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June 2021 6月刊

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In Focus

How China's Mineral Supplies are Powering the Global Energy Transition
中国矿产供应如何推动全球能源转型

Sun, wind and water – the resources of our future are inexhaustible and provided to us by nature in an endless supply. But only at first glance: Although the energy coming from the sun and wind, as well as the rivers and oceans is indeed infinitely renewable, the raw materials required for the technology to convert their power into electricity is anything but. Whether it is the photovoltaic cells used to collected solar power, the giant turbines harvesting energy from wind or the batteries needed to store the energy these two provide – their production is heavily dependent on the availability of a handful of elements and a group of 17 rare earth minerals with exotic names such as neodymium, titanium, lithium and cobalt.

As the world is set on transitioning into a clean energy future, the question of how to keep up a sustainable supply of critical minerals and metals remains largely unaddressed. According to a study by the Dutch consulting company Metabolic, conducted in cooperation with scientists from Leiden University, the availability of these elements must increase twelvefold by 2050 in order to meet the greenhouse gas emission targets decided upon in the Paris Climate Agreement. China – because of its vast size and wealth of natural resources – is going to play a major role in supplying the world's growing demand for highly sought-after raw materials.

As the side effects of the world's fossil fuel diet became more and more evident, the need to harness energy in a regenerative way led to a surge of increasingly sophisticated technologies aimed at creating a low-carbon economy. In addition, the utilization of constantly replenished forms of energy was widely expected to ease the longstanding global conflicts surrounding the few major sources of fossil fuels. Yet assembling the buildings blocks to capture that energy will nevertheless require us to continue looking to the earth's crust – for minerals that are geographically even more concentrated than the coal, oil and natural gas resources mankind has relied on during the past two centuries.

太阳、风和水——我们未来的资源是取之不尽的，大自然为我们提供了无尽的供应。然而，这只是看上去：虽然来自太阳、风、江河和海洋的能源确实是可无限再生的，但将能源转化为电力所需的原材料却并非如此。无论是用于收集太阳能的光伏电池、收集风能的巨型涡轮机还是用于储存这两种能量的电池——它们的生产非常依赖某些元素以及17种稀土元素，这些稀土元素的名称别具一格，如钕、钛，锂和钴。

随着世界向清洁能源的未来过渡，如何保持关键矿物和金属的可持续供应仍未从根本上得到解决。根据荷兰咨询公司Metabolic与莱顿大学合作的一项研究，截止到2050年，这些元素的可用资源必须增加12倍，才能满足巴黎气候协议的温室气体排放目标。中国幅员辽阔，自然资源丰富，将在满足世界对原材料日益增长的需求方面发挥重要作用。

The raw materials for the technology converting the power of renewable energy sources into electricity – including magnets for wind turbines – come from a group of critical minerals and rare earth elements
将可再生能源转化为电能（包括风力涡轮机的磁铁）所需的原材料来自关键矿物和稀土元素
Source / 图片来源: unsplash.com

随着化石燃料的副作用越来越明显，以可再生方式利用能源的需求导致以低碳经济为目的的技术激增，并且这些技术日益先进。此外，人们普遍认为，对可再生能源的使用将缓解围绕着少数化石燃料主要来源展开的长期全球冲突。然而，发展获取可再生能源技术的同时，我们仍然需要继续将目光投向地壳，去寻找在地理上比人类过去两百多年来所依赖的煤炭、石油和天然气更为资源集中的矿物。

According to a recently published study by the International Energy Agency (IEA), the three nations leading the world in the production of lithium, cobalt and rare earths control well over three-quarters of global output. Among these countries, China takes on a significant role not only due to possessing the largest resources of many key energy transition minerals – including 70 percent of the world's rare earth supplies – but also because it is controlling a large share of global downstream refining operations for virtually every major element.

During the past decade, China has accelerated its moves to not only secure strategic resources, but also takes on a dominant role within global supply chains. A domestic push for building mining and processing firms, as well as providing financial incentives for lithium-ion battery manufacturing facilities led China to become the global hub of energy transition minerals. Even the supply chains for lithium and cobalt, elements predominantly extracted in countries such as Chile, Argentina or the conflict-ridden DR Congo, are today mostly in the hands of China. While China only produces relatively small amounts of these elements, it accounts for 65 percent of the world's processed cobalt and nearly 60 percent of processed lithium, respectively. When it comes to processed rare earth elements, China is even responsible for providing nearly 90 percent of the supply on the global market.

At the same time, however, China's exports of rare earths have actually been decreasing, despite the country ending its official export quota on these elements in 2015. Industry experts attribute the drop to China's ambitions of developing a domestic high-end production chain to cement its dominant position on the market. Among policy makers, these developments have raised the concern of even tighter supply bottlenecks as a result. But for the time to come, China itself is still heavily dependent on imports of critical minerals, for example copper from Chile or zinc from Australia, and also continues to be the world's biggest importer of rare earths. These complex trade relationships highlight the need for economic engagement to tackle the critical challenges en route to securing a clean-energy future for the planet. From semiconductors used in solar panels, to magnets required for wind turbines or batteries needed to get electric vehicles on the streets – it is certain that the green infrastructure of the future can only be built in collaboration with China.

根据国际能源署（IEA）最近发表的一项研究，三个国家在锂、钴和稀土生产方面领先世界，掌握着全球四分之三的产出。在这些国家中，中国的角色极为重要，不仅因为中国拥有很多能源转型关键矿产的最多资源，包括全球稀土供应的70%，而且还因为中国几乎控制着全球下游精炼业务的很大一部分，几乎覆盖了每个主要元素。

在过去十年中，中国不仅加快了战略资源的获取，而且在全球供应链中占据了主导地位。在国内推动建立采矿和加工企业，以及为锂离子电池生产设备提供财政激励，使中国成为全球能源转型矿产的中心。即使是主要在智利、阿根廷以及冲突多发地刚果（金）等国进行开采的锂和钴的供应链，如今也大多掌握在中国手中。虽然生产量较少，但中国分别占世界钴加工总量的65%和锂加工总量的近60%。在稀土元素加工方面，中国甚至负责全球市场近90%的供应。

China is producing a large share of many key energy transition minerals – including 70 percent of the world's rare earth supplies
中国占据了许多重要的能源转型关键矿产的大部分生产份额，其中包括全球70%的稀土供应
Source / 图片来源: greatstock.co.za

然而与此同时，尽管中国在2015年取消了对稀土元素的出口配额限制，中国的稀土出口一直在降低。业内专家将其归因于中国发展国内高端生产链以巩固其市场支配地位的雄心。在决策者中，这一发展现状引发了他们对供应瓶颈进一步收紧的担忧。但在未来一段时间内，中国自身仍非常依赖重要矿产的进口，例如从智利进口铜或从澳大利亚进口锌，同时也是全球最大的稀土进口国。这些复杂的贸易关系凸显了经济参与的必要性，以应对确保地球清洁能源未来的关键挑战。从太阳能电池板所用的半导体，到风力涡轮机所需的磁铁，以及电动汽车所需的电池，未来的绿色基础设施建设一定离不开与中国的合作。

Building

Steel & Climate – Transformation and Decarbonization of the Chinese Steel Sector

A contribution by Dr.-Ing. Hans-Bernd Pillkahn, PROASSORT

钢铁与气候 — 中国钢铁领域的转型与去碳化

来自PROASSORT公司的Hans-Bernd Pillkahn博士的客邀文章

China is bound for climate neutrality: As the country aims to become the economic powerhouse of the world, President Xi Jinping heralded the decarbonization of China's economy by 2060. Yet China's ambitions create a challenging target for a country, which is already nowadays home to half of the world's industrial metal production.

China's one-billion-tons heavy steel industry alone accounts for around 15 percent of the country's annual CO_2 emissions – second only to the emissions resulting from domestic power generation. However, leading Chinese steel companies have already started to outline initial steps on the long way to carbon neutrality. Among the ambitious goals the Chinese steel sector set for itself are peaking carbon emissions by 2025 and cutting greenhouse gas emissions by 35 percent until 2035. With these measures, the industry aims to reduce its residual CO_2 emissions by one billion tons over the following 25 years. But to formulate a target is one thing; its implementation remains another.

