2060 碳中和：中国如何发挥城市的作用实现这一目标

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引言

新冠疫情自暴发以来，在全球蔓延，对人们的生命和生计造成严重的威胁。与此同时，一个更大的威胁正悄然迫近：气候变化。2015 年在巴黎，地球上几乎每个国家都同意采取行动，要把全球平均气温较工业化前水平升高控制在 2 摄氏度之内，并为把升温控制在 1.5 摄氏度内而努力。但是，《巴黎协定》的减排承诺也只占需要减少排放量的三分之一。未来尚需付出更大努力——而城市将扮演主要角色。

碳排放占全世界总量 28%的中国，已经设定了雄心勃勃的减排目标：2030 年二氧化碳排放要达到峰值，2060 年要实现碳中和。达到这一目标殊为不易，但却是势在必行。1909 年以来[1]，中国的平均气温升高了 1.5 摄氏度，这意味着国土更加温暖湿润。1980 年至 2012 年期间，华东地区的海平面上升了 93 毫米，上世纪 70 年代至今，冰川已经融化了 10%。

[1] "China's Third National Assessment Report on Climate Change," Ministry of Science and Technology, the China Meteorological Administration, Chinese Academy of Sciences and Chinese Academy of Engineering

这是眼下的情况。如果中国的排放保持现在的水平，那么到了 2030 年，酷热和致命热浪将会波及中国 1000~4500 万的人口。1980 年那场 50 年不遇的特大降水，在 2030 年再次发生的可能性提高了 2 到 3 倍，而在 2050 年，可能性高达 3 到 6 倍。每年由于酷热和潮湿而损失的户外工作时间，到 2030 年，损失的户外工作时间比例将从 4%上升到 6.5%；到 2050 年将攀升至 9%，相当于 1~1.5 万亿美元 GDP。

中国正在建设多元能源供应体系，经济发展朝着更加清洁和更低能源密集转型。同时由于发电、居民供暖，以及钢铁、水泥等工业的需求上升，中国的煤炭消耗总量持续小幅上涨[2]。2019 年，中国的总能源消耗中，煤炭占比 58%，这一比重正逐渐下降。低排放能源在中国初级能源使用中占比低于四分之一：水电（8%），天然气（8%），核能（2%），风能、太阳能等非水利可再生能源（5%）。中国正在采取实际行动应对气候变化。中国的可再生能源和燃料投资占全球近三分之一；2018 年，中国拥有全球 95%以上的电动公交车队和近乎一半的

[2] BP Statistical Review of World Energy, 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf

电动乘用车（EV）[3]。提升能源效率、更多使用可再生能源也减少了空气污染。国际能源署（IEA）的资料显示，到 2024 年，中国的可再生能源新增装机量将一直占全世界的 40%。简而言之，通过提升可再生能源、天然气、电力使用比重，中国正加快构建绿色多元的能源供给体系。但另一方面，经济的持续发展，以及对煤炭的持续依赖，也意味着中国迈向碳中和之路任重道远。

城市对中国的脱碳化起着举足轻重的作用——15 座城市贡献了中国三分之一的 GDP，城市既是经济增长的引擎，又是温室气体排放的源泉。城市也具备了采取行动的条件：关键决策者、大规模的投资基金和充足的投资人、一流的大学和智库，以及不断壮大的高收入人群，他们都很关心可持续性发展。有四个方面至关重要：发展零碳电网，提高能源利用效率，鼓励新一代出行方式，做好消费者需求管理。城市往往扮演着更重要的角色。通过不断开发和推广气候解决方案、调动投资、支持国际合作，中国的城市将能推动区域甚至全球的脱碳化进程。

为论证这一点，本报告第一部分首先从国际视角出发，阐述一个城市如何达到零碳排放。第二部分探讨了北京如何成为脱碳化和低碳技术发展的领先者。第三部分分析了中国城市如何推动区域甚至全球脱碳化进程。最后，第四部

[3] "Renewables in Cities," 2019 Global Status Report, https://www.ren21.net/reports/cities-global-status-report/

分我们就公共和民间机构各自应承担的责任提出了建议。

一、国际视角：成为零碳排放城市

19 世纪 80 年代以来，地球的平均气温升高了约 1.1 摄氏度。地球变暖可能意味着热浪和洪水等急性灾害更频繁、更严重，而干旱和海平面上升等慢性灾害可能会加剧。

中国在 2016 年签署了《巴黎协定》，根据这一协定，要达到把升温控制在 1.5 摄氏度以内的目标，二氧化碳排放需要保持在全球“碳预算”（针对某升温目标，二氧化碳累计排放量上限）内，即 570 千兆吨（二氧化碳）。根据目前的预测，即使签约国全部履行承诺，到 2030 年[4]，2 摄氏度的碳预算仍将消耗约 80%，而 1.5 摄氏的预算则所剩无几[5]。

全球城市虽然只占陆地面积约 2%，却消耗了三分之二的能源，容纳了 55%的人口，产生了 70%的二氧化碳排放[6]，同时也贡献了 80%的全球 GDP[7]。在中国，

[4] United Nations Environment Programme (UNEP)
[5] United Nations Environment Programme Emissions Gap Report 2017
[6] “Why cities?” C40 Cities, accessed January 12, 2018, c40.org
[7] “Urban world: Mapping the economic power of cities,” McKinsey Global Institute, 2011, McKinsey.com

城市贡献了 85%的 GDP。上述数据随着城市化的发展还会上升。每年全球有 6500 万人移居城市，按此速度，到 2050 年，世界人口大概会有 70%[8]聚集在城市。可以想见，城市对温室气体（GHG）排放趋势有着极其显著的影响。

速度就是关键：今天城市在能源、建筑标准、土地使用，到公共交通等所有领域做出的决策和投资，都与未来几十年的碳排放息息相关。要实现各自的碳排放目标,城市应将采取的行动优先排序,同时确保实施的各项条件到位。以下我们列出了五大优先事项[9] ：

（一）零碳电网

世界各国都必须大幅降低化石燃料的消耗，同时增加水能、核能、太阳能、风能等低排放、零排放发电[10]。城市有两个机会：投资开发集中式可再生能源，同时赋能分布式可再生能源实现智能化。城市可以与电力企业以及中央、地方政府密切协作，加快电网脱碳步伐。到 2030 年实现电力结构中 50%~70%来自可再生能源，相当于所需总减排量的 35%~45%。

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[8] "Human population: Urbanization," Population Reference Bureau, 2007, pbr.org

[9] "Focused acceleration: A strategic approach to climate action in cities to 2030," C40 Cities and McKinsey & Company, 2017, https://www.c40.org/researches/mckinsey-center-for-business-and-environment

[10] "Pathways to obstacles to a low-carbon economy," Arnout de Pee and Lord Adair Turner, April 2017, McKinsey.com

目前已有一些实践。比如，哥本哈根在 2000 年成立了一个电力合作社，由市政公用事业投资离岸两公里的一处海上风车园（风电场），发电能力为 40 兆瓦。丹麦国家能源公司 Orsted 也持有股份。海上风车园可为全国供电，它将帮助丹麦实现最终目标，即全国一半的电力供应来自海上风能。

即使可再生能源条件没有丹麦优越的城市，也可以为供电脱碳化找到创新方法。墨尔本的电力 90%来自煤炭。市中心高楼林立，几乎没有为安装可再生能源留有空间[11]。在现有的国家政策框架下，该市与政府、文化、教育机构携手，从 2016 年开始构建一个可再生能源采购系统。十年间，每年购买 110 兆瓦小时的可再生能源电[12]。到了第二阶段进一步增加。在多方共同努力下，新渠道的采用已经让城市的排放降低了 5%。

（二）提高建筑物能源使用效率

[11] "Cities100: Melbourne – Tearing up to buy renewable energy," Cities100, October 30, 2015, C40.org

[12] "Melbourne Renewable Energy Project: A new generation of energy," City of Melbourne, accessed February 20, 2021

由于安装了数百万台供热设施、空调、热水、照明、电器，以及设备，大部分城市的建筑物是排名第一的能耗大户——也是碳排放超级大户。建筑物内的供热和制冷占了能耗的 35%~60%，约占将近 40%的城市碳排放。除了提升电器、设备的能效标准之外，商用和住宅楼宇本身的能效提升也会帮助城市大幅降低排放。我们的分析表明，很多城市仅仅通过优化建筑物能耗模式，就已实现 55%的减排目标，这还不包括电器能效提升。

眼下城市有五个重大机遇：提升新建筑物能效标准；翻新建筑物外立面（安装隔热屋顶，改善墙面保温，安装节能窗户，提高门框密封性）；采用低碳技术，升级暖通（HVAC）系统；使用 LED 照明；进一步推广建筑物自动化和控制。建筑的减排成本通常为负，在上述领域的投资一般可在 5 到 15 年内收回。从长远来看，提升建筑能效为气候韧性、清洁空气，以及宜居性奠定了基础。

布鲁塞尔的例子表明，供热、制冷、能量需求、密封性，以及通风等采取高标准的建筑物，造价几乎等同于传统的低能效建筑物。“被动式建筑”是指能耗极低、只需要极少甚至不需要供热、制冷的房屋，可大幅降低楼宇运营成本。集中供暖和供冷可提高供暖供冷能效，以东

京晴空塔（Sky Tree Town）建筑群为例，包括一幢高层住宅楼，商业设施，以及办公楼，在其多楼宇暖通系统中，组合使用了热泵和水塔。与独立使用的系统相比，这一“社区系统”将能耗降低了 44%，同时减少 50%的碳排放[13]。

针对现有建筑物的节能改造，翻新建筑物立面可以将供热和制冷需求降低 40%，结合安装规模小些的暖通系统，或者采用自然通风，可以控制取暖或制冷的需求。像旧金山或者多伦多这样的城市，已经制定了规划，帮助低收入社区翻新房屋，改进暖通设施，减少室内冷凝和由此产生的霉，降低健康风险[14]。

（三）鼓励新一代出行方式

城市在发展，商品和人的流动也随之发展。城市脱碳需要更好、更清洁的出行方式。城市应加快以公共交通出行为导向的开发，倡导使用公共交通、步行、骑自行车出行，发展新一代汽车，包括货运车。在汽车方面，目前有四大趋势不应错过：电气化、共享出行、自动驾

[13] Japan for Sustainability, “District heating and cooling of Tokyo sky tree area largely reduces energy use, CO2 emissions,” October 29, 2013, https://www.japanfs.org

[14] “Cities100: Toronto – Apartment retrofits prioritize resident well-being,” Cities100, November 15, 2016, c40.org; “Cities100: San Francisco – Equitable retrofits lower energy bills,” Cities100, November 15, 2016, c40.org”

驶，以及无线互联[15] 。这些趋势叠加将为出行减排带来很大机遇——到 2030 年，将贡献城市交通减排的 20%~45%。

城市可以出台激励和政策措施，加快电动汽车的普及，比如提供补贴、专用驾驶车道和停车点，支持建设充电站。欧洲有 220 多个城市已经设立或者计划设立零排放，或者低排放区[16]。

比如加州北部最大的城市圣何塞，生产了全美五分之一的电动汽车，在 2020 年推出了一项投资高达 1400 万美元的计划，旨在将充电桩数量增加一倍，以及进一步推广脱碳汽车[17] 。

这些行动的未来发展前景广阔。为此，城市应针对人力和技术进行投入。这三个“赋能元素”的快速和稳健发展，对实现碳中和极为关键。

（四） 做好消费者需求管理

[15] “Focused acceleration: A strategic approach to climate action in cities to 2030,” C40 Cities and McKinsey & Company, 2017, https://www.c40.org/researches/mckinsey-center-for-business-and-environment

[16] “Overview of low emissions zones,” Urban access regulations in Europe, urbanaccessregulations.eu

[17] Press release, “News release: $14 MILLION ELECTRIC VEHICLE CHARGING STATION INCENTIVE PROJECT LAUNCHES IN SAN JOSÉ”, City of San Jose, https://www.sanjoseca.gov/Home/Components/News/News/1861/4699

带动客户和各产业参与脱碳化——比如，推广低碳做法，发展循环经济——有助于城市实现自己的碳排放目标。

绿色生活方式不一定消费要更少，而是指它能够保护环境、提升生活品质。比如，增加植物性膳食比重，例如喝豆奶，既有利于健康，也减少了农业碳排放[18]。又比如共享经济，共享汽车、共享工具或其他共享形式，能减少消费者支出和产品浪费。由于疫情，很多上班族都改变了出差和通勤方式，不但减少了飞行碳排放，在某些地方，还减少了汽车碳排放，而且因为在家工作，很多公司的工作效率反而提高了。比如威尔士政府正在考虑出台政策支持远程办公，如建立远程办公中心[19]。

城市可以在学校、社区中心，以及其他机构提供学习机会，举办脱碳化或未来出行展览，增强居民的可持续环保意识——也许还能增加对低碳产品和解决方案的需求。

*遵循 “循环经济” 原则。*提升能效、使用可再生能源只能减少 55% 的温室气体排放。剩下的排放来自食物和工业品的生产、消费过程。这就需要“循环经济”发挥作用了——让工业品和材料在设计、使用、

[18] Reducing food’ s environmental impacts through producers and consumers, Poore, J & Nemecek, T, https://ora.ox.ac.uk/objects/uuid:b0b53649-5e93-4415-bf07-6b0b1227172f

[19] Llywodraeth Cymru Welsh Government, https://gov.wales/remote-working, January 11, 2021

再使用的良性循环中闭环流动。资源管理、养分流动、逆向物流一体化，做到工业品回收、分类、再利用，而无需再填埋或者焚烧。资源要再生，而不是废弃。

循环经济既有利于经济发展，又把资源利用对自然环境的影响降低到尽可能小的程度，它能够带来巨大的经济、社会、环境效益，节省材料成本，并显著减少温室气体排放[20]。

建设繁荣、宜居、有韧性，并且具备再生能力的城市，是市政府的重要责任。遵循循环经济原则的做法之一就是让居民的生活、工作、娱乐离得更近一点。机动车安装脱碳引擎，共享出行则会减少拥堵，这样空气就清洁多了。更多的人选择步行或是骑车上班，不但有利于身体健康，还能拉进居民与社区以及本地商业的关系。马路和停车场就可以改成绿色空间或者新住宅和商户。

