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EFFICIENT AND CLEAN WINTER HEATING BY GROUND-SOURCE ENERGY HEAT PUMP IN NORTHERN CHINA

- AN EMERGING GREEN INDUSTRY OF INTEGRATED HEATING AND COOLING

北方冬季地能热泵高效清洁取暖

热冷一体化新兴绿色产业

本刊独家专访——吴德绳

Exclusive Interview —— Wu Desheng

中國地熱能

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EVER SOURCE SCIENCE &TECHNOLOGY DEVELOPMENT GROUP CO.,LTD.

恒有源科技发展集团有限公司简介

恒有源科技发展集团有限公司（简称恒有源科技）持续专注于浅层地能热泵取暖技术研发与应用，公司的主营业务是在中国北方冬季取暖地区，大力推广“**地能热泵高效清洁取暖**”技术、加速推进“**热冷一体化新兴绿色产业**”发展。

北方冬季的“地能热泵高效清洁取暖”在新时代已实现“三个替代”：

1. **能源的替代：**使用浅层地能（深度小于 120 米、温度低于 25 度的地热能的简称）替代传统化石能源；
2. **产品的替代：**采用高效节能的热泵替代传统锅炉；
3. **热能获取方式的替代：**通过电力驱动热泵“搬运”低温热能，替代锅炉高温燃烧化石能源的方式。实现“温度对口、品位相当”的能源分级科学合理利用。

围绕“三个替代”，企业原创发明了一种环保高效的地能采集技术，并以原始创新技术为核心、融合国际通用地能采集和热泵技术，集成创新了三个取暖系统，全面满足新时代北方地区冬季取暖的需求，践行“能源生产和消费革命、农村生活方式革命”。

1. **原始创新：**北京中关村原始创新技术——“单井循环换热，地下水 100% 回灌”环保、高效的地能采集技术。
2. **集成创新：**公司以原创技术为核心，融合国际通用地能采集和热泵技术进行的集成创新，包括以下三个取暖系统：
   (1) 适用于城乡集中供暖的地能热泵环境系统；
   (2) 适用于自采暖的农村农户的独立计量、分间取暖的地能热宝系统；
   (3) 适用于统一规划，按需分期投入的分布式地能冷热源站系统。

公司积极支持和发展原创技术系统的区域经销商、集成创新系统的成套产品项目代理商以及地方发展合作商。公司开展地能热泵高效清洁供热的标准化系统专有技术合作及成套产品的租赁，打造专业的系统运维平台服务于客户，确保将温暖送到千家万户。

恒有源员工的三条行为准则：

1. 安全第一，标准当家；
2. 扎扎实实打基础，反反复复抓落实；
3. 负责任做每件事，愉快工作每一天。

我们的追求：

人与自然和谐共生。

我们的愿景：

以北京中关村原创的最严格标准保持地下水质量的浅层地能（热）采集技术为核心，结合国际通用低温热能采集技术，因地制宜地让浅层地能（热）作为冬季取暖的替代能源，进一步完善“温度对口，能源品位相当”的取暖能源的科学、合理利用；进一步践行北方冬季“地能热泵高效清洁取暖”；加速推进“热冷一体化新兴绿色产业”发展。

恒有源科技发展集团有限公司
EVER SOURCE SCIENCE &TECHNOLOGY DEVELOPMENT GROUP CO.,LTD.

Corporate Profile of Ever Source Science & Technology Development Group Co., Ltd.

Ever Source Science & Technology Development Group Co., Ltd. (HYY) continuously focuses on the research, development, and application of shallow geothermal energy heat pump heating technologies. The company's primary business is the promotion of **High-Efficiency Clean Geothermal Heat Pump Systems** in northern regions of China during winter, as well as advancing the development of **the Emerging Green Integrated Heating-and-Cooling Industry**.

The High-Efficiency Clean Geothermal Heat Pump Systems for northern winters has achieved the "Three Transformative Substitutions" in the new era:

1. **Energy Substitution:** Utilizing shallow geothermal energy (geothermal resources with depths of less than 120 meters and temperatures below 25° C) to replace traditional fossil fuels.
2. **Product Substitution:** Employing high-efficiency, energy-saving heat pumps to replace traditional boilers.
3. **Substitution of Heat Acquisition Method:** Using electricity to drive heat pumps that "transfer" low-temperature heat, replacing the high-temperature combustion of fossil fuels in boilers. This enables scientific and rational graded utilization of energy, ensuring appropriate matching of temperature requirements and energy quality.

Based on these "Three Transformative Substitutions", the company has independently invented an environmentally friendly and highly efficient geothermal energy collection technology. With this original innovation as its core, and by integrating internationally adopted geothermal collection and heat-pump technologies, HYY has developed three integrated heating systems that comprehensively meet the winter heating needs of northern China in the new era, contributing to the "Energy Production and Consumption Revolution" and the "Rural Lifestyle Revolution".

1. **Original Innovation:** A Zhongguancun (Beijing) original innovation—the Single-well Circulation Heat Exchange System with 100% Groundwater Reinjection, an environmentally friendly and highly efficient geothermal energy collection technology.
2. **Integrated Innovation:** Based on the original technology and combined with internationally common geothermal collection and heat-pump techniques, the company has developed three integrated heating systems:
   (1) HYY Geothermal energy heat pump environmental system, suitable for urban centralized heating.
   (2) HYY Ground source energy treasure system, suitable for independent metering and individual room heating for rural households.
   (3) HYY Shallow geothermal energy distributed cooling and heating source system, suitable for unified planning and on-demand investment.

The company actively supports and collaborates with regional distributors of the original technology system, project agents of integrated innovation packaged products, and local development partners. It also engages in proprietary technical cooperation for standardized high-efficiency clean geothermal heat-pump heating systems and in the leasing of packaged system products. A professional operation-and-maintenance platform has been established to serve customers and ensure reliable heating for every household.

Three Codes of HYY Staff Conduct:

1. Safety first, standards prevail.
2. Build a solid foundation and ensure thorough implementation.
3. Be a responsible doer and a happy worker.

Our Pursuit:

Harmonious coexistence between humanity and nature.

Our Vision:

Leveraging Beijing Zhongguancun's original shallow-geothermal energy extraction technology, which meets the strictest standards for groundwater quality protection, as the core, and integrating internationally recognized low-temperature heat-collection technologies, we aim to apply shallow geothermal energy as a sustainable alternative for winter heating in a manner suited to local conditions. This further refines the scientific and rational utilization of heating energy by ensuring proper alignment between temperature requirements and corresponding energy grades. It also advances the implementation of High-Efficiency Clean Geothermal Heat Pump Systems in northern winters and accelerates the development of the Emerging Green Integrated Heating-and-Cooling Industry.

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Краткое описание компании «Хэнъююань Групп Ко., Лтд по развитию науки и техники»

Компания «Хэнъююань Групп Ко., Лтд по развитию науки и техники» (сокращённо Хэнъююань Технолоджи) непрерывно концентрируется на исследованиях, разработках и применении технологий тепловых насосов, использующих поверхностную геотермальную энергию для отопления. Основным направлением деятельности компании является активное продвижение на севере Китая, в регионах с зимним отоплением, высокоэффективной и экологически чистой технологии отопления «**геотермальные тепловые насосы**», а также ускоренное развитие новой зеленой отрасли **«интегрированные системы отопления и охлаждения».**

Отопление с помощью высокоэффективных и экологически чистых геотермальных тепловых насосов на севере Китая в новую эпоху достигло «трех замен»:

1. **Замена источников энергии:** использование поверхностной геотермальной энергии (сокращенно геотермальная энергия с глубиной менее 120 метров и температурой ниже 25 градусов) для замены традиционных ископаемых энергоносителей.
2. **Замена продуктов:** использование высокоэффективных и энергосберегающих тепловых насосов для замены традиционных котлов.
3. **Замена способа получения тепловой энергии:** использование тепловых насосов, приводимых в действие электричеством, для “перемещения” низкотемпературной тепловой энергии вместо сжигания ископаемых энергоносителей в котлах при высоких температурах. Это позволяет реализовать научно обоснованное и рациональное использование градации энергии в соответствии с принципом “соответствия температур и адекватности уровня”.

Основываясь на концепции «трех замен», предприятие разработало оригинальную технологию экологичного и высокоэффективного сбора геотермальной энергии. Эта первоначальная инновационная технология, объединенная с международными общепринятыми методами сбора геотермальной энергии и технологиями тепловых насосов, позволила создать три интегрированные инновационные системы отопления. Эти системы полностью удовлетворяют потребности в зимнем отоплении в северных регионах в новую эпоху, реализуя на практике «революцию в производстве и потреблении энергии, а также революцию в сельском образе жизни».

1. **Первопроходческие инновации:** Разработанная в пекинском районе Чжунгуаньцунь уникальная технология — экологичный и высокоэффективный метод сбора геотермальной энергии «циркуляционный теплообмен в одной скважине со 100% закачкой грунтовых вод обратно».
2. **Интегрированные инновации:** Компания на основе собственной оригинальной технологии, объединив её с международными общепринятыми методами сбора геотермальной энергии и технологиями тепловых насосов, провела интеграционные инновации, включающие следующие три системы отопления:
   (1) Геотермальная тепловая насосная экологическая система, применимая для централизованного теплоснабжения в городских и сельских районах;
   (2) Система «Геотермальный тепловой блок» для сельских домохозяйств с автономным отоплением, обеспечивающая независимый учёт и покомнатное регулирование обогрева;
   (3) Распределённая система геотермальных источников тепла и холода, применимая для централизованного планирования и поэтапного ввода в эксплуатацию в соответствии с потребностями.

Компания активно поддерживает и развивает региональных дистрибьюторов, работающих с системами оригинальных технологий, проектных агентов комплексных продуктов, созданных на базе интегрированных инновационных систем, а также местных партнеров по развитию. Мы осуществляем сотрудничество в области передачи ноу-хау для стандартизированных систем высокоэффективного и экологически чистого теплоснабжения на основе геотермальных тепловых насосов, а также предлагаем аренду комплексных продуктов. Создавая профессиональную платформу для эксплуатации и технического обслуживания систем, мы нацелены на обслуживание клиентов и гарантированное обеспечение теплом каждого дома.

Три правила поведения сотрудников компании «Хэнъюань»:

1. Безопасность — прежде всего, стандарты — во главе угла.
2. Прочно закладывать основы, последовательно внедрять на практике.
3. Ответственно подходить к каждому делу, работать с радостью каждый день.

Наше стремление:

Гармоничное сосуществование человека и природы.

Наше видение:

Основываясь на самой строгой в Пекине Чжунгуаньцуне оригинальной технологии сбора поверхностной геотермальной энергии, которая гарантирует сохранение качества грунтовых вод, и объединяя её с международными общепринятыми технологиями сбора низкотемпературной тепловой энергии, мы стремимся адаптировать поверхностную геотермальную энергию в качестве альтернативного источника для зимнего отопления с учетом местных условий. Это позволит усовершенствовать научно обоснованное и рациональное использование энергии для отопления в соответствии с принципом «соответствия температур и адекватности энергетического уровня», а также активнее внедрять на севере Китая высокоэффективное и экологически чистое отопление на основе геотермальных тепловых насосов и ускорить развитие новой зеленой отрасли, объединяющей системы отопления и охлаждения.

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人物专访

——吴德绳先生

人物简介

吴德绳，男，1939 年出生，江苏常州人，中共党员，教授级高级工程师，资深暖通空调专家和建筑设备工程教育家。曾任中国制冷学会副理事长，北京市建筑设计研究院院长兼党委书记、总工程师等职，现为该院顾问总工程师。长期担任住建部（原建设部）高等教育建筑环境与设备工程专业评估委员会主任、教育部高等学校教育认证委员会委员、中国建筑学会常务理事、中国建筑学会暖通空调分会副主任委员、北京市土木建筑学会理事长、《建筑热能通风空调》编审委员会顾问等职。

工作简历：1957 年考入清华大学土建系学习；1963 年至 1992 年历任建筑设计领域工程师、主任工程师、总工程师；1992 年至 2003 年任北京市建筑设计研究院院长等领导职务，2003 年至今任顾问总工程师。曾主持和领导三十余项大型工程项目设计，参与北京国际大厦、京城大厦、东方广场等重要地标工程设计，领导编制北京市申办 2008 年奥运会申报书中的场馆设计规划部分，为申奥成功作出重要贡献。荣获全国优秀设计院院长、优秀共产党员及全国五一劳动奖章等荣誉。长期担任清华大学、西安交通大学等高校的教学督导及客座教授。

吴老先生把一生最宝贵的时光全部奉献给我国的建筑事业，也是清洁可再生能源应用于建筑采暖 / 制冷的倡导者。2025 年 9 月 8 日吴德绳先生接受了本刊访谈组的远程专访。如今虽已是 86 岁的高龄，但谈话极富哲理，逻辑性极强。表现出不寻常的专业素质和丰富的管理经验。本刊访谈组以问答方式发表对吴老先生访谈的主要内容，以飨读者。

本刊访谈组：最近中央召开的城市工作会议在建筑领域引起热烈反响。您认为会议提出的建设现代化的人民城市的目标和我们行业里经常提到的“北方冬季地能热泵高效清洁取暖，发展热冷一体化新兴绿色循环产业”有怎样的关系？

吴德绳先生：建设现代化人民城市的核心是“以人为本”与“可持续发展”的结合，这恰与我们暖通行业推动的地能热泵技术、热冷一体化新兴绿色循环产业形成了“目标—手段”的深度契合。从人民大会堂到国家大剧院的设计实践中，我们始终追求“建筑为人服务”：既要满足万人会场的恒温需求，也要避免传统供暖带来的污染与能耗问题。如今中央强调的“人民城市”，本质上是要求建筑从“功能满足”向“品质提升”升级，而地能热泵技术正是实现这一升级的关键抓手：它既解决了北方冬季清洁取暖的民生痛点，又通过“热冷一体化”实现了能源的高效利用，这与城市发展中“低碳优先、民生为本”的导向完全一致。

2024 年国家发改委发布的《加快推动建筑领域节能降碳工作方案》明确提出支持地热能应用，这进一步说明行业技术路径已被纳入国家战略框架。我们常说“暖通专业是建筑的“呼吸系统”，现代化人民城市需要健康、高效的“呼吸”，而地能热泵等绿色技术正是构建这一系统的核心骨骼。

本刊访谈组：随着“双碳”目标推进，供暖、制冷系统作为建筑能耗的核心环节面临低碳转型压力。您认为在这个领域开发利用浅层地热能的前景如何？

吴德绳先生：“双碳”目标极大地推动了浅层地热能的开发利用。从技术特性来看，浅层地热能具有稳定性强和零碳排放的优势，尤其适合北方冬季供暖兼夏季制冷的需求，这与我们行业多年倡导的“能源梯级利用”理念也高度契合。

我一直认为世界能源是不会短缺的。为了营造舒适的生活环境，不应动用化石燃料燃烧而造成大气污染的不利状况，浅层地热能是合理的选择。新能源在不断地发现，耗能设备在不断地向节能化进步，这些明显的事实都在支持我的观念。

浅层地热能的发展不仅要突破技术难关，更要建立“研发—应用—运维”的全链条体系，让技术真正落地为减排实效。未来随着储能技术、智能调控的发展，浅层地热能与太阳能、生物质能的协同利用，将成为建筑低碳转型的重要方向。

本刊访谈组：您曾主持参与人民大会堂、国家大剧院等标志性建筑的供暖、制冷系统设计。这些项目在空间结构、功能需求上极具特殊性，当时面临的最大技术挑战是什么？最终是如何平衡“建筑美学”与“供暖、制冷系统设计实用性”之间的矛盾？

吴德绳先生：这两个项目的技术挑战，本质上都是“突破建筑形态限制，实现功能与美学的共生”。以人民大会堂为例，万人会场与五千人宴会厅的超大空间，对供暖制冷的均匀性、稳定性提出了极高要求——当时我们面临的最大难题是如何在不破坏建筑庄重风格的前提下，布置足够的换热设备。最终通过“分层送风 + 辐射供暖”的复合系统，既保证了室内温度波动控制在 ±1°C以内，又将设备巧妙隐藏于吊顶与墙体结构中，实现了“看不见的系统，感受到的舒适”。

国家大剧院的挑战则更为特殊，其“湖中明珠”的壳体造型带来了三大难题：一是双曲面钛金属板外壳无法布置传统空调外机；二是地下 32.5 米的舞台仓需要解决深层土壤换热问题；三是景观水池需兼顾“冬季不结冰、夏季不长藻”的景观需求与能源利用效率。针对这些问题，我们团队选用了创新的“恒有源地能热泵环境系统”，将大剧院地下岩土体作为冷热源，采用热冷一体化的机组。既满足了建筑美学要求，又实现了能源的高效利用。在平衡美学与实用性时，我们始终坚持“建筑形态服务于功能需求，系统设计融入建筑肌理”的原则：比如将钛金属板与玻璃的拼接节点与空调风口结合，让技术设备成为建筑美学的一部分，而非对立面。这些实践也让我深刻认识到：真正的技术突破，往往是在满足极致需求的过程中诞生的。

本刊访谈组：您任职、兼职北京市建筑设计研究院的院长和党委书记、总工、顾问总工多年。您一生从事建筑行业并卓有成效。作为建筑领域的老前辈，您对现在建筑学科的现状有哪些改进的意见？

吴德绳先生：我认为房屋建筑学科的现在情况是发展迅速，不断出现新状况。过去的一些做法有改动的必要。我们对高校的建筑学科、建筑和建筑设计院的职能编制都是可以做些革命性的思考和改动。我们都知道，没有不老化的建筑和设备及装修。那么维修更换部件就是正常的不能避免的过程。让发现故障和处理故障更为直接，不是最最应该的吗？那人的美学观念不正因而向此方向建立吗？谁说房子内管道都得藏起来？这就是我盼望的革命性的发展的合理的方向。至于建设一项新建筑的立项工作最应避免的是为没有建设必要的建设项目立项。建造一个没有必要建造的建筑物那不就是最得不偿失的浪费吗？这种合理性评估是多种专业人员科学合作才能会商而得的。这机构、这方法和这工作经验正有待创新性的集体努力。