A constructive solution to address the transformation of China's steel sector aims at employing an intelligent mixture of conventional ("old") and disruptive ("new") technologies. These instruments can be simultaneously introduced according to a defined step by step approach. Up to now, continuous improvement processes – in short CI – have driven the advancement of conventional technologies. But given their toll on the environment, one might argue that the C no longer stands for "continuous" – it might as well be substituted with "cruel". Provincial governments in China have already started to act in response to the negative side effects brought on by conventional steel production. For example, local authorities in the province Hebei decided to shut down some environmentally harmful raw steel plants in Tangshan, China's steelmaking hub, putting on ice a production capacity of 50 million tons.

As a result, companies might be forced to close their sinter plants. Steel smelters will rather be required to feed blast furnaces with prepared iron ore – so-called pellets – along with a share of scrap metals instead of

中国正在为实现气候中和努力：致力于成为经济强国的同时，国家主席习近平宣布要在2060年达到经济脱碳的目标。然而，这一宏伟目标也带来了挑战，因为中国现在已经是世界上一半工业金属的生产国。

仅中国的10亿吨重钢工业就占了中国二氧化碳年排放量的15%左右，仅次于国内发电造成的碳排放量。然而，中国的主要钢铁企业已经开始着手计划实现碳中和的初步步骤。中国钢铁业为自己设定的宏伟目标包括，2025年达到碳排放峰值，2035年将温室气体排放量减少35%。通过这些措施，钢铁业计划在未来25年内减少10亿吨的残余二氧化碳排放量。但制定目标是一件事，如何实施则是另一个问题。

Cold-Processed High-Performance Secondary Steel Resources (C-HSR) for nodular iron from tin plate scrap
用于球墨铸铁的冷加工HSR
Source / 图片来源: PROASSORT

适用于中国钢铁业转型的一个建设性解决方案在于将传统（“旧”）的和颠覆性（“新”）的技术智慧地结合在一起。这一方案的相关举措可以按照设定好的阶段性计划同时引入。到目前为止，持续改进过程（continuous improvement，简称CI）推动了传统技术的进步。但考虑到它们对环境造成的损害，有的人可能会认为，C不再代表“持续的”——它或许更适合由“残忍”（cruel）替代。中国的省级政府已经

continuing to rely on lump ore. Incorporating a share of 30 percent scrap is currently considered to be the best available technique. Yet in order to meet the increasing long steel demand of up to 500 million tons, Chinese companies are forcefully shifting from blast oxygen furnaces to modern electric arc furnaces (EAF) with scrap preheating.

Depending on the electricity source, implementing these measures holds the potential to cut greenhouse gas emissions by up to two-thirds relative to current levels. China's Ministry of Industry and Information Technology (MIIT) plans to further accelerate the transformation of the domestic steel sector by putting a 20 percent EAF contingent on the manufacturing of raw steel – in comparison to a share of 40 percent in the European Union and 70 percent in the United States. But even reaching this modest goal would require China to source 200 million additional tons of raw materials it currently lacks to produce recycled steel of high-quality. And pushing the efficiency of old conventional technologies merely represents a bridging effort on the way to achieve climate neutrality – the produced steel remains gray. It is rather the adoption of Direct Reduced Iron (DRI) that will mark a crucial step towards a fundamental transformation.

In the future, hydrogen is anticipated to adopt the role of the carbon-bearing natural gases currently used as reducing agents to convert direct reduction grade iron ore pellets to DRI. Once the current required to split hydrogen out of water via electrolysis and fire the electric arc furnaces can finally be supplied by renewable energy, the ultimate stage of building a carbon neutral economy is reached: Green steel.

But hardly in contact with the "Waterworld", China's steel industry must think of ways to generate a substitute for the sinfully expensive green DRI, along with the high-quality ore required for its production. That is where High-Performance Secondary Steel Resources (HSR) enter the equation. HSR comprise recycled raw materials of pure steel at a high-quality level. These are produced in different series and equipped with precise alloy elements. Each series is aligned with a corresponding steel application: long or flat, deep drawing or high strength, commodity or high-performance. Its high metallic content, specific bulk density and the lack of a surface coating combine to make HSR superior to DRI. As an important economic effect, however, HSR brings the required alloy elements back into the cradle.

Current state-of-the-art technology for the manufacturing of flat and long steel products are so-called mini mills. They are based on integrated EAF, characterized

开始就传统钢铁生产带来的负面影响采取行动。例如，河北省地方当局决定关闭中国钢铁中心之一唐山市一些对环境有害的粗钢厂，减少产能5000万吨。

作为这些措施的后果，企业可能被迫关闭烧结厂。钢铁冶炼厂可能被要求用铁矿石（所谓的球团）以及一部分废料作高炉给料，而不是继续依赖块矿。30%的废料比被认为是目前最好的可用技术。然而，为了满足日益增长的高达5亿吨的长钢需求，中国企业正大力从氧气高炉向采用废料预热的现代电弧炉（EAF）转变。

根据电力来源的不同，实施这些措施最高可使温室气体排放量比目前减少三分之二。中国工业和信息化部计划进一步加快国内钢铁行业的转型，力争将电炉钢产量占粗钢总产量比例提升到20%，而这一比例在欧盟和美国分别为40%和70%。但即使达到这一较为朴素的目标，也需要中国额外采购2亿吨原材料，以生产高质量的再生钢。而提高旧的传统技术的效率只是在实现气候中和的道路上起了间接作用——生产钢铁的过程仍然是灰色的。相反，采用直接还原铁（DRI）将标志着向根本转变迈出了关键一步。

在未来，氢有望代替目前被用作还原剂的含碳天然气，将直接还原级铁矿球团转化为直接还原铁。一旦电解水制氢和点燃电弧炉所需的电能最终可由可再生能源提供，碳中和经济的最终阶段就达到了：绿色钢铁。

但在进入氢能时代前，中国钢铁业需要为极其昂贵的绿色直接还原铁找到替代品，以及生产其所需的优质矿石。高性能二次钢材料（High-Performance Secondary Steel Resources，简称HSR）是一个很好的选择。HSR含有高质量纯钢的再生原材料，有不同的类型，并含有精密合金元素。每个类型都与相应的钢材应用相一致：长或扁、深冲或高强度、大宗商品或高性能。HSR的高金属含量、特定的体积密度以及表面涂层的缺乏使其优于直接还原铁。HSR将所需的合金元素带回了摇篮，是一项重要的经济效益。

目前制造扁钢和长钢产品的最先进技术是所谓的"小型钢厂"（mini mills，又称为紧凑型钢厂或短流程钢厂）。它以电弧炉为基础，具有极低的能耗和碳足迹，以及很高的回收利用率。这些优势提供了理想的物流工作流程：从铁水到半成品只需几分钟，从钢铁

by an unprecedentedly low energy consumption and carbon footprint, as well as a high share of recycled content. These advantages provide optimal logistical workflows: Only a few minutes necessary to go from hot metal to semi-finished products, only a couple of kilometers separating the steel plants from its customers. At the same time, the advanced technology allows the production of both commodity and high-strength steel with a mean DRI share of 50 percent, while scrap accounts for the other half of the share. Additionally, charging the HSR would potentially even enable to produce super deep drawing steel and lower the share of DRI to 30 percent or less.

But how can all of this be achieved? The first step is to build a circular steel economy between the manufacturers of flat steel and OEM or Tier 1 automotive stamping shops for the recycling of pre-consumer scrap – potentially recovering up to 50 percent of new or pre-consumer scrap during the process. The business model behind these cradle-to-cradle activities could be tolling. The steel plant is paid for reprocessing the precious raw material into galvanized steel sheets. These are subsequently dezinced in a PROASSORT high-performance facility, a process that comes without any additional costs due to zinc prices currently standing at 3,000 USD per ton. During the process, a built-in sensor-based sorting unit developed by PROASSORT can be adjusted for obtaining the desired composition of the metal. In a final step, the upcycled steel is mechanically compacted and thus the required Cold-Processed HSR (C-HSR) is born.

