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Clearing the air

Prompted by the dense brown fog that has affected much of China, the government's strategy includes emergency plans for when weather conditions create spikes of hazardous air pollution. But will these measures prove effective? **Arnold M Howitt** investigates

In January 2013, Beijing and much of eastern China experienced an extended period of severe air pollution. Beijing was blanketed with dense 'brown fog' – exceptional even for a city used to very hazy skies. Visibility was dismal from one side of the street to the other. Local air quality monitors recorded some pollutants at levels never before measured. Schools were closed to reduce children's exposure.

Beijing's siege of brown fog stirred up strong, long-simmering emotions among Chinese citizens about the health and quality-of-life effects of air pollution. During and after this episode, widespread criticism, permitted by the party's propaganda department, spread in social media as well as in newspapers and on television. Many voices called for action to clean the air, not only in the capital, but throughout China.

In September 2013, after months of intense internal deliberations, China's central government issued a 10-point blueprint to improve the nation's severely compromised air quality. Most of the provisions in the *Action Plan for Air Pollution Control and Prevention* are long-term; they aim to reduce air pollution over a five-year time frame and beyond.

But in addition, the action plan requires major regions to develop stand-by emergency measures that can be implemented immediately to protect the public and cut hazardous emissions when pollution levels spike because of atmospheric conditions.

These emergency plans have now had their first tests in several jurisdictions, providing some evidence about both the potential and the challenges of using emergency contingency measures to curb regional pollution.

China's rapid economic development over the past 35 years has brought costs as well as benefits, most notably severe environmental degradation of air, water and land. China's cities have air pollution levels that far exceed its own national standards, which are much less stringent than the standards in the US or in Europe. Of particular concern are levels of PM 2.5 – small particulate matter – regarded internationally as the most hazardous to human health. Daily average PM 2.5 levels in the most polluted Chinese cities are eight to ten times higher than in the US cities with the worst air quality. In unfavourable weather conditions in China, normally high pollution levels can rise to extremely hazardous levels.

Beijing and much of eastern China experienced an extended period of severe air pollution in January 2013, prompting widespread criticism from inhabitants and citizens

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The five-year action plan for air pollution prevention and control that was promulgated by China's cabinet, the State Council, in September 2013, sets ambitious targets for reducing pollutants substantially. To achieve this, the action plan strengthens previous policies and includes a number of specific new measures to reduce harmful emissions. It promises both a tightening of environmental laws and stricter regulatory enforcement.

More generally – and likely taking effect over a longer than five-year time frame – the plan pledges to reduce overall dependence on coal as an energy source. It also proposes to encourage state-owned and private enterprises to adopt energy-efficient technologies and promises to create market incentives for firms to innovate in preventing pollution.

The action plan requires institutional innovation too. Recognising that China's air pollution problems cut across the boundaries of individual provinces, the plan mandates the development of regional co-operation mechanisms that will achieve policy co-ordination across provincial boundaries.

In particular, the action plan targets three major regions of concentrated population and economic activity: Beijing-Tianjin-Hebei; the Yangtze River Delta (including Shanghai); and the Pearl River Delta (including Guangzhou and Shenzhen). For example, it aims for PM 2.5 reductions of 25 per cent in Beijing.

Most of the pollution control action plan has a medium- and potentially long-term focus. But recognising that severe pollution episodes like Beijing's are likely to recur before other measures succeed, the action plan mandates that major cities and multi-province regions develop crisis plans to combat extended-duration spikes of pollution.

Beijing and other cities promulgated emergency plans almost immediately after the action plan was publicly released in September 2013. Using a national air quality index system covering multiple pollutants, the Beijing plan developed a four-grade pollution warning classification – labelled blue, yellow, orange and red alerts, in escalating order – that would be based on data from an improved pollution monitoring and forecasting system.

Fugitive dust

At each alert level, an increasing number of contingency measures are triggered. These are split into health protection and pollution mitigation measures. The health protection measures remind at-risk target populations to avoid outdoor activities. The mitigation measures include both recommended and mandatory policies.

In the most severe situations, a red alert triggers 'six stops and one wash' – widespread street washing to hold down fugitive dust is coupled with mandatory curtailment of certain activities, including prohibitions on barbecue use; fireworks bans; motor vehicle use prohibitions on alternate days, based on license plate numbers; closing educational establishments from kindergarten through to high school; and industrial and construction work stoppages.

It was not long before, a number of cities ▶

needed to utilise their contingency plans. In mid-October 2013, Harbin, a city of 11 million in north-east China, became the first city actually to implement its emergency measures after experiencing extraordinarily high levels of PM 2.5 (40 times the daily level considered safe by the World Health Organization), along with dense fog that forced its airport to close and created dangerous highway conditions.

In late December 78 cities, mainly in northern China, experienced pollution levels that exceeded the upper limit of the government's air quality index, very far into the zone considered unhealthy by the WHO. In Tianjin, a city of 14 million people that shares its 'air shed' (a region of common air circulation) with Beijing, officials issued an order barring 20 per cent of motor vehicles (with license plate numbers ending in '3'or '8') from the city's roads. But the order produced so many complaints from local residents that the city suspended the ban even before it took effect.

In January and February 2014, China again experienced a surge of pollution to unsafe levels, with Shanghai and Beijing, among many others, becoming shrouded in brown fog. Beijing hesitated for several days before declaring an orange alert – the second highest level – and implementing emergency contingency measures.

Looking to the future, making these air pollution emergency plans work well requires China to face several kinds of challenges: scientific, technical, institutional, and operational.