本刊访谈组：您长期致力于行业人才培养，特别是对年轻人的培养。您有许多关于年轻人修养和身心健康的著作都深受他们的喜爱。从您的经验看，如今的年轻暖通工程师最需要锤炼的能力是什么？您当年带团队时，最看重成员的哪些素质？

吴德绳先生：世界的科技发展进程已经对年轻人的专业取向和努力方向有了新的要求。但培养青年的教育学原则不但不应动摇反而应更加坚持。每个青年最好的发展目标就是“造就成最好的自己”。这既是因人而异的原则，又是每个人快乐工作和快乐生活的美好状况。因之，对年轻人的帮助绝对不准使用“你不该如何或你不要如何”之说法。要尽量开放式的让他们随时随年龄的每一段落自由地去追求。我回顾自己一生中进步较好的过程就是这样的经历。

当年我带团队时，最看重成员的两个素质：一是“责任心”，暖通系统关系到建筑的安全与舒适，任何一个参数失误都可能导致严重后果，比如人民大会堂的供暖系统若出现故障，影响的是国事活动的正常开展，这就要求团队成员必须严谨细致、敢于担当；二是“创新勇气”，但这种创新不是盲目求新，而是基于工程实践的理性突破，比如我们在国家大剧院采用我国创新的单井循环地能采集技术，正是在充分调研、反复论证的基础上实现的。此外，我还特别强调“身心健康与人文修养”，暖通工程师不仅要懂技术，还要理解建筑与人的关系——就像我常常提到的：“好的设计应该让使用者感受不到技术的存在，只体会到舒适与便捷。”希望年轻人既能扎根工程实践，又能保持对生活的热爱，在技术与人文的平衡中实现职业价值。

在本次采访的末尾，吴总又语重心长地说：

我如今已经是八十六岁的老人了，如果还有人愿意听我对一些问题的见解，这让我十分感动和感谢。因为这些交流都涉及我一生从事和热爱的专业。

近年来我也关注着世界信息化和数字化的发展信息。我既对它的作用很有信心，也没有减少我自己思考和创新的积极性和自信。在这样的心情下我常写些随笔草稿。既是愿为行业有兴趣的同仁们留点儿故事也为不虚度余年而充实快乐。闪出了古文字中的一句：“盈缩之期，不但在天；养怡之福，可得永年”。

谢谢读到本篇的读者们。

编者的话：

吴总在这里引用了两句古诗：*“盈缩之期，不但在天； 养怡之福，可得永年”*。据我们检索，这些诗句出自曹操的四言乐府诗《龟虽寿》，该诗是《步出夏门行》的第四篇。以下是诗句所在的全诗：

神龟虽寿，犹有竟时；
腾蛇乘雾，终为土灰。
老骥伏枥，志在千里；
烈士暮年，壮心不已。
盈缩之期，不但在天；
养怡之福，可得永年。
幸甚至哉，歌以咏志。

单井循环换热地下水100% 回灌系统技术的实施要点

作者：王学志

一、技术简介

单井循环换热地下水 100% 回灌系统技术是北京中关村的原创技术，可高效环保采集浅层地热能替代化石能源取暖。它以地下水为介质，循环采集储存于地下岩土体中的浅层低温热能，通过系统封闭加压实现地下水 100% 同井回灌，不消耗、不污染地下水。供暖效果相对稳定，不受天气影响，可保证在最恶劣的气候条件下中国北方广大群众的温暖过冬。单井循环换热地下水 100% 回灌系统技术按结构分为：无换热颗粒型地能采集井和有换热颗粒型地能采集井，见图 1、图 2。

二、技术原理

单井循环换热地下水 100% 回灌系统技术利用密封器将地能采集井分为三个区，从上向下依次为加压回水区、密封区和抽水区。井水由置于抽水区的电潜泵抽出，输送到地能热泵机组进行热交换后，返回加压回水区，在压力的作用下从采集井上部的滤水管进入周围岩土体自上而下进行热交换，通过采集井下部的滤水管再次进入抽水区由电潜泵抽出，完成浅层地能热的采集循环。

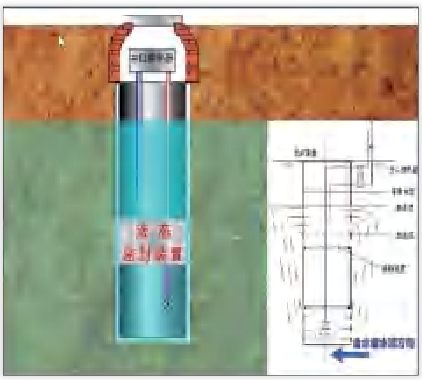

图 1 无换热颗粒型地能采集井

图 2 有换热颗粒型地能采集井

三、技术特点

1、系统封闭(密封无曝气)，水作为“介质”循环使用，对区域地下水水质无影响，系统环保高效；

2、通过系统加压实现 100% 同井回灌，解决了地下水回灌难的问题，有效避免了土体塌陷、移砂等潜在地质灾害；

3、单井布置灵活、占地面积小，高效采能，破解了城市中心建筑物容积率高、密度大、可供采能的区域受限等痛点；

4、技术成熟、可靠。

四、技术支撑

2012 年，北京市政府相关部门颁布了《单井循环换热地能采集井工程技术规范》，为单井循环换热地下水 100% 回灌系统技术地能采集井的设计、施工、验收和运行维护提供了统一标准。

多年来，恒有源科技公司通过各种地质条件下浅层地热能的采集的试验，现已掌握适用于卵砾石、岩石及泥沙等多种地层地质的单井循环换热地下水 100% 回灌系统技术。可结合各种建筑物的实际情况，就近因地制宜的采集取得随处都有的、“冰冻三尺”以下的浅层低温热能（低于 25°C），单套系统的地热能采集功率可达 500kW。此外，公司产品实现了模块化生产，可根据需求进行科学搭配、迅速安装。

五、施工管控

施工前对项目所在地的水文地质情况进行调研，详细分析地层岩性、水位、水量、地下水径流方向等数据，对采集井的井深、结构、材质等进行讨论，出具完善的采集井设计图纸。根据设计图纸、现场条件、工期要求，编制完善的施工组织计划，做好人员、材料、设备、资金的充分准备。

检验进场材料，确保质量、规格、数量符合要求；落实技术交底，确保施工人员熟悉设计图纸及安装要求；严控施工过程，确保井深、井径及垂直度符合要求，焊接饱满无缺陷，洗井至水清砂净，施工后调试合格。总之，严把质量关，分工明确责任到人，确保采集井施工质量合格，满足设计要求。

施工应根据项目地质情况选择最优施工工艺：

1、适用于卵砾石、岩石地质的恒有源原创一次性成井工艺，将井管通过钻头直接安装到设计深度。本工艺利用压缩空气排除孔内岩屑残渣，取代传统钻井液，无需泥浆护壁，不需要填充滤料，提高井周边地层的渗透系数，在提升成井效率的同时减小了施工作业场地。

2、适用于流沙等容易塌孔的土层的正循环钻井工艺，是从钻杆内注循环泥浆，钻碴因比重轻于泥浆而自浮于泥浆中，并随泥浆上升到孔顶排出。随着钻碴的逐渐加多，泥浆浓度越来越大，浓泥浆有利于钻孔护壁，不易塌孔。

3、适用于岩层、砾石及密实土层的反循环钻井工艺，是钻杆吸出夹带钻碴的循环泥浆，并从孔顶补充泥浆以保持孔内液面，从而保证孔壁的稳定性。因大大减少重复碾磨钻碴的无效劳动，可使钻进效率大幅度提高。

六、运维保障

制定调度运行方案，通过监控平台控制等方式对采集井进行精细化管理；日常进行监督检查及生产安全巡视；定期对采集井进行巡检；建立快速高效的联络机制，保证及时报修、抢修；根据地质及运行情况，可采用洗井等对应措施，保障采集井效果，延长使用寿命。

公司动态：恒有源集团接待北京市相关政府部门探讨地热能采集技术与水资源税收取

2025 年 6 月上旬，恒有源集团先后接待了北京市发展和改革委员会（市发改委）、北京市农村工作委员会（市农委）联合考察组及北京市、区、所三级税务部门的考察调研。各方重点围绕恒有源集团的核心技术——单井循环换热地下水 100% 回灌系统技术的应用推广及水资源税收取等议题进行了深入交流与实地考察。

一、市发改委、市农委联合考察技术应用潜力

2025 年 6 月 3 日，北京市发改委能源处领导一行联合北京市农委相关领导莅临恒有源集团考察。

考察伊始，集团向领导们详细汇报了技术发展与应用情况。随后，双方就**单井循环换热地下水 100% 回灌系统技术**的核心原理、应用效果及发展前景进行了全面研讨。领导们对该项技术表现出浓厚兴趣，并就其关键性能指标、环境影响等问题进行了细致询问。

领导们对恒有源集团的技术成果给予了高度认可。此外，双方还就**地热能开发利用中涉及的水资源税收取政策及执行情况**展开了充分讨论，为后续政策执行奠定了基础。

到访照片

二、三级税务部门实地调研项目运行与税收实践

2025 年 6 月 11 日，北京市税务局、海淀区税务局及四季青税务所联合考察组到访恒有源集团。

为深入了解技术长期运行效益及税收实践，考察组首先实地参观了恒有源集团应用单井循环换热地下水 100% 回灌系统技术的两个**稳定运行超过 20 年的标杆项目**：海淀外国语实验学校与四季香山住宅小区。在现场，考察组重点调研了项目的**历年运行费用、系统稳定性、用户收费模式**等实际运营数据。

实地考察结束后，集团向税务局领导做了专题汇报。在随后的座谈中，双方再次聚焦**水资源税收取问题**，对于恒有源集团**实施的、能够实现地下水“百分百回灌”的浅层地热能采集技术**，领导们听取了详细汇报，并针对此类技术的**水资源税征收原则、计量方法与政策适用性**给出了具体的指导意见和建议。

到访照片

这两次考察活动不仅是北京市相关政府部门对恒有源集团在浅层地热能开发利用领域的技术实力与贡献的肯定，也为企业在技术推广应用中面临的政策性问题提供了宝贵的沟通渠道和方向指引，有助于推动清洁能源技术的健康发展和相关政策的完善。

发展热泵高效清洁取暖热冷一体化新兴绿色循环产业——为建设现代化人民城市做贡献

作者：杨明忠

提要：中央城市工作会议部署了现代化人民城市建设目标，热泵高效清洁取暖产业将重构城市供热万亿版图，产业技术赋能城市发展五大转变、精准对接七项重点任务，政策护航加速产业落地。企业迎来了发展热泵高效清洁取暖——热冷一体化新兴绿色循环产业的最佳契机。

2025 年 7 月 14 日至 15 日，中央城市工作会议在北京隆重召开，习近平总书记发表了重要讲话，总结了新时代以来我国城市发展成就，分析了城市工作面临的形势，明确了做好城市工作的总体要求、重要原则和重点任务。

会议指出，党的十八大以来，党中央深刻把握新形势下我国城市发展规律，坚持党对城市工作的全面领导，坚持人民城市人民建、人民城市为人民，坚持把城市作为有机生命体系统谋划，推动城市发展取得历史性成就。我国新型城镇化水平和城市发展能级、规划建设治理水平、宜业宜居水平、历史文化保护传承水平、生态环境质量大幅提升。

会议强调，当前和今后一个时期城市工作的总体要求是：坚持以习近平新时代中国特色社会主义思想为指导，深入贯彻党的二十大和二十届二中、三中全会精神，全面贯彻习近平总书记关于城市工作的重要论述，坚持和加强党的全面领导，认真践行人民城市理念，坚持稳中求进工作总基调，坚持因地制宜、分类指导，以建设创新、宜居、美丽、韧性、文明、智慧的现代化人民城市为目标，以推动城市高质量发展为主题，以坚持城市内涵式发展为主线，以推进城市更新为重要抓手，大力推动城市结构优化、动能转换、品质提升、绿色转型、文脉赓续、治理增效，牢牢守住城市安全底线，走出一条中国特色城市现代化新路子。

本次会议为中国大地生活着 9.4 亿人口的 690 多座城市指明了新时代的发展方向，在这一重大战略背景下，热泵高效清洁取暖热冷一体化新兴绿色循环产业作为城市绿色低碳技术应用的重要形式之一，可以成为推动城市高质量发展的重要力量。

一、产业赋能：热泵技术助力城市高质量发展转变新实践

我国城镇化正从快速增长期转向稳定发展期，中国的城镇化率已达到 67%，城市发展正从大规模增量扩张阶段转向存量提质增效内涵式发展为主的阶段，从大规模建设时代转为大的治理、大的更新时代。会议要求城市工作要深刻把握、主动适应形势变化，转变城市发展理念，更加注重以人为本；转变城市发展方式，更加注重集约高效；转变城市发展动力，更加注重特色发展；转变城市工作重心，更加注重治理投入；转变城市工作方法，更加注重统筹协调。

在以上城市发展的五大转变中，热泵高效清洁取暖热冷一体化新兴绿色循环产业可以大有所为，助力城市的高质量发展。热泵是一种高效能量转换装置，供热的方式从“烧燃料”到“搬热量”，通过消耗少量电力将低品位热能转化为高品位热能，能源利用效率远高于传统锅炉又大幅度减少了污染物排放。例如，华北地区的电热泵替代项目平均综合节能率达 31.6%（等价值）和 70.8%（当量值）。根据对华北地区的调研，热泵供暖系统相比燃煤锅炉，大气污染物（NOx、SO_2、PM2.5）排放量减排超 90%，相比燃气锅炉，NOx、PM2.5 也有显著减少。

1、热泵清洁取暖热冷一体化新兴产业让建筑冬暖夏凉，提高人民的生活居住环境的舒适度，体现了更加注重以人为本的理念；

2、热泵技术通过能源的高效利用和循环利用，依靠一份电力驱动可以得到三份以上的热量，适用于城市建筑的分布式取暖，也可形成区域冷热源网，充分体现了用能的集约高效；

3、热泵清洁取暖让城市因地制宜地增加可再生能源、余热资源的应用，减少对传统化石能源的依赖，实现城市特色发展；

4、热泵清洁取暖可以将传统化石能源燃烧供暖的污染治理投入转变为清洁取暖的前期投入，从根本上实现城市清洁化、低碳化发展；

5、在政府统一协调推进下，热泵高效清洁取暖将形成一个热冷一体化新兴产业，实现绿色循环发展。

二、使命担当：热泵产业精准对接城市发展七大重点任务

会议部署城市工作七个方面的重点任务：一是着力优化现代化城市体系。着眼于提高城市对人口和经济社会发展的综合承载能力，发展组团式、网络化的现代化城市群和都市圈，分类推进以县城为重要载体的城镇化建设，继续推进农业转移人口市民化，促进大中小城市和小城镇协调发展，促进城乡融合发展；二是着力建设富有活力的创新城市。精心培育创新生态，在发展新质生产力上不断取得突破；依靠改革开放增强城市动能，高质量开展城市更新，充分发挥城市在国内国际双循环中的枢纽作用；三是着力建设舒适便利的宜居城市。坚持人口、产业、城镇、交通一体规划，优化城市空间结构；加快构建房地产发展新模式，稳步推进城中村和危旧房改造；大力发展生活性服务业，提高公共服务水平，牢牢兜住民生底线；四是着力建设绿色低碳的美丽城市。巩固生态环境治理成效，采取更有效措施解决城市空气治理、饮用水源地保护、新污染物治理等方面的问题，推动减污降碳扩绿协同

增效，提升城市生物多样性；五是着力建设安全可靠的韧性城市。推进城市基础设施生命线安全工程建设，加快老旧管线改造升级；严格限制超高层建筑，全面提升房屋安全保障水平；强化城市自然灾害防治，统筹城市防洪体系和内涝治理；加强社会治安整体防控，切实维护城市公共安全；六是着力建设崇德向善的文明城市。完善历史文化保护传承体系，完善城市风貌管理制度，保护城市独特的历史文脉、人文地理、自然景观；加强城市文化软实力建设，提高市民文明素质；七是着力建设便捷高效的智慧城市。坚持党建引领，坚持依法治市，创新城市治理的理念、模式、手段，用好市民服务热线等机制，高效解决群众急难愁盼问题。

在七个方面的重点任务中，热泵高效清洁取暖热冷一体化新兴绿色循环产业精准对接，可以充分担当成为新时代城市工作“施工图”中一部分，加速实现城市发展目标。

1、现代化城市体系的建设中人民取暖能源形式的选择是重要的一环，而充分应用热泵获取可再生能源取暖是最优解之一，其布置的灵活性也更加适用于不同的城市建筑和园区规模。

2、富有活力的创新城市建设要求精心培育创新生态，在发展新质生产力上不断取得突破，高质量开展城市更新。热泵高效清洁取暖系统可以适应建筑原有内部标准的采暖设施，仅对原有化石能源取暖的源头进行更新，并且将形成新质生产力催生热冷一体化新兴绿色循环产业，形成固定的产业就业。

3、热泵高效清洁取暖可以提升人民取暖制冷舒适水平，助力建设舒适便利的宜居城市。

4、我国能源消耗总量中约 10% 是用于建筑供暖的能源，燃烧化石能源供暖也是碳排放的主要组成，利用热泵取暖可以简单地将取暖能源消耗的 2/3 转变为绿色可再生能源，如果引入绿电驱动，那么整个系统将是零碳系统。国际能源署（IEA）研究数据显示，目前市场上可用的热泵能效是天然气锅炉的三到五倍，即使在当前的发电组合结构下，安装热泵代替化石燃料锅炉也能在所有主要供暖市场中显著减少温室气体排放，随着电力系统的脱碳，这一优势将进一步增强。这一技术特性使热泵热冷一体化产业成为建设绿色低碳美丽城市的重要支撑，零排放供暖对于中国城市建设和“双碳”目标实现意义重大。

5、热泵高效清洁取暖大大降低了建筑用能需求，该技术可以与太阳能、蓄热等多能互补应用，形成多元化的能源供应体系，提高城市能源系统的抗风险能力，减少城市发展面临的能源安全危机；同时，热泵系统安装灵活，运行无燃烧、无爆炸风险，可适应不同建筑结构和使用需求，在城市更新、老旧小区改造等工程中具有广泛应用前景，有助于推进城市基础设施生命线安全工程建设，是建设安全可靠的韧性城市重要举措。

