

A Full-Chain Decarbonization Model Powers Hardware Factories Toward Zero Carbon

全链路协同降碳模式 助力五金工厂迈向“零碳”



国家电网
STATE GRID

国网永康市供电公司

STATE GRID YONGKANG ELECTRIC POWER SUPPLY COMPANY





A Full-Chain Decarbonization Model Powers Hardware Factories Toward Zero Carbon

Challenges

“Net-zero factories” are a critical pathway to achieving carbon peaking and carbon neutrality. Yongkang, a world-class hardware industry cluster, hosts tens of thousands of enterprises characterized by high pollution, high emissions, and high energy consumption, with total carbon emissions reaching millions of tons. In the pursuit of net-zero operations, these factories face three key challenges: unclear carbon accounting data, undefined decarbonization paths, and poor results. Addressing these challenges is pivotal, not only to provide a replicable transition model for hardware, steel, and chemical sectors, but also to deliver a breakthrough approach to advancing the entire industrial system toward net zero.



Interface of the energy management platform for hardware factories

Solution

In collaboration with the Zhejiang Electric Power Research Institute, State Grid Yongkang Power Supply Company (“State Grid Yongkang” for short) has developed a collaborative full-chain decarbonization model. This model drives action across three core fronts— monitoring, offsetting, and consumption—to accelerate the development of net-zero factories among Yongkang’s hardware enterprises.

Carbon accounting: a power-carbon factor accounting system for measurement traceability and dynamic calibration

Accurate carbon accounting on the monitoring side is the foundational first step toward building a net-zero factory. Research by the International Energy Agency (IEA) indicates that over 60% of emissions reduction initiatives fail due to initial data inaccuracies. To ensure carbon data is credible, traceable, and verifiable, State Grid Yongkang independently developed the "Hardware Power-Carbon Factor Accounting" system. Built on blockchain technology, the system establishes a dynamic, full-chain carbon footprint accounting framework—segmented by time-of-use and grid zone—tracking emissions from generation and transmission to final consumption. The carbon footprint data for each kilowatt-hour of electricity can be accurately obtained. Factories can precisely determine their power-carbon factors under various scenarios, such as peak versus off-peak periods or coal-fired versus solar power, enabling accurate emissions calculations. For example, using the system, Haers accurately calculated and controlled its carbon emissions, becoming the first hardware enterprise to achieve ISO 14068 carbon neutral certification in March 2025.

Carbon reduction: a waste-to-value service for green energy generation

A 100% green electricity supply is decisive for near-zero emissions. However, the green energy coverage rate for Yongkang's hardware factories was only 45%, well below industry-leading levels. To expand green energy sources, State Grid Yongkang targeted industrial smelting furnaces, establishing a specialized "Waste-to-Value" service team. This team provides customized, enterprise-specific technical services for high-efficiency heat transfer and flue gas power generation, converting smelting waste heat into electricity.

To date, the company has developed customized waste heat recovery solutions for 128 factories, 36 of which have completed retrofits. These initiatives achieve an annual carbon reduction of over 2 million tons—equivalent to the annual emissions of about 667,000 gasoline-powered cars. For example, Haers, through the "Waste-to-Value" service, has saved approximately 44,800 m³ of natural gas and generated 60 MWh of green electricity.



The "Waste-to-Value" service team conducts a survey at a hardware factory

Carbon management: the "Lu Ban" platform for precision energy efficiency

Carbon management on the consumption side directly impacts both emissions reduction and long-term competitiveness. State Grid Yongkang developed "Lu Ban," China's first energy management platform for hardware factories, named after the ancient master craftsman. The platform enables a closed-loop energy management process from monitoring, diagnosis to optimization through data insight, intelligent decision-making, dynamic control, and carbon tracing. It facilitates the transition from broad energy control to precision governance. Deployed in nearly 100 hardware factories in Yongkang, "Lu Ban" has delivered average energy savings of 8%-15% and serves as a widely emulated innovation across the industry.



Multiple Benefits

Environmental

In 2024, annual carbon emissions from Yongkang hardware factories decreased by 26.8% compared to 2023. Waste heat recovery initiatives saved approximately 224,000 m³ of natural gas and generated 300 MWh of green electricity.

Economic

The "Lu Ban" platform has enabled participating enterprises to reduce average electricity consumption by 15%-25%, saving approximately US\$420,000–700,000 annually and improving production efficiency by 15%-20%. The power-carbon factor allows factories to significantly lower their product carbon footprint, mitigating the impacts of policies such as the EU's Carbon Border Adjustment Mechanism (CBAM) and enhancing market premium potential by 8%-12%.

Social

With the support of State Grid Yongkang, the city has achieved outstanding results in green factory and industrial park development. This includes 24 municipal-level, 2 provincial-level, and 5 national-level green factories, as well as 2 municipal-level, 2 provincial-level, and 1 national-level green industrial parks.



