associated GHG emissions in China[35], cement was included in the IISD GPP Model and the impacts of GPP analyzed.

As seen above, GHG emissions are the most important non-fiscal cost associated with cement, constituting as much as a quarter of their total cost. Given the scale of cement production, this corresponds to very large social costs. The estimated 137 megatonnes of CO_2 emission associated with government procurement of cement in China in 2015 cost an estimated 18.2 billion CNY. Furthermore, the social cost of carbon used in the model was selected to be conservative—other studies have put the figure up to five times higher than the 132.42 CNY/tonne used in the model. This likely underestimate of social costs combined with the likely underestimate of public cement procurement described above points to a potentially very high social cost associated with public procurement of cement in China, which is not surprising given its known environmental impacts and significance in national GHG emission inventories. It should be noted that a carbon pricing mechanism would formalize this non-fiscal cost of cement as a proper fiscal cost, and reinforce any GPP policy aimed to increase the purchase of sustainable cement by making it more affordable relative to more emission-intensive grades.

In addition, it should also be noted that the differences in GHG intensity between the three tiers could in fact be higher than what was modelled. In the model, GHG mitigation in cement production stems purely from reduced energy consumption in cement production, but GHG mitigation in cement can also occur as a results of different limestone mining practices and different use of composite materials in cement that reduce the amount of clinker that is used. Neither of these potential GHG mitigation pathways were modelled due to data constraints, but would be an important part of the picture in any effort to lower the GHG emissions from cement production and their social cost.

The costs of SO_2, NO_x, and PM emissions from cement production were not found to be a strong driver of total inclusive costs, but this may be due to underestimation of their significance. There is evidence that the "main ecological problem of cement production is dust and soot," and that "soot usually contains sulphur oxides, nitrogen oxides, carbon oxides, other toxic gases and dust." Indeed, dust emissions from cement (which are referred to as PM in the model) "accounted for 27.1 per cent of total dust emission from national industrial production" (Huo, n.d.). Therefore while the model's results may indicate modest

[35] The emissions of CO_2 from the cement industry accounts for approximately 21.8 per cent of total CO_2 emission from national industrial production (Huo, n.d.)

impacts from non-GHG emissions related to cement, there is reason to think that these costs may in fact be significantly higher.

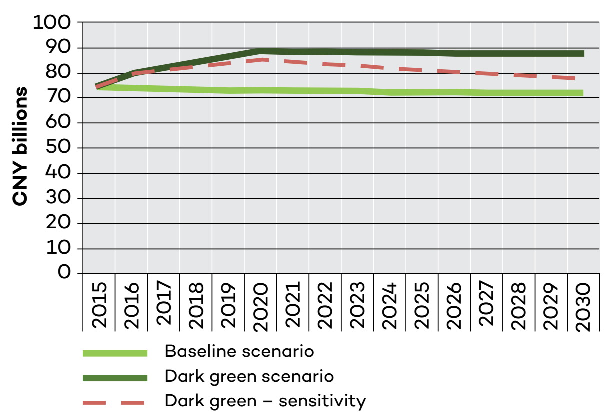
The prices used for cement in the above results are another important point of discussion. Tier 3 and Tier 2 prices were modelled based on market data from China, but because Tier 1 cement is modelled based on developed country standards it was not possible to confidently identify and price its equivalent in the Chinese marketplace. Therefore, an average of developed country cement prices were used to estimate Tier 1 cement's price, and simply converted to CNY (no purchasing power parity adjustments were done). This means that Tier 1 cement is priced as if it were purchased on international markets. In fact, because of its economies of scale, it is reasonable to think that China could produce this grade of cement at a lower price than that seen on the international market. A falling domestic price for Tier 1 cement is therefore the subject of the sensitivity analysis presented in the next subsection.

Finally, as made clear from the results above, there is a notable cost of GPP leadership in cement —the purchase of sustainable cement does not pay for itself in the form of energy savings or avoided health and environmental costs. If government wishes to support the domestic sustainable cement market by acting as a reliable buyer for producers of more sustainable grades of cement, it will involve extra cost. However, this type of investment in the sustainable cement market is critical given the massive scale of the cement sector in China and its present levels of emissions intensity and associated health and environmental costs.

Sensitivity Analysis

A sensitivity analysis is conducted to see how sensitive the results are to assumptions about the price of Tier 1 cement. As stated above, Tier 1 cement is priced as if it were purchased on international markets, but one can imagine investment in production capacity leading to a falling price for Tier 1 cement in China. An alternative Dark Green scenario, in which the price difference between Tier 3 and Tier 1 cement falls linearly between 2015 and 2030 to half of its current level is seen in Figure 66. As seen in the Figure, such a falling price would lead to declining costs relative to the baseline scenario, but costs still remain higher overall due to the higher costs of Tier 1 cement. This sensitivity test shows that falling prices for sustainable cement, while perhaps not enough to make sustainable cement effectively cheaper than the more common grades, would help lower the gap seen between the two and make the cost of GPP leadership in cement less costly.

Figure 66: Sensitivity analysis on total inclusive costs of cement, given falling prices for Tier 1 cement



Monte Carlo Analysis

In order to assess the potential impacts of model inputs' uncertainty, the following input variables were given an uncertainty rating of low, medium or high. A normal distribution was applied to these variables with a respective standard deviation of 5 per cent, 10 per cent or 25 per cent of their input value. The model was then re-run one thousand times, sampling within these distributions and producing a set of results that reflected uncertainty in model inputs.

- **Current and projected levels of procurement** – medium level of uncertainty
- **GHG emissions intensity** – medium level of uncertainty
- **SO_2, NO_x, PM emissions intensity** – medium level of uncertainty
- **Product prices** – medium level of uncertainty
- **Monetization values** – high level of uncertainty, right-skewed[36]

Figures 67 through 69 provide Monte Carlo analysis results for cement, visualizing the degree of uncertainty associated with model results as a result of inputs variable uncertainty.

Figure 67: Monte Carlo analysis for total inclusive cost of cement - baseline scenario

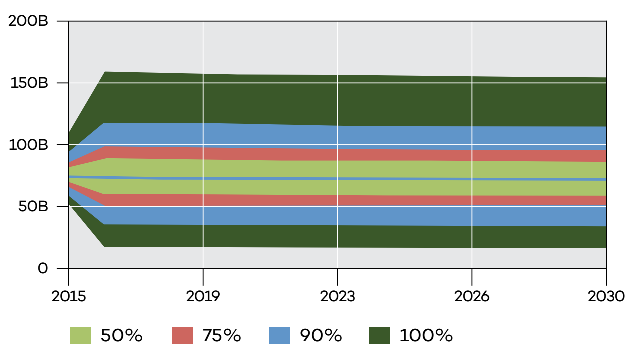


Figure 68: Monte Carlo analysis for total inclusive cost of cement - Light Green scenario

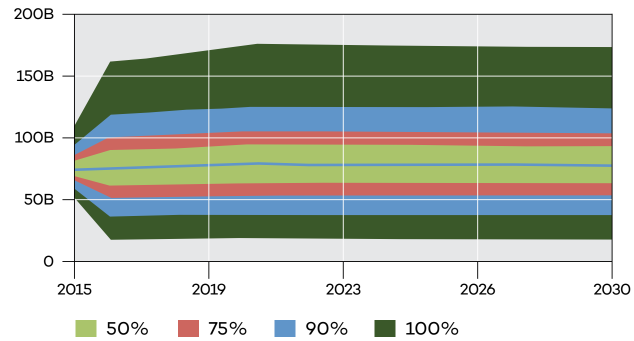
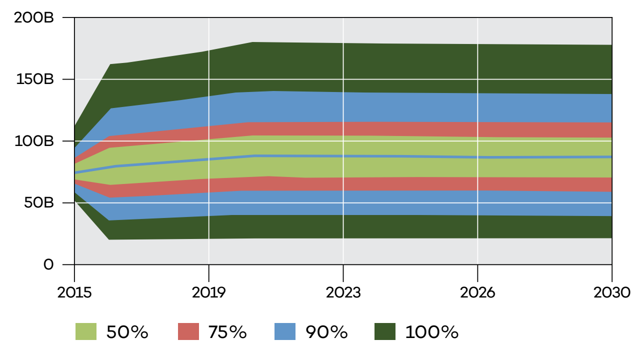


Figure 69: Monte Carlo analysis for total inclusive cost of cement – Dark Green scenario



2.3 Summary of model results

As presented above, many findings and lessons can be drawn from the IISD GPP Model. A summary of model results for the five product categories is provided below. Results are presented for the both the costs presently associated with procurement in China as well as how they are expected to evolve under the modelled GPP scenarios.

[36] Monetisation variables' probability distributions were right skewed to account for the fact that they are likely underestimates.