让不同的利益相关者携起手来，增强循环经济践行意识，让他们参与规划，以及经济激励措施和政策，这样，在从“索取——生产——废弃”的线性经济向更加清洁的循环制造经济的转变中，城市可以参与其中。布鲁塞尔正在朝着这样的愿景努力，每年拨款 1300 万欧元给

[20] The Circular Economy in Detail, The Ellen MacArthur Foundation

“布鲁塞尔地区循环经济项目”。2016 年以来，已经有 200 多家企业、1400 多名市民接受了培训并获得支持，推广循环经济做法。

（五）加大低碳技术投资力度

如果各国切实履行各自在《巴黎协定》中做出的减排承诺，那么对很多低碳技术的需求将会上升，比如，太阳能光伏（PV）、能源存储、金属循环利用、电动汽车、氢燃料电池，以及碳捕集和封存（CCS）等。凭借政治、金融、人力的优势，城市可以成为最理想的孵化器和测试基地。城市可以与地区政府、行业龙头、学术机构和智库展开合作，提供科研经费、基金、场地，或其他资源支持创新。最后，要将想法付诸实践的话，城市应就新技术的使用设立明确的目标。比如东京制定了到 2030 年生产 100 万个燃料电池及建成 150 个加氢站的目标，确保氢能在“零排放东京战略”中占据重要地位[21]。

二、案例分析：北京如何成为去碳化示范城市

中国很多大城市有着能干有为的政府，有完备的脱碳化蓝图，有民营、国有企业的支持，还有世界一流的大学和科研机构，有足够的能力推进脱碳化。

[21] “Case Study: Zero Emission Tokyo Strategy”, C40 cities, December 18 2020, https://www.c40.org/case_studies/zero-emission-tokyo-strategy

本节我们将以北京为例，探讨它目前的脱碳化进程，取得了哪些成功，以及未来将如何发展。

2018 年，北京排放的二氧化碳总量是 1.5 亿吨，其中 70%来自建筑物和交通运输，随着北京向服务型经济[22]转型，这一比重还会进一步上升。随着钢铁等重工业如首钢等迁出北京，2016 年工业对 GDP 贡献下降了 20%，到 2019 年为 16%[23]。而留下的重工业如燕山石化未来也可能搬迁转移。即使这样，北京的总排放量还是在持续上升。

2010 年以来，北京市采取了一系列卓有有效的行动，将碳强度降低了一半。目前北京的碳强度在国内是最低的。

- 全面禁燃煤：煤炭不再是居民供热的主要来源，转而使用天然气和电力。
- 能效：北京设立了明确的能耗总量和强度“双控”目标，从 2016 年到 2020 年，将能源强度削减 13%。

[22] Beijing Municipal Ecology and Environment Bureau, July 2020; http://sthjj.beijing.gov.cn/bjhrb/index/ztzl/2020nqgdtrzchd/hdxx/10823030/index.html

[23] 2019 Beijing Statistical Yearbook, Municipal Bureau of Statistics Survey Office of the National Bureau of Statistics Beijing

- 交通管理：大力发展公共交通、支持电动汽车、兴建充电基础设施，这些举措都降低了交通污染排放。过去五年间，北京的地铁线路总长增加了三分之一。

某种意义上说，北京已经实现了初期目标。接下来如自动驾驶（AV）布局、发展氢能、工业脱碳所需的碳捕集、利用和封存技术（CCUS）等成本高昂，且更复杂。而且，服务行业和家庭需求消耗了北京市能源的 80%以上。由此产生的碳排放比起工业企业来说，更难追踪，而传统的自上而下的应对方式可能成效不佳。这是很多城市共有的问题，这同时也提供了新的机遇。中国的城市应该鼓励企业与个人参与脱碳、开发气候变化基层应对方案。

（一）动员：开发气候变化的基层应对方案

降低排放要求企业和个人从用电、出行到供热制冷等方方面面做出改变。在以下四个方面采取行动将产生很大作用。

1、电网脱碳

电网脱碳必须是第一步，因为它是实现经济系统其他领域，如建筑和运输脱碳化的先决条件。北京从邻近省区如河北、内蒙古、陕西[24]购买了 70%的电

[24] "At the end of the 13th Five-Year Plan, the proportion of electricity outside Beijing will increase to 70 percent," Beijing News, Apr 21 2017, http://epaper.bjnews.com.cn/html/2017-04/21/content_678806.htm?div=0

力，这些地区传统上一直是火力发电，但近年来开始大力发展可再生能源。以河北省张家口为例，该市建成了几十个风电场，总装机容量超过 1000 万吉瓦。北京可与周边省市一起扩大可再生能源开发，这是一个办法。除此之外，北京可以在市内从两方面入手，加速清洁能源转型。

*增加分布式太阳能发电。*鉴于北京市人口和建筑物的密集程度，在市区发展分布式太阳能潜力有限，但可以在可用土地更多的顺义和平谷这类郊区发展，然后这些分布式发电站可以接入中央电网，销售多余电量。

*增加需求端电网灵活性。*风能和太阳能发电具有间歇性和波动性特点，使用得越多，就越是需要优化需求端管理来增加电网的系统灵活性，才能平衡波动。电价分时计费（TOU）是一个办法，用电高峰期价格就更高些。这样有助于保证需求与供给一致。2015 年开始，北京推出了此类举措，但由于各时段价差很小，消费者行为改变不明显。如果要让分时计费发挥更大作用，应该鼓励需求端储存电力。比如说，商务楼安装蓄电池，将非高峰时段的电储存起来，留到高峰时段使用，或者电动汽车车主可以在用电高峰期将富余电量卖给电网。

2、提升建筑物能效

北京建筑物是排放大户，在建筑物总能耗中，市政府和商务楼的能耗占了一半。很多建筑物有条件选择高能效设备和电器。大部分建筑物能效投资在 5 到 15 年内就可以收回。可考虑采取以下四项最具前景的战略行动。

安装高能效设备和电器。供热和制冷是建筑物碳排放的最大来源。北京很多建筑物仍使用老式陈旧的暖通系统，采用低能耗设备可减少碳排放，如电热泵、节能空调，以及电力、太阳能供热等。至于照明，北京只需继续更换更节能的 LED 灯[25]。

一个更具雄心壮志的计划是安装更多的自动化系统，实现楼宇智能运维。自适应恒温器联网后，用户可以利用动态传感器自动调节室温，甚至可以将照明亮度调整为自然光线[26]。多伦多、悉尼，以及英国好几座城市已经与房地产公司开展合作，向其提供信息、工具、技术和市场支持，以加快提升建筑物能效[27] 。

[25] "Global heating methods report ", Beijing Energy Conservation and Environment Protection Center, https://www.bjbeec.cn/hyzx/5585.jhtm

[26] "The supportive programmes your city needs to drive towards zero-carbon buildings" , C40 Implementation Guides, https://www.c40knowledgehub.org/s/article/The-supportive-programmes-your-city-needs-to-drive-toward-zero-carbon-buildings?language=en_US

[27] Better Buildings Partnership, https://www.betterbuildingspartnership.co.uk/

推广低能耗设计。改进建筑物节能设计，能够减少对供热[28]和制冷的需求。这是 2021 年 1 月 1 日正式实施的《居住建筑节能设计标准》中的部分技术内容。未来北京可考虑引入雄心勃勃的净零排放标准，升级这一体系。这是欧盟正在做的，从 2018 年开始，所有的新建公共建筑都必须达到近零排放。从 2020 年开始，所有的新建建筑必须达到这一标准[29] 。

北京可以划定零碳排放社区或者城区作为试点，并为公私合作创造机会。北京也可以鼓励低碳建筑价值链创新，如新材料。在纽约市，创新企业测试系统为初创企业提供机会，绿色建筑新技术在推向市场之前，可先在市政建筑中进行测试[30]。

翻新老旧建筑。老旧建筑翻新以外立面为主，翻新后可将供热和制冷需求降低 40%，既节省电费、减少排放，又提升了生活品质。北京有十分之四的住宅建于 1990 年之前，大部分都可以这样升级改造。

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[28] McKinsey Center for Business and the Environment

[29] "Nearly Zero Energy Buildings", European Commission, https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en

[30] "New York City Buildings Opening Doors for Green Tech Startups", Green Real Estate Law

目前旧房翻新已经开展起来。2020 年，北京市政府出资改造 80 个老旧小区，这是总体方案的一部分[31]。要扩大改造范围，北京可以尝试新商业模式，引入社会资本。比如，市政府可以考虑将商业地产开发与住房改造加以捆绑。其他鼓励企业和居民行动起来的办法还有贴息贷款、简化审批流程、推行政府主导大宗采购降低资本成本等。2016 年，为推进老旧小区改造，青岛制定了激励计划。市领导估计全市将有 5000 万平方米的老旧住宅需要提升能效水平。目前翻新完成已近一半，减少预期二氧化碳排放量约 29.8 万吨[32] 。

*建筑节能智能化。*人们如果能自主管理所消耗的热能，用多少热交多少钱，就更有意愿改变行为。北京的住宅楼能耗中，供热占了约 40%。大部分情况下，供热收费是按照住房面积计算的，所以居民一般会成天开着取暖设备。改为按热计量收费可能会增强居民的节能意识。哈萨克斯坦在其绿色战略中推出了一项热计量表安装项目，目标是到 2025 年达到居民楼 100%全覆盖。2020 年已覆盖 60%的居民楼[33]。

[31] Beijing Municipal of Housing and Urban-rural Development, http://zjw.beijing.gov.cn/

[32] "Cities100: Qingdao is incentivizing high-quality retrofits for an energy-efficient housing stock", C40 Knowledge, October 2019, https://www.c40knowledgehub.org/s/article/Cities100-Qingdao-is-incentivising-high-quality-retrofits-for-an-energy-efficient-housing-stock?language=en_US

[33] "Clean Household Energy Consumption in Kazakhstan: A Roadmap," International Energy

3、鼓励新一代出行方式.

公共交通贡献了北京 10%~15%的温室气体排放[34]，其中大部分来自乘用车。北京人喜欢开车，私家车数量从 2015 年的 560 万辆增加到 2020 年的 660 万辆[35]。北京市一直在鼓励和支持使用电动汽车。2015 年，北京开始推行出租车、公交车的电动化，纯电动车车主还能享受优惠政策，比如购车额度放宽。到 2020 年，电动汽车占北京市汽车销量的 60%[36]。尽管种种努力，北京马路上 95%的车辆仍旧是传统燃油车。至少在未来 10 年，燃油车仍是排放大户。我们认为，北京不妨从以下三个方面入手降低交通运输的碳排放。

*加快绿色能源汽车推广。*北京可以借鉴洛杉矶、马德里、巴黎的做法，为燃油车制定禁售时间线。北京的充电站布局堪称中国最大。目前电动汽车销售攀升，所以北京淘汰燃油车有很好的基础。汽车产业也正在为

Agency, December 20, https://www.iea.org/reports/clean-household-energy-consumption-in-kazakhstan-a-roadmap

[34] "Carbon emission from urban passenger transportation in Beijing" , Zijia Wang, Feng Chen, Transportation Research Part D: Transport and Environment, 2015, https://www.sciencedirect.com/science/article/abs/pii/S1361920915001534

[35] Beijing Municipal Public Security Bureau, http://jtgl.beijing.gov.cn/jgj/jgxx/95495/ywsj/index.html2

[36] Beijing's 2020 total number of passenger car quota announced, People's Daily

此做足准备。国有企业北汽集团于 2020 年在北京停售燃油车[37]。如果政府能够设定一个明确的时间线，汽车基础设施行业就更容易进行调整，以便确保北京有足够的充电桩。举例来说，英国石油公司（BP）联合出行服务商滴滴，成立一家合资企业，在中国建设电动汽车充电基础设施[38]。

北京还可以抓住时机加紧发展氢能汽车产业。2020 年氢能汽车产量为 7000 辆[39]，中国计划到 2030 年，生产 100 万辆氢能汽车[40]。国内以广东的行动最迅速，加氢燃料站全国最多。广州还请来氢能汽车先行者韩国现代建设一座氢燃料电池厂[41]。北京将建设一座氢能工业园，显示了想要引领氢能汽车产业发展的雄心[42]。

*投资交通运输为导向的开发项目。*好的城市规划和开发能缩短通勤距离、

[37] "Stop selling fuel vehicles and car companies to accelerate electrification," Beijing Daily, Jan 2019
[38] BP China, "BP 与滴滴携手布局中国新能源车充电网络", August 1 2019, https://www.bp.com/zh_cn/china/home/news/press-releases/news-08-01-2019.html
[39] Yilei Sun and Brenda Goh, "Chinese automakers announce targets to raise hydrogen vehicle sales," Reuters, Sep 15 2020, https://www.reuters.com/article/china-autos-hydrogen/chinese-automakers-announce-targets-to-raise-hydrogen-vehicle-sales-idUSKBN2650L0
[40] "Energy-saving and new energy vehicle technology roadmap 2.0", Ministry of Industry and Information Technology, https://www.miit.gov.cn/jgsj/zbys/qcgy/art/2020/art_7eea943abda746339d899bd5fd520c92.html
[41] Song Jung-a, "Hyundai to build China factory as part of hydrogen vehicles push", Financial Times, January 15 2021, https://www.ft.com/content/a390ad28-03d5-4283-a9f3-550c5a7fc04f
[42] Beijing Municipal Government, "[Daxing District] China-Japan industrial park to be built in Daxing", August 14 2020, http://wb.beijing.gov.cn/en/center_for_international_exchanges/events/202012/t20201216_2166063.html