6、热泵冬季循环采集地下 10 度以上地能或空气中的能源等可再生能源能量，通过热泵的“搬运”功能将温度提升到 50 度左右来保证室内 20 度左右的温度，从能源品位上看应用更为合理。而不是传统燃烧化石能源上千度的高温来保证 20 度的需求，从能源品位合理应用的角度，燃烧化石能源的高温更应该放到所需的工业场景，热泵取暖能源供需品位相当，是“道德用能”，是城市文明的体现。

7、热泵高效清洁取暖可以实现完善的数字化精准控制、实现智慧供暖，通过物联网、大数据等技术实现远程监控、智能调节和能源优化配置，提高能源利用效率。同时，热泵系统运行数据可以为城市能源规划、基础设施建设提供重要参考，推动城市治理体系和治理能力现代化，是便捷高效的智慧城市的重要组成。

三、政策护航与企业实践：携手共建现代化人民城市

基于热泵在我国城市建设和能源结构转型中的重要角色，国家发展改革委会同工业和信息化部、生态环境部等多部门联合印发的《推动热泵行业高质量发展行动方案》（发改环资〔2025〕313 号），为热泵产业发展提供了强有力的政策支撑。这一政策红利不仅为相关企业发展注入了强劲动力，更为产业转型升级指明了路径。《行动方案》从四个维度构建保障体系：在建设保障方面，支持将热泵纳入地方供热规划，优化开发利用办理流程；在政策支持方面，发挥政府投资带动效应，结合大规模设备更新和消费品以旧换新支持热泵推广；在标准引领方面，完善热泵全链条标准体系；在国际合作方面，鼓励参与国际标准制定和能效互认。这些政策措施形成了全方位、多层次的支持体系，为企业开展技术研发、市场拓展和国际合作提供了广阔空间，政策支持体系的不断完善为热泵产业发展创造了良好环境。

中央城市工作会议强调“城市的核心是人，关键是十二个字：衣食住行、生老病死、安居乐业”，热泵清洁取暖热冷一体化新兴绿色循环产业正是从“住”的维度，为实现居民安居乐业提供了有力保障。

恒有源科技发展集团有限公司作为热泵清洁取暖热冷一体化新兴绿色循环产业中的一员，始终坚持创新驱动发展战略，在技术研发、产品制造、市场应用等方面取得了显著成效。企业以原始创新技术为核心，融合国际通用地能采集和热泵技术，集成创新了三个取暖系统，全面满足新时代北方地区冬季取暖的需求，践行“能源生产和消费革命、农村生活方式革命”。企业将以习近平新时代中国特色社会主义思想为指导，深入贯彻落实中央城市工作会议精神，按照《推动热泵行业高质量发展行动方案》要求，进一步加大技术研发投入，攻克关键核心技术，提升产品质量和服务水平，加入到建设现代化人民城市这一项系统工程当中，践行“人民城市人民建，人民城市为人民”的理念，以推动热泵清洁取暖热冷一体化新兴绿色循环产业发展为己任，为建设创新、宜居、美丽、韧性、文明、智慧的现代化人民城市贡献更多力量，与社会各界携手共创美好未来。

适用于农村建筑分间取暖的恒有源地能热宝系统模块产品介绍

作者：刘宝红

恒有源地能热宝系统（简称地能热宝）是专为北方城镇郊区和农村建筑开发的浅层地能分户取暖系统，通过少量花钱的电能搬运大量温度相对恒定的不花钱的浅层地热能为建筑物冬季供暖，兼有夏季制冷，同时可提供生活热水，是地能无燃烧为建筑物智慧取暖的电高效替煤自采暖系统。

地能热宝每房间都是一套独立系统，按需启停，遥控器操作，温度可在 16°C -32°C区间控制，可以人在哪屋开哪屋设备，不在不开，方便行为节能，取暖成本相当于燃煤的成本。

一、系统的特点

• 方便行为节能

每个房间都是一套独立系统，可以人在哪屋开哪屋设备，不在不开，方便行为节能。

• 省心、省事、省钱、省能

运行安全无燃烧；遥控器分间控制；费用约为燃煤 38%；能耗约为燃煤 15%（费用及能耗均为海淀区罗家坟村郑氏家数据）。

• 稳定供暖

不受恶劣天气影响，低温天气稳定供暖，供暖温度有保证。

• 模块化设计与制造，安装简单

模块产品工厂预制 + 现场拼装，安装简单可复制。

二、系统类型及成套模块产品

地能热宝按采能方式分为单井循环换热集中采能分布式用能的地能热宝系统（单井循环换热集中、安全、高效、省地采集浅层地能，分户用能，又称单井循环换热地能热宝系统）和地埋管换热分户采能地能热宝系统（地埋管换热分散采集浅层地能，自己采能自己用，又称地埋管换热地能热宝系统）。

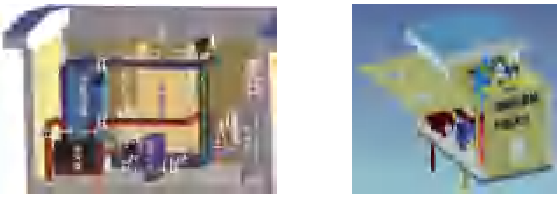

图 1 二次网循环模块产品（适用于单井循环换热地能热宝系统）

图 2 二次网循环模块产品（适用于地埋管换热地能热宝系统）

图 3 三次网循环模块产品（通用）

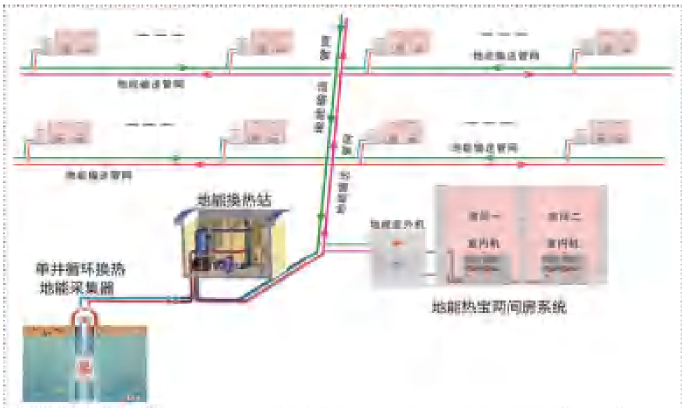

图 4 单井循环换热地能热宝系统示意图

2.1 单井循环换热地能热宝系统

单井循环换热地能热宝系统由一次网循环、二次网循环和三次网循环组成，标准系统制热量有 500kW、1000kW、2000kW 三个规格，分别对应 100 户、200 户、500 户村。系统示意图见图 4，标准系统成套模块产品见表 1。

单井循环换热地能热宝系统适用于砾石地质项目，单井循环换热可实现集中、安全、高效、省地采集浅层地能。系统集中采集浅层地热能，分户用能，用户每平方米一个冬季需要分摊 5-10kWh 的公共能源电耗。

表 1 单井循环换热地能热宝系统成套模块产品表

系统型号	HYY II		500	1000	2000
制热量	kW		500	1000	2000
循环	模块名称	参数			
一次网	/	采集功率（kW）	500	1000	2000
二次网	换热器模块	换热面积（m^2）	100	200	400
		进出口总管径	DN125	DN150	DN250
		承压	1.6MPa		
	二次循环模块	循环流量（m^3/h）	100	200	400
		单泵功率（kW）	7.5-18.5		
		循环泵模块扬程（m）	12-20		
		水泵数量	2-3 台（含备用泵）		
		承压	1.6MPa		
		主管管径	DN125	DN150	DN250
	定压补水模块	水箱容积（m^3）	1	2	10
		稳压罐容积（L）	40	80	200
		补水流量（m^3/h）	2	4	10
		定压范围	0.2-0.3MPa，选型时需向本公司咨询		
	配电柜模块	配电量（kW）	45-160kW，选型时需向本公司咨询		
		控制	潜水泵、二次泵变频控制		
三次网	地能热宝机组	适配型号	DNV-I-56、DNW-I-35+35、DNV-I-75、DNV-I-280AN8		
	三次网配件		铜管标配长 5m 或根据项目热宝机组型号适配		
	电气配件		根据项目热宝机组型号适配		

注：部分参数（如定压范围、配电量、地能热宝机组型号）需根据具体项目情况选型，请咨询本公司技术人员，电话 +86-400-655-8899。

2.2 地埋管换热地能热宝系统

地埋管换热地能热宝系统由二次网循环和三次网循环组成，标准系统制热量有 5.6kW、7.4kW、7.6kW、30kW 四个规格，单个系统可覆盖取暖房间数量 2-10 间，用户可根据需求多个系统组合应用。系统示意图见图 5，系统成套模块产品见表 2。

地埋管换热地能热宝系统适用于非砾石地质项目，地埋管换热分散采集浅层地能，自己采能自己用，实现 100% 分户计量。选用过程中需注意地质条件与采集浅层地热能初始成本关联度高；换热效率低，地能采集敷设占地面积大。

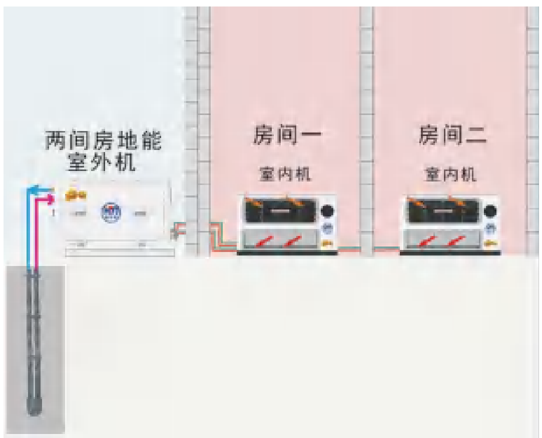

图 5 地埋管换热地能热宝系统示意图

表 2 地埋管换热地能热宝系统成套模块产品表

系统型号	HYY II	5.6	7.4	7.6	30
制热量	kW	5.6	7.4	7.6	30
电源	V	220			380
功率	kW	1.5	2	2	9
循环	模块名称				
二次网	竖孔地埋管成套产品	SK-4	SK-6/2		SK-4*6
		孔深 100m、U 型 De32 管			
	二次循环模块	GM-B-0.5、HM-0.5 接口 DN25（内丝）			ECXHB-24 流量 $6m^3/h$、扬程 17m、接口 DN50
	补水定压产品	BSDY-SD 容积 4L、De32 热熔口			BSDY-1-10 流量 $1m^3/h$、扬程 10m、接口 DN20
	二次网配件	PJXH2-5.6	PJXH2-6/2		PJXH2-4*6
		PE 管连接件			
三次网	地能热宝机组	DNV-I-56	DNW-I-35+35	DNV-I-75	DNV-I-280AN8
		工质 R410A	工质 R22	工质 R410A	工质 R410A
		水路接口 DN25			水路接口 DN32
	三次网配件	PJXH3-5.6	PJXH3-7.4	PJXH3-7.6	PJXH3-30
		6.35/9.52	6.35/12.7	6.35/9.52	12.7/25.4
		铜管标配长 5m			铜管、分歧管，根据项目适配
	电气配件	PJDQX-5.6	PJDQX-7.4	PJDQX-7.6	PJDQX-30
		电源线长 1.5m、控制线长 9m			电源箱、电线（根据项目适配）

注：HYY II -30 型号铜管、分歧管等需根据具体项目情况适配，请咨询本公司技术人员，电话 +86-400-655-8899。

三、产品鉴定与能效

地能热宝连续入选《北京市 2015 年节能低碳技术产品推荐目录》(详见京发改〔2015〕1354 号文)、《北京市 2020 年节能低碳技术产品推荐目录》(详见京发改〔2020〕1889 号文)，获得政府节能主管部门的认可与推广。

地能热宝核心产品地能热泵变频机组（又称地能热宝机组，图 6 为地能热宝机组一级能效标识）全年综合性能系数 ACOP（热泵型）高达 5.25，高于国家标准 GB19577-2024 一级能效值 4.4。

图 6 地能热宝机组一级能效标识

从华北电力大学体育中心项目浅谈热泵热冷同时供应系统的应用及系统能效分析

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摘要：热泵热冷同时供应系统是将热泵的吸热端（蒸发器）和放热端（冷凝器）两端进行应用，同时满足建筑供热和制冷的需求。研究该系统在华北电力大学体育中心项目中的应用，介绍系统组成，提出“热泵热冷同时供应系统性能系数（$COP_{sys\ (h+c)}$）”的概念，并对其进行对比分析，得出热泵热冷同时供应系统与热泵系统单一供热或供冷相比，性能系数能够大幅度的提高，实现节能效益，此方式是进一步挖掘热泵系统节能潜力的重要措施和研究方向。

关键词：热泵、性能系数、热回收、热泵热冷同时供应系统性能系数（$COP_{sys\ (h+c)}$）

引言

热泵具有高效节能特点，使其在供热制冷领域中得到了广泛的应用。近年来随着科技的发展和技术的进步，其运行可靠性和能效比都有了很大程度的提升，热泵技术已经成为目前供热制冷领域应用中的首选技术。

热泵的本质是一种热量的搬运设备，热泵系统是集热泵、水泵、管道阀门等组成的热量搬运系统。热泵系统把热量从一端搬运至另一端，吸收热量的一端（蒸发器）体现为制冷功能，放出热量的一端（冷凝器）体现为供热功能。目前热泵系统的应用多为对其中一端功能的应用，要么用其放出热量的一端用来供热，要么用其吸收热量的一端用来制冷。由于热泵的特性，一端放热，必然有另一端吸热，反之亦然，在对一端功能进行应用时，其另一端的功能就白白浪费掉了，如果考虑将这部分浪

费掉的功能也进行利用，即两端（一端热一端冷）的热冷同时应用，必然能够带来较大的经济效益。而且，从提升热泵系统能效方面考虑，目前热泵系统中热泵机组、循环水泵等主要耗能设备的能效水平已经很高，很难有大幅度的提升空间。采用热冷同时供应能够直接提高热泵系统能效，是今后热泵技术应用的一个重要发展方向。

本文简述热泵热冷同时供应系统的原理、几种常用的方式，并结合华北电力大学体育中心项目的实际案例，分析热泵热冷同时供应系统在实际应用中的能效情况。

一、热泵热冷同时供应系统

1.1 热泵热冷同时供应系统原理

热泵热冷同时供应系统主要是在热泵夏季制冷时，对系统排热回收利用，达到减少整个系统能耗的目的。对于个别在冬季供热时有制冷需求的系统，也可以实现对冬季制冷量的利用，但是后者应用较少（例如建筑内区冬季需要空调制冷的情形等），且其与前者排热利用原理大同小异，本文着重介绍前者的方式。

热泵系统夏季制冷运行时，其吸热端（蒸发器）吸收空调制冷系统的热量，将空调制冷系统的循环水温度由 12°C降低到 7°C，满足空调制冷的需求；其放热端（冷凝器）将系统排热释放至室外环境中（如室外空气、土壤砂石、地表水等），完成整个制冷循环。整个过程中没有对空调排热加以利用，使其完全浪费掉。热泵热冷同时供应系统在不改变吸热端（蒸发器）的前提下，将热泵的放热端（冷凝器）连接至用户端，比如生活热水加热、泳池池水加热、空调系统再热等，通过调整放热端（冷凝器）的温度，使其满足用户的需求，将原来排放至室外环境中的排热回收利用，达到热泵热冷同时供应的目的。

系统运行时，与单独供热或单独制冷比较，消耗了同等的电能，但是同时满足了供热和供冷两个功能需求，其系统能效得到了大幅度的提升，实现了节能降费的目的。

1.2 系统的优势

（1）一套热泵系统的投资满足了供热和供冷两个功能，节省了初始投资。

（2）消耗同等的电能，实现了供热和供冷两个功能，系统能效得到了大幅度的提升，降低了系统的能耗，实现了节能降费的目的。

1.3 系统的应用条件

（1）建筑中有同时供热和供冷的需求场景，且其温度需求在热泵运行的稳定工况范围内；

（2）建筑用热量和用冷量相匹配，能够满足热泵稳定运行的要求。

1.4 系统的应用方式

在对热泵夏季制冷排热的回收利用时，根据热回收量的大小，分为全热回收方式和部分热回收方式。从系统设计方面划分，分为系统热回收设计和热回收热泵机组两种方式。

（1）全热回收方式

全热回收方式是在热泵系统空调不变时，将其放热端（冷凝器）排热全部进行回收利用的形式。这种形式回收的热量大，能够满足一定的稳定用热需求，比如生活用水加热、泳池池水加热、空调再热等，也能带来较大的经济效益，本文重点介绍全热回收的方式应用。

全热回收方式，可采用系统热回收设计和热回收热泵机组两种方式。系统热回收设计时，系统采用常规的热泵机组，通过系统管道设置切换阀门的方式实现热量回收（详见下图 1）；热回收热泵机组即机组本身自带热回收功能（热泵设置两个放热端（冷凝器）），可以通过管道直接与不同需求侧连接实现热量回收，无需进行水路管道的切换（详见下图 2）。

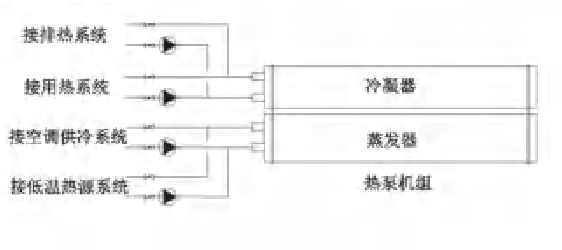

图 1

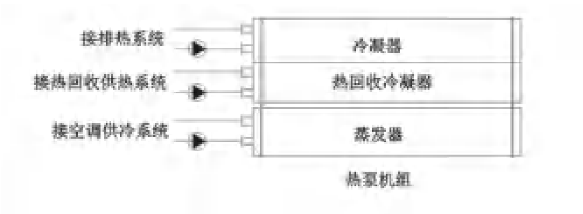

图 2

（2）部分热回收方式

部分热回收方式是在热泵系统空调制冷时，将其放热端（冷凝器）排热的一部分进行回收利用，一般为回收其排热的高温部分。

在热泵的运行过程中，工质在放热端（冷凝器）由高温高压的气体变为高温高压的液体过程中实际分为三个阶段：高温气体的冷却段、气体变为液体的冷凝段和液体的过冷段，部分热回收主要是回收高温气体在降温冷却过程中释放的显热，此部分热量的温度较高，但其总量较小，约占冷凝放热总热量的 10%-15%，一般应用在有较小热量需求的场景中，比如提供洗手盆热水等，本文对此种方式的应用不做重点介绍。