The results of the model show that increased GPP ambition and stringency in China have several benefits. These benefits include energy cost savings, avoided health costs and avoided environmental costs, in addition to other non-modelled but notable benefits, such as green innovation, market development and green industry development. Over the model's time horizon, the extra costs associated with realizing these significant benefits only exceed 20 per cent in one instance, and in some cases are even negative—meaning that, for some products, with time, GPP will pay for itself. The model does not speculate about future technologies and product prices, but it is reasonable to expect that ongoing market innovation will lead to further reductions in environmental impact and lower prices, and that therefore the extra fiscal cost associated with GPP for some products is likely to be even smaller than what is presented in the model results.

Figure 70 shows how the costs of procurement break down in China by comparing products' health and environmental costs to their direct fiscal costs. There is considerable variation in terms of how how these costs compare across products. For example, CNY 1 of procurement spending on cars in China is estimated to lead to CNY 0.87 of health and environmental costs—the highest of all the product categories. However, it should be noted that these costs are expected to fall in 2018 when the new fuel standard introduced in the country significantly lowers the sulphur content of gasoline.[37]

Figure 70: Health and environmental costs associated with CNY 1 of procurement spending (estimate for 2015)

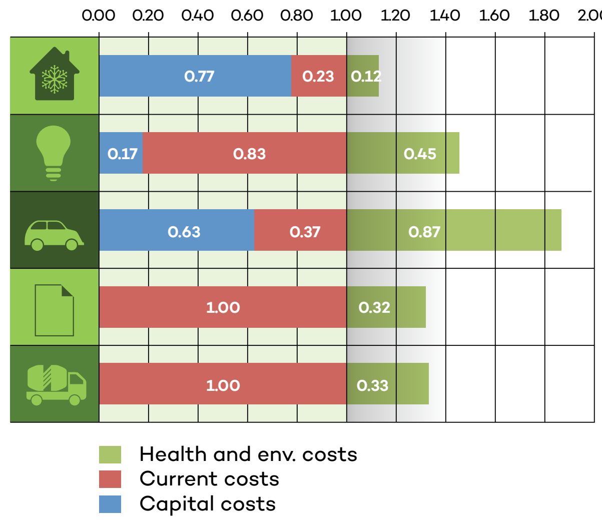


Figure 71 shows the total fiscal versus inclusive absolute cost of procurement in each of the five product categories under the baseline scenario. As seen in the figure, cement has, by far, the largest aggregate cost, mainly due to the extremely large scale of cement procurement in China. This category also has notable health and environmental impacts, which account for approximately 24 per cent of its total inclusive costs. It should be noted that the results seen in this figure are only indicative, since the procurement figures that are used in the model rely on proxy data and assumptions, due the limited reliable data available on aggregate procurement expenditures in China.[38]

[37] The introduction of this standard explains the drop in inclusive costs for cars that is seen in Figure 71 below in the year 2018.

[38] See the Technical Annex for more detail on sources and methods

Figure 71: Total fiscal versus inclusive costs of procurement under the baseline scenario

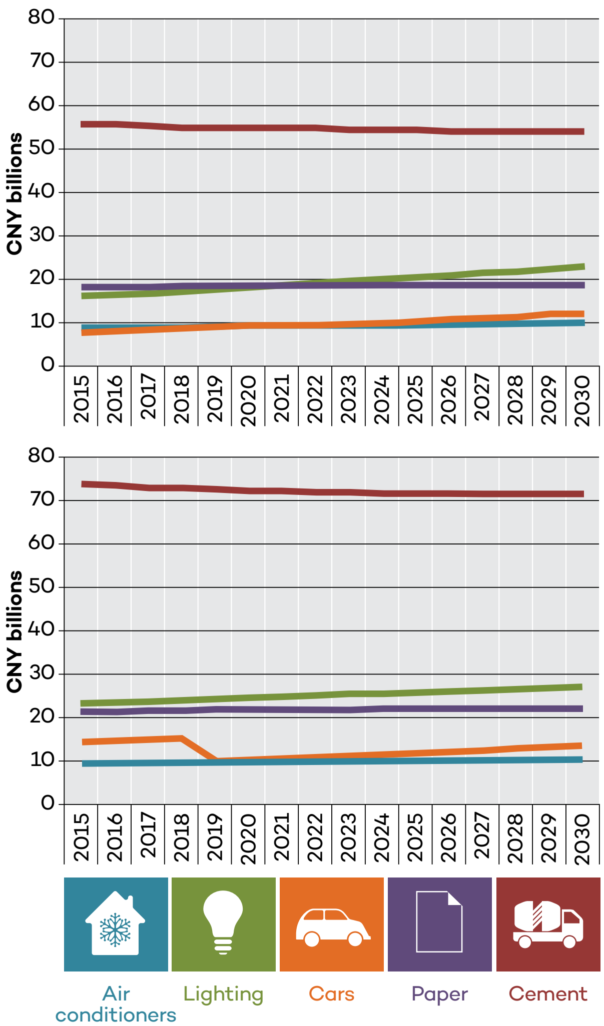


Figure 72 below provides an overview of the avoided health and environmental costs associated with implementation of the Light Green and Dark Green scenarios. The procurement of more sustainable grades of cement in China would be associated with significant health and environmental cost savings due to the very large scale of procurement in the sector. Other products have comparatively smaller impacts, either because the scale of their procurement is comparatively small (e.g., cars), or because the difference in environmental impacts between the regular good and the green alternative is comparatively small (e.g., air conditioners, which are in fact affected by both drivers).

It should be noted again here that not all types of known environmental impacts could be modelled and that, therefore, some of the values seen in Figure 72 may be underestimated. For example, only the environmental impacts associated with the usage phase were modelled for air conditioners, since production and disposal-phase impacts (which some have estimated to be as high as 30 per cent of total impacts) could not be reliably quantified and monetized.

Figure 72: Total discounted health and environmental costs savings under the Light Green and Dark Green s cenarios for the period 2015–2050

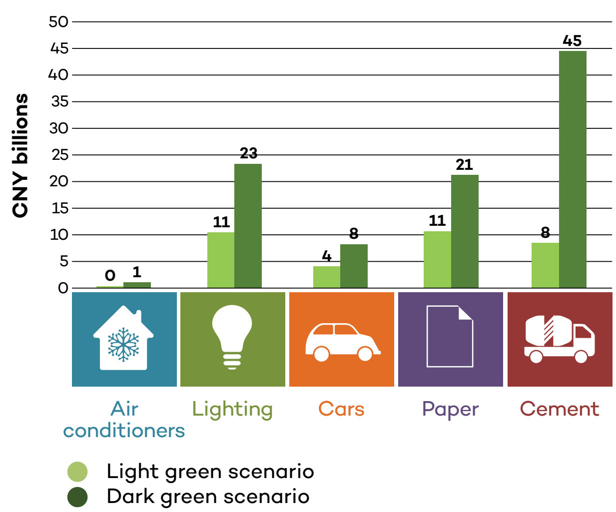


Figure 73 provides additional context to the results seen in Figure 72, showing the cumulative GHG emissions mitigation over the period 2015-2030 that results from increased GPP ambition in each of the product categories. GPP in cement is notable here as well in terms of its potential impacts.

Figure 73: Cumulative GHG emission mitigation associated with the Light Green and Dark Green scenarios for the period 2015-2030

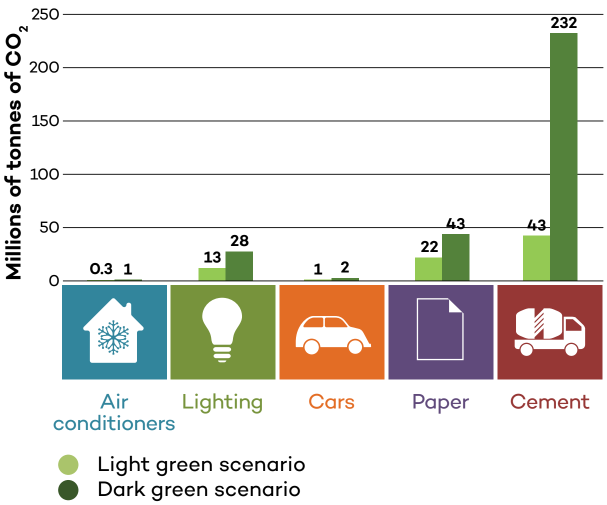


Figure 74 provides a summary of inclusive costs for each of the product categories under the three model scenarios. It uses present value discounting to provide an integrated picture of the total inclusive cost of procurement under each scenario for the period 2015–2050. Figure 75 provides the same information using levelized costs.

Figures 74 and 75 show that, in the product categories of lighting, cars and paper, increasing the level of ambition and stringency in GPP policy and implementation is less expensive from an inclusive cost perspective than employing comparatively less stringent or ambitious GPP practices—in other words, GPP in these product categories pays for itself with time.