减少碳排放。北京市可以通过打造密度更高的综合交通枢纽，将分散的城区连接起来，这些枢纽融办公楼、商场、教育、休闲、娱乐于一体。最终的设想是让北京形成“15 分钟生活圈”——人们只需步行 15 分钟就能获得最基本的生活服务。这也能降低城市的总体服务成本，为驾车找到可行的替代出行方式，比如步行、骑自行车、使用公共交通。世界很多城市包括成都、墨尔本、巴黎都在城市规划中融合了这一理念[43]。

4、做好消费者需求管理

鼓励消费者和产业参与脱碳化，有助于城市达成碳排放目标。以下是极具前景的两种做法。

倡导低碳生活。实现大规模脱碳化需要消费者拥抱绿色转型。过去十年，北京市民的环保意识不断提高，对空气污染、水质，还有气候变化越来越关心。基于此，市政府可以与企业一起，帮助消费者实现零碳生活。2016 年 8 月，蚂蚁金服在支付宝公益板块正式推出蚂蚁森林。用户步行替代开车、在线缴纳水电煤、网络购票等行为节省的碳排放量，将被计算为虚拟的“绿色能量”，用来在手机里养大一棵棵虚拟

[43]Peter Yeung, “How '15-minute cities' will change the way we socialize”, BBC, January 4, 2021, https://www.bbc.com/worklife/article/20201214-how-15-minute-cities-will-change-the-way-we-socialise

树。虚拟树长成后，支付宝蚂蚁森林和公益合作伙伴就会在地球上种下一棵真树，或守护相应面积的保护地，以培养和激励用户的低碳环保行为。目前蚂蚁森林用户超过 2 亿人，很受欢迎。这一公益行动有利于改变用户购买行为，比如减少使用塑料袋。

*将“循环经济”原则付诸实践。*循环经济是改变资源的线性消耗方式——从原材料到组装、消耗，再到废弃——转变为循环流动、反复使用材料。北京 2019 年产生了 1000 万吨生活垃圾。这些垃圾经过有效再循环，可成为有用的生产材料。发展循环经济有助于确保直接排放取得的成绩，增加的消耗而产生更多的间接排放不会被抵消。 政府可以采取的一项短期措施是加大回收再利用废弃物的力度。私有部门可从中分一杯羹——闲鱼是阿里巴巴旗下非常活跃的二手交易平台。京东则为消费者回收二手衣物和手机，美团正在试点“青山计划”回收外卖餐盒。

（二）创新：北京如何规划未来低碳技术的发展

对于钢铁、石油、天然气这类减排困难的产业，通过现行的政策和技术手段能够解决 30%~70%的排放问题，剩下的就需要通过发展新技术解决了。

新兴技术在大规模推广之前，一般要经过概念开发、早期试验、扩大规模这

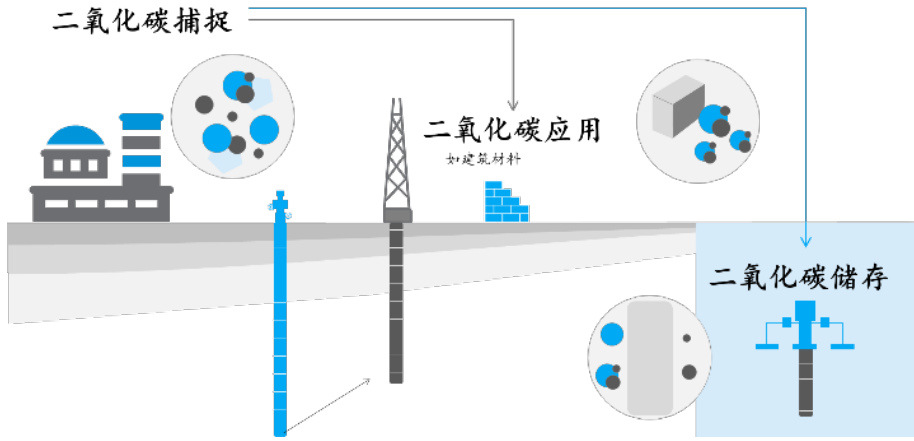
三个阶段。政府可以介入后两个阶段并提供支持。目前中国的绿色科技主流，即太阳能电池板技术，就是一个例子。由于成本高昂，太阳能的开发和利用在 2000 年前进展缓慢。之后随着政府的大力扶持，太阳能光伏产业在中国迅猛发展，经济效益不断改善。今天，太阳能光伏成本有时能看齐化石燃料，甚至在不需要补贴的情况下，也具备这种竞争力。

太阳能光伏之后会是哪个领域？自动驾驶的试点和规模扩张可以驶入快车道了。从排放的角度来看，自动驾驶的主要潜在优势是缓解交通拥堵。此外，自动驾驶与拼车出行一起布局可以取代私家车的需求。这就意味着公路上行驶的车辆更少、更高效，减少了排放，缓解了拥堵。话虽如此，短期内自动驾驶是无法实现大规模使用的，自动驾驶试点项目产生的数据将会帮助大家了解其对交通和安全的潜在影响，设计自动驾驶最佳布局战略，因此十分重要。

另外两种技术——碳捕集、利用和封存（CCUS）以及氢能——在整个能源体系完成减排的最后一英里前，还有很长的路要走。这两项技术前景远大，可以考虑放到快车道加以发展（见附文 1 和附文 2)。

附文 1：低碳未来中的碳捕集、利用和封存（CCUS）

碳捕集、利用和封存（CCUS）是指从发电厂或工厂等大型固定源头，捕获二氧化碳，然后储存或者用作他途。这样二氧化碳



不再排放到大气中，所以 CCUS 可以在减排中发挥重要作用。

在中国，发电厂和工厂的碳排放占全国总量的 70%。

中国有着丰富的煤炭储备，部分地区高度依赖煤炭。但是，煤炭既造成污染，排放强度又高。如果煤发电时采用 CCUS 技术，就能大幅减排。麦肯锡研究显示[44]，在中国，预计到 2050 年，CCUS 技术将捕获二氧化碳 13 亿吨。

这就是潜力。

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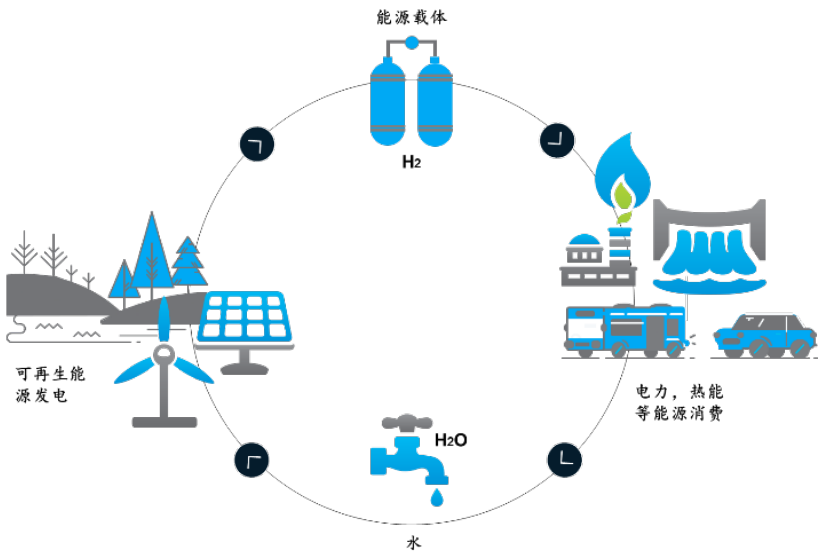
[44] "Leading the battle against climate change: Actions for China," McKinsey Global Institute https://www.mckinsey.com/business-functions/sustainability/our-insights/leading-the-battle-against-climate-change-actions-for-china

现实层面存在两个主要问题。第一是成本。哪怕有政府补贴，如要全产业推广，碳捕集成本还是太高——每吨为 450 元。如果得到有效的政策支持，形成规模经济，这一成本将会大幅下降。第二，CCUS 产业尚未形成明确的业务模式，即使 CCUS 成本降低，应如何盈利？目前 CCUS 只是碳捕获厂和封存厂的附加成本。一种选项可以是把 CCUS 看作政府出资的公用事业。另一种是建立碳交易市场，定价高于 CCUS，鼓励企业有动机地采用 CCUS 技术减少碳排放。

附文 2：低碳未来中的绿色氢能

绿色氢能用电解等低碳排放技术获取，生产过程消耗的是可



再生能源（“灰色氢能”来自化石燃料，生产采用的是煤气化或蒸汽重整等能量密集的工艺，“蓝色氢能”介于两者之间，来自 CCUS 封存二氧化碳的过程）。氢气燃烧时只产生水，制作时可以不产生碳排放。

目前世界初级能源供给有四分之三来自化石燃料，这也是大部分温室气体来源，氢能可以取而代之。麦肯锡研究显示，到 2030 年，中国的绿氢需求将从现在的几近于无，上升到 1800 万吨，需求主要来自钢铁厂和交通运输业。

在钢铁行业，氢能可以替代煤炭做炼铁还原剂。在交通运输领域，氢燃料电池可以取代燃油内燃机。氢能潜力巨大，特别是在长途交通运输领域，比如航空、公交、卡车等，因为大部分电动汽车最高续航 600 公里，而且充电时间也久。

随着氢能价格降低，氢能在其他方面的用途，比如住宅供暖等，

也有了可能性。鉴于从海外输入氢气的成本较高，预计中国将依靠国内供应满足需求。同时作为市场和生产方，有利于中国在氢能技术发展中发挥主导作用。

为充分挖掘氢能的潜力，需要建设更多的基础设施，如输送管道和加氢站，以解决供需不匹配的问题。可再生能源丰富的东南地区和内蒙古较适合生产绿色氢能。对氢能的需求很可能来自东北和沿海地区，建设管道输送氢气可以解决这个问题。

此外，为了创造和满足城市需求，还需要建设氢气储存和加氢站。至少在一开始，可能要由城市、地区和中央政府主导，因为成本可能很高，市场也不确定。这是德国正在做的：2020 年，德国宣布作为其零碳计划的一部分，计划投资 90 亿欧元建设氢能基础设施。

另一个优先事项是推动市场化。为此，可能需要出台激励措施刺激初始需求。氢能技术正在快速进步，成本也在降低。氢燃料电池电动车（FCEV）是一个发展潜力巨大的领域。北京打造了包括生产、储存、运输和汽车制造在内的完整的氢能价值链，

也正建设氢能产业园，加快打造价值链。未来，北京可以探索关键应用场景，打造示范项目，吸引新的投资。

话虽如此，氢能开发尚待完善，其商业价值仍面临挑战。例如，FCEV 存在电池成本高、储氢安全等问题。因此，进展较为缓慢。为发挥其潜力，政府可能需要给氢能发展更多的实质性支持。

促进新技术的规模化发展，需要政府、产业界、民间投资和科研单位各方开展合作。北京市政府可以扮演指挥的角色，统揽全局，协调各方。

首先，北京可以阐明新科技如自动驾驶、CCUS、氢能在其长期去碳化愿景中具有怎样的作用；其次，制定短期目标（如 2020 年 9 月发布氢能产业规划，力争 2025 年前实现氢燃料电池汽车累计推广量突破 1 万辆），鼓励私营部门和科研单位科技攻关，激发想象力。北京市领导还可以通过制定政策和标准，为产业试点 CCUS 和氢气项目保驾护航。例如，就二氧化碳储存和运输立法，可以降低 CCUS 先行者的法律风险。

为降低部署成本，必须改进 CCUS 和氢能的技术。北京拥有世界一流的科研人

才，具备优越的条件。清华和北大在氢燃料电池技术研究方面处于领先地位。此外，总部在北京的石油天然气公司已经开始投资氢气和 CCUS 项目，作为其低碳战略的一部分。

北京还可以优化新技术创业支持体系。办法之一是政府出资设立创新实验室，让创业者可以互相交流，与政策制定者分享他们的想法。被誉为创新国度的以色列，在海法北部投资 400 万美元建立了一个创新实验室，专注于环境技术研发。2017 年，瑞典启动了政府与产业界的联合项目，建立了三个清洁技术中心——研究如何减少温室气体排放，提高能源效率，加强能源安全[45] 。一旦某项新技术试点可行，北京可以开展示范项目或将其列为政府优先采购，支持私营企业将这些创新技术从试点推向市场。

三、中国城市如何支持地区和全球脱碳化

城市具备了人才、资金、规模和影响力等必要条件，能够引领市场导向的绿色技术

[45] Cleantech Hubs Innovation by Sweden, https://cleantechhubs.se/

创新。为实现这一目标，需要同时在区域和国际层面采取行动。

在区域层面，城市可以鼓励和支持所在区域的脱碳化。具体可以从以下四个方面入手：

大力推进区域内绿色基础设施。城市可以借助其购买力，从周边地区采购更清洁的能源。太阳能和风能之类的可再生能源发电是间歇性和波动性的，为保证电力系统运行的安全性和稳定性，需要储能设备对电能进行有效地存储，这就导致整套系统的成本远高于传统的火力发电站。大城市可以与周边各级政府和能源供应企业合作，提高经济效益，比如签署长期的电力购买协议（PPA），同意提高可再生能源的购买价格等。

这一领域目前已有实践。2015 年，华盛顿特区签署了一项电力购买协议（PPA），从宾夕法尼亚州的风电厂购买总输出功率达 46 兆瓦（MW）的电力[46]，可满足华盛顿特区 30%~35%的用电需求。2020 年，被称为“一平方英里”的伦敦金融城签署了一项电力购买协议，从多塞特一家太阳能电厂购买总输出功率达 49.9 兆瓦的电力，预计可满足伦敦金融城一半的用电需求[47]。该电厂预计为伦敦金融城总计节省 300 万英镑的能源支出，而长期稳定

[46] C40 Cities Climate Leadership Group and C40 Knowledge Hub, “How cities can create demand for large-scale clean energy generation”, March 19, https://www.c40knowledgehub.org/s/article/How-cities-can-create-demand-for-large-scale-clean-energy-generation?language=en_US