Application Scenarios

Carbon accounting, waste heat recovery, and energy management for factories in the hardware, steel, chemical, and other energy-intensive industries



全链路协同降碳模式 助力五金工厂迈向“零碳”

问题与挑战

“零碳工厂”是实现“双碳”目标的关键路径。永康作为“世界级五金产业集群”，聚集着数以万计的五金企业，这些企业具有高污染、高排放、高能耗的“三高”特性，碳排放总量已达百万吨级。在“零碳工厂”建设中，这些企业普遍面临碳核算数据不清、减碳路径不明、效果不佳三大难题。解决这些问题，不仅将为五金制造以及钢铁、化工等多个高碳行业提供一条可复制的转型路径，还对扎实推动整体工业体系向零碳目标迈进具有重要的破局价值与示范意义。



五金工厂应用能效管理平台界面图

解决方案

国网永康市供电公司联手浙江电力科学院，从监测端、抵消端、能耗端三端发力，创新构建全链路协同降碳模式，加速永康五金企业“零碳工厂”建设的步伐。

算碳：研发电碳因子核算系统，实现计量溯源、动态校准

监测端算碳是“零碳工厂”建设的第一块多米诺骨牌，国际能源署（IEA）研究显示，超过60%的减排方案失效源于初始数据偏差。为了让五金工厂实现碳数据真实可信、可溯、可核，国网永康市供电公司自主研发“五金电碳因子核算”数字化系统。系统以区块链技术为核心，分时、分区构建从发电、输配到用电的全链条碳足迹动态核算体系，精准获取每度电的碳足迹数据。在该系统的帮助下，大量五金工厂能够精准获取单位产品在峰时段、谷时段以及纯煤电供电、纯光伏供电等多种生产用电场景下的电碳因子，进而获取精准的碳排放数据。比如，哈尔斯公司应用该系统后，准确核算与控制碳排放情况，最终在2025年3月成为五金行业首个通过ISO 14068组织碳中和认证的企业。

减碳：开发窑炉余热回收服务，实现绿能替代、利废生金

100%绿电供应直接决定工厂能否实现近零排放目标，永康的五金工厂绿能覆盖率仅为45%，显著低于领先企业水平。为增源扩绿，国网永康市供电公司将目光瞄准工业冶炼窑炉，成立“变废为宝”服务专组，“一企一策”地为企业提供高效传热与排烟发电技术服务，将工厂冶炼废热转化为电能。

截至目前，国网永康市供电公司已为128家工厂量身定制余热回收方案，其中36家率先完成改造，年减碳量超200万吨，约等于66.7万辆燃油轿车的年均碳排放总量。还以哈尔斯公司为例，“变废为宝”服务让其节省天然气量约4.48万m³，合计产生绿电6万千瓦时。



“变废为宝”服务专组在五金工厂调研

管碳：研发能效管理平台“鲁班”，实现智慧节能、精准增效

能耗端管碳，直接影响工厂的减排效果与长期竞争力。为此，国网永康市供电公司创新研发全国首个五金工厂能效管理平台“鲁班”，通过“数据透视-智能决策-动态调控-碳踪溯源”，帮助企业进行能源“监测-诊断-优化”的闭环管理，让工厂用能实现从“粗放管控”转向“精细治理”的变革。目前，平台已应用于永康近百家五金工厂，实现平均节能8%-15%的显著成效，创新举措在五金行业内被广泛学习和借鉴。



多重价值

环境效益

2024年，永康五金工厂年减排较2023年下降26.8%，余热回收利用累计节省天然气量约22.4万m³，合计产生绿电30万千瓦时。

经济效益

能效管理平台“鲁班”让企业电耗平均降幅达15%-25%，节省电费300-500万元/年，生产效率提升15-20%。电碳因子帮助企业显著降低产品碳足迹，规避欧盟碳边境调节机制（CBAM）等政策的影响，市场溢价能力提升8%-12%。

社会效益

在国网永康市供电公司的助推下，永康在国家、省、市级的绿色工厂及园区建设上都取得亮眼成绩，共诞生24家金华市级绿色工厂、2家浙江省级绿色低碳工厂、5家国家级绿色工厂、2个金华市级绿色园区、2个浙江省级绿色低碳工业园区、1个国家级绿色工业园区。



应用场景

五金、钢铁、化工等产业的工厂碳排放计量、余热回收、能源管理

About “GoldenKey – SDG Solutions”

To implement the assertion that sustainable development is the “golden key” to solving current global problems proposed by Chinese President Xi Jinping and to respond to the Decade of Action, “GoldenKey – SDG Solutions” (GoldenKey) was launched by China Sustainability Tribune in October 2020. The initiative aims to identify, shape, and promote outstanding corporate SDG solutions in China, tackle humanity's greatest challenges and drive sustainable development in China and beyond. In 2021, the GoldenKey was selected as the UN Good Practices (#33560).

As one of China's most influential platforms for sustainable development, GoldenKey has been held for six consecutive sessions. A total of 2,365 corporate SDG solutions have been collected, with 1,054 selected as outstanding SDG solutions. These solutions span areas such as climate action, well-being for all, rural vitalization, tech4SDG, quality education, action4nature, and zero waste. They stand out for their clear problem definition, outstanding innovation, strong replicability, and significant integrated value, demonstrating the capability and innovation of Chinese enterprises in advancing the SDGs.