On the other hand, for air conditioners and cement, there are increased costs associated with the Light Green and Dark Green scenarios. Therefore, there is a "cost of GPP leadership" in these categories in the sense that increasing the level or stringency of GPP does not pay for itself in the form of energy savings and avoided health and environmental costs, according to the results of the model. Therefore, realizing the benefits that are presented in Figures 74 and 75 for these categories, as well as other benefits such as green innovation, market development and green industry development, will require a degree of investment on the part of government. However, because of the large scale of the private market for air conditioners and its associated impacts, and because of cement's significance as a major contributor to China's national GHG emissions inventory, these product categories are key GPP policy-making spheres. There-fore, GPP leadership in these categories is an important investment and

policy action, despite higher fiscal costs. Furthermore, because some types of impacts could not be reliably quantified and monetized in the model, it is likely that the investment required for government to provide leadership in these categories is overestimated, and that the cost of GPP leadership in these will therefore not be as large as it appears in the model results presented below.

Figure 74: Total inclusive discounted cost of procurement under the baseline, Light Green, and Dark Green scenarios for the period 2015–2050

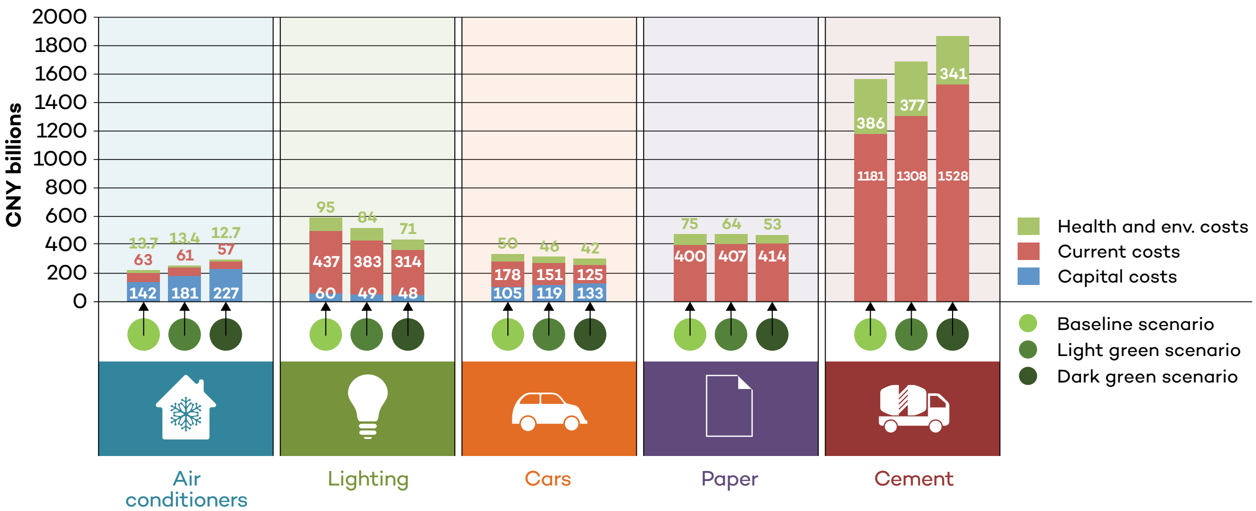
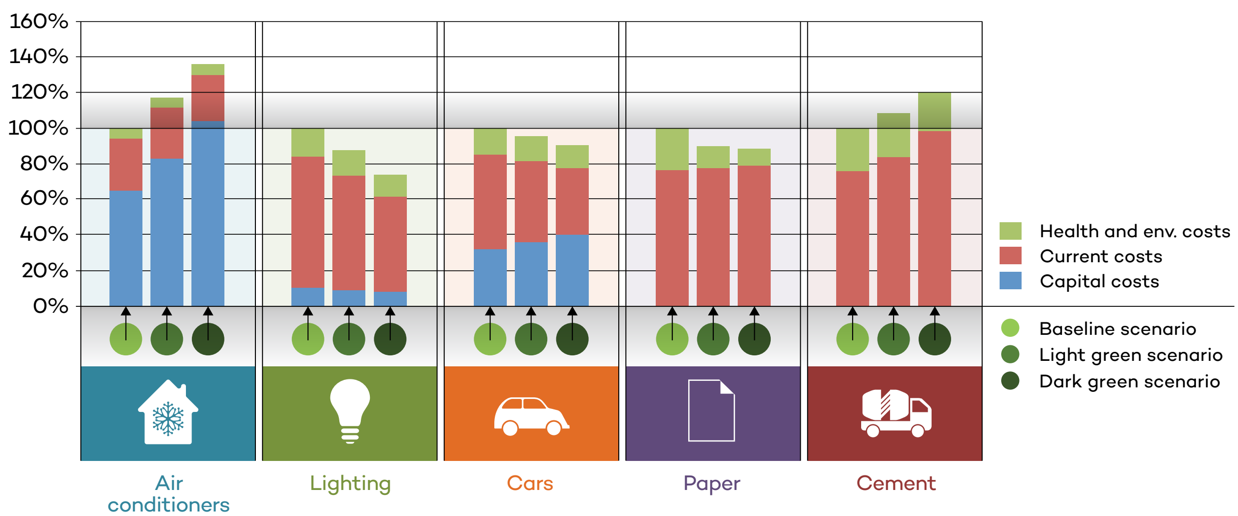


Figure 75: Total inclusive discounted cost of procurement under the baseline, Light Green, and Dark Green scenarios for the period 2015–2050 (levelized costs view)



Part 3:
Next Steps

New Applications and Extensions of the IISD GPP Model

As explored in the previous section, the IISD GPP Model quantifies the environmental and social externalities of government procurement, through which we underline the value proposition of GPP in China. In this section we examine the areas where the model can be extended in order to improve its applicability, including coverage of a wider range of public purchases.

Furthermore, we also provide recommendations for the application of the IISD GPP Model, both at the national and local level, discussing how it can be used for optimal budget allocation and policy making by helping procurers to understand better the different trade-offs that they are facing in procurement. These issues are especially pressing in the current environment of budgetary constraints, where the need for proper tools for assessment is very much needed to justify the initial higher costs of buying green.

Improving the IISD GPP Model

The results of the IISD GPP Model confirm that, for most product categories covered, the green alternative is the optimal choice for procurers when following a life-cycle approach. In other words, the indirect benefits of buying green outweigh the higher direct costs of the newer and more efficient technologies used, while for other products there is a small cost of GPP leadership associated with realizing the demonstrated benefits. While we consider the outputs, as discussed in detail in Section 2, we also recognize that there are certain areas for improvement of the model in order to get a more comprehensive and, if desired, more customized results.

Improve regional disaggregation: Due to the lack of available data, the model currently uses nationwide averages when monetizing the various externalities. However, the quality of the outputs can be improved if more data becomes available for each relevant region. The cost of air pollution, for example, well illustrates the importance of regional data. Sulphur dioxide (SO_2) is one of the major air pollutants with proven negative impact on human health and ecosystem services. In areas where the level of SO_2 is already close to reaching regulatory limits, the environmental and social costs of additional SO_2 emissions are clearly higher than in areas with lesser SO_2 levels. Therefore, through regional disaggregation of the data, the costs can be adjusted to reflect these underlying differences and improve the output of the model accordingly.

Extend the scope of externalities: So far the various assessment tools used by procurers have only included the financial costs and benefits of the different procurement choices under consideration. The IISD GPP Model extends the scope of this assessment to include externalities, where prevailing methodologies exist to quantify them. Other important externalities exist that could not be covered in the model at this stage, due to the lack of reliable data or difficulties in measuring them. However, various new methodologies are currently being tested by academics, as well as NGOs, providing valuations for a wide range of environmental and social impacts. For instance, the economic impact of the green economy is one area where the scope of the model could be extended further. This includes the impact of GPP on the pace of innovation, employment (in the form of green jobs) and GDP growth. Another more specific example is the impact of acid rain created by SO_2 pollution. Currently, the model incorporates the effect of acid rain only on crop production, but ignores others such as its negative impact on aquatic environments, forests and erosion of infrastructure.

Extend the range of product categories: In this project, the potential of the IISD GPP Model has been illustrated through an analysis of five product categories. This, of course, represents only a fraction of the different types of products the government buys. Making the calculations for a wider range of products could provide a more accurate picture and quantifiable impact of GPP as opposed to the "business-as-usual" scenario. For example covering the product categories of the ECP and ELP lists could provide a strong argument for making the lists mandatory. It is important to note, however, that the lack of data could be a significant barrier when expending the scope of the model.

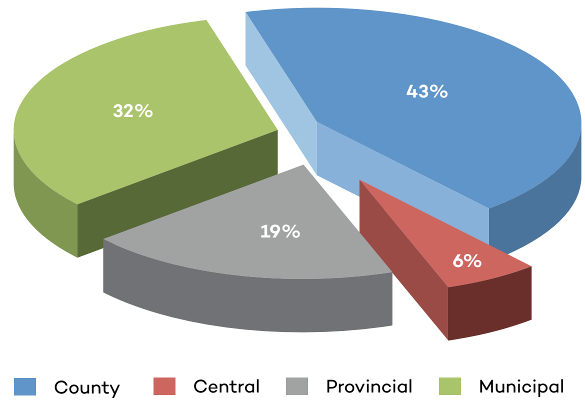
Applying the IISD GPP Model

In this section we present further applications of the IISD GPP Model. We demonstrate its potential to provide day-to-day support to policy-makers and procurers around the world, at both national and local levels.