[47] Newsroom City of London, “City’s ‘pioneering’ green energy deal could be blueprint for local authorities”, November 18 2020, City of London, https://news.cityoflondon.gov.uk/citys-pioneering-green-energy-deal-could-be-blueprint-for-local-authorities

的收入将有力地支撑电厂建设。悉尼也达成了一项 10 年期的电力购买协议，将从新南威尔士州获得风电和太阳能供电[48]。

采用区域排放核算。传统上城市的温室气体计算仅限于市区的能源排放。但由于城市居民消费的食物、商品、服务往往来自外部，而这类排放未能计入城市总量。如以消费为基础进行排放核算，则可将其计入城市排放总量。一旦采用这一标准，中国城市就会对排放源有更好的了解，进而决定是通过消费者教育、公共采购，还是采取其他策略来相应降低排放。

地区产业升级。日益壮大的服务业已取代制造业，跃升为中国经济第一大产业。着力打造这一“支柱产业”呼声日高。城市可以帮助周边地区的高排放产业实现升级。以河北省为例，其经济的快速发展依赖于高能耗产业。2020 年，炼钢、化工、设备制造等高能耗产业占河北经济产出的 40%。河北消耗的能源占全国的 7%，但 GDP 贡献只有 4%。从能源结构来看，煤炭是其最主要的一次能源（占消费总量的 75%）[49]，因此工业脱碳化应该是其要务，在这方面北京积累了丰富的专业知识。

[48] “We’ ve made the switch to 100% renewable energy”, City of Sydney News, July 1 2020, https://news.cityofsydney.nsw.gov.au/articles/weve-made-the-switch-to-100-renewable-energy

[49] China Statistical Yearbook 2019, China Statistics Press (2019)

分享最佳做法和政策。北京、上海、成都等大城市在设立（并达到）脱碳化目标和建立碳管理法律框架方面，走在了中国其他城市之前。领先城市应该在其所在区域分享这方面的专业知识，甚至共同设立标准。此外，北京等城市已经完成了从重工业主导向服务业主导的转型。因此也可以帮助所在区域完成产业结构转型。脱碳化之路并非顺畅无阻，往往会出现成本升高、短期失业等种种困难。城市可以利用自己的教育资源对工人进行培训，好让他们胜任新的工作。城市还可以提供线上培训课程或者开办地区学校。德国采取了类似举措。为顺利实现 2038 年无煤化的愿景，德国政府出台了 450 亿美元的方案，帮助主要煤炭生产州关闭煤炭资产，培训产业工人再就业[50]，[51]。

在国际层面，城市拥有丰富的实践经验和金融专长，也有国际优势，可以在推进脱碳化和制定气候政策方面，扮演越来越重要的角色。以下是三个可行思路。

[50] Johnny Wood, "This is Germany's $45 billion, 18-year plan to move away from coal", World Economic Forum, January 23 2020, https://www.weforum.org/agenda/2020/01/coal-lignite-germany-renewables-energy/

[51] Cynthis Elliot, "Planning for a 'Just Transition:' Leaving No Worker Behind in Shifting to a Low Carbon Future", World Resources Institute, March 25 2019, https://www.wri.org/blog/2019/03/planning-just-transition-leaving-no-worker-behind-shifting-low-carbon-future

调动资本投入绿色项目。北京等城市正在稳步成长为中国的绿色金融中心。自 2019 年起，北京环境交易所作为市政府指定的北京市碳排放权电子交易平台，已经纳入 1200 多个绿色项目，并与银行、保险、信托、证券、基金、产业联合会，以及第三方评估公司等 20 多家机构建立了伙伴关系。

未来，城市可以与监管方、私有投资，以及研究机构一起为“绿色”金融产品出台一整套规范并加以实施，就像欧盟制定的《欧盟可持续金融分类方案》那样。在这方面，各方已经有一些探索，如中国人民银行于 2020 年开始着手起草一项绿色债券市场法规，其他国际金融机构也在研究制定绿色投资指数。

城市还可以通过与有意向的金融机构——公有、民间，或者多边机构——就绿色债券和其他类型的投资展开合作，建立合作伙伴关系。比如说，*亚洲基础设施投资银行（AIIB）*计划到 2025 年，把一半资金投入气候相关的项目。AIIB 还推出了总额 5 亿美元的亚洲气候债券投资组合，旨在应对气候债券市场的不足，推动气候投融资发展。

与合作伙伴联手打造创新示范项目。在这方面，新加坡绿色智慧城市

登加新镇提供了一个很好的案例[52]。登加于 2016 年开始建设，计划提供 4.2 万个住宅单位，这里建有无机动车商业区，配备了垃圾自动回收和中央制冷系统，住户可以通过一款 app 管理自己的能源消耗和用水量，还包括一条 100 米宽的生态走廊，作为野生动物的安全通道。登加新镇显示出当政府坚定可持续城市开发的决心，就会取得丰硕成果。登加经验为中国的城市开发提供了有益借鉴。

支持高级别协商和协作。没有坚实、一以贯之的国际协作，就无法打造一个低碳、具备环境韧性的未来。排放大户北京、成都、大连以及其他 C40 城市成员，有着强大的经济和组织力量，可以牵头主办未来的高级别气候大会， 也许还可以接棒苏格兰格拉斯哥市，举行下一届联合国缔约国大会（COP）[53]，并更积极地召集国际磋商会议。另外，中国城市还可以带头探索具有亚洲特色的解决办法。

[52] Oscar Holland, "Singapore is building a 42,000-home eco 'smart city,' " February 1 2021, https://edition.cnn.com/style/article/singapore-tengah-eco-town/index.html

[53] UN Climate Change Conference UK 2021, https://ukcop26.org/

四、城市在行动：公共和私有部门的各自角色

城市是脱碳化的重要力量，但城市无法单打独斗，中央政府和私营部门也扮演重要角色。

（一）公共部门：与利益相关者一起建设可持续性发展的韧性城市

城市脱碳需要团队协作。不论是地方还是中央政府，其作用之一就是将各方组织起来朝着同一个方向发力。

1、成立公私合作机制。

政府公共采购起着举足轻重的作用。将环境标准纳入公私合作关系，并优先考虑具备减排潜力的项目，这将有力地激励建筑商等各方认真对待脱碳化问题。

政府对城市经济各个部门起着统领作用，因此可以牵头与私营部门及其他伙伴开展合作，集中力量推进如可再生能源、自动驾驶等绿色创新举措。例如，公私投资基金可以确定优先考虑哪些项目，试点成功后再扩大规模。地方政府可以成立实体或数字孵化器，为企业家、学校和科学家交流想法提供平台。

最后，企业、社会组织和政府可以联合起来向公众宣传可持续发展规范，并为实现具体目标共同努力。全球反塑料污染行动伙伴计划（global plastic action partnership）是一个由政府、企业和公益机构在 2018 年发起的合作项目，旨在清理海洋塑料垃圾。目前已经开展了切实的行动，印度尼西亚正在试点一种广泛适用的方法，并通过了相关立法，目标是到 2025 年将海洋塑料垃圾减少 70%[54] 。

2、加快发展绿色金融

环境与经济密不可分。中国不但认可这一点，事实上，已经将绿色发展作为“十四五”规划中的核心发展理念。中国为促进绿色投资多元化和建立全国碳交易市场所做的努力是彰显绿色经济效益的实例。但

[54] Luhut B. Pandjaitan, “Here’ s how Indonesia plans to take on its plastic pollution challenge”, World Economic Forum, January 20 2020, https://www.weforum.org/agenda/2020/01/here-s-how-indonesia-plans-to-tackle-its-plastic-pollution-challenge/

未来仍需不懈努力。为实现环境污染控制目标，以及 2030 年碳达峰的国际承诺，中国预计每年需要 4,240 亿至 5,660 亿美元的绿色投资[55] 。绿色债券*是一种固定收益工具*，专门用于*为气候和环境项目*筹集资金，由于其结构相对简单、附加成本低、透明度要求高，因而是一种理想的融资工具。中国政府对绿色金融和绿色债券的支持，将有助于绿债发行人降低发行成本或获得财政补贴。部分省级政府已经制定了补贴计划，单个发行人最高可申请 550 万元人民币的偿付额度[56]。综合来看，最有效的办法是由中央政府设立市场标准，包括界定什么是绿色金融产品，并制定监管报告要求[57]。

为减少温室气体排放，2021 年中国将启动全国碳交易市场。目前，该排放交易系统覆盖了中国电力行业，以及约 2000 个能源发电设施，仅此一项就占全国总排放量的 30%。今后，与水泥、钢铁、铝、化工和石

[55] Huan Shao, Bridget Boulle, Yanjing Wu, Yuqing Long, Rui Zhang, "China's Green Bond Issuance and Investment Opportunity Report," Climate Bonds Initiative and SynTao Green Finance, supported by UK PACT, October 2020

[56] Huan Shao, Bridget Boulle, Yanjing Wu, Yuqing Long, Rui Zhang, "China's Green Bond Issuance and Investment Opportunity Report," Climate Bonds Initiative and SynTao Green Finance, supported by UK PACT, October 2020

[57] In Europe, this was done successfully through launching new requirement through EU Taxonomy Regulation.

油天然气等相关的重工业也将被纳入[58]。政府可以通过进一步鼓励私人投资减排，让减排更具成本效益，进而加强全国碳交易市场的影响力。为了充分发挥碳交易市场的潜力，中国可以加大推广碳信用（通常也叫"碳补偿"）。将中国核证自愿减排量（CCER）产品作为碳补偿额度推广，并纳入全国碳市场，这是向低碳未来加速转型的一个良好开端。到目前为止，中国政府 CCER 审定项目累计达 2856 个，备案项目 1047 个。"中国温室气体自愿减排项目"如果取得成功，可以与全球其他国家分享经验和解决方案来加速减排进程。

3、培养长期韧性，启动绿色复苏

政府可以出台激励措施吸引私营部门和那些优先发展绿色项目的机构。以基础设施刺激方案为例，深化资本市场，制定激励措施，让私有部门能够在基础设施融资中起到更大作用，比如，为公私合作伙伴关系投资打造能动环境。政府可以借刺激项目引导公共和民间资金进入可持续性的、有环境韧性的绿色基础设施，加速夯实易受气候变化损害的基础设施。举例来说，可以评估发行方与《巴黎气候协定》所列目

[58] Huw Slater, Wang Shu, Dimitri De Boer, "China's national carbon market is about to launch", China Dialogues, January 29, 2021, https://chinadialogue.net/en/climate/chinas-national-carbon-market-is-about-to-launch/

标，如减缓气候变化、气候适应、能源低碳转型的一致程度[59]。中国政府可以考虑邀请更多的私有部门，在诸如新电动汽车充电站、数据中心等脱碳化领域，扎实有效地开展项目。政府的刺激方案还可以优先考虑山西和东北这些碳密度高的地区，设置开发基金，全面加快这些地方的碳减排。

（二）私营部门：将可持续性融入战略和工作

一旦政府营造明确而稳定的监管环境，私营部门就有了方向，甚至可以加快步伐实现低碳化。我们相信，可持续性将成为一种竞争优势。先人一步、发现并采用可持续性商业模式的公司，必将处于有利地位。

1、制定零碳战略

零碳战略必须具体和透明，既传递出企业的决心，又向资本市场表明其意愿。企业在制定零碳战略后，可以考虑如何脱碳化运营，如参加自愿性碳市场，寻找节省成本的减排办法[60]。世界经济论坛

[59] Sir Danny Alexander, Sir John Armitt, Makhtar Diop and Catherine Mckenna, "What infrastructure stimulus investments could be the most important for governments to pursue now", McKinsey Website, January 20 2021, https://www.mckinsey.com/business-functions/operations/our-insights/what-infrastructure-stimulus-investments-could-be-the-most-important-for-governments-to-pursue-now-and-why

[60] Christopher Blaufelder, Cindy Levy, Peter Mannion, and Dickon Pinner, "A blueprint for scaling voluntary carbon markets to meet the climate challenge," McKinsey Website, January 29 2021, https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

资料显示，投资循环经济项目和可再生能源发电等一些技术成熟且价格合适的做法（12 美元每吨碳当量），能够以低成本降低供应端 40%的排放[61] 。

一批跨国石油天然气企业正在朝着这一方向前进，纷纷公布了全生命周期减排的宏伟目标。它们树立了明确的目标，基于不同的碳估价做场景评估，因而能够更好地把握风险和机遇。基于此，这些油气公司能随着情况的变化，随时调整投资组合。

2、反思传统工作方式

疫情期间，技术、数字化、新的工作方式的应用大大提速，不可能再回到从前。麦肯锡估计[62]，在发达经济体中，20%~25%的人在家每周工作三到五天，并不会降低生产力。这可能会催生新的工作方式，因而影响出行相关的排放。同时，新的工作方式能够提升人们对“15 分钟城市”概念的兴趣，也即市民出门步行 15 分钟，就能满足基本生活所需。此外，新冠疫情加速了劳动者需求的转变。商业领袖和政府应在职业技能培训等举措中，融入气候变化风险意识和脱碳化理念。

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[61] “Net-Zero Challenge: The supply chain opportunity”, WEF, January 2021, https://www.weforum.org/reports/net-zero-challenge-the-supply-chain-opportunity

[62] Susan Lund, Anu Madgavkar, James Manyika, Sven Smit, Kweilin Ellingrud, Mary Meaney, and Olivia Robinson, “The future of work after COVID-19”, McKinsey Global Institute, February 18 2021, https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

3、应用高科技能力

数据的质量和透明度对企业计量、检测、减少温室气体排放至关重要，可以借助大数据、人工智能（AI）、自动化等快速提升能力的技术。实际上，这些技术如果应用得当，将会发挥更大的作用。大数据能够帮助企业更好地利用资源；自动化能让运营更高效（因此也能降低排放密度）；人工智能可以针对项目做预测、模拟，指导员工采取绿色行为。

□ □ □

展望未来，将会出现以下几大趋势。一是人口将持续涌入城市。联合国数据显示，到 2050 年，超过三分之二（68%）的全球人口将居住在城市区域。仅仅中国就会贡献 2.25 亿的新增城市居民[63] 。第二大趋势是中国经济将继续

[63] United Nations News, "68% of the world population projected to live in urban areas by 2050, says UN" , May 16 2018, https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

增长，在造福民众的同时也会给自然资源带来压力。第三大趋势是人们的环保意识、包括对气候变化的认识不断增强。在中国如此，全世界也如此。城市领导人、企业和居民需要勠力同心，合力应对这些趋势带来的挑战。

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Carbon neutral by 2060: How cities can help China get there

McKinsey

Introduction

Traumatic as COVID-19 has been, destroying lives and livelihoods around the world, an even larger risk could be looming: climate change. In Paris in 2015, almost every country on the planet agreed to take action to limit the rise in global temperatures to no more than 2 degrees Celsius (and preferably 1.5) above pre-industrial levels. But the pledges made in Paris would only account for a third of required emissions. More needs to be done—and cities have a major role to play.