A heavily industrialized country like China has plenty of used scrap to spare, which is in turn urgently needed to balance future HSR demands. These materials increasingly originate from urban mining, a resource distinguished by its distressing non-metallic burden and wide-ranging composition of alloy elements – called heavy or shear scrap by steel recyclers. While the quantity of these materials will grow over the next decades, their use for directing future steel fabrication towards climate neutrality is rather limited. Similar to what the aluminum or copper industry has been doing, the steel sector has to build up a secondary steel refining industry. By doing so, the excess scrap could be sorted, pyrometallurgically refined and eventually granulated to form Hot-Processed HSR (H-HSR).

From a technological perspective, all of these incentives pose a challenging but manageable task. Economically speaking, the refining effort will be facilitated by the high price of green DRI as a result of limited hydrogen and clean electricity supplies – and politically by saving the planet.

厂到客户只有几公里的距离。同时，这一先进技术既可以生产大宗商品钢，也可以生产高强度钢，直接还原铁平均占比50%，废料占比另外的50%。此外，调整HSR的品类甚至有可能生产超深冲钢，并将直接还原铁的比例降低到30%或更低。

但这一切如何实现呢？第一步是在扁钢制造商和原始设备制造商（OEM）或一级汽车冲压车间之间建立循环钢铁经济，以回收消费前的废料——在这一过程中，可能回收多达50%的新废料或消费前废料。这一从摇篮到摇篮行为背后的商业模式可能是收费的。钢铁厂就把珍贵的原材料加工成镀锌钢板而收费。这些镀锌钢板之后在PROASSORT高性能设施中被进行脱锌处理，而这一处理无任何额外成本，因为锌价目前为每吨3000美元。在这一过程中，可以调整PROASSORT研发的内置传感器分选装置，以获得所需的金属成分。在最后一个步骤中，用机械方法压实循环钢，从而产生所需的冷加工HSR（C-HSR）。

像中国这样一个高度工业化的国家，有大量的废旧物资可供使用，而废旧物资恰恰是平衡未来的HSR需求迫切所需的。这些材料越来越多地来源于城市矿山，这种资源以非金属占比高和种类众多的合金元素著称，被钢铁回收商称为重废料或剪切废料。虽然这些材料的数量将在未来几十年内增长，但它们对于未来钢铁制造走向气候中和的作用相当有限。就像铝业或铜业一样，钢铁业必须建立一个二次精炼行业。这样，多余的废料可以被分类、火法冶金精炼，并最终颗粒化，形成热加工HSR。

As a Hot-Processed High-Performance Secondary Steel Resource (H-HSR), excess scrap can be sorted and refined to form granulated iron
作为热加工HSR，多余的废料可以被分选和精炼成铁粒
Source / 图片来源: Uvån Hagfors Teknologi (UHT)

从技术角度看，这些激励措施引发了一项具有挑战性但可应对的任务。从经济层面看，由于氢和清洁电力供应有限造成绿色DRI成本过高，政治层面则有拯救地球的目标，这些都将促进精炼领域的发展。

Energy

SinoTrough: Innovative Solar Technology for a Sustainable Energy System in China

A contribution by Dr.-Ing. Gregor Bern, Ningzi Xia and Francisco Torres Sartori, Fraunhofer Institute for Solar Energy Systems ISE

SinoTrough: 面向中国可持续能源系统的创新型太阳能技术

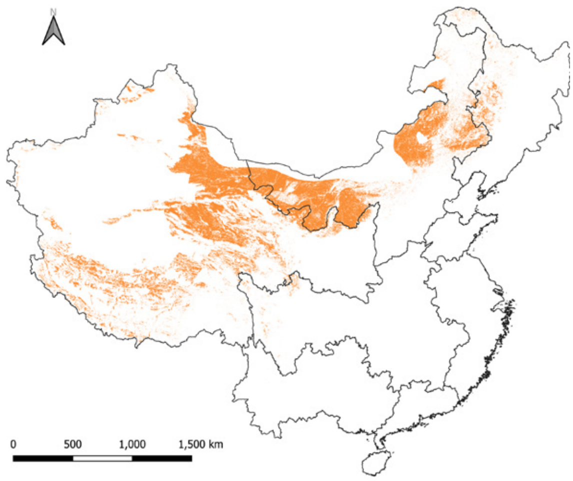
来自德国弗朗霍夫太阳能研究所 Gregor Bern博士、夏宁梓和Francisco Torres Sartori的客邀文章

Unlike fossil fuels, concentrating solar power (CSP) plants can generate clean and cost-effective electricity. Concentrating solar collectors, such as a parabolic trough, convert heat generated by sunlight into electricity. In sunny regions, they supply renewable electricity on demand by using large thermal storage facilities. In an energy market highly penetrated by fluctuating renewable energies such as wind power and photovoltaics without storage, CSP with thermal storage contributes to flexibility of the electricity system and helps maintain grid balance. These thermal storage facilities allow for the generation of electricity whenever needed and thus support a non-fluctuating renewable energy provision by also taking into account possible time gaps between the availability and demand of energy. On top of that, thermal storage also allows the generation of electricity even at night-time when the sun is not shining. Therefore, CSP represents a promising technology to support China in its ambitious goals to peak CO_2 emissions before 2030 and subsequently reach carbon neutrality by 2060.

Demand in solar thermal power plants and solar collectors has been growing around the world, and especially in China. In response to the rising demand, the German-Chinese SinoTrough project focuses on the development of collector systems to further increase the efficiency and reliability of the technology and reduce production costs. The project aims at developing an innovative parabolic trough collector to fit the needs of the Chinese market and energy system. In addition, the project takes into consideration the resilience needed to adjust to the harsh environmental conditions in Northwest China as well as the socio-economic adaptation to the Chinese market.

The SinoTrough project is funded by the German Federal Ministry of Education and Research (BMBF) as part of the "CLIENT-II Funding Initiative". Fraunhofer Institute for Solar Energy Systems (ISE) in Germany serves as the network coordinator and scientific partner, providing research on the Chinese energy market,

与化石燃料相比，光热发电能够生产更加清洁并划算的电力。例如槽式集热器等光能集热器可以将太阳光中的热能转化为电力，在阳光充足的区域可以通过大型储热设施根据需求生产可再生电力。当能源市场被大量如无储能功能的风能或光伏这一类不稳定的能源占据时，具备储热功能的光热发电可以增加电力系统的灵活性，同时有助于维持电网的供求平衡。这些储热设施使得电厂可以在有需要时随时发电，因此针对需求和可用性之间的时间差提供了一种稳定的可再生能源。更重要的是，储热使得发电可以在没有光照的夜晚进行。这一切使得CSP可能成为中国实现其雄心勃勃的目标的助力，即在2030年达到二氧化碳排放峰值并到2060年实现碳中和。



Orange dots depict areas deemed suitable for the installation of CSP power plants in the northern and northwestern regions of Mainland China
中国大陆适合建光热发电站的地点由橘黄色圆点标注，集中在华北、西北地区
Source / 图片来源: Fraunhofer Institute for Solar Energy Systems ISE

中国乃至全球对光热发电站和光热集热器的需求都在持续增长。面对这些不断上涨的需求，中德合作的SinoTrough项目专注发展集热器系统，提高该技术的效率以及可靠性，并降低生产成本。该项目旨在为中国市场和能源系统专门研发一种创新型槽式集热器，考虑到了集热器对中国西北地区严峻环境条件的适应性，以及针对中国市场所需的社会经济方面的调整。

the role of CSP in its energy system, social acceptance in the relevant regions, as well as the socio-economic impacts on the Chinese market. In parallel, the German company sbp sonne is developing the innovative parabolic trough collector, while the Chinese company RoyalTech will build a prototype in Northwest China demonstrating the technological improvement. In the end, Fraunhofer ISE and the Chinese Academy of Science will measure and assess the collector's performance on site.

After successful development and product launch in China, the goal is to enable the newly developed SinoTrough collector to be offered to further markets around the world, thus contributing to the transformation of the global energy system and climate mitigation. Possible transfer markets include the Middle East, North Africa, and South America.