National level

As illustrated on Figure 76 below, procurement at the central level is only a small portion (6 per cent) of the total government procurement in China. However, the IISD GPP Model is not only an invaluable tool at the procurement level, but it also has a wide range of uses at the national policy making level. The results of the model could form the basis of new policy initiatives by demonstrating the significance of GPP and providing the necessary arguments for change. It also gives more weight to the recommendations presented in this paper supporting their implementation at the national level. In addition, any new policy initiatives can be run through the model to see whether they achieve the expected outcome. The model also makes the case for GPP to be included in national master plans, such as the 13th Five-Year Plan, strengthening green consumption in China.

Figure 76 (Hu & Yi, 2014) - Procurement share per governmental level in 2012



The model can also be used by procurers and policy-makers in other countries seeking to position GPP as a motor for greener growth. The IISD GPP Model is particularly useful to quantify both negative and positive externalities and therefore make more informed budget and resource allocation decisions at the national level. It highlights the importance of assessing value-for-money across the life cycle of the asset, instead of solely making procurement decisions based on the financial costs at the time of purchase. The value-for-money approach has recently received increasing attention among procurers internationally. Nevertheless, without the proper assessment tool or methodology the credibility to analyse all relevant externalities could be questioned. The IISD GPP Model satisfies this need at the product level.

Local Level
As demonstrated earlier, the IISD GPP Model can be used to compare policy scenarios and guide national policies. However, at the local level it also has a wide range of uses including procurement, capacity building, assessment and reporting. As the majority of procurement takes place at the municipal and county level (75 per cent as per Figure 76) the use of the model for procurement decision making is discussed in more detail here.

For example, given China's increased focus on green growth, eco-civilisation and green consumption, government officials at the local level are also expected to explore new ways to realize these goals. As discussed in this paper, GPP is a powerful "pulling" force when it comes to stimulating green innovation. On the other hand, local procurers do not have any systemic, rigorous tools at their disposal to understand, but more importantly, to evaluate the net benefit that GPP provides versus the more traditional ways of procurement, and therefore they have difficulties to justify the higher price associated with green products. This results in GPP being approached and understood differently across jurisdictions, and in some cases, leads to questions about the actual impact of GPP initiatives.

The IISD GPP Model provides a solution for the issues raised above by offering an objective way to quantify and compare procurement choices. In addition, it provides a reliable assessment, monitoring and reporting mechanism for GPP. This will be essential if environmental considerations are to be integrated in the performance evaluation of procurers, as suggested in this paper. The model can also be used to evaluate the environmental and social impact of bids during the tendering process.

As highlighted earlier in this paper, however, the quality of the model's output is only as good as the quality of its input. Therefore, the importance of collecting relevant data at the regional level cannot be emphasized enough. Furthermore, in order to take full advantage of the GPP leveraging potential of the model, capacity building mechanisms need to be put in place to increase the awareness and general GPP knowledge of procurers. Better understanding of the inputs and outputs of the IISD GPP Model should be one of the priorities of the trainings provided. This will help officials understand better the different externalities of their procurement decisions.

The IISD GPP Model is easily customizable to provide more relevant results in the local context. Regional data can be used to reflect the unique costs of externalities in the region; new environmental, social and economic considerations can be included or excluded as needed (e.g. the net benefit of energy-efficient products will depend on the source of energy used in the region and/or adjusting the cost of air pollution depending on the local concentration of pollutants).

Develop a Model for Infrastructure Projects

Infrastructure projects constitute the largest part (59.9 per cent) of public procurement in China and indeed all other emerging countries. In fact, the OECD reports that the global infrastructure gap by 2030 is approaching USD 80 trillion. As also discussed in Section 1, the expected impact of GPP can only be realized at scale if infrastructure is also covered by the relevant GPP policies. Considering that a significant part of CO_2 emissions come from infrastructure, there is a pressing need for greening infrastructure, both brownfield and greenfield projects. However, this requires a robust methodology that enables procurers to compare and evaluate bids objectively with the aim of achieving value-for-money across the life cycle of the asset.

The IISD GPP Model is a product based tool, and while it can be extended to include various building materials (like cement is already included as part of this report), its potential to cover the specific externalities of infrastructure is limited in its current state. To monetize these externalities a new model needs to be developed, building on the existing IISD GPP Model. It needs to select one of the following routes as a basis of evaluation: 1. Externalities associated with building materials, 2. Externalities associated with the use of infrastructure. Of course, ideally both areas should be covered in the model, at least to some extent, in order to get the most accurate picture of the green credentials of the project.

A GPP model for infrastructure could help policy-makers to evaluate and rank the various national investment priorities, while bridging their respective national infrastructure gaps in an informed and sustainable fashion. Bringing transparency through knowledge based modelling would not only support a better climate resilience assessment, but it would also materially improve the project's bankability, attracting private capital in case of PPPs. In addition, a model based infrastructure evaluation system could provide more transparency on the environmental performance of SOEs in the infrastructure sector, establishing an environmental track record, while encouraging green innovation in the area.

International Climate Agreement – COP21 Paris

At the time of publication expectations are high for the upcoming COP21 in Paris. A universal and legally binding climate agreement is expected to be reached focusing on two main goals: 1. Mitigation by reducing greenhouse gas emissions in order to limit global warming to below 2 Celsius degrees; 2. adaptation by raising awareness of adaptation practices and technologies as well as upscaling climate-resilient infrastructure solutions.

The climate agreement is expected to set ambitious targets demanding ambitious policies from all countries. The reduction of GHG emissions at the national level will require carefully targeted policies, while considering their budgetary requirements and economic impact. Due to the lack of quantitative evidence, policy-makers often struggle to find the right balance between meeting the agreed targets and minimizing other unintended consequences of their policies. The IISD GPP Model provides clear evidence about the extent of GHG reduction expected from GPP, which could contribute significantly to the climate agenda articulated at the COP21 in Paris. Furthermore, the results of the model provide a way to validate these policies and at the same time provide the quantitative basis for evaluating GPP's impact on green consumption and sustainable growth.

Sustainable Development Goals

The recently articulated Sustainable Development Goals (SDGs) are designed to be the continuation of the Millennium Development Goals (MDGs) coming to an end in December 2015. SDGs are a set of goals and targets that UN member countries are expected to use in their policy making between 2016 and 2030. It includes 169 targets within 17 main goals making the SDGs much more specific than the previous MDGs. China will also need to work toward meeting these goals during the coming 15 years.

For GPP, the SDGs are particularly important as Goal 12 “Ensure sustainable consumption and production patterns”, Target 12.7 “Promote public procurement practices that are sustainable, in accordance with national policies and priorities” as well as Goal 9 “Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation” requires countries to implement efficient and stringent GPP policies. By following the recommendations presented in this paper, China will have the necessary policy framework to tackle Goal 9 by extending GPP practices to infrastructure development. In addition, China will have a comprehensive GPP framework in place and can become a leading example of meeting Target 12.7 promoting sustainable public procurement practices.

Implementation

GPP is expected to be included in the upcoming 13th Five-Year Plan providing the political will needed to evaluate the current GPP policies and address any potential shortcomings. This significantly increases the chances of implementing some (or all) of our recommendations and highlights the importance of the IISD GPP Model and its findings. Furthermore, through the 13th Five-Year Plan we expect GPP to receive the necessary budgetary support with clear responsibilities assigned for greening procurement processes at the level of the procuring entities (principal and municipal governments).

All of the above are essential for the implementation of more comprehensive GPP policies in China. It is important to emphasize that not all of the recommendations are intended to be implemented immediately. Suggestions for improving the current procurement list approach used could be integrated in current policies in the short term, while the functional specifications based procurement would be more of a long-term priority.

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Technical Annex

The following sections describe the sources, methods and assumptions used to develop estimates of model parameters. The first section describes the set of general model inputs; followed by sub-sections on electricity, fuel and monetization values; and sub-sections detailing the individual product modules in the model.

General model inputs

Population

A current total population figure of 1.4 billion was used for the country and assumed to evolve in line with projections from the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat (UN DESA), drawn from World Population Prospects: The 2012 Revision (UN DESA, 2012).

Public employees

The number of public employees in the country was based on information from the Commission Office of Public Sector Reform and estimated to be 45 million (Business and Economy, 2013). This total public employees figure was then combined with population estimates as seen above to estimate a population to public employees ratio of 28:1, which was assumed to hold true over the time horizon of the model (i.e. the number of public employees was projected to proportionally change in line with the total national population). Top 10 China also verified the reliability of this estimate.