China, which accounts for 28 percent of global emissions, has set a goal for carbon dioxide (CO2) emissions to peak before 2030 and to be carbon neutral by 2060. Meeting that target will be difficult, but the stakes are high. Average temperatures in China have increased as much as 1.5°C since 1909, [64] and climate change could mean a warmer and wetter country. Sea levels off eastern China rose 93 millimeters between 1980 and 2012, while glaciers have shrunk 10 percent since the 1970s.

That is the recent past. In the near future, if China's emissions continue to rise at

[64] "China's Third National Assessment Report on Climate Change," Ministry of Science and Technology, the China Meteorological Administration, Chinese Academy of Sciences and Chinese Academy of Engineering

the current rate, the threats of extreme heat and lethal heat waves could affect 10 to 45 million people by 2030. The kind of heavy precipitation that was a once-in-50-years event in 1980 is expected to be two to three times more likely in 2030 and three to six times more likely in 2050. The average share of outdoor working hours lost each year to extreme heat and humidity would increase from 4 percent to as much as 6.5 percent in 2030 and 9 percent in 2050; the latter would be equivalent to $1 trillion to $1.5 trillion in GDP.

Coal supplied around 58 percent of China's total energy consumption in 2019, a figure that is gradually declining. In addition, the country has been diversifying its energy supplies and shifting towards a cleaner and less energy-intensive economy. But China's overall coal consumption continues to rise slightly, driven by demand growth in electricity, residential heating, as well as industries such as steel and cement.[65] And lower-emissions energy sources still account for less than a quarter of China's primary energy usage: hydroelectric (8 percent), natural gas (8 percent), nuclear power (2 percent), and non-hydro renewables like wind and solar (5 percent).

China accounts for almost a third of global investment in renewable power and fuels; in 2018, it was home to more than 95 percent of the world's electric bus fleet and

[65] BP Statistical Review of World Energy, 2020, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-full-report.pdf

nearly half of all electric vehicle (EV) passenger cars.[66] Energy efficiency and the greater use of renewables has also helped reduce air pollution. According to the International Energy Agency (IEA), China is set to account for 40 percent of global renewable capacity expansion to 2024. In short, then, China is gradually greening its energy supply, through the greater use of renewables, natural gas, and electricity. But its growing economy, and continued reliance on coal, means that China's road to carbon neutrality will be long and difficult.

As the wellspring of both economic growth and greenhouse gas (GHG) emissions—15 cities account for a third of the country's GDP[67]-- Chinese cities have a major role to play in decarbonization. Cities are also equipped to take action. They are home to key decision makers, large investment funds and investors, leading universities and think tanks and a growing number of high-income individuals interested in promoting sustainability. Four areas are critical: decarbonizing their electricity grid; optimizing energy efficiency; encouraging next-generation mobility; and strengthening consumer demand management. And they can also play a role beyond their own boundaries. By developing and scaling up climate solutions; mobilizing investment; and supporting international

[66] "Renewables in Cities," 2019 Global Status Report, https://www.ren21.net/reports/cities-global-status-report/

[67] Xiaozhao Lin, "Top 50 Chinese cities," Yicai News, August 27 2019, https://www.yicai.com/news/100310170.html

collaboration, China's cities can help further regional and even global decarbonization.

To demonstrate how that could happen, we first offer a global perspective on how cities can decarbonize. Section 2 looks specifically at how the city of Beijing can become a leader in decarbonization and related technologies. Section 3 considers what China's cities can do to foster regional and global decarbonization. Finally, Section 4 discusses the respective roles of the public and private sectors.

Section 1: A global perspective on urban decarbonization

Since the 1880s, the Earth's average temperature has risen by about 1.1 degrees Celsius. A warmer Earth could mean that acute physical hazards such as heat waves and floods could grow in frequency and severity, and chronic hazards, such as drought and rising sea levels, could intensify.

Under the Paris Agreement, which China signed in 2016, meeting the 1.5°C goal requires staying within a global "carbon budget"(the cumulative amount of carbon dioxide emissions permitted to keep within a certain temperature threshold), of 570 gigatons of CO2. Under current projections, even if all the nations who signed meet their commitments, the 2-degree carbon budget will be about 80 percent depleted

by 2030,[68] and the 1.5-degree budget almost gone.[69]

While cities only account for about 2 percent of the global landmass, they consume two-thirds of the world's energy, house 55 percent of the world's population, contribute 70 percent of global CO2 emissions,[70] and generate about 80 percent of global GDP[71] —85 percent in China. As urbanization advances, all of these figures could rise. With 65 million people a year moving to cities, they could be home to almost 70 percent[72] of the world's population by 2050. Cities therefore have enormous influence on the trajectory of GHG emissions.

Speed, then, is of the essence: the choices and investments cities make today, on everything from energy and building standards to land use and public transit, will affect emissions for decades to come. To meet their emissions targets, cities need to prioritize their actions and then ensure that the conditions are in place to execute them. There are five priorities.[73]

1.1 Decarbonizing the electricity grid

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[68] United Nations Environment Programme (UNEP)

[69] United Nations Environment Programme Emissions Gap Report 2017

[70] "Why cities?" C40 Cities, accessed January 12, 2018, c40.org

[71] "Urban world: Mapping the economic power of cities," McKinsey Global Institute, 2011, McKinsey.com

[72] "Human population: Urbanization," Population Reference Bureau, 2007, pbr.org

[73] "Focused acceleration: A strategic approach to climate action in cities to 2030," C40 Cities and McKinsey & Company, 2017, https://www.c40.org/researches/mckinsey-center-for-business-and-environment

To limit global warming, the world will have to significantly reduce the consumption of fossil fuels and expand low- and no-emissions power generation, such as hydro, nuclear, solar, and wind.[74] Cities have opportunities on two fronts: investing in the expansion of centralized renewables and enabling the smart expansion of distributed renewables. With focused acceleration and close collaboration with utilities and regulators, cities could achieve a renewable grid mix of 50 to 70 percent by 2030, accounting for 35 to 45 percent of the total emission reductions required.

There are examples of how this could work. Copenhagen, for example, launched a cooperative in 2000 through its own utility to invest in a 40-megawatt wind farm two kilometers off its coast. Denmark's national energy producer, Orsted, also has an ownership stake and the electricity produced is sold all over the country. Denmark's ultimate goal: to supply half of its electricity with offshore wind.

Even cities with less-favorable conditions for renewables have found innovative ways to decarbonize their electricity supply. Melbourne gets its

[74] "Pathways to obstacles to a low-carbon economy," Arnout de Pee and Lord Adair Turner, April 2017, McKinsey.com

energy from a utility that uses coal for 90 percent of its power generation. Its city center is dominated by high rises, leaving little space for on-site renewables.[75] Working within existing national policy, the city worked with government, cultural, and educational institutions since 2016 to develop a renewable- energy procurement system to buy 110 gigawatt (GW) hours of new renewable electricity per year over ten years.[76] A second phase added more. Together, the new sources have reduced the city's emissions by five percent.

1.2 Optimizing energy efficiency in buildings

With millions of space heating systems, air conditioners, hot water, lights, appliances, and equipment, buildings are the biggest consumers of energy in most cities – and the biggest emitters of CO2. Heating and cooling account for 35 to 60 percent of energy use in buildings and generate, on average, nearly 40 percent of urban emissions. Cities can significantly reduce emissions by addressing not only the efficiency of appliances and equipment but also the efficiency of commercial and residential buildings themselves. Our analysis indicates that many cities can meet up to 55

[75] "Cities100: Melbourne – Tearing up to buy renewable energy," Cities100, October 30, 2015, C40.org

[76] "Melbourne Renewable Energy Project: A new generation of energy," City of Melbourne, accessed February 20, 2021

percent of their emissions abatement targets by improving how buildings consume energy; that does not include additional opportunities in appliances.

There are five major opportunities: raising energy efficiency standards for new buildings; retrofitting building envelopes (cooler roofs, improved wall insulation, high-efficiency windows, and better air seals on door frames); upgrading heating, ventilation, and air conditioning (HVAC) systems with lower-carbon technologies; using more LED lighting; and expanding the use of building automation and controls. Investments in these areas can often be recouped in five to 15 years, while building a foundation for long-term resilience, clean air, and livability.

The city of Brussels has demonstrated that building to high standards in heating, cooling, energy demand, airtightness and ventilation, can cost almost exactly as much as conventional, lower-efficiency construction. Operating costs in what are known as “passive buildings”— ultra-low energy structures that require little or no energy for space heating and cooling—are, however, much lower. Tokyo’s Sky Tree Town, a complex consisting of a high-rise residential building as well as commercial facilities and offices, uses a combination of heat pumps and water tanks in its multi-

building HVAC. This "district system" has reduced energy use by 44 percent and emissions by 50 percent compared with individual systems.[77]

For existing stock, renovating the building envelope can reduce heating and cooling demand by 40 percent and allow the installation of smaller HVAC systems or the use of natural ventilation to limit the need for heating or cooling altogether. Cities such as San Francisco and Toronto have created programs to enable lower-income communities to retrofit their homes, improving HVAC operations while reducing health hazards such as indoor condensation and mold in the process.[78]

1.3 Encouraging next-generation mobility

As cities grow, so does the movement of goods and people. Options for better, cleaner mobility include accelerating transit-oriented development; encouraging mass transit, walking, and cycling; and enabling next-generation vehicles, including freight transport. On the latter, there are four powerful trends to work with: electrification, shared mobility, autonomous vehicles and wireless connectivity.[79] Combined, these

[77] Japan for Sustainability, "District heating and cooling of Tokyo sky tree area largely reduces energy use, CO2 emissions," October 29, 2013, https://www.japanfs.org

[78] "Cities100: Toronto – Apartment retrofits prioritize resident well-being," Cities100, November 15, 2016, c40.org; "Cities100: San Francisco – Equitable retrofits lower energy bills," Cities100, November 15, 2016, c40.org"

[79] "Focused acceleration: A strategic approach to climate action in cities to 2030," C40 Cities and

mobility opportunities could account for a significant share—20 to 45 percent—of the urban emissions reductions needed by 2030.

Cities can provide incentives and regulations to speed EV adoption, such as subsidies, designated driving lanes and parking spots, and support for the construction of charging stations. More than 220 European cities have implemented or plan to implement zero- or low-emission zones.[80]

For example, the northern California city of San José—home to one out of five EVs in the United States, launched a $14 million project in 2020 to double the availability of charging infrastructure and to increase access to zero-emission vehicles.[81]

These are the most promising actions. To get there, cities need to engage with people and invest in technology. The swift and sure development of these three "enablers" is essential to reaching carbon neutrality.

1.4 Strengthening consumer demand management

McKinsey & Company, 2017, https://www.c40.org/researches/mckinsey-center-for-business-and-environment

[80] "Overview of low emissions zones," Urban access regulations in Europe, urbanaccessregulations.eu

[81] Press release, "News release: $14 MILLION ELECTRIC VEHICLE CHARGING STATION INCENTIVE PROJECT LAUNCHES IN SAN JOSÉ", City of San Jose, https://www.sanjoseca.gov/Home/Components/News/News/1861/4699

Encouraging customers and industries to participate in decarbonization initiatives—for example, by promoting lower-carbon options and building a circular economy—can help cities meet their targets.

Adopting a green lifestyle does not necessarily mean consuming less, but doing so in a way that protects the environment and improves the quality of life. For example, shifting to a more plant-based diet, or using more soy milk, can bring health benefits while lowering carbon emissions for agriculture.[82] Or take the sharing economy, whether of cars, tools, or other items; this can cut both consumer costs and product waste. Many workers have changed their travel and commuting patterns due to the pandemic; this has not only reduced emissions from aviation and, in some places, cars, but working from home has also improved productivity for many companies. The government of Wales, for one, is devising policies to encourage remote working, for example by supporting remote working hubs. [83]

By offering learning opportunities in schools, community centers, and other agencies; hosting decarbonization or future of mobility exhibitions; and establishing volunteer programs, cities can help their residents become more sustainability-conscious—and perhaps increase demand for low-carbon

[82] Poore J and Nemecek T, Reducing food' s environmental impacts through producers and consumers, https://ora.ox.ac.uk/objects/uuid:b0b53649-5e93-4415-bf07-6b0b1227172f

[83] Llywodraeth Cymru Welsh Government, https://gov.wales/remote-working, January 11, 2021

products and solutions.

Implementing "circular economy" principles. Energy efficiency and switching to renewables would only address 55 percent of GHG emissions. The rest comes from how food and products are made and used. That is the role of the "circular economy"—in which products and materials are kept in use, in a virtuous cycle of design, use, and reuse. Instead of tossing materials into landfills or incinerating them, a system of resource management, nutrient flows, and reverse logistics makes the return, sorting, and reuse of products possible. Think regeneration, not reuse.