Community and market acceptance

The SinoTrough project aims to make sure that relevant communities and market participants can voice their opinions and offer valuable feedback during its implementation. Fraunhofer ISE is studying the socio-economic acceptance in addition to the technical performance by involving stakeholders in this process. These studies could offer a key perspective for investors and policy makers to analyze the values of CSP projects especially when considering system integration of the technology. With such consideration, two online surveys are currently open to investigate the market and community acceptance respectively. The market acceptance questionnaire targets key stakeholders on the CSP supply chain in China such as engineering, procurement and construction (EPC), component manufacturers and investors, while the community acceptance questionnaire is designed for long-term residents in Inner Mongolia, Gansu, and Qinghai Province. Contributions are very much appreciated and will help make the SinoTrough project a success for the involved partners, the respective communities and the Chinese market. To further engage relevant stakeholders and increase social acceptance, a workshop will be organized in the late summer of this year to introduce the SinoTrough project and present results from the technological and socio-economic research.

Impact on economic development and electricity grid optimization

The method of input-output analysis and the Jobs and Economic Development Impacts (JEDI) for CSP Model are used for assessing the potential economic impacts

该项目由德国联邦教育与研究部的“CLIENT-II基金计划”资助。德国弗朗霍夫太阳能研究所（Fraunhofer ISE）担任组织协调并作为科研伙伴，对中国能源市场、光热发电在该系统中的角色、相关地区的社会接受程度以及项目对中国市场的经济影响进行研究。与此同时，德国施莱希伯格曼合伙人太阳能有限公司（sbp sonne）负责研发槽式集热器，而中国常州龙腾光热科技股份有限公司则负责在中国西北地区建设展示改进技术的原型。弗朗霍夫太阳能研究所与中国科学院将对集热器的性能进行现场测量和评估。

在成功研发并在中国发布产品后，最终目标是使得新研发出的SinoTrough集热器同样可以用于其他市场，以此为全球能源系统转化以及减缓气候变化做出贡献。潜在的转移市场有中东、北非以及南美洲。

社区和市场接受程度

SinoTrough项目希望确保相关社区和市场能够表达他们的想法、能够被听见。弗朗霍夫太阳能研究所在研究技术性能之外还在研究相关社会经济接受程度，并让利益相关者参与到这个过程内。这方面的研究可以为投资方和政策制定者提供一个用来评估光热发电项目价值的关键角度，尤其是考虑到如何将这项技术融合到电力系统之中。考虑到这一点，现在有两份分别用来研究市场接受度和社区接受度的线上调查问卷等待填写。市场接受度调查问卷目标群体是中国光热发电供应链中的主要利益相关者，如工程总包、零部件生产商、投资方等，而社区接受度调查问卷是为长居内蒙古、甘肃、青海省的居民设计的。如果您符合以上条件，愿意填写相关问卷，我们将不胜感激！您的参将帮助SinoTrough成为一个对相关合作伙伴、社区和中国市场来说都成功的案例。为了能够进一步加强利益相关者的参与并提高社会接受度，今年夏末我们将会举办一场研讨会，来介绍SinoTrough项目以及技术方面还有社会经济方面研究的成果。

对经济发展和电网优化的影响

项目的潜在经济影响分析使用了投入产出分析法以及光热储能发电(CSP)就业和经济发展模型(JEDI)。根据初步分析的估计，一座运用SinoTrough技术的50 MW的示范电厂在常年运作中可以创造243个工作岗位，其中44个来自电厂，77个来自供应链，122个来自诱导效应。在这样的一座电厂二十五年的运行期内，通过该电厂、当地供应链以及家庭消费其工资收入可产生约4.32亿美元的经济产出。

of the project. Primary analysis estimates that a 50 MW demonstration plant using SinoTrough technologies would create 243 jobs, out of which 44 are onsite, 77 from the supply chain, and 122 as induced effects during annual operation. Over a lifetime of 25 years, such a plant would approximately generate 432 million USD of economic output, taking into the account revenue created from the local supply chain, and household spending of employment income, in addition to the plant itself.

In order to pave the way for a higher share of renewable energy in the power grids of the future, a model region in China was investigated based on prerequisites deemed necessary for a successful implementation of this initiative. The Fraunhofer ISE simulation tools Entigris and ColsimCSP were used to identify the potential of a storable and plannable technology for power generation aimed at strengthening the Chinese grid and meeting rising energy supply demands in the long term. As a result, suitable areas for CSP installation in China were identified through an assessment of technical potentials, which are predominantly located in northwestern and northern regions. The expansion of an inter-regional transmission grid and installed capacity of renewables were subsequently predicted under a reference scenario and a High Renewable Energy Share Scenario (HighRES). In both scenarios, greenhouse gas emissions in China would peak by 2030. Yet, in the reference scenario, the share of renewables in the electricity mix only reaches 38 percent, whereas in the HighRES scenario, the share of renewables comprises 50 percent. As a result, the analysis suggests that the HighRES scenario would require twice as much grid infrastructure compared with the reference scenario to enhance inter-regional connectivity.

The results underline how different technologies should be combined to identify and implement the most beneficiary power supply for a society. Costs and benefits of investment in 24/7 electricity generation, grid stability and local impact of technological advancements on employment must be considered together. Enhanced grid capacity allows for the efficient distribution of energy from the regions of generation to serve the high power demand of the economic hubs located in the southeast of the country, while storage technologies enable filling the gaps between the supply and demand curves. The right combination of wind, hydropower, photovoltaic and CSP with suitable storage technologies, in synergy with an expanded electricity grid, will support China on its path towards carbon neutrality.

为了给采用更高比例可再生能源的未来能源系统铺好前路，我们为中国大陆地区建模分析了前提条件，运用弗朗霍夫太阳能研究所的模拟工具Entigris和ColsimCSP，来鉴定一项可储能、可规划的技术有多大的潜能可以在长期改善中国能源供应以及电网。作为结果，我们通过分析技术潜力确认了中国适合建造光热发电站的地区，主要集中在西北和华北地带。我们还在参考场景和可再生能源高比例的场景下预测了跨区域输电网的扩张情况和可再生能源的装机容量。两种场景中，中国都会在2030年达到温室气体排放峰值。参考场景中，可再生能源供电量占总量38%，可再生能源高比例场景中该比例则占到50%。分析显示，高比例场景所需的电网基础设施是参考场景的两倍，以此来增加区域之间的连通性。

这些结果强调了应该如何结合不同的技术来为一个社会鉴定并实施益处最大的供电方式：二十四小时供应电力所带来的投资成本和收益、电网稳定性和科技进步对当地就业的影响应该同时被参考。提高电网容量可以使发电区域和东南的用电地区之间的能源供应更加有效，而正确结合风能、水能、光伏和光热储能发电，加上一个强大的电网将会助力中国在迈向碳中和的道路上继续前进。

以下是市场调查问卷和社区调查问卷的二维码：

BMBF-Project Office “Clean Water”
德国联邦教育研究部（BMBF）“清洁水”创新研究项目办公室

The BMBF-Project Office “Clean Water” at Tongji University Shanghai, which was implemented to support the Water Research Cooperation between BMBF and the Chinese Ministry of Science and Technology and its projects in July 2012 (introduced in previous Econet Monitors), supports all CLIENT II-projects in China.

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自2012年7月起，位于上海同济大学的BMBF “清洁水” 项目办公室协助 BMBF 与 中国科技部 之间的水研究合作（详见Econet旧刊介绍），以及所有与中国合作的CLIENT II-研究项目。

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Sino-German Scientific Exchange on Key Technical Issues for International Carbon Markets

A contribution by Axel Michaelowa, Juliana Kessler and Aglaja Espelage, Perspectives Climate Research

国际碳市场关键技术问题的中德交流

来自Perspectives Climate Research公司的Axel Michaelowa、Juliana Kessler和Aglaja Espelage的客邀文章

At the 25th Conference of the Parties (COP 25) to the UN Framework Convention on Climate Change (UNFCCC) in December 2019, for the second time in a row the rules for the new carbon market mechanisms under Article 6 of the Paris Agreement (PA) could not be agreed. While it is clear that there will be two principal approaches to international carbon markets – Article 6.2 cooperative approaches organized by groups of countries without international oversight and an Article 6.4 mechanism (A6.4M) overseen by an international supervisory body – the 'devil lies in the details'. At COP 25 five main "crunch issues" prevented agreement in the negotiations. They included the accounting of mitigation not covered by nationally determined contributions (NDCs), the generation of adaptation finance through Article 6.2, the transition of pre-2020 emission credits from the Clean Development Mechanism (CDM), the operationalisation of the 'overall mitigation in global emissions' (OMGE) concept as well as the stringency of baseline setting approaches and additionality determination under the A6.4M. After the COVID-19 pandemic put a halt to climate negotiations in 2020, the virtual session of the two permanent subsidiary bodies (SBs) from 31 May to 17 June 2021 was the first official negotiation meeting since the pandemic's outbreak.