GDP growth

Future GDP growth rates used in the model were based on projections found in the Organisation for Economic Co-operation and Development (OECD) statistics database (OECD Stat, 2015). Annualized figures were used in the model, beginning with a figure of 6.9% for 2015 and gradually falling, reaching 4.8% in 2020, 3.9% in 2025, and 3.5% in 2030.

Electricity

Electricity price (2015)

The electricity price used for the year 2015 is 0.85 CNY/ kWh. This is based on data from the Beijing Municipal Commission of Development and Reform (Beijing Municipal Commission of Development and Reform, 2015). This figure was assumed to reflect the average price paid for electricity across the country. Top 10 China verified the reliability of this estimate.

Electricity price growth

Electricity prices are assumed in the model to grow annually at a rate of 2.5%. This figure is based on the Twelfth-five-year-plan research report in 2012 (Electricity Industry Association, 2012). According to the report, in 2015, the electricity price was projected to be 0.71 CNY/ kWh (this figure was replaced in the model with the more up-to-date number seen in the Electricity price (2015) model input description above). It also projects that in 2020 the electricity price will be 0.8022 CNY/kWh. This corresponds to a price increase of 13% and an annual growth rate of 2.5%, which was assumed to hold true over the model's time horizon. Top 10 China verified the reliability of this estimate.

Emissions intensity of electricity

The emissions intensity of electricity is modeled using emission coefficients, which describe how many units of emissions are produced on average in the generation of one kilowatt-hour (kWh) of electricity in China. Emission intensities of electricity are included for GHG, SO_2, NO_x, and PM emissions. These coefficients are estimated for the year 2015 given the present estimated generation mix used in the production of electricity in the country, and change over time as the mix of generation sources changes.

Two scenarios are used to describe the change in the mix of generation sources – a standard scenario in which the generation mix evolves in line with China's international pledges surrounding the emissions intensity of its electricity sector; and a more pessimistic scenario, in which renewable energy is not deployed as quickly. The more pessimistic scenario values were used in sensitivity analyses.

For the standard scenario, figures for the present mix of generation sources being used in China were taken from International Energy Agency (IEA) data, and projections were based on figures from China National Renewable Energy Centre (CNREC). The projection figures used are mainly drawn from its China High Renewable Energy Penetration Scenario and Roadmap Study Brochure (China National Renewable Energy Centre, 2015), combined with present data from International Energy Agency (IEA Statistics, 2015). The resultant estimated generation mix is displayed in Table A. For the more pessimistic scenario, figures were drawn from the China Electricity Council, based on a comparatively slower renewable energy deployment timetable (Economic Daily, 2014).

Table A: Electricity generation mix used in IISD GPP Model

Generation source	2015	2020	2025	2030
Nuclear power	5%	4%	4%	4%
Natural gas	4%	6%	6%	5%
Coal	68%	60%	49%	38%
Hydropower	16%	15%	16%	15%
Solar energy	1%	3%	7%	13%
Wind energy	4%	9%	15%	22%
Other renewables	2%	3%	3%	3%

Source: International Energy Agency (IEA), China's National Energy Board (NEB)

In order to produce figures for the average GHG, SO_2, NO_x and PM emission intensity of electricity for each year covered in the model's time horizon, China-specific figures for the average emissions intensities of different electricity generation sources were weighted by each source's share in the overall generation mix (Hu, 2011). The results are summarized in Table B below.

Table B: Projected emission intensity of Chinese electricity production

Year	Emission Coefficients			
	CO_2 emissions (kg/kWh)	SO_2 emissions (g/kWh)	NO_x emissions (g/kWh)	PM emissions (g/kWh)
2015	0.578	3.15	2.24	0.20
2020	0.523	2.81	2.02	0.18
2025	0.425	2.27	1.64	0.15
2030	0.338	1.81	1.31	0.12

Source: IEA Statistics, 2015; China National Renewable Energy Centre, 2015; Hu, 2011

Fuel

Fuel price (2015)

The fuel price used for the year 2015 is 7.2 CNY per liter. This is based on national average gasoline market price data taken on August 7th, 2015 (Oil Prices Net, 2015). This figure was assumed to reflect the average price paid for fuel across the country. Top 10 China verified the reliability of this estimate.

Fuel price growth rate

The projected growth in fuel prices that is used in the model is based on estimates for the growth in the global price of oil, and is assumed to grow annually at a rate of 5.8%. This figure is based on the Medium-Term Oil Market Report 2015 of the International Energy Agency (IEA), which has global prices averaging roughly USD 55/bbl in 2015 and ramping up gradually to USD 73/bbl in 2020 (International Energy Agency, 2015), representing an average annual growth rate of 5.8%. This growth rate is assumed to hold over the model's time horizon. Top 10 China verified the reliability of this estimate.

Emissions intensity of fuel

Similar to electricity above, the emissions intensity of fuel is modeled using emission coefficients, which describe how many units of emissions are produced on average in the consumption of 1 liter of gasoline in China. Emission intensities of fuel are included for GHG, SO_2, NO_x, and PM emissions. These coefficients are estimated for the year 2015 and change over time as the characteristics of gasoline that is consumed in the country change.

For fuel emission intensity, the SO_2, NO_x and PM intensity of gasoline consumption was modelled based on the standards found in Limits and Measurement Methods for Emissions from Light-duty Vehicles, published by the Department of Environmental Protection and the State Administration of Quality Supervision, Inspection and Quarantine (Department of Environmental Protection & The State Administration of Quality Supervision, Inspection and Quarantine, 2005). Stages 4 and 5 of the fuel quality standard were used to describe the emission intensity of gasoline combustion for the periods 2015–2018 and 2018–2050, respectively. A standard CO_2 intensity of 2.375 kg/L was applied throughout the model period (SAE-China & CATARC, 2013), which is consistent with data from the U.S. Energy Information Administration (EIA).

In some cases, additional complementary sources were used in order to fill gaps in the data and to adjust variables' units for input into the model, for example, supporting information was used to convert the Sulphur content of fuel seen in the fuel standards into SO_2 emissions and to weight PM emissions according to the respective contributions of PM2.5 and PM10 (Liao et al., 2012; Xu, Li, Huang, Cheng & Liu, 2014). Table C summarizes the emissions intensities used for SO_2, NO_x, and PM in the model.

Table C: Gasoline emissions intensities used in the IISD GPP Model

Pollutant	Units	Fuel standard 4 (effective Jan. 2014)	Fuel standard 5 (effective Jan. 2018)
SO_2	Grams/ kilogram of gasoline	<0.05	<0.01
NO_x	Grams/ kilometre driven	<0.08	<0.06
PM	Grams/ kilometre driven	<0.0237	<0.0045

Source: Department of Environmental Protection & The State Administration of Quality Supervision, Inspection and Quarantine, 2005; Liao et al., 2012; Xu, Li, Huang, Cheng & Liu, 2014

Monetization values

Social cost of carbon

The social cost of carbon values the impact of carbon based on the environmental, economic and health impacts of global warming. Because the health and environmental costs of green-house gases are so strongly linked and difficult to separate, a social cost of carbon is provided which captures both spheres of impact, unlike other monetized pollutants in the model where they are provided separately. The social cost of carbon used in the model is 0.13242 CNY/kg CO_2 based on figures from the Interagency Working Group on Social Cost of Carbon, which in July 2015 updated its previous estimates to a new figure of $36 USD per metric ton of CO_2 (Interagency Working Group on Social Cost of Carbon, 2013, revised 2015).

Sulphur dioxide (SO_2) – health cost
A 2015 study in the journal Energy by Zhang, Zhang, and Bi found that the health cost of SO_2 in China is 48512.1 CNY/ton (Zhang, Zhang & Bi, 2015). This study uses adjusted concentration response ratios[39] to avoid double counting direct effects of SO_2 and effects of sulfate contained in particulate matter[40]. The estimate was converted into alternative units for input in the model, making the health cost of SO_2 estimated to be 0.05748 CNY/g

Sulphur dioxide (SO_2) – environmental cost
Environmental damage from SO_2 is primarily a result of acid rain. This has direct economic effects on agricultural production. A 2007 study by the World Bank in partnership with China's State Environmental Protection Administration made estimates of the economic losses to agriculture associated with SO_2 and acid rain. The total value was estimated for 2003 to be 30 billion CNY (World Bank, 2007). This total cost was divided by the 21.59 megatonnes of SO_2 emissions estimated for 2003 in order to produce a cost per unit of emissions, which was then adjusted for inflation to produce an estimated environmental cost of 0.001923 CNY per gram of SO_2.

Acid rain is also known to play a role in forest dieback and defoliation, yet no clear trend exists, and a quantitative relationship is difficult to attain. Dieback of forest would have direct economic costs, through the loss of harvestable timber, as well as environmental costs, as forests perform services such as carbon sequestration, erosion control, and wildlife habitat. Studies in China suggest that acid rain and SO_2 has reduced the extent of coniferous forests. However, these values are tentative and not sufficiently robust to be used in the model. Valuation of the damage of acid rain would require estimates of the relationship between SO_2 and forest extent, and a monetary value of forest ecosystem services. Such figures were not available and therefore the monetization of environmental impacts of SO_2 is based solely on impacts on crop production, meaning that the cost used in the model is almost certainly an underestimate.