As an instrument to decouple economic growth from resource use and environmental impact, adopting circular economy principles could have major economic, social and environmental benefits, saving materials costs and significantly cutting GHG emissions.[84]

City governments have an important role to play in building thriving, livable, resilient cities that are regenerative by design. One way for cities to embed circular economy principles is to foster closer proximity between where people live, work, and play. The air gets cleaner as vehicles switch to zero-emission engines and congestion reduces as shared transit increases. More

[84] The Circular Economy in Detail, The Ellen MacArthur Foundation, https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail

people walk and cycle to work, boosting health and interactions with local businesses and communities. Land that was previously dedicated to roads and car parks could become green spaces or new homes and businesses.

By working with various stakeholders to raise awareness of circular economy practices, embedding them into planning, and the use of economic incentives and regulation, cities can be part of the transition from a take-make-waster linear economy to a cleaner and more production circular economy. The city of Brussels has begun working towards this vision, allocating €13 million a year to the Brussels Regional Programme for a Circular Economy. Since 2016, more than 200 companies and 1,400 individuals have been educated and supported in the implementation of circular economy approaches.

1.5 Spurring investment in low-carbon technologies.

If countries genuinely commit to cutting their emissions in line with the Paris agreement, demand could grow for a wide range of low-carbon technologies, including wind turbines, solar photovoltaics (PV), energy storage, metal recycling, EVs, hydrogen fuel cells, and carbon capture utilization and storage (CCUS). With their political, financial, and human resources, cities can be ideal incubators and testing grounds. Through

collaboration with regional governments, industry leaders, academic institutions and think tanks, cities can offer grants, funding, space or other resources for innovation. Finally, to put ideas into actions, cities need to set specific targets for new technology implementations. Tokyo, for example, has stated a goal of 1 million residential fuel cells and 150 hydrogen stations by 2030 as part of its effort to ensure that hydrogen is a key part of its Zero-Emission Tokyo Strategy. [85]

[85] "Case Study: Zero Emission Tokyo Strategy", C40 cities, December 18 2020, https://www.c40.org/case_studies/zero-emission-tokyo-strategy

Section 2: Case study: How Beijing can become a decarbonization role model

Many of China's most important cities are characterized by capable local government, well-established decarbonization plans, supportive private and state-owned companies, and world-class universities and research institutions. Decarbonization, then, is well within their capabilities. In this section we consider the example of Beijing, examining what it is doing; where it has succeeded; and what comes next.

The city of Beijing emitted 150 million tons of CO2 in 2018, 70 percent from buildings and transportation, a share that is expected to increase as Beijing continues its transition to a service-driven economy.[86] The contribution of industry to the city's GDP fell from 20 percent in 2016 to 16 percent in 2019,[87] as heavy

[86] Beijing Municipal Ecology and Environment Bureau, July 2020; http://sthjj.beijing.gov.cn/bjhrb/index/ztzl/2020nqgdtrzchd/hdxx/10823030/index.html

[87] 2019 Beijing Statistical Yearbook, Municipal Bureau of Statistics Survey Office of the National Bureau of Statistics Beijing

industries like Beijing Shougang, a steel manufacturer, moved to other regions. The remaining heavy industries, such as Yanshan Petrochemical, are likely to do so in the future. Even so, overall emissions are still rising.

The city has taken several effective actions to reduce its carbon intensity by half since 2010, and it is now the lowest in China.

- Phasing out coal: Coal is no longer the main residential heating source, replaced by natural gas and electricity-based heating devices.
- Energy efficiency: Beijing has set clear goals for energy consumption and intensity, and cut the latter by 13 percent from 2016 to 2020.
- Transportation management: The expansion of public transportation and support for EVs, including charging infrastructure, has helped decrease emissions from transportation. In the last five years, the length of the Beijing subway system has risen by a third.

In a sense, Beijing has already picked the low-hanging fruit. What comes next, such as the deployment of autonomous vehicles (AVs), hydrogen, and carbon capture, utilization and storage (CCUS), will likely be more expensive and complicated. Moreover, the service and household sectors consume more than 80 percent of the city's energy. Their emissions are more difficult to track than those of large industrial companies, and traditional top-down approaches are less effective. This, however, is true for many cities, and can also be seen as an

opportunity for leadership.

2.1. Mobilization: How Beijing can help develop grassroots responses to climate change

Cutting emissions requires changing how companies and individuals conduct their daily lives, from how they build their homes, to how they travel, to how they stay warm or cool. The following four actions have high potential.

2.1.1 Decarbonizing the electricity grid.

This needs to be the first step, because decarbonizing the grid is also a necessary condition to decarbonize other parts of the economy, including building and transportation. The city of Beijing purchases about 70 percent of its electricity from the surrounding regions, including Hebei, Inner-Mongolia, and Shanxi.[88] These provinces historically generated power from coal, but have recently been investing heavily in renewable energy. Zhangjiakou, in Hebei province, for example, has built several wind farms with capacity of more than 10 million gigawatt (GW). One approach, then, is for Beijing to work with these provinces to build even more renewable capacity. Here are two options.

[88] "At the end of the 13th Five-Year Plan, the proportion of electricity outside Beijing will increase to 70 percent," Beijing News, Apr 21 2017, http://epaper.bjnews.com.cn/html/2017-04/21/content_678806.htm?div=0

Expand distributed solar power generation. Due to Beijing's population and building density, the potential to expand distributed solar power within the city is limited. It could, however, expand solar power distribution to suburbs such as Shunyi and Pinggu, which have more land available. These resources could be connected to the central grid to allow the sale of surplus electricity.

Increase demand-side grid flexibility. Because wind and solar are intermittent, the more they are used, the more important it is that there is real-time, demand-side flexibility to fill the gaps. One way to do so is to adopt time-of-use (TOU) electricity pricing, with higher prices for peak-hour usage. This helps to ensure that demand matches supply. Beginning in 2015, Beijing started such efforts, but because the price differential was minimal, consumers have been slow to change their behavior. To amplify the effect of TOU pricing, demand-side electricity storage should be encouraged. For example, commercial buildings could install batteries to store electricity at non-peak hours for peak-hour use, or EV owners could sell electricity to the grid during peak hours.

2.1.2 Optimizing energy efficiency in buildings.

Buildings are major emitters in Beijing, with municipal and commercial units

accounting for about half of all building energy consumption. Many of them have the resources to upgrade to high-efficiency equipment and appliances. Most building-efficient investment can be recovered in five to 15 years. Here are four promising strategies.

Install high-efficiency equipment and appliances. Heating and cooling are the largest sources of building emissions—and many Beijing buildings have distinctly old-fashioned HVAC systems. Installing low-carbon technologies, such as electric heat pumps, high-efficiency air conditioning, and electric- or solar-based heating, can help decrease emissions. For lighting, Beijing needs to continue its ongoing shift to more efficient LEDs. [89]

A more ambitious plan of action is to install more automation and upgrade management. Adaptive thermostats connected to the Internet allow users to automatically adjust room temperatures using motion sensors and can even adjust bulb brightness to the level of sunlight.[90] Toronto, Sydney, and a number of cities in the United Kingdom have started partnerships to provide

[89] "Global heating methods report ", Beijing Energy Conservation and Environment Protection Center, https://www.bjbeec.cn/hyzx/5585.jhtm

[90] "The supportive programs your city needs to drive towards zero-carbon buildings" , C40 Implementation Guides, https://www.c40knowledgehub.org/s/article/The-supportive-programmes-your-city-needs-to-drive-toward-zero-carbon-buildings?language=en_US

real estate companies with the information, tools, and technical and market support to accelerate improvements in building efficiency.[91]

Promote low-energy consumption design. Improved building design can reduce the need for heating[92]and cooling once structures are built; that is one of the principles behind a new energy-efficiency building code that will come into effect in Beijing later this year. Beijing can eventually upgrade the code to incorporate ambitious net-zero standards, as the European Union (EU) is doing. Beginning in 2018, all new public buildings are mandated to be nearly zero-energy, and from 2020 onwards, all new buildings will have the same mandate.[93]

Beijing can designate zero-carbon neighborhoods or districts to test solutions, and to create opportunities for public-private collaboration. It can also encourage innovation in the low- carbon building value chain, such as new materials. In New York City, the Municipal Entrepreneurial Testing System allows businesses to test new green building technologies in

[91] Better Buildings Partnership, https://www.betterbuildingspartnership.co.uk/
[92] McKinsey Center for Business and the Environment
[93] "Nearly Zero Energy Buildings", European Commission, https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en

municipal buildings before releasing to the market.[94]

Retrofit aging buildings. Renovating aging buildings, focusing mainly on their envelopes, can reduce heating and cooling demand by as much as 40 percent, cutting both utility costs and emissions, while raising living standards. Four out of 10 apartments in Beijing were built before 1990; most could use such upgrades.

There have been efforts to retrofit aging buildings. In 2020, the Beijing municipal government paid to upgrade 80 aging apartment complexes as part of a broader renovation program.[95] To scale up, Beijing could encourage private capital participation by exploring new business models. For example, the city government could consider bundling the right to develop commercial property with a residential retrofit project. Other options to encourage businesses and residents to act include subsidized loans, streamlined permitting processes, and starting a government-led bulk purchase program to lower capital costs. In 2016, Qingdao set up a retrofit incentive program to renovate housing stock. City leaders estimated that more than 50 million square meters of old residential buildings required

[94] "New York City Buildings Opening Doors for Green Tech Startups", Green Real Estate Law

[95] Beijing Municipal of Housing and Urban-rural Development, http://zjw.beijing.gov.cn/

efficiency upgrades. Almost half of the required retrofits have been completed, lowering expected emissions by an estimated 298,000 tons of CO2.[96]

Implement smart measurement of building energy consumption. When people have control over their usage, and understand the costs, they are more likely to change their behavior. Heating accounts for about 40 percent of energy consumption for residential buildings in Beijing. In most cases heating is charged per square meter, so residents tend to keep their heaters on all the time. Converting to heat metering is likely to make residents reserve energy. Kazakhstan, for example, launched a meter installation program as part of its green strategy. As of 2020, 60 percent of residential buildings are covered, with the goal of 100 percent by 2025[97].

2.1.3 Encouraging next-generation mobility.

Passenger transportation contributes 10 to 15 percent of Beijing's GHG

[96] "Cities100: Qingdao is incentivizing high-quality retrofits for an energy-efficient housing stock", C40 Knowledge, October 2019, https://www.c40knowledgehub.org/s/article/Cities100-Qingdao-is-incentivising-high-quality-retrofits-for-an-energy-efficient-housing-stock?language=en_US

[97] "Clean Household Energy Consumption in Kazakhstan: A Roadmap," International Energy Agency, December 20, https://www.iea.org/reports/clean-household-energy-consumption-in-kazakhstan-a-roadmap

emissions[98], with the majority coming from passenger cars. Beijingers like their cars; ownership has risen from 5.6 million in 2015 to 6.6 million in 2020. [99] The city has been working to encourage EVs. In 2015, it began efforts to electrify the taxi and bus fleets; it also offers favorable terms to EV car owners, such as additional purchase quotas. As a result, in 2020, EVs accounted for more than 60 percent of car sales in Beijing. [100] Nevertheless, gasoline-powered cars still account for around 95 percent of the wheels on Beijing's roads, and thus will remain a big emitter for at least the next decade. Here are three approaches to reduce transport-related emissions.

*Accelerate adoption of green vehicles***.** Beijing can set a clear timeline to ban the sales of petrol cars, as other cities are doing, including Los Angeles, Madrid, and Paris. With its extensive charging network—the biggest in China—and the fast uptake in EV sales, Beijing has an excellent foundation to phase out petrol cars. Automobile industries are preparing. BAIC, a large stated-own automobile company located in Beijing, stopped petrol car sales in the city from 2020.[101] If the government were to set an exact timeline, it

[98] "Carbon emission from urban passenger transportation in Beijing" , Zijia Wang, Feng Chen, Transportation Research Part D: Transport and Environment, 2015, https://www.sciencedirect.com/science/article/abs/pii/S1361920915001534

[99] Beijing Municipal Public Security Bureau, http://jtgl.beijing.gov.cn/jgj/jgxx/95495/ywsj/index.html2

[100] Beijing's 2020 total number of passenger car quota announced, People's Daily, http://en.people.cn/n3/2020/0208/c90000-9655569.html

[101] "Stop selling fuel vehicles and car companies to accelerate electrification," Beijing Daily, Jan 2019

would be easier for the entire car infrastructure to adjust and to ensure that there are enough charging stations. For example, the oil major, bp, and Didi, a car-sharing service, formed a new company in 2019 to build charging stations around China.[102]

Beijing can also seize the opportunity to hasten the development of the hydrogen car industry. China plans to roll out one million hydrogen cars by 2030,[103] up from 7,000 in late 2020.[104] Within China, Guangdong has moved fastest, with the most hydrogen fueling stations; Guangzhou has also invited South Korea's Hyundai, an early mover in hydrogen cars, to build a hydrogen fuel-cell factory. [105] In building a hydrogen industrial park, Beijing would demonstrate its ambition to become a leading city in the Hydrogen Car industry. [106]

Invest in transit-oriented development. Better urban planning and

[102] BP China, "BP 与滴滴携手布局中国新能源车充电网络", August 1 2019, https://www.bp.com/zh_cn/china/home/news/press-releases/news-08-01-2019.html

[103] "Energy-saving and new energy vehicle technology roadmap 2.0", Ministry of Industry and Information Technology, https://www.miit.gov.cn/jgsj/zbys/qcgy/art/2020/art_7eea943abda746339d899bd5fd520c92.html

[104] Yilei Sun and Brenda Goh, "Chinese automakers announce targets to raise hydrogen vehicle sales," Reuters, Sep 15 2020, https://www.reuters.com/article/china-autos-hydrogen/chinese-automakers-announce-targets-to-raise-hydrogen-vehicle-sales-idUSKBN2650L0

[105] Song Jung-a, "Hyundai to build China factory as part of hydrogen vehicles push", Financial Times, January 15 2021, https://www.ft.com/content/a390ad28-03d5-4283-a9f3-550c5a7fc04f

[106] Beijing Municipal Government, "[Daxing District] China-Japan industrial park to be built in Daxing", August 14 2020, http://wb.beijing.gov.cn/en/center_for_international_exchanges/events/202012/t20201216_2166063.html

development can reduce emissions by shrinking commutes. Beijing could launch transit development programs that connect sprawling areas with denser, mixed-use transportation hubs that include office buildings, stores, and education, leisure, and recreation opportunities. The ultimate idea is to make Beijing a "15-minute-city"--allowing people to access most essential services within a 15-minute walk. This could reduce overall service costs to the city and provide viable alternatives, such as walking, bicycling, and public transport, to the use of a car. A number of cities, including Chengdu, Melbourne and Paris, have incorporated this idea into their planning[107].