China and Germany play a key role in international carbon market mechanisms. China has been the world's leader in the generation of CDM emission credits. Being the largest greenhouse gas emitter, the Chinese government announcement of aiming at carbon neutrality by 2060 has led to renewed vigour in the development of domestic policy instruments, including the start of a national emissions trading system (ETS) for the power sector in 2021, building on experiences with provincial systems since 2013. German companies have acquired a large amount of CDM credits for

在2019年12月举行的《联合国气候变化框架公约》（UNFCCC）第25届缔约方大会（COP 25）上，就《巴黎协议》第六条下的新碳市场机制规则再次未能达成一致。细节决定成败，很明显，国际碳交易市场将有两种主要方式：6.2条中的无国际监督的两个或多个国家的碳排放交易和6.4条中的由国际机构监督的机制。在第25届缔约方会议上，五个主要的"关键问题"阻碍了谈判达成协议。其中包括国家自主贡献（NDC）未涵盖的缓解措施的核算、通过第6.2条产生的适应基金、由清洁发展机制（CDM）而来的2020年前的信贷的转换、全球总体减排（OMGE）概念的实施，以及6.4条下基线设置方法和额外性评估的严格性。2021年5月31日至6月17日两个联合国常设附属机构的在线会议是自2020年新冠疫情导致气候谈判暂停后的首次正式谈判会议。

中国和德国在国际碳市场机制中发挥着关键作用。中国在产出清洁发展机制排放信贷方面世界领先。作为最大的温室气体排放国，中国政府宣布在2060年实现碳中和，这一宣布为国内相关政策和举措的发展注入了新的活力，包括在借鉴省级交易系统经验的基础上，2021年在电力系统开启全国碳排放权交易系统（ETS）。德国公司已经获得了大量欧盟碳排放权交易系统下的清洁发展机制信贷，德国政府也大力支持了许多发展中国家的能力建设，使它们能够参与清洁发展机制。尽管欧盟已从清洁发展机制的坚定支持者转变为最直言不讳的反对者，但德国仍在继续支持发展中国家碳市场的创新方法，例如硝酸气候行动小组（NACAG）以及在西非和东非的区域碳市场联盟。德国的相关举措中值得一提的是由德国联邦环境、自然保护与核安全部资助、来自Perspectives Climate Research公司的碳市场专家担任主席的"碳市场机制工作组"（CMM-WG）。CMM-WG是非正式的对话平台，政府代表和专家

use under the EU ETS, and the German government has strongly supported capacity building in many developing countries to enable their participation in the CDM. While the EU has turned from a strong supporter of the CDM to its most vocal opponent, Germany continues to support innovative approaches to carbon markets in developing countries, including the Nitric Acid Climate Action Group (NACAG) and regional carbon market alliances, for example in West and East Africa. A noteworthy feature of the German approach is the "Carbon Market Mechanisms Working Group" (CMM-WG) funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and chaired by carbon market experts from Perspectives Climate Research. The CMM-WG serves as highly informal platform for dialogue. In regular intervals, government representatives and experts come together and discuss key technical questions under Chatham House Rules. Sharing lessons learned, challenges encountered and success stories from their activities enables to develop joint understanding how to improve international carbon market mechanisms. In this manner, the dialogue aims to consolidate a common understanding of key technical issues, thus contributing to the development of robust rules that respect environmental integrity for scalable mitigation approaches. So far, the CMM-WG activities have focused on issues related to Article 6 methodologies for additionality determination and baseline setting with an emphasis on programmatic and sectoral approaches for Article 6 crediting.

Sino-German technical discussions on Article 6 cooperation

In the CMM-WG context, repeated dedicated sessions bringing together Chinese and German experts and government representatives have taken place and discussed important elements of the Article 6 negotiations.

A key consideration in Article 6 cooperation is the host country's strengthened oversight role in the PA context necessary to avoid double counting when transferring internationally transferred mitigation outcomes (ITMOs) (see figure on the right).

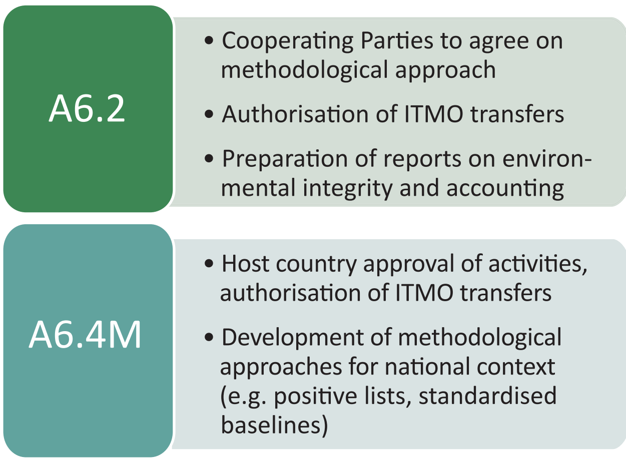
In the CDM context, China had already required an activity-specific minimum sales price for credits prior to granting approval letters. Such national requirements will also play an important role in Article 6

定期聚在一起，在查塔姆大厦规则下，讨论关键技术问题。通过分享经验教训、遇到的挑战和成功案例，有助于就如何改进国际碳市场机制增进共同认识。通过这种方式，这一对话平台旨在巩固对关键技术问题的共同理解，从而帮助为可扩展的缓解办法制定尊重环境完整性的有力规则。到目前为止，CMM-WG主要专注于与第6条额外性评估和基线设置方法有关的问题，重点是第6条信用额度的规划方法和行业方法。

关于第6条合作的中德技术讨论

在CMM-WG框架下，中德专家及政府代表多次召开专门会议，就第6条的协商探讨了重要内容。

第6条合作的一个重要考虑是东道国在《巴黎协定》框架下更强的监督作用，这是在进行减排成果的国际性转让（IMTOs）时避免重复计算的必要条件（见下图）。



Host country oversight in Article 6 cooperation
第6条合作中的东道国监督
Source / 图片来源: Perspectives Climate Research

在清洁发展机制框架下，中国在发放核准书之前会要求一个与具体活动有关的信用额度的最低销售价格。此类要求将在第6条合作中发挥重要作用，以确保东道国从基于市场的合作中获益。在这方面，他们需要在保障达成国家自主贡献和激励私营企业之间找到平衡。各个国家的批准和授权过程，以及发展适合本国情况的方法学和措施（包括第6.4条下标准化基线和额外性相关的正面清单）将变得很重要。

根据《巴黎协定》的目标，需要重新考虑额外性的概念，这一概念决定了如果没有来自出售排放信用额度的收入，一项活动是否不会发生。在第6条的框架下，额外性涉及三个不同方面（见下页图）。

cooperation to ensure that host countries are benefitting from market-based cooperation. Here, they will need to find the right balance between safeguarding NDC achievement and incentivising private sector action. Country-specific approval and authorisation processes will gain importance as well as the development of methodological approaches appropriate in the national context, including standardised baselines and positive lists for automatic additionality under Article 6.4.

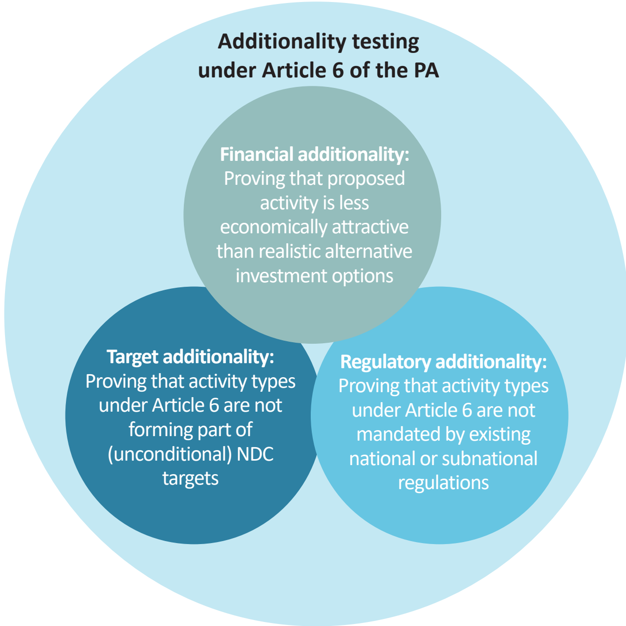
In the light of the PA's ambition cycle, the concept of additionality, which determines whether an activity would not have happened without revenues from sale of emission credits, needs to be reconsidered. Three 'shades' of additionality can be distinguished in the context of Article 6 (see figure on the right).