Nitrous oxide (NO_x) – health cost
A 2015 study in the journal Energy by Zhang, Zhang, and Bi found that the health cost of NO_x in China is 32732.0 CNY/ton (Zhang, Zhang & Bi, 2015). This study uses adjusted concentration response ratios to avoid double counting direct effects of NO_x and effects of nitrate contained in particulate matter[41]. The estimate was converted into alternative units

[39] Calculating the health cost of air pollutants requires concentration-response ratios, which link concentrations of pollution to health endpoints. Several health endpoints are valued for PM, SO_2, and NO_x, including death, chronic bronchitis, reduced activity days, respiratory hospital visits, and cardiovascular hospital visits. Avoided mortality, or death, is valued using the Value of Statistical Life (VSL), which measures the sum of what people would be willing to pay to reduce their risk of dying by small amounts. These amounts add up to one statistical life. Chronic bronchitis is valued as a fraction of the VSL. The value of reduced activity days is obtained using a benefit transfer approach. The value of respiratory and cardiovascular hospital visits is estimated using the cost of illness approach that sums direct expenses (medication etc.) and indirect expenses (lost wages etc.).

[40] SO_2 contributes to the formation of particulate matter. Particulate matter contains sulfate, a product of SO_2. As a result the World Bank argues that calculating the health effects of the two separately could be double counting (World Bank, 2007).

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for input in the model, making the health cost of NO_x estimated to be 0.03879 CNY/g.

Nitrous oxide (*NO_x*) – environmental cost
The environmental impact of NO_x is based on its impact on climate change (NO_2 is a constituent of NO_x). The IPCC gives a Global Warming Potential (GWP)[42] of 298 for NO_2 (IPCC, 2007). This GWP is then multiplied by the Social Cost of Carbon as seen above to produce an estimate for the environmental cost of NO_x of 0.03946 CNY/g.

NO_x also plays a role in the formation of acid rain. However, nitrogen is an important nutrient, so it is unclear what role NO_x plays in damage from acid rain, since an increase of nitrate in acid rain may increase vegetation growth (World Bank, 2007). Because of the uncertainty associated with this impact pathway, the environmental cost of NO_x is based solely on its contribution to climate change.

Particulate matter (PM) – health cost
A 2015 study in the journal Energy by Zhang, Zhang, and Bi found that the health cost of PM in China is 34595.1 CNY/ton (Zhang, Zhang & Bi, 2015). This value includes avoided mortality, chronic bronchitis, reduced activity days, respiratory hospital visits, and cardiovascular hospital visits[43]. The value in the study is for PM2.5 but also includes PM10, which is converted to PM2.5 at a ratio of 0.60 for PM2.5 to PM10 (Zhang, Zhang & Bi, 2015). The estimate was converted into alternative units for input in the model, making the health cost of PM estimated to be 0.04099 CNY/g.

Particulate matter (PM) – environmental cost
The environmental impact of PM is based on its impact on climate change. However, Global Warming Potential (GWP)[44] of PM cannot be found directly.

Tollefson et al. use a GWP of 447.5 in their estimation of a monetary cost for PM emissions (Tollefsen, Rypdal, Torvanger & Rive, 2009) by combining the GWP of two components of PM: black carbon (449) and organic carbon (-1.5). The GWP of PM is multiplied by the Social Cost of Carbon seen above to produce an estimate for the environmental cost of PM of 0.05926 CNY/g.

In addition to its effect on global warming, a more general environmental cost of PM is its impact on vegetation and ecosystems. PM is a heterogeneous mixture of different chemicals, including nitrates, sulfates, and traces of heavy metals. However, the impact of PM on vegetation and ecosystems depends on the chemical composition and deposition mode, which is highly specific to different regions (Grantz, Garner & Johnson, 2003). Due to

[42] GWP represents the amount of climate change impact a mass of pollutant has in as an equivalent mass of CO_2. CO_2's GWP is 1. The GWP of a pollutant varies considerably over time as pollutants break down at different rates, so the time frame over which it is estimated is important. The international standard is to calculate GWP over 100 years.

[43] Calculating the health cost of air pollutants requires concentration-response ratios, which link concentrations of pollution to health endpoints. Several health endpoints are valued for PM, SO_2, and NO_x, including death, chronic bronchitis, reduced activity days, respiratory hospital visits, and cardiovascular hospital visits. Avoided mortality, or death, is valued using the Value of Statistical Life (VSL), which measures the sum of what people would be willing to pay to reduce their risk of dying by small amounts. These amounts add up to one statistical life. Chronic bronchitis is valued as a fraction of the VSL. The value of reduced activity days is obtained using a benefit transfer approach. The value of respiratory and cardiovascular hospital visits is estimated using the cost of illness approach that sums direct expenses (medication etc.) and indirect expenses (lost wages etc.).

[44] GWP represents the amount of climate change impact a mass of pollutant has in as an equivalent mass of CO_2. CO_2's GWP is 1. The GWP of a pollutant varies considerably over time as pollutants break down at different rates, so the time frame over which it is estimated is important. The international standard is to calculate GWP over 100 years.

the inherent complexity of this impact pathway and a lack of suitably robust data on the topic, the environmental cost of PM was based solely on its role as a contributor to climate change.

Mercury – health cost
The major health effect of mercury is its role as a developmental neurotoxin, and the cost of mercury pollution is estimated based on its impact on IQ levels, which are then is linked with future earnings. A 2008 study by Spadaro and Rabl estimated the worldwide average health cost of mercury based on a mean of several studies that estimated the cost of the loss of a single IQ point in the USA, which was then adjusted by GDP/capita to find a global average cost of an IQ point. They find the health costs of mercury to be $1500 USD/kg (Spadaro & Rabl, 2008). This estimate was converted for use in the model by adjusting for inflation and Purchasing Power Parity, making the health cost of Mercury estimated to be 0.005534 CNY/mg.

Air conditioners

Variable		Units	Input value
Total stock (2015)		Air conditioners	16.3 million
Annual procurement (2015)		Air conditioners	1.63 million
Energy consumption	Tier 3	Kilowatts	980.18
	Tier 2	Kilowatts	941.25
	Tier 1	Kilowatts	856.11
Price	Tier 3	CNY	3,538
	Tier 2	CNY	4,585
	Tier 1	CNY	5,834
Annual usage		Hours	1,136
Lifetime		Years	10

Total stock (2015)
The estimate of the total stock of publicly owned air conditioners in China is 16.3 million. This figure was produced using a combination of various sources (Wanwei Home Appliances Net, 2014, National Civil Service Network, 2012, Xinhua Network, 2015). This estimate was verified by Top 10 China.

Annual procurement (2015)
Air conditioners in the model have a lifetime of 10 years (see below for more information on this estimate). This means that, on average, 10% of the stock of air conditioners is being replaced in a given year. This finding is therefore combined with the estimate of the total stock of air conditioners (as seen above) to produce an estimate for 2015's aggregate annual public procurement of 1.63 million air conditioners, which is modeled to be 100% Tier 3 air conditioners (see the Energy Consumption description below for more information).

Target number of AC per employee
It is assumed in the model that the ratio of air conditioners to public employees in 2015 reflects the desired ratio of air conditioners to employees, and the need for air conditioners will evolve in line with number of employees (see above for sources and methods used for the estimation of these figures). This ratio is 2015 was approximately 32 employees for each air conditioner.

Energy consumption
The energy efficiency levels associated with air conditioners are provided by Top 10 China based on market research. The energy efficiency levels used represent an average of fixed and variables speed air conditioner types, and small and large sized air conditioners, weighted by their respective market shares. This averaging was done so that it would be possible to model a 'representative' air conditioner, and in this sense does not refer to any specific air conditioner available in the Chinese marketplace, but rather a composite

of available air conditioners. The three tiers of air conditioners in the model have levels of energy consumption of 980.18 kW, 941.25 kW, and 856.11 kW. The government considers an EER greater than 3.4 to be energy efficient (PC Group, 2015). The market average air conditioner used to define the baseline scenario in the model has energy consumption of 980.18 kW, which equates to an EER of 3.44, and therefore is believe to be representative of current standards and practices in air conditioner GPP.

Price per unit

The price levels associated with air conditioners are provided by Top 10 China based on their market research. The price levels used represent an average of fixed and variable speed air conditioner types, and small and large sized air conditioners, weighted by their respective market shares. This averaging was done so that it would be possible to model a 'representative' air conditioner, and in this sense does not refer to any specific air conditioner available in the Chinese market-place, but rather a composite of available air conditioners. The three tiers of air conditioners in the model have prices of 3537 CNY, 4585 CNY, and 5834 CNY, and correspond to the levels of energy efficiency presented above.