■ **Monitoring and forecasting:** If emergency measures are to forestall severe pollution episodes, forecasters must be able to predict these spikes with sufficient lead time to permit expeditious implementation of contingency plans. That poses a substantial set of technical and practical problems for meteorologists and other atmospheric scientists.

First, they must have sufficient monitoring capacity to generate data about both meteorological conditions and levels of harmful pollutants. In recent years, China has invested significantly in upgrading its monitoring stations, but the capacity required, along with sufficient numbers of skilled technical staff, will have to be developed further. Moreover, it will have to be replicated in the many localities that may be subject to pollution emergencies.

Second, scientists must be able to predict not only the timing, but also the magnitude of these episodes. Forecasters need to gauge accurately how bad air quality will become and therefore what package of measures will be required in response. To do this, scientists will have to develop enhanced atmospheric models calibrated for conditions in each locality, gather data more frequently, process that data rapidly, and make accurate forecasts with sufficient lead time so that senior government officials at the city and provincial levels can make decisions about the extent and timing of emergency measures.

This capacity is not yet fully in place. As China seeks to apply emergency pollution control policies, it will be testing the practical limits of scientists' understanding of meteorology and atmospheric chemistry and their ability to generate timely, accurate predictions about weather and pollution levels. It will need time to gain experience and improve the quality of forecasting. Critically, it will have to develop sophisticated understanding of meteorology and pollution formation, not only in a single, national setting, but also under the varying conditions in each region or city subject to severe pollution.

The quality and precision of these forecasts matter if the emergency plans are to work well. Over-estimating the severity of looming atmospheric conditions may lead to implementation of contingency plans that will impose unnecessary and unwelcome costs on private and state-owned businesses, government agencies, and individuals whose activities will be disrupted. But underestimating potentially bad pollution episodes may result in inadequate or late action that would undermine the impact of emergency measures.

■ **Timely decision-making:** Weather and pollution forecasts are necessary but insufficient conditions for effective implementation of contingency measures. Subject to difficult political cross pressures, senior government officials in affected jurisdictions have to make affirmative – and probably controversial – decisions to mandate restrictions that enterprises and individuals may resist or resent deeply. Tianjin's abortive effort to restrict the use of cars illustrates this problem.

Because air sheds are larger than political jurisdictions, moreover, pollution control often cannot be achieved by the actions of individual city or provincial governments. This is true particularly in the concentrated population and industrial centres of Beijing-Tianjin-Hebei and the Yangtze and Pearl

Local air quality monitors recorded some pollutants at levels never before measured. Schools were closed to reduce children's exposure

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River Deltas. The national pollution action plan therefore requires the development of regional co-operation mechanisms to encourage co-ordinated policies and actions.

That will not prove easy – in part because the costs and benefits of pollution control are not evenly distributed. For example, as was true during the 2008 Olympics, relieving polluted conditions in Beijing and Tianjin may require pollution controls or shutdowns of factories in Hebei province where air quality may not be as bad. Not surprisingly, that creates contrasting incentives for local leaders in these neighbouring jurisdictions.

Decision-making is harder under time pressure. While differing local interests may be reconciled in long-range negotiations on a regional plan, the imposition of contingency plans during a pollution emergency is very different. It requires decisive, short-term commitments in the face of rapidly evolving atmospheric conditions and considerable uncertainty about direct impacts on air quality.

Who will have the formal authority or sufficient informal influence to decide when regional measures will be put into effect, and how will possibly conflicting jurisdictional views be reconciled in a tight time frame? As experience with pollution alerts evolves, will regionally binding, immediate decisions be made by senior officials of a single, powerful jurisdiction – eg, the leadership of the Beijing municipal government? By a consultative group of officials from each affected jurisdiction in a given region? By higher-level decision-makers in the central government who will informally exert influence on local decision-makers? The regional co-ordination mechanisms called for in the national pollution action plan still need to be developed and put into effective operation.

This is further complicated by substantial potential for post-emergency second-guessing and controversy. Officials must navigate, on one hand, the danger of requiring perhaps unneeded measures like closing factories and schools or broadly restricting auto usage. On the other hand, they will be wary of being seen as under-reacting to a pollution crisis. Perceived mistakes could undermine the future credibility of emergency measures and perhaps damage the careers of responsible officials.

- **Implementation capacity:** Senior leaders' decisions to implement emergency contingency measures do not ensure that they will be effectively put into timely operation. Specific policies vary significantly in terms of the difficulty of notifying the people who must act, getting them to implement the measures, and, when necessary, taking action to enforce restrictions. Some emergency measures require action by only a small number of entities – for example, operators of power plants – and emergency procedures can be developed in advance. But other options may involve very large numbers of affected individuals or entities – hundreds of thousands of motorists who must restrict their driving, or thousands of factories, large and small, that have to curtail operations. Getting their attention in advance is frequently difficult, as is creating a sense of urgency and conveying what they must do in a moment of crisis. If people or entities resist compliance, compelling their co-operation may not be possible because of a shortage of administrative resources to detect them and enforce the measures – and there may be official reluctance to impose sanctions on large numbers of individuals.

Final thoughts

Once the United States and other western countries began to deal seriously with their own problems of environmental degradation, it took several decades to bring pollution levels down to, or near, levels considered safe for health. That work is still unfinished. China has started along that same path and is making significant progress, notwithstanding the environmental pressures that continued rapid economic development creates. But the process of clearing the air in China is likely to take decades as well.

In the meantime, emergency pollution control measures may play a role in alleviating the crises created by adverse meteorological conditions. But there are significant scientific, technical, institutional, and operational challenges in making contingency plans work. China's experiment with these measures is still in its early stages – too soon to tell whether they can be effective. CRJ

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