1.5 热泵热冷同供应机组的性能系数分析

根据能量守恒定理，在热泵搬运热量的过程中，有以下等式成立：

$$Q_h=Q_c+N \qquad (1)$$

$$Q_h+Q_c=Q_h+（Q_h-N）$$

$$Q_{(h+c)}=Q_h+Q_c=Q_h+Q_h-N=2Q_h-N \qquad (2)$$

$$COP_{(h+c)}=\frac{Q_{(h+c)}}{N}=\frac{2Q_h-N}{N}=2\,COP-1 \qquad (3)$$

$$COP=\frac{Q_h}{N} \qquad (4)$$

式中：

COP——热泵机组制热性能系数；

$COP_{(h+c)}$——热泵热冷同时供应性能系数；

Q_c——制热工况，热泵机组吸热端（蒸发器）的吸热量（即热泵机组的制冷量）（kWh）；

Q_h——制热工况，热泵机组的制热量（kWh）；

$Q_{(h+c)}$——热冷同时供应工况，热泵机组的制冷量和制热量（kWh）；

N——热泵机组供热工况的耗电量（kWh）；

目前行业内，热泵机组的性能系数 COP 一般都在 3.5 以上，结合以上推导可知，热泵热冷同时供应时，热泵机组整体的性能系数 $COP_{(h+c)}$ 可以达到 6 以上，与单独供热时比较，有大幅度的提高，能够实现更大的节能效益。

二、在华北电力大学体育中心项目的应用案例

2.1 项目简介

华北电力大学体育中心室内场馆主要包含游泳馆、篮球馆和羽毛球馆，设计中央空调系统满足冬季供暖和夏季制冷需求。

项目总供暖负荷 2579kW，空调制冷负荷 3007kW，生活热水最大小时热负荷 400kW，泳池池水加热负荷 700kW（其中维温加热负荷 350kW）。

2.2 项目方案

项目原设计采用燃气锅炉房满足供暖、生活热水及泳池池水用热需求，采用电制冷机组结合冷却塔满足空调制冷需求。考虑后期运行成本及节能减排的要求，通过优化设计，采用地源热泵系统替代原燃气锅炉 + 电制冷的方案。

项目夏季空调制冷的同时，有生活热水和泳池池水加热的持续用热需求，具备同时供热和供冷的场景，可以进行热冷同时供应的设计；另外项目空调制冷负荷为 3007kW，远大于生活热水和泳池池水加热持续用热负荷 1100kW 的需求，能够满足热泵稳定运行的要求，因此该项目具备热泵热冷同时应用的条件。因此，在优化设计中，采用了热泵热冷同时供应的方式，设计全热回收的形式满足了生活热水及泳池池水加热需求。

项目全热回收热泵系统采用水路切换的方式，热泵机组吸热端（蒸发器）与空调制冷系统和地源系统连接，放热端（冷凝器）与生活热水及泳池池水加热系统连接。在夏季运行时，热泵机组吸热端（蒸发器）与空调制冷系统之间阀门开启，与地源系统之间阀门关闭，将空调制冷排热全热回收利用，实现热泵热冷同时供应；在其余季节运行时，热泵机组吸热端（蒸发器）与空调制冷系统之间阀门关闭，与地源系统之间阀门开启，热泵机组开启制热模式运行，满足生活热水及泳池池水加热需求。

经过优化计算，项目供热供冷同时供应热泵机组小时供热量为 550kW，其中生活热水设计热泵机组小时供热量为 200kW，泳池池水加热设计热泵机组小时供热量为 350kW，热泵系统供热温度为 50°C。

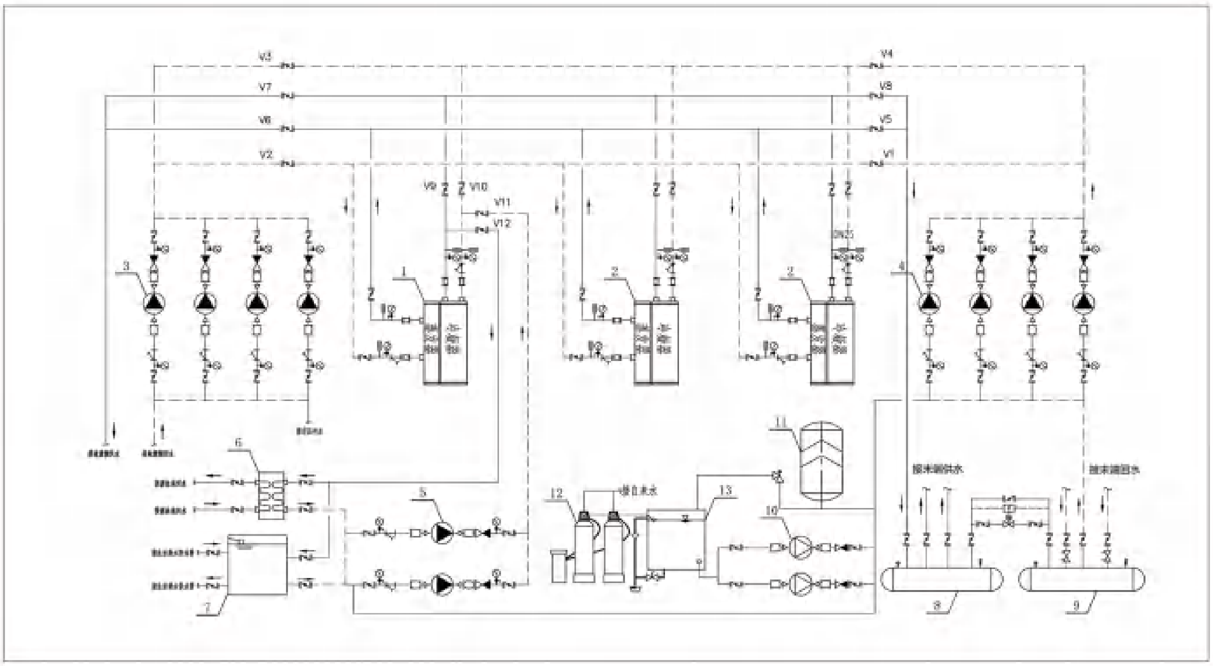

图 3 项目系统图

1—热冷同时供应热泵机组；2—冬季供暖夏季制冷热泵机组；3—地源侧循环泵；4—末端侧循环泵；5—生活热水及泳池池水加热热源循环泵；6—泳池池水加热换热器；7—生活热水箱；8—末端系统分水器；9—末端系统集水器；10—补水定压泵；11—定压罐；12—软化水装置；13—软水水箱

阀门切换说明：

冬季供暖及过渡季运行：V1、V3、V5、V7 开启；V2、V4、V6、V8 关闭

夏季制冷运行：V2、V4、V6、V8 开启；V1、V3、V5、V7 关闭

生活热水及泳池池水加热运行：V9、V10 开启；V11、V12 关闭

2.3 系统运行策略

项目生活热水和泳池池水加热需求相对稳定，为保证热泵稳定运行，项目设计热泵机组采用制热模式运行，并根据生活热水和泳池池水加热需求自动调整热泵机组压缩机运行比例，使其供热量实时满足用热需求。由于项目的用冷量远大于项目的用热量，热冷同时供应系统的制冷量不足以满足项目的全部用冷需求，其不足部分由其他热泵机组进行补充调节，以保证满足空调制冷的需求。

三、系统能效分析

3.1 系统参数

目前国家及相关行业规范，已经对热泵系统单独供热及单独制冷时的系统能效比做了定义：热泵系统制热性能系数（COP_{sys}）、系统制冷能效比（EER_{sys}），但对热泵热冷同时供应时的系统性能系数还没有统一定义，因此本文提出，在热泵系统热冷同时供应时，系统的性能系数定义为“热泵热冷同时供应系统性能系数（$COP_{sys\ (h+c)}$）[1]”，

本文主要对比分析热泵系统单独供热时制热性能系数（COP_{sys}）或单独供冷时制冷能效比（EER_{sys}）与热泵热冷同时供应系统性能系数（$COP_{sys\ (h+c)}$）的情况，为简化计算，在计算制热性能系数、制冷能效化时简化采用热泵设计工况运行一个小时的数据。热泵单独制热性能系数、热泵单独制冷能效比与热泵热冷同时供应系统性能系数计算按照以下简化公式计算：

$$EER_{sys} = \frac{Q_{sc}}{\sum Ni+\sum Nj} \tag{5}$$

$$COP_{sys} = \frac{Q_{sh}}{\sum Ni+\sum Nj} \tag{6}$$

$$COP_{sys\ (h+c)} = \frac{Q_{s\ (h+c)}}{\sum Ni+\sum Nj} = \frac{Q_{sc}+Q_{sh}}{\sum Ni+\sum Nj} \tag{7}$$

式中：

EER_{sys}——热泵系统制冷能效比；

COP_{sys}——热泵系统制热性能系数；

$COP_{sys\ (h+c)}$——热泵热冷同时供应系统性能系数；

Q_{sc}——制冷工况，热泵系统的累计制冷量（kWh）；

Q_{sh}——制热工况，热泵系统的累计制热量（kWh）；

$Q_{s\ (h+c)}$——热冷同时供应工况，热泵系统的累计制热量和制冷量（kWh）；

∑Ni——系统对应运行工况运行时，所有热泵机组耗电量（kWh）；

∑Nj——系统对应运行工况运行时，所有水泵耗电量（kWh）。

注[1]：COP 为 Coefficient Of Performance 缩写，表示性能系数；sys 为 System 系统缩写，表示系统；h 为 heat 缩写，表示制热；C 为 cool 缩写，表示制冷。

3.2 设备参数

表 1 系统参数表

参数	热泵系统单独供冷工况	热泵系统单独供热工况	热泵系统热冷同时供应工况
热泵机组制冷量（kWh）	517	-	442.7
热泵机组制热量（kWh）	-	648.2	648.2
热泵吸热端（蒸发器）供回水温度（℃）	7℃ /12℃	7℃ /12℃	7℃ /12℃
热泵放热端（冷凝器）供回水温度（℃）	35℃ /30℃	50℃ /45℃	50℃ /45℃
热泵机组运行功率（kWh）	91.1	160.3	160.3
地源侧循环水泵功率（kWh）	15	15	-
末端侧循环水泵功率（kWh）	15	-	15
生活热水及泳池池水加热循环水泵功率（kWh）	-	7.5	7.5

3.3 系统能效比对比分析

表 2 系统能效计算表

参数	热泵系统单独供冷工况	热泵系统单独供热工况	热泵系统热冷同时供应工况
Q_{sc}（kWh）	517	-	487.9
Q_{sh}（kWh）	-	648.2	648.2
$Q_{s(C+H)}$（kWh）	-	-	1030.8
∑Ni（kW）	91.1	160.3	160.3
∑Nj（kW）	30	22.5	22.5
EER_{sys}	4.27	-	-
COP_{sys}	-	4.04	-
$COP_{sys(h+c)}$	-	-	6.21

通过计算可以看出，在热泵系统单独供冷时，系统能效比 EER_{sys} 为 4.27，在热泵系统单独供热时，系统性能系数 COP_{sys} 为 4.04，在热泵系统热冷同时供应时，热泵热冷同时供应系统性能系数 $COP_{sys(h+c)}$ 为 6.21。

热冷同时供应系统性能系数较单独供冷提高 45.4%，较单独供热提高 53.7%，显然热泵热冷同时供应系统性能系数有显著的优势，与本文 1.5 中理论分析基本一致，证明热泵热冷同时供应系统确实具有较大的节能优势。

从以上计算数据还可以看出，热泵热冷同时供应系统性能系数不是简单的系统能效比 EER_{sys} 和系统性能系数 COP_{sys} 相加，因为在热冷同时供应时，要考虑用热端和用冷端两端的温度需求，进而影响热泵机组本身耗电量，而且热冷同时供应时，对应的水泵运行功率也与热冷分别供应时不同，影响其性能系数。

四、结语

对热泵热冷同时供应系统的原理、应用方式的研究，并结合其在华北电力大学体育中心项目的应用实例，对其系统能效进行分析对比，得出以下结论：

1、在进行热泵系统对建筑供热供冷设计时，应详细分析建筑用热用冷需求，在有条件的前提下，尽可能采用热泵热冷同时供应系统，节省初始投资和运行费用；

2、应用热泵热冷同时供应系统的关键是建筑用热和用冷可以与热泵本身运行相匹配，以保证系统运行稳定；

3、在进行热泵热冷同时供应系统设计时，应选用合理的系统形式，实现较大的经济效益；

4、目前，热泵单独供热或单独制冷系统的系统能效提升空间已经很小，热泵热冷同时供应系统与其单独供热供冷比较，性能系数有较大幅度的提高，此方式是进一步挖掘热泵系统节能潜力的重要措施和研究方向。

西山林场管理处改造工程

作者：王学志

一、项目简介

西山林场管理处位于北京市海淀区西山森林公园，总建筑面积3600平方米，建筑物功能属办公楼建筑。该建筑原供暖（冷）系统建于2012年，采用地埋管+冷却塔热泵系统，室内采用风机盘管系统，冷热源机房配置1台YSSR-200AG和1台HT200A/2地能热泵机组。

由于原供暖（冷）系统运行时间较长，管道老化严重，部分地埋管竖孔能量采集装置出现故障，因无法维修，使得系统供热（冷）量无法满足正常需求，同时设备老化也导致系统故障频繁、设备运行噪声大，严重影响办公楼内的日常办公。

二、项目技术方案

1、受场地面积及布局的限制，区域内已不能布置足够的地埋管竖孔能量采集装置，因此建设单位选择了适合城镇集中供暖的恒有源地能热泵环境系统，该系统采用了恒有源原创——单井循环换热地下水100%回灌系统技术，省地、高效、环保。结合本工程所处的地理位置与地质条件，最终确定在办公楼后面的绿地内布置了4套型号为CJXH-80的单井循环换热地下水100%回灌系统技术，单套系统的地能采集功率80kW，循环水量16m^3/h。

2、拆除室外冷却塔及配套设备，解决噪音及水量损失的问题。

3、根据系统评估结果，确定需要更换的老旧设备，如热泵主机、循环水泵等。选用高效节能、性能可靠的新型设备，实现设备升级。

4、采用先进的智能控制系统，实现对热泵主机、水泵、阀门等设备的精确控制和优化运行。集成远程监控功能，方便实时监测和管理系统运行，实现控制系统升级。

5、水泵等设备安装减震器，机房内部安装隔音材料，机房门更换为隔音性能良好的隔音门，对机房内孔洞、缝隙进行密封处理。

三、项目实施

本项目于2025年3月15日开工，2025年4月23日完工，建设工期40天。

改造后系统于2025年5月20日开始进行制冷运行，至今已稳定运行近120天。经现场多日观测，取得了以下运行效果：

1、室内温度在23℃～25℃之间。

2、机房门外噪声不高于50dB，末端室内噪声不高于39dB，日常办公不再受其影响。

3、运行期间，设备正常，未发生任何故障。

4、实现了单井循环地下水100%回灌。

此外，本工程采集井施工采用了恒有源原创的一次性成井技术，将井管通过钻头直接安装到设计深度（井深72米）。利用压缩空气排除孔内岩屑残渣，取代了传统的钻井液，不需要泥浆护壁，不需要填充滤料，提高了井周边地层的渗透系数，在保护场地周边环境的同时解决了施工作业场地面积较小的问题。

四、项目完工照片

采能系统占地面积小

采能系统隐于绿化中

机房安装隔音材料

机房更换水泵、安装减震垫

中国科学家发现KPF6全温区压卡效应，或将革新供暖/制冷行业

本刊编辑部综合报道

在供暖/制冷技术的发展历程中，科学家们不断探索创新，力求突破传统技术的局限。今年八月，中国科学院金属研究所的科研团队取得了一项重大突破，他们在无机塑晶材料六氟磷酸钾（KPF6）中首次发现了全温区压卡效应。这一发现不仅在基础科学研究领域具有重要意义，更为供暖/制冷行业的发展带来了新的曙光。

一、压卡效应：制冷技术的新希望

传统的供热/制冷机组采用热泵技术，是通过气体压缩和膨胀来实现热量的转移。这种技术虽然应用广泛，但存在能耗高、有害气体排放等问题，而且其效率受到气体循环系统复杂性的限制。随着全球对节能减排和环境保护的日益重视，开发新型高效、环保的供暖/制冷技术迫在眉睫。

固态相变热量转移技术应运而生，成为备受关注的替代方案之一。其核心原理是利用固体材料在外界施加不同“场”（如磁场、电场或压力）时，材料内部结构（即“相”）发生变化，这个过程会吸收或释放热量，从而实现制冷或供暖。根据施加“场”的不同，可分为磁卡效应（用磁场控制相变）、电卡效应（用电场控制相变）、弹卡效应（用机械应力控制相变）以及压卡效应（用压力控制相变）。

然而，在过去，这些固态相变方法都面临一个共同的关键技术瓶颈：传统固态相变材料仅能在室温附近极窄的温区内发生压力诱导相变，效应范围非常有限。为了实现较宽温区的连续供热/制冷，科学家们不得不将多个具有不同相变温度的材料串联起来，形成多级热量转移装置。但这种方式极大地增加了系统的复杂性，无论是从设计、制造还是维护的角度来看，都带来了诸多难题。

二、重大突破：KPF6的全温区压卡效应

中国科学院金属研究所的团队经过深入研究，在无机塑晶材料KPF6中取得了突破性进展。他们首次观察到了“全温区压卡效应”，这意味着通过施加压力，KPF6能在从室温（约25°C）到液氦（-269°C）的极低温区实现压卡效应。KPF6成为了迄今为止唯一的全温区固态相变供暖/制冷材料。