Average running time

The average running time per year used in the model for an air conditioner unit is 1136 hours per year. This estimate is calculated by Top 10 China based on air conditioner standard GB21455-2013.

Lifetime

The model uses a lifetime for air conditioners of 10 years. This estimate is based on the finding that municipal governments mandate a lifetime of 10 years for air conditioners in China, and the fact that the "Lifetime regulations on safe use of household appliances," which are set by Chinese government, call for a maximum lifetime for air conditioners of 8 to 10 years (China AC Industry Network, 2015)

Lighting

Variable		Units	Input value
Total stock (2015)		Bulbs	263.9 million
Annual procurement (2015)		Bulbs	100.3 million
Energy consumption	CFL	Watts per bulb	14
	LED	Watts per bulb	10
Mercury emissions from disposal	CFL	Milligrams per bulb	2.97
	LED	Milligrams per bulb	0
Price	CFL	CNY per bulb	21.46
	LED	CNY per bulb	37.71
	Smart switch	CNY per bulb	20.2
Annual usage	Without smart switch	Hours	4680
	With smart switch	Hours	3744
Lifetime	CFL	Years	1.7
	LED without smart switch	Years	5.3
	LED with smart switch	Years	6.68

Total stock (2015)

The estimate of the total public lighting stock in China is 263.9 million bulbs (a bulb in the model has associated lighting of 775 lumens, equivalent to a 60W incandescent bulb, a 14W CFL bulb, or a 10W LED bulb (Eartheasy, 2015b)). To estimate this figure, data on typical office space per worker was gathered (CoreNet Global, 2012), and combined with the finding that 500 lux of lighting is needed for an office environment, to produce an estimate of the lighting requirement per employee (The Engineering ToolBox, 2015b). This lighting requirement was converted from lux to lumens to produce an estimate of lighting need of 4645 lumens per employee (RapidTables, 2015). This figure was then multiplied by the estimate for the number of public employees presented above to produce as estimate of the total public lighting stock in the country in 2015.

Annual procurement (2015)
Estimations of the total procurement of lighting are based on the stock presented above and the fact that bulbs need to be periodically replaced as they reach the end of their useful life. Different bulb types have different lifetimes (see below for more information on this), and so the estimate of annual procurement is weighted to account for these differential lifetimes. It is assumed that there are no incandescent bulbs in the public stock (CFL purchasing has been mandated for some time now), and that CFLs and LEDs form two thirds and one third of the stock, respectively. These factors lead to an annual lighting procurement estimate of 100.3 million bulbs. In the baseline scenario, procurement is modeled to follow the assumed distribution for CFL and LED bulbs (two thirds CFL, one third LED).

Target amount of lighting per employee
It is assumed in the model that the ratio of light bulbs to public employees in 2015 reflects the desired ratio of light bulbs to employees, and the need for lighting will evolve in line with number of employees (see above for sources and methods used for the estimation of these figures). This ratio is 2015 was approximately 5.86 bulbs per employee.

Mercury emissions
Figures for the mercury content of bulbs used in the model were 3 milligrams per CFL bulbs and 0 milligrams for LED bulbs (LED bulbs do not contain mercury). The figure for the mercury content of CFL bulbs was based on CEC standards (Department of Environmental Protection, 2012b) and corresponded with other findings on bulbs' mercury content (DesignRecycle, 2015). It was also found that the share of CFL bulbs which are properly disposed of was less than 1 percent in China (Minmetals Rare Earth Research Institute Ltd., 2009) and therefore it was assumed that 99% of the mercury content of CFL bulbs (2.97 milligrams) were emitted at the bulbs' disposal stage.

Energy consumption
The energy consumption of the 775 lumen 'representative' bulb used in the model was found to be 14W for CFL bulbs, and 10W for LED bulbs (Eartheasy, 2015b)[45]. These numbers were regularly cited in literature comparing the differences between these types of bulbs.

Price per unit
Prices used per bulb in the model were based on research into the Chinese marketplace and in each case represent the average price of a large number of bulbs that match the modeled bulbs' characteristics. Prices used in the model for a CFL bulb and an LED bulb are 21.46 CNY and 37.71 CNY, respectively (Taobao, 2015a).

[45] The level of energy consumption of a smart switch enabled bulb does not change, only its hours of operation do. This indirectly affects these bulbs energy consumption (and also their lifetimes).

The prices of smart switches were also estimated based on market research, and were doubled in the model to account for the fact that they would also have associated installation costs. The estimated price used in the model is 10.1 CNY per switch, or 20.2 CNY with installation costs (1688.com, 2015a; 1688.com, 2015b).

Average running time
The average running time used for a bulb in the model was drawn from a study focused on lighting use in office buildings. It finds that on average lights are operated 53% of the time, or 4680 hours per year (U.S. Energy Information Administration, n.d.).

Smart switch enabled lights do not run as much because the switch automatically disables the lights when they are no needed. It was found that smart switches could be expected to reduce lighting hours of operation to 43% of the time, or 3744 hours per year (U.S. Energy Information Administration, n.d.).

Lifetime
CFL and LED bulbs were found in the literature on the subject to have expected lifetimes of 8,000 hours and 25,000 hours respectively (Eartheasy, 2015b). Combining these figures with the average annual usage figures presented above yielded CFL and LED expected lifetimes of 1.7 and 5.3 years respectively, or 2.14 and 6.68 years when equipped with smart switches, respectively.

Cars

Variable		Units	Input value
Total stock (2015)		Cars	318,400
Annual procurement (2015)		Cars	39,800
Energy consumption	Gasoline car	Litres per kilometre	0.0772
	Hybrid car	Litres per kilometre	0.0551
	Electric car	Kilowatt hours per kilometre	0.15625
Price[24]	Gasoline car	CNY	106,000
	Hybrid car (initial price)	CNY	144,000
	Electric car (initial price)	CNY	306,000
Annual usage		Kilometres per year	15,183
Lifetime		Years	8

Total stock (2015)
The stock of public sector cars in 2015 is estimated to be 318,400 cars. This value is estimated by multiplying the estimated annual procurement of vehicles by their expected lifetime (see below for more information).

Annual procurement (2015)
The annual procurement of cars is estimated to be 39,800 cars. This finding was generated by dividing the total estimated domestic public sector expenditure on cars of 4.253 billion CNY (Ministry of Finance, 2014) divided by the average market price for cars, which was weighted by car type and their respective market shares (China Association of

Automobile Manufacturers, 2014; Top 10 China & Anbound Corporation, 2011).

Target amount of cars per employee

It is assumed in the model that the ratio of cars to public employees in 2015 reflects the desired ratio of cars to employees, and the need for cars will evolve in line with number of employees (see above for sources and methods used for the estimation of these figures). This ratio is 2015 was approximately 226 employees per car.

Energy consumption

The figures for fuel efficiency of gasoline and hybrid cars in the model are based on market research by Top 10 China. The levels of fuel efficiency represent an average of what is available in the market, weighted by cars' engine size and their respective market shares (China Association of Automobile Manufacturers, 2014; Top 10 China & Anbound Corporation, 2011). This averaging was done so that it would be possible to model a 'representative' car, and in this sense the model does not refer to any specific car available in the Chinese marketplace, but rather a composite of available cars. For gasoline and hybrid cars the level of fuel efficiency used in the model is 0.0772 liters of gasoline per kilometer and 0.0551 liter of gasoline per kilometer, respectively. Figures for electric cars were based on a study on the energy consumption of electric cars under conditions of typical cities in China (Chen, Peng & Fang, 2009), and were estimated to be 0.15625 kWh per kilometer.

Price per unit

The average price of a representative gasoline car in the model is 106,000 CNY, based on market research and weighted by cars' engine size and their respective market shares (China Association of Automobile Manufacturers, 2014; Top 10 China & Anbound Corporation, 2011). The price levels associated with hybrid and electric cars are based on a Deutsche Bank Group report on the subject focused on the Chinese context. The report finds an average hybrid car price of 144,000 CNY and an average electric car price of 306,000 CNY per car in China (Deutsche Bank Group, 2012).

Average driving distance

An average annual driving distance of 15,183 kilometers per car per year is used in the model based on research data on public cars in Guangdong Province. (Guangzhou Daily, 2012)

Lifetime

A public sector car's average lifetime is estimated in the model at 8 years based on Ministry of Commerce regulations specifying the restricted lifetime of cars used in different applications in China (Ministry of Commerce of PRC, 2013).

[46] Prices for hybrids and electrics reflect plans to waive the 10 per cent purchasing tax in cases of government procurement (Fleming, 2014).