2.1.4 Strengthening consumer demand management.

Encouraging customers and industries to participate in decarbonization initiatives can help cities meet their targets. Here are two high-potential possibilities.

Advocate a low-carbon lifestyle. For large-scale decarbonization, consumers need to embrace going green. In the last ten years, Beijing residents have become more aware of environmental issues, including air pollution, clean water and climate change. To build on this, the city could work with companies to enable consumers to decarbonize their lives. Ant Financial, for example, launched the Ant Forest Program in 2016. The

[107]Peter Yeung, "How '15-minute cities' will change the way we socialize", BBC, January 4, 2021, https://www.bbc.com/worklife/article/20201214-how-15-minute-cities-will-change-the-way-we-socialise

digital program builds a scoring system based on how environmentally friendly a purchase is, such as buying a metro ticket instead of fuel for a car. The scores allow users to grow virtual trees and compete with friends. The popular program, which has 200 million users, has cultivated long-term behavioral change in purchasing decisions, including reducing plastic bag usage.

Put "circular economy" principles into action. A circular economy means shifting resource consumption from linear flows—raw materials to assembly to consumption to disposal— to circular flows in which materials are repeatedly re-used. For example, Beijing produced 10 million tons of residential waste in 2019. This waste could instead become useful production inputs through effective recycling. Shifting to circular economy principles could help ensure that efforts to control direct emissions are not compromised by greater indirect emissions from increased consumption. One short-term step is for the government to work with industries to scale up the use of recycled waste. There is private-sector interest in this idea—Alibaba has created Xianyu, a robust secondhand market. JD helps consumers to recycle old clothing and mobile phones, and Meituan, a food-delivery and consumer-service platform with 240 million users, has set up a pilot to collect used tableware.

2.2 Innovation: How Beijing can orchestrate the development of next-generation low-carbon technologies

For hard-to-abate sectors, such as power, steel, oil, and gas, 30 to 70 percent of emissions can be addressed through current policies and technologies. The rest will need to be addressed through new and developing technologies.

An emerging technology normally goes through three stages before mass adoption: concept development, early experimentation, and scale-up. Government support can help companies in the latter two stages. Solar panel technology, now a mainstream green technology in China, is one example. Due to high costs, the development and adoption of solar power was slow before 2000. With strong government support since then, the solar PV industry in China has advanced rapidly, improving the economics. Today, the cost of solar PV is sometimes competitive with fossil fuels, even without subsidy.

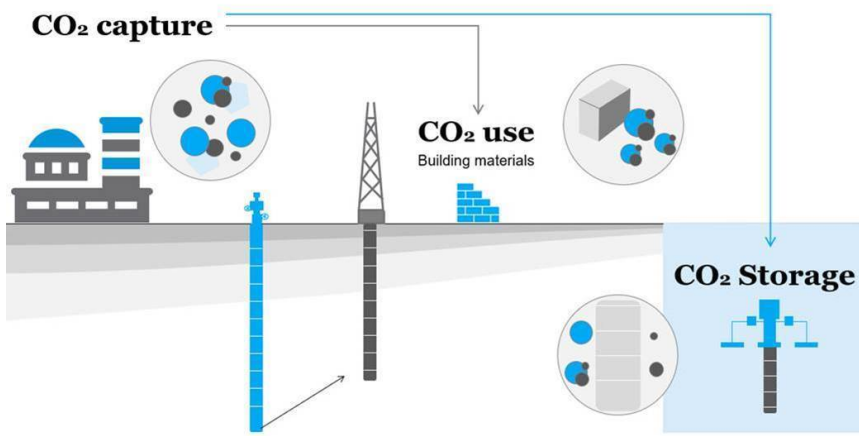
With that example in mind, what could be next? AVs are one possibility to put on the fast track for experiment and scale up. From an emissions perspective, the main potential benefit of autonomous technology is to improve traffic flow. In addition, the deployment of AVs, in conjunction with ridesharing, may remove the need to

own a car. That could mean fewer, more efficient cars on the road, improving both emissions and congestion. Nevertheless, AVs are unlikely to achieve the critical mass needed in the near future. In the meantime, data collection from AV pilot programs will be essential to understand their potential impact on traffic and safety and to devise the best strategies for deploying AVs.

Two other technologies—CCUS and hydrogen—could go a long way to complete the last mile of reducing emissions in the energy system. They are both promising enough to be put on the fast track to development (see sidebars on CCUS and hydrogen).

SIDEBAR: The role of carbon capture, utilization and storage (CCUS) in a low-carbon future

Carbon capture utilization and storage (CCUS) refers to capturing CO2 from large stationary sources, such as power plants or



industrial facilities, then either storing that CO2 or using it to make other goods. Because the CO2 never reaches the atmosphere, CCUS could play a significant role in emissions-reduction. The power and industrial sectors contribute as much as 70 percent of China's emissions.

China has sizeable coal reserves and some regions rely heavily on it. Coal, however, is both polluting and emissions-intensive. The application of CCUS to coal assets could make it a much lower-emission source of power. According to McKinsey research,[108] *CCUS could capture about 1.3 billion tons of CO2 in China by 2050.*

That is the potential.

In reality, there are two major issues. First, there is cost. Even with subsidies, the cost of CCUS--450 RMB per ton of CO2 abated-- is too high for wide industrial use. With effective policy support, that cost could fall substantially, as economies of scale kick in. Second,

[108] "Leading the battle against climate change: Actions for China," McKinsey Global Institute https://www.mckinsey.com/business-functions/sustainability/our-insights/leading-the-battle-against-climate-change-actions-for-china

the CCUS industry does not yet have a clear business model: even if it becomes less expensive, how does it make money? Right now, CCUS is simply an additional cost for both the capture facility and the storage facility. One possibility is to treat CCUS as a utility funded by government. Another is to establish a carbon market with a price that is higher than that of CCUS to incentivize businesses to reduce CO2 emission using CCUS.

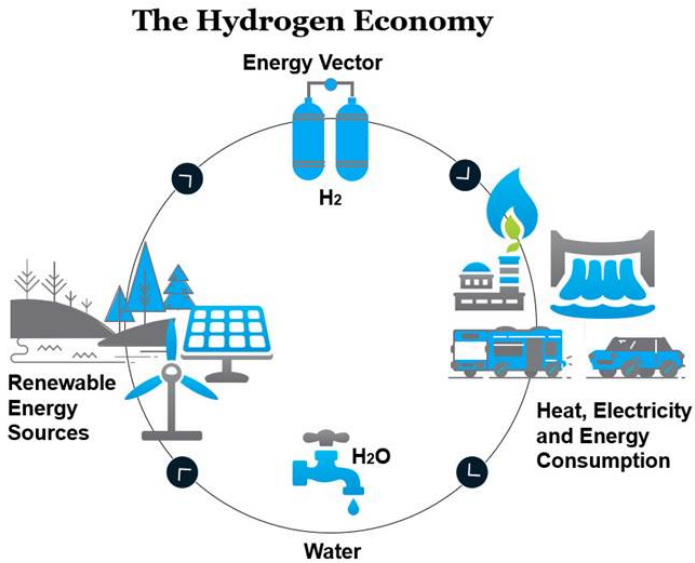
SIDEBAR: The role of green hydrogen in a low-carbon future

Green hydrogen is produced through low-emissions technologies, such as electrolysis, and is powered by renewables. ("Grey hydrogen" uses fossil fuels, through energy-intensive processes such as coal gasification or steam reforming. "Blue hydrogen" is somewhere in between; it is created when CO2 is sequestered via CCUS.) Hydrogen only emits water when burned and can be made without releasing CO2.

Hydrogen could be used in place of the fossil fuels that currently provide about four-fifths of the world's primary energy supply—and which are responsible for the bulk of GHG emissions. According to McKinsey research, hydrogen demand in China could

rise from next to nothing now to 18 million tons by 2030, primarily in the steel and transportation sectors.

In the steel industry, hydrogen could replace coal as a reducing agent in iron-making. For the transportation sector, hydrogen fuel-cell vehicles could play a role in replacing the gas-powered internal combustion engine. The potential is high, especially in long-distance transportation including aviation, buses, and trucks, as most EVs have a range of less than 600 kilometers range and



take longer to charge.

As the price of hydrogen technology falls, other uses, such as residential heating, also become possible. Given the high cost to transport hydrogen from overseas, China is expected to meet demand with domestic supply. This could enable it to take a leading role in the development of hydrogen technology, as both market and producer.

To realize the full potential of hydrogen, however, more infrastructure needs to be built, such as pipelines and hydrogen-fueling stations, to resolve the mismatch between supply and demand. Renewable energy-rich regions, such as the southeast and Inner Mongolia, are better suited to produce green hydrogen – but demand is likely to come from the northeast and coastal regions. Hydrogen pipelines could solve this problem.

In addition, to create and meet urban demand, storage and hydrogen-fueling stations will be needed. At least at first, city, regional, and national governments might want to take the lead, as the cost is likely to be high and the market uncertain. That is what Germany is doing; in 2020, the country announced a plan to invest €9 billion to build hydrogen infrastructure as part of its

decarbonization plan.

Another priority is to get the market going. To do so, incentives may be required to generate initial demand. Hydrogen technology is improving fast and costs are coming down. One high-potential area is hydrogen fuel-cell electric vehicles(FCEVs). Beijing is home to a complete hydrogen value chain, including production, storage, transportation, and vehicle manufacturing. It has also started to construct a hydrogen industrial park, specializing in vehicle development. In the future, Beijing could carry out demonstration projects in key applications as a way to attract new investments.

Even so, hydrogen has to be considered a work in progress, and the economics are still daunting. For example, FCEVs are encountering problems with high battery cost and hydrogen storage safety. Progress has therefore been slow, and to reach its potential, hydrogen may need more substantial government support than it has gotten so far.

END OF SIDEBAR

Bringing next-generation technologies to scale will call for collaboration among the

government, industry, private investors, and research institutions. The Beijing city government could become something like a conductor to orchestrate this effort.

It could start by articulating how it sees the role of new technologies such as AVs, CCUS and hydrogen, in its long-term decarbonization vision. Then it could set out short-term targets (such as the recent announcement of a plan to get at least 10,000 hydrogen cars on the road by 2025), to activate the skills and imagination of the private sector and research institutions. Beijing's leaders could also design policies and set standards in order to create a safe space for industries to pilot CCUS and hydrogen projects. For example, legislation on how to store and transport CO2 could reduce the legal risks for the CCUS first movers.

To lower the cost of deployment, technology improvements in CCUS and hydrogen are necessary, and with its world-class talent, Beijing is well placed. Tsinghua University and Beihang University are leading researchers in hydrogen fuel cell technology. In addition, Beijing-based oil-and-gas companies have started to invest in hydrogen and CCUS projects as part of their low-carbon strategy.

Beijing can also work to cultivate a supportive startup environment for new technologies. One way to do so is to create government-sponsored innovation labs where entrepreneurs can share their ideas with each other and with policy makers. Israel, which is already known for its innovation culture, has established a $4 million innovation lab in northern Haifa that will focus on environmental

technology. In a joint government-industry initiative, in 2017, Sweden set up three clean-tech hubs—to research ways to decrease GHG emissions and increase energy efficiency and security.[109]

Once an experiment is proved, Beijing can support the private sector in bringing these innovations from pilot to market, by carrying out demonstration projects or making them a priority for public procurement.

Section 3. How Chinese cities can foster regional and global decarbonization

Cities have all the necessary attributes—talent, money, size, and influence—to become a market-oriented green technology innovation leader. To do so, it needs to act both regionally and globally.

On the regional level, cities can encourage and support decarbonization of its

[109] Cleantech Hubs Innovation by Sweden, https://cleantechhubs.se/

corresponding region. Here are four possible actions.

Promote regional green infrastructure. Cities could use its buying power to buy cleaner energy from surrounding areas. Renewable energies such as solar and wind power are intermittent. To generate electricity continuously, they need to be paired with energy storage, which makes the whole system more expensive than a traditional thermal power station. Major cities could work with neighboring governments and power generation companies to improve the economics, for example by signing long-term power purchase agreements (PPAs) and agreeing to higher purchase prices for renewable energy.

There are working examples of such efforts. In 2015, Washington DC signed a power-purchase agreement (PPA) to buy the entire output of a 46MW wind farm in Pennsylvania[110]; this will cover 30 to 35 percent of the city's electricity demands. In 2020, the City of London, the neighborhood that includes London's financial district, signed a PPA to purchase 49.9 MW of power from a solar farm in Dorset, projecting to power half of its electricity demand.[111] The guaranteed revenues will support the construction of the facility, and is projected to save the

[110] C40 Cities Climate Leadership Group and C40 Knowledge Hub, "How cities can create demand for large-scale clean energy generation", March 19, https://www.c40knowledgehub.org/s/article/How-cities-can-create-demand-for-large-scale-clean-energy-generation?language=en_US

[111] Newsroom City of London, "City's 'pioneering' green energy deal could be blueprint for local authorities", November 18 2020, City of London, https://news.cityoflondon.gov.uk/citys-pioneering-green-energy-deal-could-be-blueprint-for-local-authorities

City £3 million in energy costs. Similarly, Sydney entered into a 10-year PPA to purchase wind and solar from New South Wales region.[112]

Adopt regional emissions accounting. The traditional measurement of GHGs accounts for emissions within the city limits. But many of Chinese cities' emissions are released elsewhere, in the form of the food, goods, and services produced but used by residents. Consumption-based GHG counts these emissions. By adopting this standard, the cities of China would have a better sense of where their emissions are coming from and thus how to lower them, whether through consumer education, public procurement, or other strategies.