When setting a crediting baseline, the host country needs to consider national policies. Baseline stringency determines the share of mitigation outcomes retained by the host country. In the context of Joint Implementation under the Kyoto Protocol, which in many respects is similar to Article 6 under the PA, Germany ensured that the baseline levels respected both German emission limits and EU best available technology (BAT) reference values. China's emission trading system (ETS) makes use of four different technology benchmarks for the allocation of free allowances to power plant operators. These experiences on setting national performance-based benchmarks are pivotal for methodology development in an Article 6 context.

Forward-looking baseline setting also implies that net zero targets are reflected in baseline setting as both domestic and international market mechanisms will have to support host countries in achieving these targets. This also implies a shift from emission reduction activities towards removals. More international guidance will be needed for setting baselines for removal activities through negative emission technologies (see figure on the next page).

The May/June SB sessions on Article 6 implementation – two steps forward, one backwards?

Given that the political decisions on the crunch issues are to be undertaken at COP26 in Glasgow, it is not surprising that the recent negotiations did not see a resolution of those. However, the negotiations man-



The three 'shades' of additionality determination under Article 6
第6条框架下额外性贡献的三个方面
Source / 图片来源: Ahonen, Hanna-Mari; Michaelowa, Axel; Espelage, Aglaja; Kessler, Juliana; Christensen, Johanna; Dalfiume, Sandra; Danford, Erin (2021): Safeguarding integrity of market-based cooperation under Article 6: Additionality determination and baseline setting, CMM-WG Background paper, Freiburg

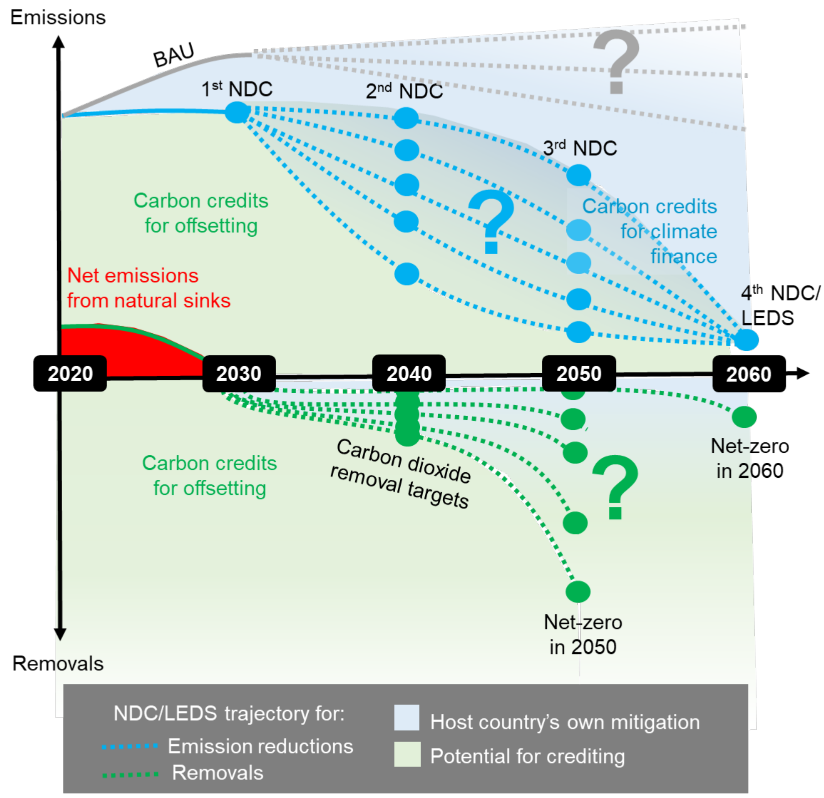
在确定信用额度基线时，东道国需要考虑国家政策。基线严格性决定东道国保留的减缓成果的份额。《京都议定书》的联合履约在许多方面与巴黎协定第6条相似，在该机制下，德国确保基线水平既尊重德国排放限值，又尊重欧盟最佳可用技术参考值。中国的碳排放权交易体系（ETS）利用四种不同的技术基准，向电厂经营者分配免费限额。在第6条的背景下，制定国家范围内的基于实际表现的基准的经验对于发展方法论至关重要。

前瞻性基准设定还意味着净零排放目标反映在基准设定中，因为国内和国际市场机制都必须支持东道国实现这些目标。这也意味着从减排活动转向清除排放。通过负排放技术进行清除活动的基线设定将需要更多的国际参考（见下页）。

关于第6条的五月/六月联合国附属机构气候变化会议：向前两步，倒退一步？

考虑到关于重要问题的决议将于在格拉斯哥举行的第26届缔约国会议上作出，最近的谈判没有就这些问题找到解决方法也就不足为奇了。然而，谈判在细节方面取得了更高层次的进展。首次详细讨论了基线设置和额外性评估的原则和可操作性。日本和欧盟等缔约方强调，需要以最佳可用技术方法或其他绩效基准的形式制定前瞻性基线。两个发展中国家

aged to achieve a much higher level of detail. Principles for and the operationalisation of baseline setting and additionality testing for the first time were discussed in detail. Parties such as Japan and the EU stressed the need for forward-looking baselines in the form of best available technologies (BAT) approaches or other performance benchmarks. A menu approach to baseline setting, which comprises performance-based benchmarks, historic (Russia) and business-as-usual approaches (African Group of Negotiators (AGN)), was promoted by two developing country groups. Besides, the AGN and South Africa supported the use of standardised baselines. What concerns additionality testing, the need to redefine additionality in the context of the PA was raised with the EU referring to "transformative action" and the Independent Alliance of Latin America and the Caribbean (AILAC) referring to alignment with environmental integrity and the long-term temperature goals as well as compatibility with transformational contribution and net zero goals. Other countries argue that regulatory additionality is sufficient (US, Japan) and call for a simplification of additionality tests (Japan). The outcomes of the May/June SB sessions reveal how important a continuous dialogue between Parties and stakeholders is on key technical issues.



Baseline setting linked to emission reduction and removal pathways
减排和清除排放路径的基线设定
Source / 图片来源: Michaelowa, Axel; Ahonen, Hanna-Mari; Espelage, Aglaja (2021): Setting crediting baselines under Article 6 of the Paris Agreement, Perspectives, Freiburg

Outlook

The ongoing exchange between Chinese and German experts shows that building a common understanding on key issues is pivotal in times where international negotiations face difficult technical choices. There is a need for further exchange of lessons learned from domestic crediting approaches and national experiences in international crediting approaches. Further dialogue sessions could discuss the carbon markets' long-term perspective regarding their contribution to the balance of emissions and sinks in the second half of the century. How should a government's approach change when a country shifts from a credit seller to a buyer?

集团提倡在确定基线方面采用菜单方式，其中包括基于绩效的基准、历史（俄罗斯）和现行方法（非洲集团，AGN）。此外，非洲集团和南非支持使用标准化基线。关于额外性评估，在《巴黎协定》的框架下重新定义额外性很有必要，欧盟提出"变革性行动"，拉丁美洲和加勒比独立联盟（AILAC）提出与环境完整性和长期温度目标保持一致并且与变革性贡献和净零排放的相容性。其他国家认为监管额外性是足够的（美国、日本），并呼吁简化额外性评估（日本）。五月/六月联合国附属机构气候变化会议的结果表明，缔约方和利益相关方之间就关键技术问题进行持续对话是多么重要。

展望

中德专家的不断交流表明，在国际谈判面临困难的技术抉择之际，在关键问题上建立共同认识至关重要。有必要就国内信用额度转让方法和国际信用额度转让方法的国家经验中吸取的经验教训进行进一步交流。未来的对话会议可以就从长期视角观察碳市场对本世纪后半叶碳排放和碳汇平衡的贡献进行探讨。当一个国家从信用额度卖方转变为买方时，政府应该在做法上有哪些转变？

Aluminium: A Barometer for China's Green Recovery

A contribution by Dr. Muyi Yang and Yixiu Wu

铝：中国绿色复苏“晴雨表”

来自杨木易博士和武毅秀的客邀文章

Last year, in the shadow of the pandemic, China saw impressive growth figures. While the US, EU and Japanese economies shrank by 3.5 percent, 6.4 percent and 4.8 percent respectively, China posted 2.3 percent GDP growth. A strong rebound in China's industrial output drew particular attention and the associated rise in energy use led to doubts: is China's recovery green enough?