从微观结构来看，KPF6在室温常压下呈现面心立方结构，其内部的六氟磷酸（PF6）分子团可以自由地随机旋转。当温度降低时，它会经历两次内部结构变化，也就是相变，转变为不同的单斜结构。而对这些不同结构施加压力，又均会转变为另外一种菱方结构。正是这些丰富且有序的相变过程，伴随显著的吸热或放热效应，使得KPF6能够实现极宽的供热/制冷温区覆盖。

三、全温区压卡效应的重大意义

这一发现从根本上改变了固态相变供热/制冷依赖“多材料组合”的传统研发思路。过去为了实现宽温区供暖/制冷，复杂的多级装置不仅成本高昂，而且效率难以提升。现在，KPF6 一种材料即可覆盖全温区，大大简化了系统的设计和构建。这对于推动供热/制冷技术的发展具有里程碑式的意义，为开发新一代高效、环保的全固态技术打开了全新大门。

在环保方面，传统气体压缩技术使用的制冷剂往往存在温室气体排放问题，对全球气候变化产生负面影响。而 KPF6 作为固态材料，在工作过程中无温室气体排放，从源头上解决了制冷剂泄漏对环境的危害，为实现绿色低碳供暖/制冷提供了切实可行的方案。

从理论能效角度来看，固态相变过程直接吸热，其理论能效比传统热泵技术有显著提升，有望大幅降低设备的能耗，符合全球节能减排的大趋势。这对于能源紧张的现状来说，无疑是一个重大利好消息。

四、对供暖/制冷行业的深远影响

对于供暖/制冷行业而言，KPF6 全温区压卡效应的发现犹如一场及时雨，将带来一系列深刻变革。

首先，在产品设计和制造方面，现有的供暖/制冷设备由于采用热泵技术实现热量转移，需要压缩机、冷凝器、节流阀等复杂部件，导致设备体积较大、结构复杂。而基于 KPF6 的全固态制冷/供暖装置采用压卡技术实现热量转移，系统得以极大简化，有望开发出更轻薄、紧凑的供暖/制冷产品。这不仅可以节省安装空间，对于一些对空间要求苛刻的场所，如小型公寓、精密仪器室等，具有极大的吸引力；同时，也有利于降低设备的制造成本和维护难度。

其次，在能效和运行成本上，如前文所述，KPF6 的固态相变制冷理论能效更高。未来应用该技术的供暖/制冷设备，在运行过程中将消耗更少的电能，从而降低用户的电费支出。对于商业建筑和大型公共场所的集中式供暖/制冷系统来说，长期的节能效益将十分可观。这不仅有助于企业降低运营成本，还能提升企业的社会形象，符合可持续发展的理念。

再者，从环保合规角度，随着全球环保标准日益严格，传统供暖/制冷设备因制冷剂问题面临越来越大的合规压力。而采用 KPF6 全固态技术的产品，无温室气体排放，更容易满足环保法规要求，在市场竞争中具有明显的优势。

此外，KPF6 全温区压卡效应还可能催生新的应用场景和产品形态。例如，开发出能够适应极端温度环境的特种供暖/制冷设备，为航空航天、极地科考、深海探测等特殊领域提供可靠的温度控制解决方案；或者设计出具有智能调节功能的个性化供暖/制冷产品，根据室内环境和用户需求实时调整制冷和制热效果，提升用户的舒适度。

中国科学院金属研究所科研团队发现的 KPF6 全温区压卡效应，为供暖/制冷行业带来了前所未有的发展机遇。尽管从实验室研究到大规模商业化应用还需要克服一系列工程化难题，如材料的规模化生产、高压驱动系统的优化、系统集成技术的研发等，但这一重大突破无疑为行业的未来发展指明了新的方向。相信在不久的将来，基于 KPF6 全固态的供暖/制冷产品将走进我们的生活，为我们带来更高效、环保、舒适的室内环境。

Personage Interview —— Mr. Wu Desheng

Profile

Wu Desheng, male, born in 1939 in Changzhou, Jiangsu Province, is a member of the Communist Party of China, a professor-level senior engineer, and a seasoned expert in HVAC and building equipment engineering education. He previously served as Vice Chairman of the Chinese Association of Refrigeration, President, Party Committee Secretary, and Chief Engineer of Beijing Institute of Architectural Design, and currently holds the position of Advisory Chief Engineer at the institute. For many years, he has been the Director of the Higher Education Building Environment and Equipment Engineering Professional Evaluation Committee of the Ministry of Housing and Urban-Rural Development (formerly the Ministry of Construction), a member of the Education Certification Committee of the Ministry of Education, a standing director of the Architectural Society of China, Vice Chairman of the HVAC Branch of the Architectural Society of China, Chairman of the Beijing Civil Engineering and Architectural Society, and advisor to the Editorial Board of Building Energy & Ventilation Air Conditioning.

Professional Experience: In 1957, he was admitted to the Department of Civil Engineering at Tsinghua University. From 1963 to 1992, he held positions as an engineer, chief engineer, and director of engineering in the field of architectural design. From 1992 to 2003, he served as President of the Beijing Institute of Architectural Design, among other leadership roles. Since 2003, he has been the Advisory Chief Engineer. He has led and directed the design of over 30 large-scale engineering projects, participated in the design of important landmarks such as Beijing International Mansion, Capital Mansion, and Oriental Plaza, and led the compilation of the venue design planning section of Beijing's bid to host the 2008 Olympic Games, making significant contributions to the successful bid. He has been honored with titles such as National Outstanding Design Institute President, Outstanding Communist Party Member, and the National May 1 Labor Medal. He has long served as a teaching supervisor and guest professor at Tsinghua University, Xi'an Jiaotong University, and other institutions.

Mr. Wu has dedicated the most valuable years of his life to China's architectural industry and is also an advocate for the application of clean and renewable energy in building heating and cooling. On September 8, 2025, Mr. Wu Desheng participated in a remote interview with our magazine's interview team. Now at the age of 86, his conversation remains profoundly philosophical and highly logical, demonstrating exceptional professional competence and extensive management experience. Our interview team presents the main content of the conversation with Mr. Wu in a Q&A format for our readers' appreciation.

Interviewer: The recent urban work conference convened by the central government has sparked enthusiastic responses in the architectural sector. What do you think is the relationship between the conference's goal of building a modern people-centered city and the industry's frequently mentioned "efficient and clean heating using geothermal heat pumps in northern winters, and the development of an emerging green circular industry integrating heating and cooling"?

Mr. Wu Desheng: The core of building a modern people-centered city lies in the integration of "people-oriented" and "sustainable development", which aligns deeply with the geothermal heat pump technology and the emerging green circular industry integrating heating and cooling promoted by our HVAC industry, forming a "goal-means" synergy. From the design practices of the Great Hall of the People to the National Centre for the Performing Arts, we have always pursued the principle of "architecture serving people": meeting the constant temperature needs of large venues while avoiding the pollution and energy consumption issues associated with traditional heating methods. The "people-centered city" emphasized by the central government today essentially requires buildings to upgrade from "functional fulfillment" to "quality enhancement", and geothermal heat pump technology is a key enabler of this upgrade. It addresses the crux of people's livelihoods of clean heating in northern winters while achieving efficient energy use through "integrated heating and cooling", which is entirely consistent with the "low-carbon priority and people-centered" direction of urban development.

The "Work Plan for Accelerating Energy Conservation and Carbon Reduction in the Construction Sector" issued by the National Development and Reform Commission in 2024 explicitly supports the application of geothermal energy, further demonstrating that the industry's technological path has been incorporated into the national strategic framework. We often say that "the HVAC profession is the 'respiratory system' of buildings". A modern people-centered city requires a healthy and efficient "respiratory system", and green technologies such as geothermal heat pumps are the core skeleton of this system.

Interviewer: As the "dual carbon" goals advance, heating and cooling systems, as core components of building energy consumption, face pressure for low-carbon transformation. What do you think are the prospects for developing and utilizing shallow geothermal energy in this field?

Mr. Wu Desheng: The "dual carbon" goals have significantly propelled the development and utilization of shallow geothermal energy. From a technical perspective, shallow geothermal energy boasts strong stability and zero carbon emissions, making it particularly suitable for winter heating and summer cooling needs in northern regions. This aligns with the concept of "energy cascade utilization" that our industry has long advocated.

I have always believed that the world's energy resources are not scarce. To create a comfortable living environment, we should not resort to burning fossil fuels, which leads to adverse atmospheric pollution. Shallow geothermal energy is a rational choice. New energy sources are continuously being discovered, and energy-consuming equipment is constantly advancing in energy efficiency. These evident facts support my perspective.

The development of shallow geothermal energy must not only overcome technical challenges but also establish a full-chain system of "R&D–application–operation and maintenance" to translate technology into tangible emission reduction results. In the future, with advancements in energy storage technology and intelligent regulation, the synergistic use of shallow geothermal energy, solar energy, and biomass energy will become a critical direction for the low-carbon transformation of buildings.

Interviewer: You have presided over or participated in the design of heating and cooling systems for iconic buildings such as the Great Hall of the People and the National Centre for the Performing Arts. These projects are highly unique in terms of spatial structure and functional requirements. What were the biggest technical challenges you faced at the time, and how did you ultimately balance the contradiction between "architectural aesthetics" and "practicality in heating and cooling system design"?

Mr. Wu Desheng: The technical challenges of these two projects essentially revolved around "breaking through the constraints of architectural form to achieve the symbiosis of function and aesthetics". Taking the Great Hall of the People as an example, the super-large spaces of the ten-thousand-seat auditorium and the five-thousand-seat banquet hall placed extremely high demands on the uniformity and stability of heating and cooling–the biggest challenge we faced at the time was how to arrange sufficient heat exchange equipment without compromising the building's solemn style. Ultimately, through a composite system of "stratified air supply + radiant heating", we not only ensured indoor temperature fluctuations were controlled within ±1°C but also cleverly concealed the equipment within the ceiling and wall structures, achieving an "invisible system with perceptible comfort".

The challenges of the National Centre for the Performing Arts were even more unique. Its shell-shaped design, the "Pearl in the Lake", presented three major problems: first, the curved titanium metal plate exterior made it impossible to install traditional air conditioning outdoor units; second, the 32.5-meter-deep underground stage area required solving the problem of deep soil heat exchange; third, the landscape pool needed to meet both the aesthetic requirements of "no freezing in winter and no algae growth in summer" and energy utilization efficiency. To address these issues, our team adopted an innovative "HYY Geothermal Heat Pump System (optimal for urban centralized heating)", using the underground rock and soil mass beneath the theater as a cold and heat source and employing integrated heating and cooling units. This not only met the architectural aesthetic requirements but also achieved efficient energy use. When balancing aesthetics and practicality, we always adhered to the principle that "architectural form serves functional needs, and system design integrates into the architectural fabric": for example, combining the splicing nodes of titanium metal plates and glass with air conditioning vents, making technical equipment part of the architectural aesthetics rather than an opposing element. These practices also made me deeply realize that true technological breakthroughs are often born in the process of meeting extreme demands.

Interviewer: You have held positions as President, Party Committee Secretary, Chief Engineer, and Advisory Chief Engineer at the Beijing Institute of Architectural Design for many years. You have spent your entire life in the architectural industry with outstanding achievements. As a senior in the field, what suggestions do you have for improving the current state of architectural disciplines?

Mr. Wu Desheng: I believe the current situation in the architectural discipline is one of rapid development, with new circumstances constantly emerging. Some past practices need to be revised. We can engage in revolutionary thinking and changes regarding the functions and structures of architectural disciplines in universities, as well as the roles of architectural design institutes. We all know that there are no buildings, equipment, or decorations that do not age. Therefore, maintenance and component replacement are normal and unavoidable processes. Shouldn't making fault detection and handling more direct be the top priority? Shouldn't people's aesthetic concepts be established in this direction? Who says all pipes in buildings must be hidden? This is the reasonable direction for revolutionary development that I hope to see. As for the project initiation of new constructions, the most important thing to avoid is initiating projects for which there is no construction necessity. Building an unnecessary structure is the most wasteful and counterproductive act. Such rationality assessments can only be achieved through scientific collaboration among various professionals. The institutions, methods, and work experience for this still require innovative collective efforts.

Interviewer: You have long been committed to talent cultivation in the industry, particularly the development of young people. Many of your works on young people's cultivation and physical and mental health are deeply appreciated by them. From your experience, what abilities do young HVAC engineers most need to hone today? What qualities did you value most in team members when you led teams in the past?

Mr. Wu Desheng: The progress of world science and technology has already placed new demands on the professional orientation and efforts of young people. However, the educational principles for nurturing youth should not be shaken but instead strengthened. The best development goal for every young person is to "become the best version of themselves". This is both a principle that varies from person to person and a beautiful state of happy work and life for everyone. Therefore, when helping young people, we must absolutely avoid using phrases like "you shouldn't" or "you must not". We should, as much as possible, adopt an open approach, allowing them to freely pursue their goals at every stage of their lives as they age. Reflecting on my own life, the periods where I made the most progress were experienced in this way.

When I led teams in the past, I valued two qualities the most in team members: First, "sense of responsibility". HVAC systems are related to the safety and comfort of buildings; any parameter error could lead to serious consequences. For example, if the heating system of the Great Hall of the People were to fail, it would affect the normal conduct of state affairs. This requires team members to be meticulous and willing to take responsibility. Second, "courage to innovate". But this innovation is not a blind pursuit of novelty; it is a rational breakthrough based on engineering practice. For example, our adoption of China's innovative single-well circulation geothermal energy collection technology at the National Centre for the Performing Arts was achieved through thorough research and repeated demonstration. Additionally, I particularly emphasized "physical and mental health and humanistic cultivation". HVAC engineers should not only understand technology but also comprehend the relationship between buildings and people just as I often mention, "good design should make users unaware of the technology's presence, only experiencing comfort and convenience". I hope young people can both root themselves in engineering practice and maintain a passion for life, achieving professional value in the balance between technology and humanity.

At the end of the interview, Mr. Wu once again spoke in a grave and earnest tone, saying:

I am now an 86-year-old man. If anyone is still willing to listen to my views on certain issues, it moves and gratifies me deeply, as these exchanges all relate to the profession I have devoted my life to and passionately love.

In recent years, I have also been following developments in world informatization and digitization. I have great confidence in its role, but this has not diminished my own enthusiasm and confidence for thinking and innovation. In this frame of mind, I often write drafts. Both to leave some insights for interested colleagues in the industry and to ensure my remaining years are fulfilling and meaningful. A phrase from an ancient text comes to mind: "It's not up to Heaven alone, to lengthen or shorten our day. To a great age we can live on,If we keep fit, cheerful and gay."

Thank you to all the readers of this article.

Editor's word

Mr. Wu cited two lines of classical poetry here: "It's not up to Heaven alone, to lengthen or shorten our day. To a great age we can live on,If we keep fit, cheerful and gay. "Our search indicates that these lines are from Cao Cao's Four-character yuefu poems "Indomitable Soul" which constitutes the fourth section of his poetic series "Strolling Out of the Xia Gate". The following Chinese poetic verses are omitted.

Key Implementation Points of the Single-well-circulation Heat Exchange System with 100% Groundwater Recharge

Author: Wang Xuezhi

I. Technology Overview

The Single-well-circulation heat exchange System with 100% groundwater recharge is an original technology developed in Zhongguancun, Beijing. It efficiently and environmentally collects shallow geothermal energy to replace fossil fuels for heating. Using groundwater as a medium, it circulates and extracts shallow low-temperature heat stored in underground rock and soil layers. Through a sealed and pressurized system, 100% of the groundwater is reinjected into the same well, ensuring no consumption or pollution of groundwater resources. The heating effect remains relatively stable and unaffected by weather conditions, guaranteeing warmth for the vast population in northern China even under the most extreme climate conditions. The Single-well-circulation heat exchange System with 100% groundwater recharge is classified by structure into Geothermal Energy Collection Well Without Heat Exchange Particles and Geothermal Energy Collection Well With Heat Exchange Particles, as shown in Fig.1 and Fig.2.

II. Technical Principle

The Single-well-circulation heat exchange System with 100% groundwater recharge utilizes a sealing device to divide the geothermal energy collection well into three zones, from top to bottom: the pressurized water return zone, the sealed zone, and the water extraction zone. Well water is extracted by a submersible pump located in the water extraction zone and transported to the geothermal heat pump unit for heat exchange. After heat exchange, the water is returned to the pressurized water return zone. Under pressure, it enters the surrounding rock and soil through the filter pipes in the upper part of the collection well, conducting heat exchange from top to bottom. The water then re-enters the water extraction zone through the filter pipes in the lower part of the collection well, where it is extracted again by the submersible pump, completing the cycle of shallow geothermal energy collection.

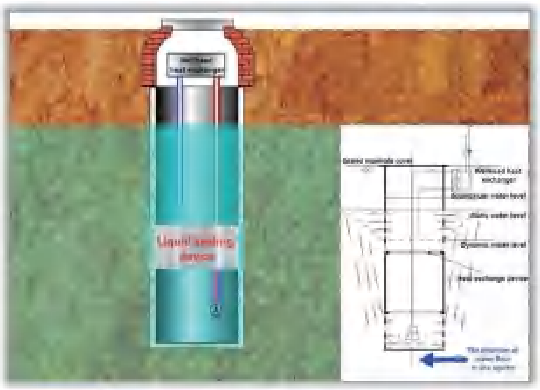

Fig.1 Geothermal Energy Collection Well Without Heat Exchange Particles

Fig.2 Geothermal Energy Collection Well With Heat Exchange Particles

III. Technical Features

1. The system operates in a closed loop (sealed without aeration), utilizing water as a circulating "medium", ensuring no impact on regional groundwater quality while maintaining high environmental efficiency.

2. Through system pressurization, 100% same-well reinjection is achieved, resolving challenges associated with groundwater reinjection and effectively mitigating potential geological hazards such as land subsidence and sand migration.

3. Single-well configurations offer flexible layout options with a small footprint, enabling efficient energy extraction and addressing urban core constraints such as high building density and limited available space for energy collection.

4. The technology is mature and reliable, with some projects having operated stably for up to 24 years.

IV. Technical Support

In 2012, relevant departments of the Beijing Municipal Government issued the Technical Code for Single Well of Geothermal Energy Collection with Circulation Heat Exchange, establishing unified standards for the design, construction, acceptance, and operational maintenance of a Single-well-circulation heat exchange System with 100% groundwater recharge. This has enhanced the technology's reliability and stability.