Upgrade regional industries. As China's service industry has been gradually overtaking manufacturing to become the largest sector of the economy, there are growing calls for stepped-up efforts to develop this "pillar industry." Cities can help their surrounding areas, especially provinces with high-emission industrial sectors, with industry upgrades. Hebei province, for example, is experiencing rapid development. In 2020, high-energy-consuming industrial sectors, including steel, chemicals, and equipment manufacture, accounted for 40 percent of Hebei's

[112] "We' ve made the switch to 100% renewable energy" , City of Sydney News, July 1 2020, https://news.cityofsydney.nsw.gov.au/articles/weve-made-the-switch-to-100-renewable-energy

economic output. Hebei consumes about 7 percent of China's energy, while contributing only about 4 percent of its GDP. With coal the primary source of power (about 75 percent of consumption),[113] industrial decarbonization should be the priority—a matter in which Beijing has considerable expertise.

Share best practices and policies. Many major cities such as Beijing, Shanghai and Chengdu are ahead of much of China in terms of setting (and meeting) decarbonization targets and establishing a legal framework for carbon management. This is expertise they could share—and even make standard—with the region. In addition, cities like Beijing have already made the transition from a heavy-industry dominated economy to one in which the service sector is more important. The city is well-positioned to help regions make this adjustment, too. Decarbonization does not come without difficulties, such as higher costs and short-term unemployment. Cities can use their education resources to prepare workers for new kinds of jobs. This could take the form of developing online training classes or opening regional campuses. Germany has done something like this; to ease the transition to becoming coal-free by 2038, the government has

[113] China Statistical Yearbook 2019, China Statistics Press (2019)

established a $45 billion package to support the closure of coal assets in major coal-producing states and to reskill the sector's workers.[114],[115]

On the international level, cities have the practical and financial expertise, as well as the global standing, to play an increasingly important role in promoting decarbonization and setting climate policy. Here are three ways they can do so.

Mobilize capital for green projects. Cities like Beijing are already well on the way to becoming China's green finance center. The Beijing Environmental Exchange, which runs the city's carbon exchange, has logged in more than 1,200 green projects since 2019. The initiative has also formed partnerships with more than 20 banks, insurance companies, trust companies, securities, funds, industry associations, and third-party assessment companies.

Going forward, cities could work with regulators, private investors, and research institutions to define and implement a set of criteria for what comprises a "green" financial product, as the EU Taxonomy Regulation

[114] Johnny Wood, "This is Germany's $45 billion, 18-year plan to move away from coal", World Economic Forum, January 23 2020, https://www.weforum.org/agenda/2020/01/coal-lignite-germany-renewables-energy/

[115] Cynthis Elliot, "Planning for a 'Just Transition:' Leaving No Worker Behind in Shifting to a Low Carbon Future", World Resources Institute, March 25 2019, https://www.wri.org/blog/2019/03/planning-just-transition-leaving-no-worker-behind-shifting-low-carbon-future

has done. The Peoples Bank of China, for example, has started drafting a Green Bond Standard in 2020, and other international financial institutions are creating green-investment indexes.

Cities can also encourage low-carbon investment by fostering partnerships with financial institutions—whether public, private, or multilateral—that have shown interest in green bonds and other kinds of investment. For example, by 2025, the *Asian Infrastructure Investment Bank* aims to direct half of its financing to climate-related projects. AIIB is also participating in a $500 million Asia Climate Bond Portfolio that aims to accelerate climate action and address the underdevelopment of the climate bond market.

Work with partners to create innovative demonstration projects. Singapore's Tengah[116] project, started in 2016, is a 42,000-home town under development that is both green and smart, with a no-car business district, automated waste collection, centralized cooling, an app that allows residents to monitor their energy and water usages, and a 328-foot-wide ecological corridor as a safe passage to wildlife. Tengah demonstrates that

[116] Oscar Holland, "Singapore is building a 42,000-home eco 'smart city,'" February 1 2021, https://edition.cnn.com/style/article/singapore-tengah-eco-town/index.html

when a government makes a commitment to sustainable urban design, results follow. Cities in China can keep an eye on Tengah, and learn from its practices.

Support high-level discussions and collaboration. Without strong, consistent international collaboration, developing a low-carbon and environmentally resilient future will not be possible. As major emitters, and given their economic and organizational strengths, cities such as Beijing, Chengdu, Dalian and other C40 member cities could offer to host future climate meetings. They can perhaps even carry the baton from Glasgow, Scotland to be the next city to host the UN Conference of the Parties (COP) in 2022[117] and to take a more active role in convening international discussions. They could also take the lead in fostering a specifically Asian approach.

Section 4: Cities at work: The role of the public and private sectors in urban decarbonization

Cities will be a critical force in decarbonization, but they cannot do it alone: national governments and the private sector also need to step up.

[117] UN Climate Change Conference UK 2021, https://ukcop26.org/

4.1 The public sector: Working with stakeholders to build resilient and sustainable cities

Decarbonizing cities will have to be a team effort. One useful role for governments, whether local or national, is to bring the stakeholders together, so that they are all pulling in the same direction.

4.1.1 Build mechanisms for public-private collaboration.

One form of government clout is the power of its purse; embedding environmental standards into public-private partnerships and giving preference to projects that demonstrate emissions-reduction potential would be powerful incentives for builders and others to get serious about decarbonization.

Because government is central to all parts of the urban economy, it is in position to take the lead in working with the private sector and other partners on initiatives to promote renewable energy, autonomous vehicles, and other green innovations. For example, a public-private investment fund could establish what projects to prioritize, test them, and then work to scale up the successful ones. Local governments could establish incubators—physical and digital spaces in which entrepreneurs, academics, and scientists can share ideas.

Finally, business, social, and government entities can work together to promote sustainability norms to the public, and to achieve specific goals. One initiative to watch is the Global Plastic Action Partnership (GPAP), a collaboration of governments, businesses, and NGOs launched in 2018 that aims to eliminate plastics from the ocean. There is real action taking place, with Indonesia testing a broad-based approach and passing relevant legislation with the goal of reducing ocean plastics 70 percent by 2025.[118]

4.1.2 Promote green finance

The environment cannot be separated from economics. China recognizes this; in fact, it has defined high environmental standards as one of its five development priorities. Its efforts to promote diversified green investment and to build a national carbon market are two examples of green economics in action. But more will need to be done. China is expected to require $424 billion to $566 billion in green investment a year to achieve China's environmental pollution control goals and the international commitment of peaking carbon emissions by 2030.[119] Green bonds, a type of fixed-income

[118] Luhut B. Pandjaitan, "Here's how Indonesia plans to take on its plastic pollution challenge", World Economic Forum, January 20 2020, https://www.weforum.org/agenda/2020/01/here-s-how-indonesia-plans-to-tackle-its-plastic-pollution-challenge/

[119] Huan Shao, Bridget Boulle, Yanjing Wu, Yuqing Long, Rui Zhang, "China's Green Bond Issuance and Investment Opportunity Report," Climate Bonds Initiative and SynTao Green Finance, supported by UK PACT, October 2020

instrument that is specifically earmarked to raise money for climate and environmental projects, are an ideal financing tool to support the required investment due to their relatively simple structure, low additional cost and transparency requirements. The Chinese government's endorsement of green finance and green bonds may help green bond issuers to reduce issuance costs or to obtain financial subsidies. Some provincial governments already have subsidy programs in place, and a single issuer can apply for reimbursement up to $848,000[120]. In this case, it would be most efficient if the national government were to set market standards, including defining what constitutes a green financial product and establishing regulatory reporting requirements.[121]

In 2021, China launched a national carbon market, with the goal of reducing greenhouse gas emissions. For now, the emissions trading system covers China's power industry and roughly 2,000 energy generation facilities. That alone represents 30% of the nation's total emissions and over time the trading system will encompass heavy industry like cement, steel, aluminum,

[120] Huan Shao, Bridget Boulle, Yanjing Wu, Yuqing Long, Rui Zhang, "China's Green Bond Issuance and Investment Opportunity Report," Climate Bonds Initiative and SynTao Green Finance, supported by UK PACT, October 2020

[121] In Europe, this was done successfully through launching new requirement through EU Taxonomy Regulation.

chemicals and oil and gas.[122] The government can strengthen the national carbon market by further mobilizing private investment for mitigating actions and achieving cost-effective abatement. To realize the full potential of the carbon market, China could further promote the use of carbon credits (often referred to as "offsets"). Promoting China Certified Emission Reduction (CCER) products as offset credits and incorporating them in the national carbon market is a good start towards accelerating the broader transition to a lower-carbon future. So far, the Chinese government has validated 2,856 CCER projects and registered 1,047 CCER projects. If done successfully, the China GHG Voluntary Emission Reduction Program can share its learnings and solutions with other countries globally to accelerate emission reduction.

4.1.3 Build long-term resilience and a green recovery.

Governments could prioritize stimulus programs that entice private-sector participation and those that put green initiatives at the forefront. Taking infrastructure stimulus as an example, one way to stretch stimulus dollars as far as possible is by deepening capital markets and developing incentives for the private sector to play a bigger role in infrastructure financing. One

[122] Huw Slater, Wang Shu, Dimitri De Boer, "China's national carbon market is about to launch", China Dialogues, January 29, 2021, https://chinadialogue.net/en/climate/chinas-national-carbon-market-is-about-to-launch/

way to do this would be creating an enabling environment for public–private partnership investment. Government stimulus programs can take this as an opportunity to direct public and private funding toward sustainable, resilient, green infrastructure—accelerating progress on shoring up infrastructure vulnerable to climate change. For instance, initiatives can aim to assess an issuer's level of alignment with the objectives of the Paris Climate Agreement: climate-change mitigation, adaptation, and low-carbon transition. [123] The Chinese government could consider inviting more private sector players to jointly carry out projects in decarbonization-focused areas such as new electrical vehicle charging stations and data centers. The stimulus program could also consider prioritizing carbon-intensive regions such as Shanxi and the Northeast for development funding to accelerate overall carbon emission reduction.

4.2 The private sector: Embed sustainability into strategy and work

Once governments enact a clear and stable regulatory environment, the private sector knows what is expected, and can even accelerate its contribution to decarbonization. We believe that sustainability will be a competitive advantage;

[123] Sir Danny Alexander, Sir John Armitt, Makhtar Diop and Catherine Mckenna, "What infrastructure stimulus investments could be the most important for governments to pursue now", McKinsey Website, January 20 2021, https://www.mckinsey.com/business-functions/operations/our-insights/what-infrastructure-stimulus-investments-could-be-the-most-important-for-governments-to-pursue-now-and-why

companies that move fast to discover and adopt sustainable business models will have an important edge.

4.2.1 Set a decarbonization strategy

This strategy should be both specific and public, both to convey the company's commitment and to signal its intentions to the capital markets. After setting up the strategy, businesses can consider how to decarbonize operations. One possible approach is to participate in voluntary carbon markets to hunt for cost-effective way to reduce emissions. [124] According to the World Economic Forum, readily available and affordable practices ($12 per ton of CO2 equivalent), such as investing in circular economy practices and renewable power, could cut supply-chain emissions as much as 40 percent, at low cost.[125]

A number of international oil and gas companies have gone in this direction, announcing ambitious targets to reduce emissions throughout the lifecycle. With a defined target, and by evaluating scenarios based on different possible prices for carbon, they are better able to understand the risks and opportunities. On that basis, they are prepared to restructure their portfolio

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[124] Christopher Blaufelder, Cindy Levy, Peter Mannion, and Dickon Pinner, "A blueprint for scaling voluntary carbon markets to meet the climate challenge," McKinsey Website, January 29 2021, https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge

[125] "Net-Zero Challenge: The supply chain opportunity", WEF, January 2021, https://www.weforum.org/reports/net-zero-challenge-the-supply-chain-opportunity

as circumstances change.

4.2.2 Review how work is done

The use of technology, digitization, and new forms of work sped up during the pandemic—and there is no going back. McKinsey has estimated[126] that in advanced economies, 20 to 25 percent of the workforce could work from home between three and five days a week without loss of productivity. That could bring big changes in where work is done, and thus in travel-related emissions, and could raise interest in the idea of the "15-minute city," in which residents can fulfill their basic needs within a 15-minute walk from home. Additionally, COVID-19 has accelerated the shift in labor demand. Business leaders and governments can work together to incorporate climate risk awareness and decarbonization into reskilling efforts.

4.2.3 Apply advanced capabilities

Data quality and transparency is critical for companies to count, monitor, and reduce GHG emissions—and fast-improving capabilities such as big data, artificial intelligence (AI), and automation can help. Indeed, used well, they can do much more. Big data, for example, can help corporations use

[126] Susan Lund, Anu Madgavkar, James Manyika, Sven Smit, Kweilin Ellingrud, Mary Meaney, and Olivia Robinson, "The future of work after COVID-19", McKinsey Global Institute, February 18 2021, https://www.mckinsey.com/featured-insights/future-of-work/the-future-of-work-after-covid-19

resources better; automation can make operations more efficient (and thus less emissions-intensive); AI can map projects and enable employees to become more aware of how to "green" their decisions.

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Several major trends are likely to be part of the future. One is that people will continue to move to cities; by 2050, more than two-thirds of the world's population (68 percent) will live in urban areas, according to the United Nations. China's cities alone will add an estimated 255 million new residents.[127] Another is that the

[127] United Nations News, "68% of the world population projected to live in urban areas by 2050, says UN", May 16 2018, https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

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Chinese economy will continue to grow. That is a good thing for its people, but does add stress on natural resources. And a third is that awareness of environmental issues, including climate change, is growing—both within China and around the world. City leaders, businesses, and residents will need to work together to deal with the challenges these trends present.

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