With the growing emphasis on green and low-carbon transformation, the number of climate-related corporate solutions featured on the GoldenKey platform has increased each year. Participating enterprises range from central state-owned enterprises and foreign-invested companies to private enterprises of all sizes and sectors, contributing to China's carbon neutrality goal through efforts in energy transition, low-carbon production and operations, digital empowerment, financial support, as well as low-carbon consumption and living. GoldenKey has become one of China's most influential and internationally recognized platforms for corporate sustainability exchange and evaluation.

From 2022 to 2025, GoldenKey and State Grid Corporation of China (SGCC or State Grid) co-hosted the “GoldenKey · SGCC Special” for four consecutive years. The event collects innovative solutions on topics such as low-carbon transformation and green grids, and has identified and promoted numerous exemplary practices within the power sector. In 2025, GoldenKey launched the “GoldenKey · Power Sector Special” in partnership with the China Electricity Council (CEC) to further collect and showcase breakthroughs by power enterprises in climate change, China's 30·60 Decarbonization Goal, and low-carbon transition of clean energy.

GoldenKey continues to optimize and upgrade China's corporate SDG solutions. Through a series of initiatives, including publications, academic forums, field research, international launches, and demonstration projects, GoldenKey showcases and promotes these solutions on domestic and global platforms such as the China International Import Expo, China International Consumer Products Expo, UN Climate Change Conferences, and IUCN World Conservation Congress. This provides replicable models for more regions worldwide and supports the implementation of the SDGs.

Additionally, GoldenKey and the International School of Low-carbon Studies of Shandong University of Finance and Economics jointly established the GoldenKey Low-Carbon Action Center. Focusing on empowering enterprises in their green and low-carbon transformation, the center provides comprehensive knowledge empowerment and capacity building, covering low-carbon strategy development, carbon management capacity building, green project implementation, application of green financial instruments and climate risk control.



GoldenKey Annual Event

关于“金钥匙——面向SDG 的中国行动”

为落实中国国家主席习近平关于“可持续发展是破解当前全球性问题的‘金钥匙’”论断，响应联合国可持续发展目标“行动十年”计划，《可持续发展经济导刊》于2020年发起“金钥匙——面向SDG 的中国行动”（简称“金钥匙”）。

“金钥匙”旨在寻找、塑造、推广来自中国企业贡献SDG的优秀解决方案，应对人类所面临的重大挑战，为推动中国和全球可持续发展贡献力量。2021年，“金钥匙”获评联合国SDG 优秀实践（编号：SDG Action#33560）。

“金钥匙”是中国可持续发展领域具有重要影响力的平台型活动，目前已成功举办六届，共征集了2365项行动，其中1054项行动脱颖而出，在气候行动、人人惠享、乡村振兴、科技赋能、优质教育、礼遇自然、无废世界等领域涌现出一批问题定义精准、创新性突出、可复制性强、综合价值显著的SDG 解决方案，展现出中国企业贡献SDG 的行动力和破解难题的创新力。

随着企业对绿色低碳转型重视程度的增加，金钥匙平台上关注气候议题的企业行动数量逐年增加，涉及企业包括不同规模、不同行业的央企、在华外企以及民营企业等，这些行动分别从能源转型、低碳生产与运营、数字化赋能、金融支持、低碳消费与生活等方面积极参与全球气候治理，贡献中国碳中和目标。“金钥匙”成为中国最具影响力和国际化的企业可持续发展交流与展示活动。

2022-2025年，金钥匙与国家电网连续四年合作举办“金钥匙·国家电网主题赛”，围绕低碳转型、绿色电网等议题征集创新方案，发掘推广了一批行业示范实践；2025年，金钥匙与中国电力企业联合会启动“金钥匙·电力行业主题赛”，旨在更广泛征集推广电力行业在应对气候变化、服务“双碳”目标、促进能源清洁低碳转型等方面的突破性行动。

“金钥匙”持续对中国企业SDG 解决方案进行优化升级，举办成果出版、学术研讨、走访调研、国际发布、推广示范等一系列活动，在中国国际进口博览会、中国国际消费品博览会、联合国气候变化缔约方大会、世界自然保护大会等国内外平台上展现和推广中国企业SDG 解决方案，为全球更多地区提供可复制的经验，助力联合国2030可持续发展目标落实。

此外，“金钥匙”还联合山东财经大学中国国际低碳学院成立“金钥匙低碳行动中心”，以推动企业绿色低碳转型为核心，提供涵盖低碳战略制定、碳管理能力提升、绿色项目实践、绿色金融工具应用及气候风险管控等全方位的知识赋能和能力建设。



金钥匙年度盛典



Read the full version of 2025 Climate Solutions from
Chinese Enterprises
获取《中国企业应对气候变化解决方案》完整案例集



Learn more about GoldenKey SDG Solutions
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“金钥匙——面向SDG的中国行动”



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