Over the years, EVER SOURCE SCIENCE & TECHNOLOGY DEVELOPMENT GROUP CO., LTD. (HYY) has conducted extensive trials on shallow geothermal energy collection under various geological conditions. The company has mastered the Single-Well Circulating Groundwater 100% Reinjection low-temperature geothermal energy system, adaptable to diverse strata such as pebble gravel, rock, and silt. Tailored to the specific conditions of various buildings, the system efficiently extracts ubiquitous shallow low-temperature geothermal energy (below 25°C) stored beneath the "three-foot-deep frost layer". A single system can achieve a geothermal energy collection capacity of up to 500 kW. Additionally, the company's products are modularized, allowing scientific customization and rapid installation based on project requirements.

V. Construction Management

Prior to construction, hydrogeological conditions at the project site are thoroughly investigated. Data on stratigraphic lithology, water level, water volume, and groundwater flow direction are analyzed in detail. The well depth, structure, and materials are meticulously planned, resulting in comprehensive design drawings for the collection well. Based on these drawings, site conditions, and project timelines, a detailed construction organization plan is developed to ensure adequate preparation of personnel, materials, equipment, and funds.

Materials delivered to the site are inspected to ensure compliance with quality, specification, and quantity requirements. Technical briefings are conducted to ensure construction personnel fully understand the design drawings and installation requirements. The construction process is strictly controlled to guarantee that well depth, diameter, and verticality meet specifications, welds are robust and defect-free, and well flushing is performed until water runs clear and sand-free. Post-construction commissioning ensures compliance with design standards. In summary, quality control is rigorously enforced, responsibilities are clearly assigned, and well construction quality is guaranteed to meet design requirements.

Construction methods are selected based on project-specific geological conditions:

1. For pebble gravel and rock formations, HYY's innovative one-time well completion process is used. This method involves installing well pipes directly to the design depth via a drill bit. Compressed air is utilized to remove rock debris from the borehole, replacing traditional drilling fluid. This eliminates the need for mud wall protection and filter material filling, enhances the permeability coefficient of the surrounding strata, reduces the construction footprint, and minimizes environmental impact.

2. For unstable layers such as quicksand, the direct circulation drilling process is employed. Circulation mud is injected through the drill pipe, and drill cuttings, being lighter than mud, float to the top and are discharged. Although efficiency is lower, the thickened mud aids in borehole wall stabilization, preventing collapse.

3. For rock layers, gravel, and compact soil, the reverse circulation drilling process is used. The drill pipe extracts mud mixed with drill cuttings while supplementary mud is added at the top to maintain liquid levels and ensure borehole stability. This approach drastically reduces the redundant work associated with re-grinding drill cuttings, thereby significantly enhancing drilling efficiency.

VI. Operational Maintenance

A dispatching and operation plan shall be formulated to enable precision management of collection wells through platform-controlled methods. Daily supervision, inspection, and production safety patrols are conducted. Regular well inspections are performed. A rapid and efficient communication mechanism is established to ensure timely reporting and emergency repairs. Depending on geological and operational conditions, measures such as well flushing are implemented to maintain well performance and extend service life.

COMPANY NEWS: EVER SOURCE SCIENCE & TECHNOLOGY DEVELOPMENT GROUP CO., LTD. (HYY) Hosts Beijing Government Delegations, Deepens Discussions on Geothermal Technology and Water Resource Tax

In early June 2025, HYY successively hosted joint inspection teams from the Beijing Municipal Development and Reform Commission (BMRC) and the Beijing Municipal Rural Affairs Commission (BMRAC), as well as delegations from municipal, district, and local tax authorities. The visits focused on in-depth exchanges and field inspections centered on the application and promotion of HYY's core technology: Single-well-circulation heat exchange System with 100% groundwater recharge and issues related to water resource tax collection.

I. BMRC and BMRAC Jointly Explore Technology Application Potential

On June 3, 2025, a delegation led by officials from the Energy Department of the BMRC, accompanied by relevant leaders from the BMRAC, visited HYY.

The meeting began with a detailed presentation by the group on the technological developments and application progress of its systems. This was followed by a comprehensive discussion on the core principles, practical effectiveness, and future prospects of **the Single-well-circulation heat exchange System with 100% groundwater recharge**. The officials showed strong interest in the technology and raised detailed inquiries regarding its key performance indicators and environmental impact.

The delegation highly acknowledged HYY's technological achievements. Furthermore, both sides engaged in thorough discussions on **policies and implementation practices related to water resource tax collection in the context of geothermal energy development**, laying a foundation for future policy communication.

Visit photos

II. Three-Tier Tax Authorities Conduct Field Research on Project Operations and Tax Practices

On June 11, 2025, a joint delegation from the Beijing Municipal Taxation Bureau, Haidian District Taxation Bureau, and Sijiqing Tax Office visited HYY.

To gain deeper insights into the long-term operational benefits and tax practices of the technology, the delegation first conducted field visits to **two benchmark projects that have been stably operating for over 20 years** using the Single-well-circulation heat exchange System with 100% groundwater recharge: the Haidian Foreign Language Experimental School and the Sijixiangshan Residential Community. On-site, the delegation focused on reviewing practical operational data, including **historical operating costs, system stability, and user charging models**.

Following the field inspection, the group delivered a thematic presentation to the tax authorities. During the subsequent discussion, both sides engaged in in-depth communication regarding **water resource tax collection**. The officials received detailed reports on HYY's **shallow geothermal energy collection technology, which achieves "100% groundwater recharge"**, and provided specific guidance and suggestions on **the levying principles, measurement methods, and policy applicability of water resource tax for such technologies**.

Visit photos

These two inspection activities not only affirmed the technical capabilities and contributions of HYY in the development and utilization of shallow geothermal energy by relevant Beijing government departments but also provided valuable communication channels and directional guidance for addressing policy-related challenges in technology promotion. This will contribute to the healthy development of clean energy technologies and the refinement of relevant policies.

Building Modern People-Center Cities by Promoting the Emerging and Green Circular Industry and Achieving Integrated Clean Heating and Cooling with Heat Pumps

Author: Yang Mingzhong

Abstract: The Central Urban Work Conference has set forth ambitious goals for building modern, people-centered cities. The high-efficiency Heat Pump clean heating industry is poised to transform the multi-billion yuan urban heating supply market. Industrial technology is driving five major transformations in urban development and precisely aligns with seven key tasks, supported by policies that facilitate and accelerate industry adoption. Enterprises now face an optimal opportunity to advance the emerging green circular industry, integrating Heat Pump high-efficiency clean heating and cooling systems.

From July 14th to 15th, 2025, the Central Urban Work Conference was grandly held in Beijing, where Chinese President Xi Jinping delivered an important speech. It summarized the achievements of urban development in China since the new era, analyzed the situation facing urban work, and clarified the overall requirements, important principles and key tasks for doing a good job in urban work.

The meeting pointed out that since the 18th National Congress of the Communist Party of China, the Party Central Committee with profound understanding of urban development in China under the new situation, adhered to the Party's overall leadership over urban work, and the principle that the people build the city and the city serves the people, and adhered to the systematic planning of the city as an organic life form, thus promoting revolutionary achievements in urban development. The level of new urbanization and urban development, the level of planning, construction and governance, the level of suitability for business and living, the level of protection and inheritance of historical and cultural heritage, and the quality of the ecological environment in our country have all been significantly enhanced.

The meeting emphasized that, both now and in the foreseeable future, urban work must be guided by the overarching goal of building innovative, livable, beautiful, resilient, civilized, and intelligent modern cities centered on people. The focus is on promoting high-quality urban development, adhering to the principle of connotative growth, and advancing urban renewal as a key approach. Efforts will be made to optimize urban structure, shift growth drivers, enhance quality, promote green transformation, preserve cultural heritage, and improve governance efficiency, all while steadfastly ensuring urban safety. These measures aim to forge a new path of urban modernization with distinct Chinese characteristics.

This conference has set a clear direction for the development of over 690 cities in China, home to a population of 940 million. In this strategic context, the emerging green circular industry–particularly high-efficiency heat pump systems for clean heating and integrated heating and cooling–stands out as a vital force in advancing high-quality urban development through low-carbon technology applications.

I. Industrial Empowerment

China's urbanization is transitioning from a phase of rapid expansion to one of stable, sustainable growth, with the urbanization rate now reaching 67%. The focus of urban development is shifting from large-scale new construction to enhancing the quality and efficiency of existing urban infrastructure through connotative development. This marks a move from an era of massive building to one of governance and renewal. The conference called for a deep understanding of these evolving dynamics, urging a transformation in urban development concepts to prioritize people-centered approaches, shift toward intensive and efficient development models, emphasize distinctive and specialized growth drivers, focus investments on governance, and adopt a more coordinated and balanced approach to urban management.

Within these five major transformations, the emerging green circular industry centered on integrated, high-efficiency heat pump systems for clean heating and cooling can play a pivotal role in supporting high-quality urban development. Heat pumps are highly efficient energy conversion devices that shift the paradigm from "burning fuel" to "transferring heat". By using a relatively small amount of electricity, they convert low-grade thermal energy into usable high-grade heat, achieving energy efficiency far superior to traditional boilers and significantly reducing pollutant emissions. For instance, in North China, electric heat pump replacement projects have achieved an average comprehensive energy savings rate of 31.6% (by equivalent value) and 70.8% (by calorific value). Studies show that, compared to coal-fired boilers, heat pump heating systems can reduce atmospheric pollutant emissions (NO_x, SO_2, and PM2.5) by over 90%, and they also demonstrate substantial reductions in NO_x and PM2.5 compared to gas boilers.

1. The emerging Heat Pump industry for integrated clean heating and cooling ensures buildings are warm in winter and cool in summer, enhancing the comfort of living environments and truly embodying the people-centered approach.

2. Heat Pump technology maximizes energy efficiency and recycling, delivering over three times the heating output from a single unit of electricity. This solution is ideal for distributed heating in urban buildings and can also establish regional networks for both cooling and heating, demonstrating intensive and efficient energy use.

3. Clean heating with Heat Pumps enables cities to expand the use of renewable energy and recover waste heat based on local conditions, reducing reliance on traditional fossil fuels and supporting distinctive urban development.

4. By shifting investments from pollution control related to fossil fuel combustion to proactive investment in clean heating, Heat Pump clean heating fundamentally drives urban progress toward clean and low-carbon development.

5. With unified government leadership and coordinated promotion, high-efficiency Heat Pump clean heating will establish an integrated heating and cooling industry, advancing green circular development.

II. Mission and Responsibility

The Heat Pump Industry Precisely Aligns with Seven Key Tasks of Urban Development

The conference identified seven key priorities for urban development, each of which aligns closely with the strengths of the heat pump industry: Firstly, optimizing the Modern Urban System: Efforts should focus on enhancing cities' overall capacity to support population growth and social-economic advancement. This includes fostering cluster-based, interconnected urban agglomerations and metropolitan areas, promoting urbanization with counties as vital hubs in a targeted manner, advancing the integration of rural migrants into cities, supporting the coordinated development of large, medium, and small cities and towns, and encouraging integrated urban-rural development. Secondly, building Vibrant and Innovative Cities: It is essential to cultivate robust innovation ecosystems that continuously generate breakthroughs in new productive forces. Cities should strengthen their vitality through reform and openness, pursue high-quality urban renewal, and fully leverage their role as nodes in both domestic and international economic flows. Thirdly, developing Comfortable and Convenient Livable Cities: Urban planning must integrate population, industry, urban spaces, and transportation, while optimizing spatial layouts. This includes establishing new models for real estate development, advancing the renovation of urban villages and dilapidated housing, thriving consumer services, elevating public service standards, and safeguarding the baseline of people's well-being. Fourthly, creating Green and Low-Carbon Beautiful Cities: Cities should consolidate environmental governance achievements and implement stronger measures to tackle urban air quality, protect water sources, and manage emerging pollutants. Emphasis should be placed on synergizing pollution and carbon reduction, expanding greenery, and enhancing urban biodiversity. Fifthly, building Safe and Resilient Cities: Progress must continue on critical infrastructure projects that ensure urban safety, such as upgrading old pipelines and limiting the construction of super high-rise buildings. Enhancements to housing safety standards, improved disaster prevention and response systems, comprehensive flood control, and robust social security measures are also vital for maintaining public safety. Sixthly, fostering Virtuous and Civilized Cities: Strengthen the systems for protecting and inheriting historical and cultural heritage. Improve management of city landscapes, safeguard unique historical, geographical, and natural assets, enhance cultural soft power, and elevate civic literacy among residents. Seventhly, advancing Convenient and Efficient Smart Cities: Uphold Party leadership and the rule of law in city governance, innovate in governance concepts, models, and methods, utilize citizen service hotlines, and efficiently address public concerns and challenges.

Across these seven priority areas, the emerging green circular industry centered on high-efficiency heat pump systems for integrated clean heating and cooling serves as a key enabler, supporting the comprehensive "blueprint" for modern urban development and expediting the realization of urban goals in the new era.

1. In building a modern urban system, energy choices for residential heating are pivotal. Fully embracing Heat Pump technology to harness renewable energy for heating stands out as an optimal solution. Its flexible deployment caters to various urban buildings and campus scales, making it highly adaptable.

2. Creating vibrant and innovative cities depends on nurturing a dynamic innovation ecosystem, consistently achieving breakthroughs in new productive forces, and implementing high-quality urban renewal. The high-efficiency, clean heating system offered by Heat Pumps

can seamlessly integrate with existing building heating infrastructure simply replacing fossil fuel sources thereby cultivating new productive forces, spawning a cutting-edge integrated heating and cooling industry, and generating stable industrial employment.

3. High-efficiency Heat Pump clean heating systems significantly enhance indoor comfort for both heating and cooling, supporting the development of comfortable and convenient livable cities.

4. Currently, about 10% of China's total energy consumption is used for building heating, with fossil fuel combustion being a major contributor to carbon emissions. Switching to Heat Pumps enables two-thirds of heating energy consumption to be sourced from green, renewable energy. When powered by green electricity, the entire system can achieve zero carbon emissions. Research from the International Energy Agency (IEA) highlights that modern Heat Pumps are three to five times more energy efficient than natural gas boilers. Even with today's energy mix, replacing fossil fuel boilers with Heat Pumps can substantially reduce greenhouse gas emissions in all major heating markets, a benefit that will grow as the power grid becomes greener. These advantages position the integrated Heat Pump industry as a cornerstone in building green, low-carbon, and beautiful cities. Achieving zero-emission heating is crucial for China's urban development and the realization of the "dual carbon" targets.

5. High-efficiency Heat Pump clean heating dramatically lowers building energy demand. This technology can be combined with solar energy, heat storage, and other multi-energy systems, creating a diversified energy supply and strengthening urban energy resilience, reducing security risks associated with energy supply. Furthermore, the flexible installation and combustion-free operation of Heat Pumps allow them to adapt to different building designs and requirements. With broad application potential in urban renewal, renovation of older residential areas, and other projects, Heat Pumps play a vital role in advancing urban infrastructure safety and are essential for building safe, reliable, and resilient cities.

6. During winter, Heat Pumps cyclically extract renewable energy from underground sources above 10°C or from the air, and, through their unique transfer function, raise the temperature to around 50°C, ensuring indoor environments remain at a comfortable 20°C. From an energy grade perspective, this approach is far more rational than burning fossil fuels at extremely high temperatures just to meet modest heating needs. High-temperature fossil fuels should be reserved for critical industrial uses, while Heat Pump heating matching supply and demand energy grades epitomizes "ethical energy use" and exemplifies urban civilization.

7. High-efficiency Heat Pump clean heating enables comprehensive digital and intelligent temperature control. Leveraging technologies like the Internet of Things and big data, these systems support remote monitoring, intelligent adjustments, and optimized energy management maximizing energy efficiency. Operational data from Heat Pump systems also provide valuable insights for urban energy planning and infrastructure development, advancing the modernization of urban governance and making them a key component of convenient, efficient, and smart cities.

III. Policy Support and Corporate Practice: Jointly Building a Modern People-Centric City

Given the significant role Heat Pumps play in China's urban development and energy transformation, the "Action Plan for Promoting High-Quality Development of the Heat Pump Industry" (F.G.Z.〔2025〕No. 313), jointly issued by the National Development and Reform Commission, the Ministry of Industry and Information Technology, the Ministry of Ecology and Environment, and other departments offers robust policy support for the industry's growth. This favorable policy environment not only energizes related enterprises but also provides a clear roadmap for industrial transformation and upgrading. The Action Plan establishes a comprehensive support framework across four key dimensions. For construction guarantees, it advocates for the inclusion of Heat Pumps in local heating plans and streamlines approval processes for their development and use. In terms of policy backing, it leverages government investment, large-scale equipment upgrades, and the replacement of outdated consumer goods to drive Heat Pump adoption. Regarding standards leadership, it enhances the complete standards system for Heat Pumps. For international cooperation, it encourages participation in formulating global standards and mutual recognition of energy efficiency. Together, these measures create a multi-layered support system, offering ample opportunities for enterprises in research and development, market expansion, and international collaboration. Continuous policy improvements foster an environment conducive to the Heat Pump industry's advancement.

The Central Urban Work Conference emphasized that "the core of a city is its people, and the key lies in twelve words: clothing, food, housing, transportation, birth, aging, illness, death, living and working in peace and contentment." The emerging green circular industry centered on integrated Heat Pump heating and cooling serves as a strong foundation for fulfilling the "housing" dimension of residents' well-being. As a leader in this industry, HYY has consistently followed an innovation-driven development strategy, achieving remarkable progress in technological R&D, product manufacturing, and market applications. Based on the "Three Transformative Substitutions", HYY has independently invented an environmentally friendly and highly efficient geothermal energy collection technology. With this original innovation as its core, and by integrating internationally adopted geothermal collection and heat-pump technologies, HYY has developed three integrated heating systems that comprehensively meet the winter heating needs of northern China in the new era, contributing to the "Energy Production and Consumption Revolution" and the "Rural Lifestyle Revolution". HYY has overcome technical challenges in shallow geothermal energy circulation and recharge, and developed a range of efficient, energy-saving, safe, and intelligent Heat Pump systems widely used in residential, commercial, office, and other sectors.