Paper

Variable		Units	Input value
Annual procurement (2015)		Tonnes of paper	3.6 million
Energy requirement	Non-recycled paper	Kilowatt hours per tonne	9,600
	Recycled paper	Kilowatt hours per tonne	3,600
Wood requirement	Non-recycled paper	Tonnes per tonne	2.9626
	Recycled paper	Tonnes per tonne	0.14813
GHG intensity	Non-recycled paper	Kilograms CO_2 per tonne	2,800
	Recycled paper	Kilograms CO_2 per tonne	554
Water use	Non-recy-cled paper	Cubic metres per tonne	15
	Recycled paper	Cubic metres per tonne	8
Waste production	Non-recy-cled paper	Kilograms per tonne	1,500
	Recycled paper	Kilograms per tonne	100
Price	Non-recy-cled paper	CNY per tonn	4,967
	Recycled paper	CNY per tonn	5,478

Annual procurement (2015)

To estimate annual procurement of paper, figures for the average national consumption of copy paper, estimated at 72kg in 2013 (Sun Paper OPBU, 2015), were multiplied by the number of public employees in the country to produce an estimate of 3.6 million tonnes of paper per year. There is good reason to believe that because of government's considerable levels of paper use that an individual employee would be associated with consumption that exceeds the national average, and so this figure for annual procurement is likely an underestimate.

Price

The prices of recycled and non-recycled copy paper were estimated based on research into the Chinese marketplace, resulting in figures of 5478.2 CNY per ton and 4967.3 CNY per ton, respectively (Taobao, 2015b).

Wood requirement

The wood required to produce a ton of non-recycled paper in China is estimated at 2.9626 tonnes, based on a comprehensive study on the subject (UNEP, 2012). According to CEC standards, recycled paper must include no more than 5% virgin wood pulp (Department of Environmental Protection, 2005), and so this ratio is applied to the wood requirement of recycled paper production, producing an estimate for the wood requirement of recycled paper production of 0.14813 tonnes of wood per tonne of paper.

Energy requirement

The energy requirement of paper production is based on a comprehensive study on the subject, and is estimated at 9,600 kWh per tonne of non-recycled paper and 3,600 kWh per tonne of recycled paper (UNEP, 2012).

GHG emissions intensity

The GHG emissions intensity of paper stems from its raw material use, energy use, and transport, but only the impacts stemming from material and energy use were modeled. A number of studies looking at these components' individual contributions were combined to produce an estimate for the GHG emissions associated with the production of one tonne of paper; figures for emissions associated with material use were specific to Asia and those for energy were adjusted to be applicable to the Chinese context (Miner, 2010; Kissinger, Sussmann, Moore & Rees, 2013; National Council for Air and Stream Improvement, 2013). The combination of these various sources produces total estimates for the GHG emissions intensity of non-recycled and recycled paper production in China of 2,880 and 550kg of CO_2 per tonne of paper produced, respectively.

Water use

The water use associated with paper production is based on a comprehensive study on the subject, and is estimated at 15 m3 per tonne of non-recycled paper and 8 m3 per tonne of recycled paper (UNEP, 2012).

Waste production

The waste production associated with paper production is based on a comprehensive study on the subject, and is estimated at 1500 kg of waste per tonne of non-recycled paper and 100 kg of waste per tonne of recycled paper (UNEP, 2012).

Cement

Water		Units	Input value
Annual procurement (2015)		Tonnes of cement	159 million
GHG intensity	Tier 3	Kilograms CO_2 per tonne	877.23
	Tier 2	Kilograms CO_2 per tonne	846.92
	Tier 1	Kilograms CO_2 per tonne	757.02
SO_2 intensity	Tier 3	Milligrams per tonne	531.21
	Tier 2	Milligrams per tonne	332.00
	Tier 1	Milligrams per tonne	207.49
NO_x intensity	Tier 3	Milligrams per tonne	531.21
	Tier 2	Milligrams per tonne	411.68
	Tier 1	Milligrams per tonne	332.00
PM intensity	Tier 3	Milligrams per tonne	79.68
	Tier 2	Milligrams per tonne	46.48
	Tier 1	Milligrams per tonne	19.92
Price	Tier 3	CNY per tonne	334
	Tier 2	CNY per tonne	395
	Tier 1	CNY per tonne	466

Annual procurement (2015)

Total national cement production in China is estimated at 2,476 megatonnes for 2014 – a staggering sum (National Bureau of Statistics of China, 2015a). The public proportion of this is estimated in the model by assuming that the government's share of total expenditure in the construction sector is equivalent to its share of total national cement production and consumption. This figure was 6% in 2012, the most recent year for which comparable data was available (National Bureau of Statistics of China, 2014b; China Government Procurement Yearbook Editorial Committee, 2013). This leads to an estimate of annual government cement procurement of 159 million tonnes for 2015.

GHG intensity

There are three sources of CO_2 emission during the process of cement production. They are CO_2 emission from materials (clinker), CO_2 emission from energy (electricity and thermal), and CO_2 emissions related to the mining of limestone and other component materials. In order to allow for the modeling of a representative unit of cement, the material composition of cement (the first driver), is fixed across the three tiers of cement included in the model. And GHG emissions stemming from the mining of materials (the third driver) could not be successfully modeled due to a lack of available data for China. Therefore, the GHG emissions intensity of cement is modeled based on the emissions stemming from the energy consumed during its production.

Findings for GHG intensity of the three tiers of cement stemming from the energy consumed in their production are based on Chinese market averages, on comparatively sustainable grades of Chinese cement, and on the average level of emissions intensity seen for cement in developed countries (Wang, Hao & Höller, 2012). Respectively, these emission intensities are as follows:

- Tier 3:
  - From thermal energy consumption: 342.7 kg CO_2 per tonne of cement
  - From electricity consumption: 59.5 kg CO_2 per tonne of cement
- Tier 2:
  - From thermal energy consumption: 315.1 kg CO_2 per tonne of cement
  - From electricity consumption: 56.8 kg CO_2 per tonne of cement
- Tier 1:
  - From thermal energy consumption: 230 kg CO_2 per tonne of cement
  - From electricity consumption: 52 kg CO_2 + per tonne of cement

To each of these emission intensities a uniform GHG intensity stemming from the materials driver of cement emissions (clinker) of 475 kg CO_2 per tonne of cement was added, yielding respective total emission intensities of 757.02, 846.92, and 877.23 kg CO_2 per tonne of cement (Huo, n.d.; World Business Council for Sustainable Development, 2005; The Engineering ToolBox, 2015a).

SO_2 intensity

SO_2 emissions intensity for Tier 3 and Tier 2 cement production is estimated in the model to be 531.21 mg SO_2 per ton and 332 mg SO_2 per ton, based respectively on the basic and more stringent requirements found in national emission standards on the subject (Department of Environmental Protection & The State Administration of Quality Supervision, Inspection and Quarantine, 2013). Tier 1 cement's SO_2 intensity is 207.49 mg SO_2 per ton, based on the assumption that the same percentage difference found between Tier 1 and 2's intensity applies to Tiers 2 and 3 as well.

NO_x intensity

NO_x emissions intensity for Tier 3 and Tier 2 cement production is estimated in the model to be 531.21 mg NO_x per ton and 411.68 mg NO_x per ton, based respectively on the basic and more stringent requirements found in national emission standards on the subject (Department of Environmental Protection & The State Administration of Quality Supervision, Inspection and Quarantine, 2013). Tier 1 cement's NO_x intensity is 332 mg NO_x per ton, based on the finding for China that it is technically feasible to use industrial waste of high calorific value and high volatility, such as used tires, and in order to reduce NO_x emission 15% to 35% (Huo, n.d.).

PM intensity

PM emissions intensity for Tier 3 and Tier 2 cement production is estimated in the model to be 79.68 mg PM per ton and 46.48 mg PM per ton, based respectively on the basic and more stringent requirements found in national emission standards on the subject (Department of Environmental Protection & The State Administration of Quality Supervision, Inspection and Quarantine, 2013). Tier 1 cement's PM intensity is 19.92 mg PM per ton, based on findings in the literature on best practices and available technology (Hu, n.d.; World Business Council for Sustainable Development, 2005).

Price

The price used for Tier 3 cement is based on market research into the price of cement in China, and uses the national average value of Portland 42.5 cement prices available for the last 9 months of 2014. Tier 3 cement is therefore estimated in the model to cost 334 CNY per tonne. It was difficult to distinguish the price of Tier 2 cement using market data and available literature, and so the assumption was made that the price difference between it and Tier 3 cement was inversely proportionate to their different levels of CO_2 emission intensity. Tier 2 cement is therefore estimated in the model to cost 395 CNY per ton. Finally, it was not possible to accurately estimate the price of Tier 1 cement in China since it is based on developed country level of emissions intensity, and research indicates that cement with this low relative level of emissions intensity is not presently available in the Chinese marketplace. Therefore to estimate the price of this type of cement, pricing data from research on international market price was used and converted to Chinese currency, yielding an estimate of 466 CNY per tonne (CW Research, 2015). However, it is likely the case that should China develop the capacity to produce this type of cement that it could produce it at a lower cost than that seen in international markets due to its economies of scale. The price estimate for Tier 1 cement in the model is therefore likely an overestimate of its actual price.

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