The recovery in aluminium production was particularly eye-catching: output had fallen off during 2019, yet rebounded to a new high in 2020, to make up almost 60 percent of global production. As manufacturing aluminium is energy-intensive, the increase meant a bump in carbon emissions. But among other uses the metal is an essential raw material for emerging sectors such as electric vehicle manufacturing and renewable power. The fluctuations in aluminium output indicate the complexity of China's journey to peak carbon and carbon neutrality.

An impressive comeback

Last year was the first in almost a decade that the service sector's contribution to economic growth failed to increase, with industry becoming the main driver of the country's economic recovery. This shows how stability measures put in place during the pandemic, such as tax breaks to small businesses to secure jobs, have supported the industrial recovery, as well as the strength and resilience of the "Made in China" supply chain.

Domestic demand drove a strong rebound in output of industrial products during the second half of 2020, with growth in aluminium representative. An alternative to steel, aluminium is used widely in construction, vehicle manufacturing, aviation and high-tech products for its light weight, strength and resistance to corrosion. Aluminium manufacturing, therefore, can be a barometer for activity in the manufacturing and infrastructure sectors.

In early 2020, the impact of the epidemic on end users of aluminium caused production growth to slow.

过去一年，在全球疫情的愁云惨淡之中，中国交出了一份相对亮眼的经济增长成绩。在美国、欧盟、日本经济分别下降3.5%、6.4%和4.8%的情况下，中国2020年GDP以2.3%的增速领跑全球。中国工业产品的强劲反弹尤其引人注目。然而，与工业增长相伴而来的能源消耗和碳排放，也引发了外界对中国的经济复苏是否足够“绿色”的担忧与讨论。

Aluminium is an essential raw material for emerging sectors such as electric vehicle manufacturing and renewable power
铝是电动汽车和新能源等新兴产业的重要原材料
Source / 图片来源：Alamy

在2020年的工业品走势中，铝的反弹曲线尤其值得玩味：中国原铝产量在2019年下跌的情况下却在疫情之年增长至新高，占到了全球原铝产量的近60%。由于制铝业具有高耗能、高排放的属性，铝产量的激增往往意味着短期的碳排效应；然而铝同时又是电动汽车和新能源等新兴产业的重要原材料。铝业的发展起伏，折射了中国走向碳达峰、碳中和之路的复杂性。

铝：亮眼的反弹曲线

疫情这一年，服务业近10年来对经济增长贡献不断提升的势头被首次打破，工业成为拉动中国经济复苏的主力军。这一方面显示了中国疫后的“六稳”、“六保”政策对工业恢复的支撑作用；另一方面也表明“中国制造”完备的产业链和快速修复能力。

受国内需求增长的推动，中国主要工业产品产量在2020年下半年强劲反弹。其中铝产量的增长颇具有代表性：铝作为钢铁的一种轻质替代品，因其轻量、高强、耐腐蚀等优势，近年来在建筑、汽车、航空、高科技器材等领域被广泛应用，因此铝的生产与消费

But by the second half of the year demand had recovered and output quickly bounced back. By the end of the year, China had set a new record for aluminium production: 370.8 million tons, or 4.9 percent growth on the previous year, representing 57 percent of global output. Booming aluminium demand in the latter half of the year quickly ate up this growth in supply and caused China to become, briefly and for the first time in over a decade, a net importer of the metal.

What green economies are made of

The rapid rebound led observers outside China to wonder if the country's 2020 recovery was going to be green enough, or if it would be a repeat of 2008's infrastructure-led recovery.

Surprisingly, China did not see the expected jump in infrastructure investment for 2020. Despite support from special central and local government bonds, infrastructure investment for the year grew at only 0.9 percent, lower than the 3.8 percent of the previous year and dwarfed by the 44.3 percent increase in 2009, the year after the financial crisis. In particular, there was much less growth in investment in railways, roads and water infrastructure such as irrigation systems and dams than there had been in 2009.

Meanwhile, China's green industries continued to do well during the 2020 recovery, with a number of emerging sectors enjoying strong growth. Electric vehicle manufacturing turned around the decline of 2019, to see 17.3 percent growth. Growth in wind and solar generation capacity broke records, as did manufacturing of silicon wafers and solar panels (up 22.2 percent and 24.1 percent respectively).

Growth in green sectors was an important driver for output of industrial products. Aluminium, for example, is used in solar and wind power, electric vehicles and ultra-high-voltage power transmission. An all-electric or hybrid passenger vehicle is estimated to use 15.8 percent or 45.2 percent more of the metal than a traditional equivalent. An all-electric bus uses 230 percent as much aluminium as a traditional one. It takes 32 tons of it to build a megawatt of solar power capacity. Wind power needs much less of the metal, at 0.56 tons per megawatt, but that is still more than traditional power sources. Much of the sudden growth in aluminium output last year went to feed emerging green sectors.

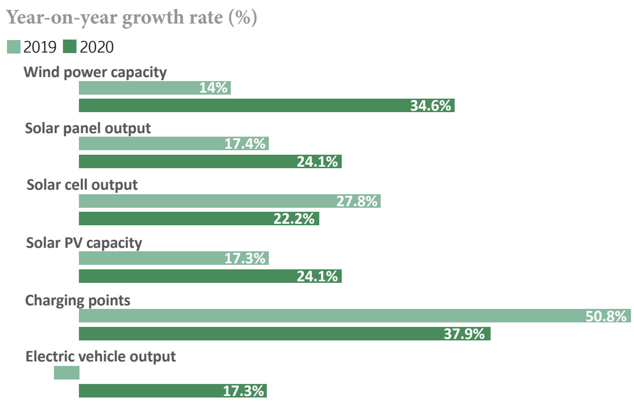
可一定程度反映出中国工业制造、基础设施建设行业的活跃度，具有一定的“行业晴雨表”的意义。

2020年初，受疫情影响中国铝终端消费行业需求受创，导致原铝产量增速受到影响，但到下半年，铝终端消费行业恢复，原铝产量快速反弹。到2020年底，中国全年原铝产量再创历史新高，同比增长4.9%，达到3708万吨，占全世界原铝总产量的57%。下半年旺盛的铝需求，不但很快消化了高速增长的原铝生产，甚至使得中国在十多年内首次短暂成为了铝产品净进口国。

铝：绿色经济的原材料

工业生产的快速反弹引出了一个外界关心的问题，那就是中国2020年经济复苏是否不够“绿色”，走了2008年金融危机之后靠基建投资拉动的老路？

一个颇令人意外的事实是，中国2020年全年的基建投资并没有出现预期的大幅增长：即使得到了抗疫特别国债和地方专项债的加持，这一年基建投资增速仅为0.9%，低于前一年的3.8%，远低于金融危机之后2009年的44.3%。其中，铁路，公路和公共水利设施方面投资增速均远小于2009的增速。这说明，疫情之后中国并没有上演如同上一次金融危机一样的“大水漫灌式”基建开发热潮。



China's rapid growth in green sectors continued in 2020
中国绿色产业发展的步伐在2020年并未停止
Source / 图片来源: National Bureau of Statistics, China Photovoltaic Industry Association, China Electric Vehicle Charging Infrastructure Promotion Alliance

与此同时，在2020年中国经济复苏的过程中绿色产业发展的步伐并未停止，一系列绿色新兴产业均取得了长足的发展。其中，新能源汽车产量一扫2019年的颓势，同比增长17.3%；光伏和风电装机总量均出现破纪录增长；光伏晶硅片和组件产量也再创新高，同比分别增长22.2%和24.1%。