Guided by the Thought on Socialism with Chinese Characteristics for a New Era, HYY will fully implement the spirit of the Central Urban Work Conference and, in line with the Action Plan's requirements, further increase investment in R&D, overcome critical technological hurdles, and continuously improve product quality and service. The company will actively participate in building a modern, people-centric city, practicing the principle of "a people's city built by the people and for the people". With the mission of advancing the green circular industry of integrated Heat Pump heating and cooling, HYY is committed to contributing to the creation of innovative, livable, beautiful, resilient, civilized, and smart modern cities, working together with all sectors of society for a better future.

Product Introduction of HYY Geothermal Compact Heating Devices for Room-by-Room Heating in Rural Buildings

Author: Liu Baohong

The HYY Geothermal Compact Heating Devices is a shallow geothermal energy-based decentralized heating system specifically developed for buildings in northern towns, suburbs, and rural areas. It utilizes a small amount of electricity to transfer a large quantity of relatively temperature-stable, cost-free shallow low-temperature geothermal energy for winter heating in buildings, while also providing summer cooling and domestic hot water. This system represents an efficient electricity-based, coal-replacing self-heating solution that leverages non-combustion geothermal energy for intelligent building heating.

Each room in the HYY Geothermal Compact Heating Devices operates as an independent system, allowing on-demand activation and deactivation via remote control. The temperature can be adjusted within the range of 16°C to 32°C. The system enables users to activate the device only in occupied rooms, promoting behavioral energy savings. The heating cost is comparable to that of coal burning.

I. System Features

• Facilitates Behavioral Energy Savings

Each room functions as an independent system, allowing devices to be activated only in occupied rooms, which promotes energy-saving behavior.

• Convenient, Effortless, Cost-Effective, and Energy-Efficient

Safe operation without combustion; remote control for room-specific management; operating costs are approximately 38% of coal burning; energy consumption is about 15% of coal burning (data based on the Zheng family in Luojiafen Village, Haidian District).

• Stable Heating

Unaffected by severe weather conditions, ensuring stable heating during low-temperature periods with guaranteed heating temperatures.

• Modular Design and Manufacturing, Simple Installation

Modular products are prefabricated in factories and assembled on-site, ensuring simplicity and reproducibility in installation.

II. System Types and Complete Modular Products

The HYY Geothermal Compact Heating Devices are categorized based on energy extraction methods into two types: the Single Well Circulation Heat Exchange Geothermal Compact Heating Devices (which centrally, safely, efficiently, and space-savingly extracts shallow geothermal energy through single well circulation heat exchange for household energy use) and the Underground Pipe Heat Exchange Geothermal Compact Heating Devices (which dispersedly extracts shallow geothermal energy through underground pipe heat exchange for self-sufficient energy use).

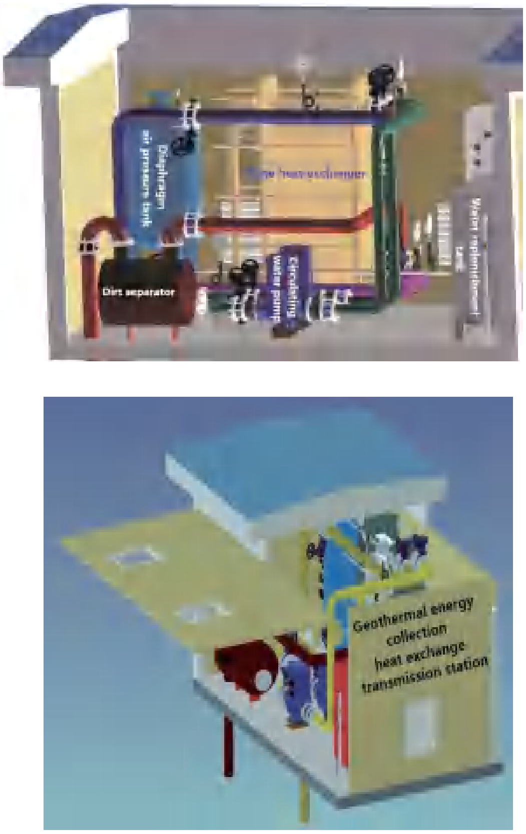

Fig.1 Secondary Network Circulation Module Product (Applicable to the Single Well Circulation Heat Exchange Geothermal Compact Heating Devices)

Fig.2 Secondary Network Circulation Module Product (Applicable to the Underground Pipe Heat Exchange Geothermal Compact Heating Devices)

Fig.3 Third Network Circulation Module Product (Universal)

2.1 Single-Well-Circulation HYY Geothermal Compact Heating Devices

The Single-Well-Circulation HYY Geothermal Compact Heating Devices consists of a primary network circulation system, a secondary network circulation system, and a third network circulation system. The standard system offers three heating capacity specifications: 500 kW, 1000 kW, and 2000 kW, corresponding to villages of 100, 200, and 500 households respectively. A schematic diagram of the system is shown in Fig.4, and the standard system's complete modular product offerings are listed in Table 1.

This system is suitable for projects in gravel geology. The single well circulation heat exchange method enables centralized, safe, efficient, and land-saving collection of shallow geothermal energy. The system centrally collects shallow geothermal energy for distributed, household-level energy consumption. Users require an allocation of 5-10 kWh of public energy electricity consumption per square meter for each winter season.

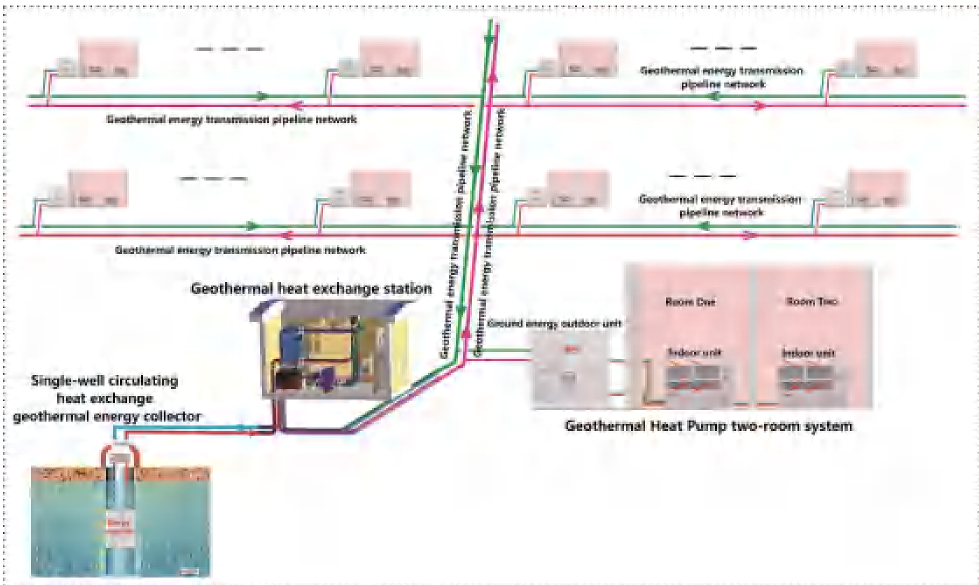

Fig.4 Schematic Diagram of the Single-Well-Circulation HYY Geothermal Compact Heating Devices

Table 1 Complete Modular Product List for the Single-Well-Circulation HYY Geothermal Compact Heating Devices

System Model	HYY II		500	1000	2000
System Model	kW		500	1000	2000
Loop	**Module Name**	**Parameters**			
Primary Network	/	kW	500	1000	2000
Secondary network	Heat exchanger module	Heat exchange area (m²)	100	200	400
		Total diameter of inlet and outlet pipes	DN125	DN150	DN250
		Under pressure	1.6MPa		
	Secondary loop module	Circulating flow rate (m^3/h)	100	200	400
		Single pump power (kW)	7.5-18.5		
		Head of the circulating pump module (m)	12-20		
		The number of water pumps	2-3 units (including backup pumps)		
		Under pressure	1.6MPa		
		Main pipe diameter	DN125	DN150	DN250
	Constant pressure water supply module	Water tank volume (m^3)	1	2	10
		Volume of the pressure stabilizing tank (L)	40	80	200
		Make-up water flow rate (m^3/h)	2	4	10
		Constant pressure range	0.2-0.3MPa. For selection, please consult our company		
	Distribution cabinet module	Distribution capacity (kW)	For power ranging from 45 to 160 kW, please consult our company for selection		
		Control	Frequency conversion control of submersible pumps and secondary pumps		
Triple network	Ground source energy treasure unit	Compatible model	DNV-I-56、DNW-I-35+35、DNV-I-75、DNV-I-280AN8		
	Three-ply network accessories		The standard length of the copper pipe is 5 meters or it can be matched according to the model of the thermal power unit of the project		
	Electrical accessories		Match according to the model of the thermal power unit of the project		

Note: Some parameters (such as pressure maintenance range, power distribution capacity, and Ground Source Energy Treasure unit model) need to be selected based on specific project conditions.

Please consult our technical staff at +86-400-655-8899.

2.2 Underground Pipe Heat Exchange Geothermal Compact Heating Devices

The Underground Pipe Heat Exchange Geothermal Compact Heating Devices consists of a secondary network circulation system (geothermal energy transportation) and a third network circulation system (geothermal energy temperature grade enhancement). The standard system offers four heating capacity specifications: 5.6 kW, 7.4 kW, 7.6 kW, and 30 kW. A single system can cover 2-10 heating rooms, and multiple systems can be combined based on user needs. A schematic diagram of the system is shown in Figure 2, and the system's complete modular product offerings are listed in Table 2.

This system is suitable for non-gravel geology projects. The underground pipe heat exchange method dispersedly extracts shallow geothermal energy for self-sufficient energy use, achieving 100% household metering. During selection, attention must be paid to the high correlation between geological conditions and the initial cost of shallow geothermal energy collection; the heat exchange efficiency is low, and the ground area required for geothermal energy collection is large.

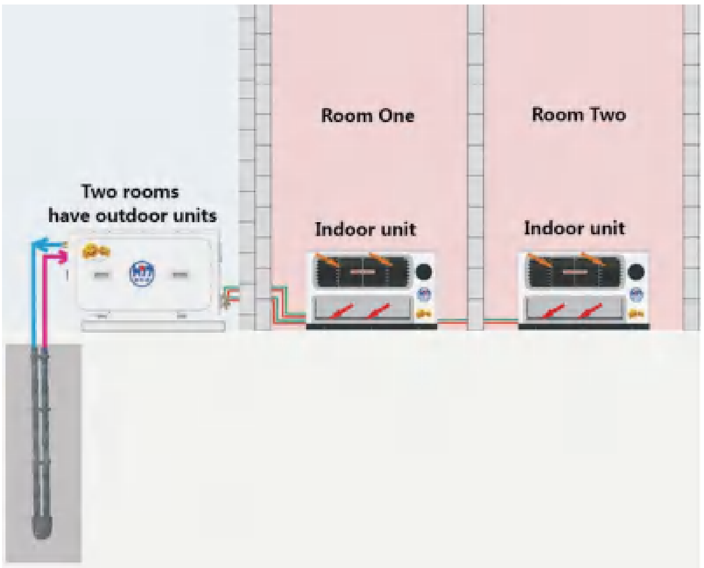

Fig.5 Schematic Diagram of the Underground Pipe Heat Exchange Geothermal Compact Heating Devices

Table 2 Complete Modular Product List for the Underground Pipe Heat Exchange Geothermal Compact Heating Devices

<table>
<tr><th>System model</th><th>HYY II</th><th>5.6</th><th>7.4</th><th>7.6</th><th>30</th></tr>
<tr><td>Calorific value</td><td>kW</td><td>5.6</td><td>7.4</td><td>7.6</td><td>30</td></tr>
<tr><td>Power supply</td><td>V</td><td colspan="3">220</td><td>380</td></tr>
<tr><td>Power</td><td>kW</td><td>1.5</td><td>2</td><td>2</td><td>9</td></tr>
<tr><td>Cycle</td><td>Module name</td><td colspan="4"></td></tr>
<tr><td rowspan="8">Secondary network</td><td rowspan="2">Complete sets of vertical hole buried pipe products</td><td>SK-4</td><td colspan="2">SK-6/2</td><td>SK-46</td></tr>
<tr><td colspan="4">Hole depth 100m、De32 U-shaped tube</td></tr>
<tr><td>Secondary loop module</td><td colspan="3">GM-B-0.5、HM-0.5
Interface DN25 (Inner thread)</td><td>ECXHB-24
Flow rate: 6m³/h, head: 17m, interface: DN50</td></tr>
<tr><td>Water replenishment and pressure stabilizing products</td><td colspan="3">BSDY-SD
Volume: 4L, De32 hot melt port</td><td>BSDY-1-10
Flow rate: 1m³/h, head: 10m, interface: DN20</td></tr>
<tr><td rowspan="2">Secondary network accessories</td><td>PJXH2-5.6</td><td colspan="2">PJXH2-6/2</td><td>PJXH2-46</td></tr>
<tr><td colspan="4">PE pipe connectors</td></tr>
<tr><td colspan="5"></td></tr>
<tr><td colspan="5"></td></tr>
<tr><td rowspan="10">Triple network</td><td rowspan="3">Ground source energy treasure Unit</td><td>DNV-I-56</td><td>DNW-I-35+35</td><td>DNV-I-75</td><td>DNV-I-280AN8</td></tr>
<tr><td>R410A</td><td>R22</td><td>R410A</td><td>R410A</td></tr>
<tr><td colspan="3">Waterway interface DN25</td><td>Waterway interface DN32</td></tr>
<tr><td rowspan="3">Three-ply network accessories</td><td>PJXH3-5.6</td><td>PJXH3-7.4</td><td>PJXH3-7.6</td><td>PJXH3-30</td></tr>
<tr><td>6.35/9.52</td><td>6.35/12.7</td><td>6.35/9.52</td><td>12.7/25.4</td></tr>
<tr><td colspan="3">The standard length of the copper pipe 5m</td><td>Copper pipes and branch pipes are adapted according to the project</td></tr>
<tr><td rowspan="2">Electrical accessories</td><td>PJDQX-5.6</td><td>PJDQX-7.4</td><td>PJDQX-7.6</td><td>PJDQX-30</td></tr>
<tr><td colspan="3">The power cord is 1.5 meters long and the control line is 9 meters long</td><td>Power box, wires (adapted according to the project)</td></tr>
</table>

Note: For model HYY II-30, copper pipes, branch pipes, etc., need to be adapted based on specific project conditions.

Please consult our technical staff at +86-400-655-8899.

III. Product Certification and Energy Efficiency

The HYY Geothermal Compact Heating Devices have been consecutively included in the Beijing Municipal Recommended Catalogue of Energy-Saving and Low-Carbon Technology Products 2015 (refer to Jing Fa Gai〔2015〕No. 1354) and the Beijing Municipal Recommended Catalogue of Energy-Saving and Low-Carbon Technology Products 2020 (refer to Jing Fa Gai〔2020〕No. 1889), receiving recognition and promotion from government energy conservation authorities.

The core product of the HYY Geothermal Compact Heating Devices, the Geothermal Energy Heat Pump Variable Frequency Unit (also known as the Ground Source Energy Treasure Unit; Figure 6 shows the Grade 1 Energy Efficiency Label of the Ground Source Energy Treasure Unit), has an Annual Combined Performance Coefficient (ACOP) for heat pumps as high as 5.25, exceeding the national standard GB19577-2024 Grade 1 energy efficiency value of 4.4.

Fig.6 Grade 1 Energy Efficiency Label of the HYY Geothermal Compact Heating Devices

Discussion on the Application and System Energy Efficiency Analysis of Simultaneous Heating and Cooling Supply System with Heat Pumps from the Case of North China Electric Power University Sports Center Project

Author: Li Yanchao

Abstract: The simultaneous heating and cooling supply system with heat pumps utilizes both the heat-absorbing end (evaporator) and the heat-releasing end (condenser) of the heat pump to simultaneously meet the building's heating and cooling demands. This study investigates the application of this system in the North China Electric Power University Sports Center project, introduces the system composition, proposes the concept of "Coefficient of Performance for Simultaneous Heating and Cooling Supply System with Heat Pumps ($COP_{sys\ (h+c)}$)", and conducts a comparative analysis. It concludes that compared to a heat pump system solely providing heating or cooling, the simultaneous heating and cooling supply system can significantly improve the coefficient of performance, achieving energy-saving benefits. This approach represents an important measure and research direction for further exploring the energy-saving potential of heat pump systems.

Keywords: Heat pump, Coefficient of Performance, Heat recovery, Coefficient of Performance for Simultaneous Heating and Cooling Supply System with Heat Pumps ($COP_{sys\ (h+c)}$)

Introduction

Heat pumps are characterized by high efficiency and energy savings, making them widely used in the fields of heating and cooling. In recent years, with technological advancements and progress, their operational reliability and energy efficiency ratio have significantly improved. Heat pump technology has become the preferred choice in current heating and cooling applications. Essentially, a heat pump is a device that transfers heat, and a heat pump system is a heat transfer system. It moves heat from one end to the other: the end that absorbs heat (evaporator) provides cooling, while the end that releases heat (condenser) provides heating. Currently, most applications of heat pump systems utilize only one of these functions, either using the heat-releasing end for heating or the heat-absorbing end for cooling. Due to the nature of heat pumps, when one end releases heat, the other must absorb heat, and vice versa. When only one function is utilized, the other function is wasted. If this wasted function could also be utilized, simultaneously using both ends (one hot and one cold) it could bring significant economic benefits. Moreover, from the perspective of improving the energy efficiency of heat pump systems, the energy efficiency levels of major energy-consuming equipment such as heat pump units and circulating water pumps in current systems are already very high, leaving little room for substantial improvement. Adopting simultaneous heating and cooling supply can directly enhance the energy efficiency of heat pump systems, representing an important direction for the future application of heat pump technology.

This article briefly describes the principles of simultaneous heating and cooling supply systems with heat pumps, several common methods, and analyzes the energy efficiency of such systems in practical applications using the case study of the North China Electric Power University Sports Center project.