绿色产业的发展是2020年工业产品产量快速增长的一个重要驱动力。仍以铝为例，铝是支撑绿色产业

A huge carbon footprint

Green industries posted impressive results for 2020, but China's carbon emissions continue to rise, in part due to the provision of raw materials to those sectors. And alongside this there is a reliance on coal for power generation and the manufacturing of cement, steel and aluminium. Smelting aluminium requires vast quantities of electricity and has always been a huge source of carbon emissions. To keep a lid on costs and ensure supplies, most of China's major aluminium makers have their own "captive" power plants, solely for powering their operations. The bulk of such power plants are coal-fired and over half are subcritical coal-burners, the least efficient and most polluting kind of coal plant. In 2020, there were 74.6 gigawatts of coal-fired captive power plants in China's aluminium sectors, over 40 gigawatts (more than Indonesia's entire coal-fired power fleet) of that made up of subcritical generators. There is plenty of scope to reduce carbon emissions in the sector. And while governments at all levels have boosted oversight of coal-fired captive power plants in the aluminium sector, and closed some inefficient plants failing to meet environmental standards, there is still a long way to go to end reliance on coal power for aluminium production.

An economy is a complex and in a sense organic system. Strong growth in emerging green industries will aid the transition to a low-carbon economy. But if changes aren't made elsewhere, those benefits may be undercut and the expected emissions reductions not achieved. As this article has explained, electric vehicles and solar power need aluminium, so growth in those sectors necessarily increases demand for the metal. In turn, the aluminium sector's reliance on coal power means it will generate carbon emissions while meeting that demand.

With peak carbon and carbon neutrality identified as important tasks for the 14th Five Year Plan, China should make further reforms to its economy, forming a new low-carbon and coal-free growth model; and setting carbon caps for high-emitting sectors in order to encourage the drawing up of roadmaps towards a green and low-carbon future.

This article was first published on the website www.chinadialogue.net

发展的一种重要工业原料，应用于光伏、风电、新能源汽车、特高压电缆设备等。据估算，每辆纯电和混合动力乘用车的铝消费量相比于传统乘用车分别高15.8%和45.2%，而每辆纯电客车的铝消费量要比传统客车高230%。此外，每兆瓦光伏设备的铝用量高达32吨。风电设备虽铝用量远小于光伏设备，但生产每兆瓦产能也需要用铝0.56吨，远高于传统电源技术。新能源汽车和光伏等绿色产业高度铝依赖的特性意味着去年激增的铝产量有不少是流向了这些新兴产品和产业。

铝：巨大的碳足迹

尽管不少绿色行业的发展在2020年交出了亮眼的成绩单，但中国继续攀升的碳排放，恰是其当前整个工业高碳排属性的注脚。从电力、水泥，钢铁、到铝业的“煤炭”依赖是这一现象背后的重要原因。仍以铝的生产为例，中国的铝业一直是碳排放大户。铝的冶炼需要大量用电，出于控制用电成本和稳定电力供应的考虑，中国的大型铝生产企业大多自备电厂，尤以燃煤电厂为主，其中又有超过半数是低效且排放标准不高的亚临界燃煤电厂。2020年，中国铝业自备燃煤电厂的总装机量达到了74.6吉瓦，其中亚临界燃煤电厂装机容量超过了40吉瓦，比印度尼西亚全国的煤电装机容量还要大。原铝生产的碳足迹具有巨大的减排空间。虽然近些年中国的各级政府加强了对铝业自备煤电厂的监管，关停了一批不符合环保规定的低效煤电产能，但毫无疑问，铝业去煤电还任重而道远。

经济是一个复杂的有机整体。新兴绿色产业的蓬勃发展虽可对经济低碳转型起到支撑作用，但如若不对经济系统其他各环节做出相应改变，也很可能事倍工半，达不到预想的减碳效果。本文的数据解读对此提供了一些佐证：新能源汽车和光伏设备等低碳技术对铝高度依赖，与之相关的绿色产业的高速发展必然会推高铝需求，而中国铝业生产对煤电的高度依赖使其在满足绿色产业发展的同时，造成了大量碳排放。

在碳达峰、碳中和被列为“十四五“期间重点工作之际，中国应进一步推动经济系统性改革，形成低碳、去碳的经济新发展格局；同时，针对高碳排、高耗能行业制定碳排放总量控制目标、推动行业出台积极的减排路径，是绿色低碳路径必不可少的工作。

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IMPRINT

June 2021 Issue

Publisher:

German Industry & Commerce Greater China | Beijing
100600 Beijing

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The Econet Monitor is published nine times per year in the framework of the Carbon Market Cooperation Project, implemented by German Industry & Commerce Greater China Beijing on behalf of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.

The greenhouse gas emissions of this issue of the Econet Monitor Magazine are offset by high-quality Gold Standard Certified Emission Reductions (GS CERs) from the Sichuan Household Biogas Programme of UPM Umwelt-Projekt-Management GmbH.

版本说明

2021年度 - 6月刊

出版商：

德中工商技术咨询服务有限公司北京分公司
北京 中国 100600

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本期德中生态杂志Econet Monitor印刷生成的温室气体排放由UPM环境项目管理有限公司四川户用沼气项目生成的高质量的清洁发展机制黄金标准核证减排量（GS CERs）进行抵消。

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中国节能协会节能服务产业委员会
emca.cn

Alternative Energy 替代能源网
alternative-energy-news.info

China Energy Web 中国能源网
china5e.com

China Greentech Initiative 中国绿色科技
china-greentech.com

China Renewable Energy Society (CRES) 中国可再生能源学会
cres.org.cn

China Renewable Energy Centre 国家可再生能源中心
cnrec.org.cn

German Energy Agency 德国能源署
dena.de

German Federal Ministry for Economic Affairs and Energy (BMWi) 德国联邦经济和能源部
bmwi.de

Energy Efficiency Export Initiative 能效解决方案倡议
efficiency-from-germany.info

Renewable Energies Export Initiative 可再生能源解决方案倡议
export-erneuerbare.de

Europe-China Clean Energy Centre 中欧清洁能源中心
ec2.org.cn/en

RETech 回收技术
retech-germany.net

Renewable Energy World 可再生能源世界研讨会暨博览会
renewableenergyworld.com

Renewables International 国际可再生能源
renewablesinternational.net

Environment 环境

German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
德国联邦环境、自然保护与核安全部
bmu.de

Federal Agency for Nature Conservation 联邦自然保护局
bfn.de

Sustainable China 可持续发展的中国
nachhaltiges-china.de

Federal Environmental Agency 德国联邦环境局
umweltbundesamt.de

The Guardian 卫报
guardian.co.uk/environment

Climate Protection & CDM 气候保护与清洁发展机制

CDM in China中国清洁发展机制
cdm.ccchina.gov.cn

China Climate Change Info-Net 中国气候变化信息网
en.ccchina.gov.cn

Chinese Renewable Energy Industries Association (CREIA)
中国可再生能源行业协会
creia.net

Climate Focus 气候聚焦
climatefocus.com

Climate Works Foundation 气候工作基金会
climateworks.org

CO2 Trade 二氧化碳交易
co2-handel.de

German Emissions Trading Authority
德国温室气体排放量交易处
dehst.de

United Nations – CDM 联合国–清洁发展机制
cdm.unfccc.int

JIKO BMUB 德国联邦环境部 联合履约处
jiko-bmub.de

KfW Carbon Fund 德国复兴信贷银行碳基金
kfw.de/carbonfund

Studies & Publications 研究报告与出版物

Asian Development Bank 亚洲开发银行
adb.org/publications

Economist Intelligence Unit 经济学人智库
eiu.com

International Energy Agency 国际能源机构
iea.org/publications

World Bank - East Asia & Pacific 世界银行–东亚及太平洋地区
blogs.worldbank.org/eastasiapacific

Economy, Finance & Law 经济、金融与法律

Germany Trade & Invest 德国联邦外贸与投资署
gtai.de

Caijing 财经网
english.caijing.com.cn

Caixin 财新网
English.caixin.com.cn

Eco-Business 生态商务
eco-business.com

Environmental Finance 环境金融
environmental-finance.com

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