I. Simultaneous Heating and Cooling Supply System with Heat Pumps

1.1 Principle of the Simultaneous Heating and Cooling Supply System with Heat Pumps

The simultaneous heating and cooling supply system with heat pumps primarily involves the recovery and utilization of waste heat discharged by the system during summer cooling operations, thereby reducing the overall energy consumption of the system. For certain systems that require cooling during winter heating operations, it is also possible to utilize the cooling capacity in winter, though such applications are relatively rare (e.g., scenarios where building interior zones require air conditioning for cooling in winter). The principle of waste heat utilization in the latter case is largely similar to the former. This article focuses on the former approach.

During summer cooling operation of a heat pump system, the heat-absorbing end (evaporator) absorbs heat from the air conditioning cooling system, lowering the temperature of the circulating water in the air conditioning cooling system from 12°C to 7°C to meet the cooling demand of the terminal air conditioning system. The heat-releasing end (condenser) discharges the system's waste heat into the outdoor environment (e.g., outdoor air, soil, sand, surface water, etc.), completing the entire cooling cycle. Throughout this process, the waste heat from the air conditioning system is not utilized and is entirely wasted. The simultaneous heating and cooling supply system with heat pumps connects the heat-releasing end (condenser) of the heat pump to the user end without altering the heat-absorbing end (evaporator). Applications include domestic hot water heating, swimming pool water heating, and reheat in air conditioning systems. By adjusting the temperature of the heat-releasing end (condenser) to meet user requirements, the waste heat originally discharged into the outdoor environment is recovered and utilized, achieving the goal of simultaneous heating and cooling supply.

During system operation, compared to standalone heating or cooling, the same amount of electrical energy is consumed, but both heating and cooling functions are simultaneously fulfilled. This significantly enhances the system's energy efficiency, reduces the overall energy consumption of the system, and achieves the purpose of energy savings and cost reduction.

1.2 Advantages of the System

(1) A single investment in a heat pump system fulfills both heating and cooling functions, saving initial costs.

(2) Consuming the same amount of electrical energy, the system achieves both heating and cooling functions, greatly improving energy efficiency, reducing system energy consumption, and realizing energy savings and cost reduction.

1.3 Application Conditions of the System

(1) The building must have scenarios that simultaneously require both heating and cooling, with temperature demands within the stable operating range of the heat pump.

(2) The building's heating and cooling loads must match to ensure stable operation of the heat pump.

1.4 Application Methods of the System

For the recovery and utilization of waste heat discharged during summer cooling operations of heat pumps, based on the amount of heat recovered, the methods can be divided into full heat recovery and partial heat recovery. From a system design perspective, they can be categorized into system heat recovery design and heat recovery heat pump units.

(1) Full Heat Recovery Method

The full heat recovery method involves fully recovering and utilizing the waste heat from the heat-releasing end (condenser) during the air conditioning cooling operation of the heat pump system. This method recovers a large amount of heat, which can meet certain stable heating demands, such as domestic hot water, swimming pool water heating, and air conditioning reheat. It also brings significant economic benefits. This article focuses on the application of the full heat recovery method.

The full heat recovery method can be achieved through either system heat recovery design or heat recovery heat pump units. In system heat recovery design, conventional heat pump units are used, and heat recovery is realized by configuring switching valves in the system pipelines (see Fig.1 below). Heat recovery heat pump units, on the other hand, come with built-in heat recovery functionality (the heat pump is equipped with two heat-releasing ends (condensers)). These units can be directly connected to different demand sides via pipelines to achieve heat recovery without the need for switching water circuits (see Fig.2 below).

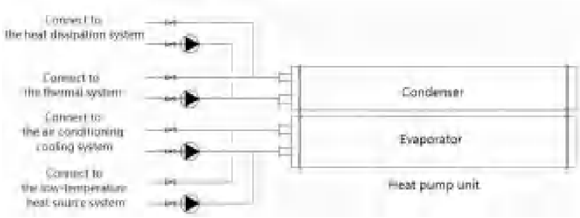

Fig.1

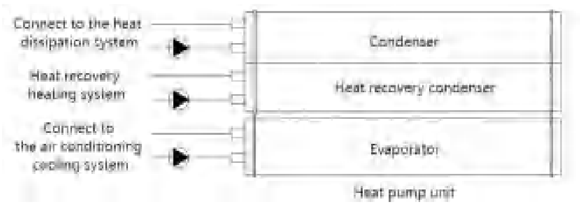

Fig.2

(2) Partial Heat Recovery Method

The partial heat recovery method involves recovering and utilizing a portion of the waste heat from the heat-releasing end (condenser) during the air conditioning cooling operation of the heat pump system, typically focusing on the high-temperature segment of the discharged heat.

During the operation of the heat pump, the working fluid undergoes three distinct phases at the heat-releasing end (condenser) as it transitions from a high-temperature, high-pressure gas to a high-temperature, high-pressure liquid: the cooling stage of the high-temperature gas, the condensation stage where gas turns into liquid, and the subcooling stage of the liquid. Partial heat recovery primarily targets the sensible heat released during the cooling process of the high-temperature gas. This portion of heat has a relatively high temperature but accounts for a small proportion of the total heat released during condensation, typically around 10%-15%. It is generally applied in scenarios with minor heat demands, such as providing hot water for hand basins. This article does not focus on detailing the application of this method.

1.5 Analysis of the Coefficient of Performance (COP) of Units in Simultaneous Heating and Cooling Supply Systems with Heat Pumps

According to the principle of energy conservation, the following equation holds true during the heat transfer process of a heat pump:

$$Q_h=Q_c+N \quad (1)$$

$$Q_h+Q_c=Q_h+(Q_h-N)$$

$$Q_{(h+c)}=Q_h+Q_c=Q_h+Q_h-N=2Q_h-N \quad (2)$$

$$COP_{(h+c)}=\frac{Q_{(h+c)}}{N}=\frac{2Q_h-N}{N}=2\,COP-1 \quad (3)$$

$$COP=\frac{Q_h}{N} \quad (4)$$

In the formula:
COP–Heating coefficient of performance of the heat pump unit;
$COP_{(h+c)}$ –Coefficient of performance during simultaneous heating and cooling supply;
Q_c–Heat absorption at the heat-absorbing end (evaporator) of the heat pump unit under heating conditions (i.e., the cooling capacity of the heat pump unit) (kWh);
Q_h–Heating capacity of the heat pump unit under heating conditions (kWh);
$Q_{(h+c)}$ –Cooling and heating capacity of the heat pump unit under simultaneous heating and cooling conditions (kWh);
N–Power consumption of the heat pump unit under heating conditions (kWh).

Currently, in the industry, the coefficient of performance (COP) of heat pump units is generally above 3.5. Based on the above derivation, it can be concluded that during simultaneous heating and cooling supply, the overall coefficient of performance $COP_{(h+c)}$ of the heat pump unit can reach above 6. Compared to standalone heating, this represents a significant improvement and enables greater energy-saving benefits.

II. Application Case Study at the North China Electric Power University Sports Center Project

2.1 Project Overview

The indoor facilities of the North China Electric Power University Sports Center primarily include a swimming pool, a basketball court, and a badminton court. A central air conditioning system was designed to meet the heating needs in winter and cooling needs in summer.

The total heating load of the project is 2579 kW, the air conditioning cooling load is 3007 kW, the maximum hourly domestic hot water heat load is 400 kW, and the swimming pool water heating load is 700 kW (including a maintenance heating load of 350 kW).

2.2 Project Solution

The original design of the project utilized a gas boiler room to meet the heating demands for space heating, domestic hot water, and swimming pool water heating, while an electric chiller unit combined with a cooling tower was used to meet the air conditioning cooling needs. Considering long-term operational costs and requirements for energy savings and emission reduction, the design was optimized by adopting a ground source heat pump system to replace the original gas boiler + electric chiller solution.

During summer air conditioning cooling, the project has continuous heat demands for domestic hot water and swimming pool water heating, creating a scenario for simultaneous heating and cooling supply. Additionally, the air conditioning cooling load of 3007 kW far exceeds the continuous heat demand of 1100 kW for domestic hot water and swimming pool water heating, ensuring stable operation of the heat pump. Therefore, the project meets the application conditions for simultaneous heating and cooling with heat pumps. Consequently, the optimized design adopted the simultaneous heating and cooling supply method, utilizing a full heat recovery approach to meet the domestic hot water and swimming pool water heating demands.

The full heat recovery heat pump system in the project employs water circuit switching. The heat-absorbing end (evaporator) of the heat pump unit is connected to the air conditioning cooling system and the ground source system, while the heat-releasing end (condenser) is connected to the domestic hot water and swimming pool water heating systems. During summer operation, the valves between the heat-absorbing end (evaporator) of the heat pump unit and the air conditioning cooling system are opened, and the valves connected to the ground source system are closed. This allows for full heat recovery of the waste heat from air conditioning cooling, achieving simultaneous heating and cooling supply. During other seasons, the valves between the heat-absorbing end (evaporator) and the air conditioning cooling system are closed, and the valves connected to the ground source system are opened. The heat pump unit operates in normal heating mode to meet the domestic hot water and swimming pool water heating demands.

Based on optimized calculations, the simultaneous heating and cooling supply heat pump units in the project provide an hourly heating capacity of 550 kW. This includes a designed hourly heating capacity of 200 kW for domestic hot water and 350 kW for swimming pool water heating. The heat supply temperature of the heat pump system is 50°C.

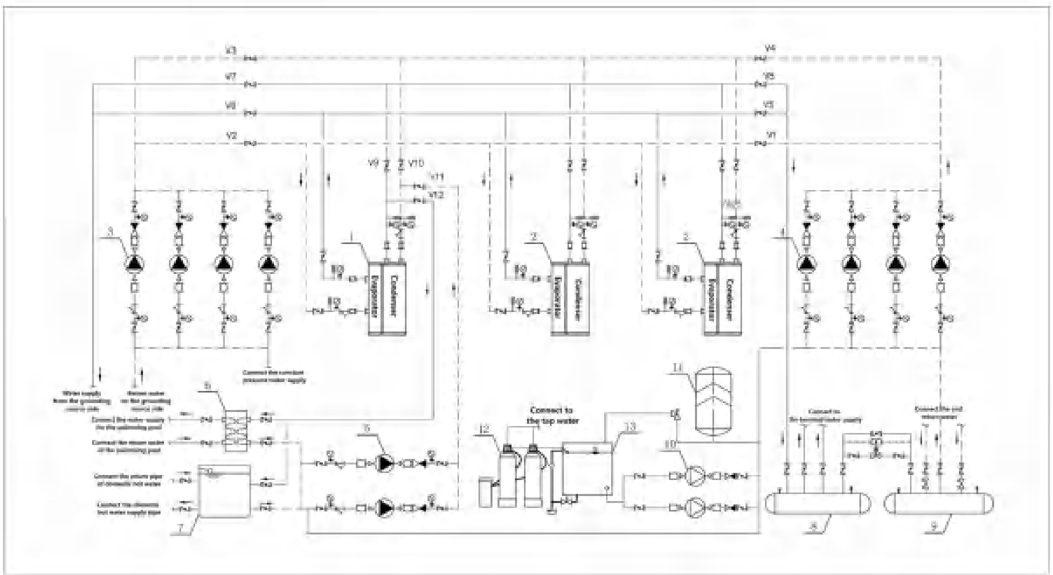

Fig.3 Project System Diagram

1–Simultaneous Heating and Cooling Heat Pump Unit; 2–Heating (Winter) and Cooling (Summer) Heat Pump Unit; 3–Ground Source Side Circulation Pump; 4–End-use Side Circulation Pump; 5–Heat Source Circulation Pump for Domestic Hot Water and Swimming Pool Water Heating; 6–Swimming Pool Water Heating Heat Exchanger; 7–Domestic Hot Water Tank; 8–End-use System Manifold (Supply); 9–End-use System Manifold (Return); 10–Make-up Water and Pressurization Pump; 11–Expansion Tank; 12–Water Softener; 13–Soft Water Tank

Valve Switching Description:

– Winter Heating and Transitional Season Operation: V1, V3, V5, V7 open; V2, V4, V6, V8 closed

– Summer Cooling Operation: V2, V4, V6, V8 open; V1, V3, V5, V7 closed

– Domestic Hot Water and Swimming Pool Water Heating Operation: V9, V10 open; V11, V12 closed

2.3 System Operation Strategy

The demand for domestic hot water and swimming pool water heating in the project is relatively stable. To ensure stable operation of the heat pumps, the project design operates the heat pump units in heating mode. The compressor operation ratio of the heat pump units is automatically adjusted based on the domestic hot water and swimming pool water heating demands to ensure that the heat supply meets the real-time thermal load. Since the cooling demand of the project far exceeds its heating demand, the cooling capacity supplied by the simultaneous heating and cooling system is insufficient to meet the entire cooling requirement of the project. The shortfall is supplemented and regulated by other heat pump units to ensure that the air conditioning cooling demand is fully met.

III. System Energy Efficiency Analysis

3.1 System Parameters

Current national and relevant industry standards have defined the system energy efficiency ratios for heat pump systems operating solely in heating or cooling modes: the heating coefficient of performance (COP_{sys}) and the cooling energy efficiency ratio (EER_{sys}). However, there is no unified definition for the system coefficient of performance during simultaneous heating and cooling operation of heat pumps. Therefore, this paper proposes that during simultaneous heating and cooling operation of a heat pump system, the system's heating coefficient of performance be defined as the "Coefficient of Performance for Simultaneous Heating and Cooling Supply System with Heat Pumps ($COP_{sys\ (h+c)}$)[1]".

This paper primarily compares and analyzes the heating coefficient of performance (COP_{sys}) during standalone heating operation or the cooling energy efficiency ratio (EER_{sys}) during standalone cooling operation with the coefficient of performance during simultaneous heating and cooling operation ($COP_{sys\ (h+c)}$). To simplify calculations, data from one hour of operation under heat pump design conditions is used for computing the heating coefficient of performance and cooling energy efficiency ratio. The calculations for the standalone heating coefficient of performance, standalone cooling energy efficiency ratio, and the coefficient of performance for simultaneous heating and cooling operation are based on the following simplified formulas:

$$EER_{sys} = \frac{Q_{sc}}{\sum Ni+\sum Nj} \quad (5)$$

$$COP_{sys} = \frac{Q_{sh}}{\sum Ni+\sum Nj} \quad (6)$$

$$COP_{sys\ (h+c)} = \frac{Q_{s\ (h+c)}}{\sum Ni+\sum Nj} = \frac{Q_{sc}+Q_{sh}}{\sum Ni+\sum Nj} \quad (7)$$

In the formula:

EER_{sys} – Cooling energy efficiency ratio of the heat pump system;

COP_{sys} – Heating coefficient of performance of the heat pump system;

$COP_{sys\ (h+c)}$ – Coefficient of performance of the heat pump system during simultaneous heating and cooling operation;

Q_{sc} – Cumulative cooling capacity of the heat pump system under cooling conditions (kWh);

Q_{sh} – Cumulative heating capacity of the heat pump system under heating conditions (kWh);

$Q_{s\ (h+c)}$ – Cumulative heating and cooling capacity of the heat pump system under simultaneous heating and cooling conditions (kWh);

$\sum Ni$ – Total power consumption of all heat pump units during operation under the corresponding conditions (kWh);

$\sum Nj$ – Total power consumption of all water pumps during operation under the corresponding conditions (kWh).

Note [1]: COP is the abbreviation for Coefficient Of Performance, sys is the abbreviation for System, h stands for heat (heating), and c stands for cool (cooling).

3.2 Equipment Parameters

Table 1 System Parameter Table

Parameter	The cooling condition of the heat pump system alone	The standalone heating condition of the heat pump system	The heat pump system is in a condition where both heat and cold are supplied simultaneously
Cooling capacity of the heat pump unit（kWh）	517	–	442.7
The heating capacity of the heat pump unit（kWh）	–	648.2	648.2
The supply and return water temperatures at the heat absorption end (evaporator) of the heat pump（°C）	7°C /12°C	7°C /12°C	7°C /12°C
The supply and return water temperatures at the heat release end (condenser) of the heat pump（°C）	35°C /30°C	50°C /45°C	50°C /45°C
Operating power of the heat pump unit（kWh）	91.1	160.3	160.3
Power of the ground source side circulating water pump（kWh）	15	15	–
Power of the terminal side circulating water pump（kWh）	15	–	15
Power of domestic hot water and swimming pool water heating circulation pumps（kWh）	–	7.5	7.5

3.3 Comparative analysis of system energy efficiency ratio

Table 2 System Energy Efficiency Calculation Table

Parameter	The cooling condition of the heat pump system alone	The standalone heating condition of the heat pump system	The heat pump system is in a condition where both heat and cold are supplied simultaneously
Q_{sc}（kWh）	517	–	487.9
Q_{sh}（kWh）	–	648.2	648.2
$Q_{s\ (C+H)}$（kWh）	–	–	1030.8
$\sum Ni$（kW）	91.1	160.3	160.3
$\sum Nj$（kW）	30	22.5	22.5
EER_{sys}	4.27	–	–
COP_{sys}	–	4.04	–
$COP_{sys\ (h+c)}$	–	–	6.21

According to calculations, when the heat pump system operates solely in cooling mode, the system energy efficiency ratio (EER_{sys}) is 4.27. When operating solely in heating mode, the system coefficient of performance (COP_{sys}) is 4.04. During simultaneous heating and cooling operation, the coefficient of performance for the simultaneous heating and cooling supply system ($COP_{sys\ (h+c)}$) reaches 6.21.

The coefficient of performance for the simultaneous heating and cooling supply system increases by 45.4% compared to standalone cooling operation and by 53.7% compared to standalone heating operation. Clearly, the simultaneous heating and cooling supply system demonstrates significant advantages in performance, which aligns closely with the theoretical analysis presented in section 1.5 of this paper. This confirms that the simultaneous heating and cooling application of heat pump systems indeed offers substantial energy-saving benefits.

The calculation data further reveals that the coefficient of performance for the simultaneous heating and cooling supply system is not simply the sum of the system energy efficiency ratio (EER_{sys}) and the system coefficient of performance (COP_{sys}). This is because, during simultaneous operation, the temperature requirements at both the heating and cooling ends must be considered, which affects the power consumption of the heat pump units themselves. Additionally, the operational power of the water pumps during simultaneous heating and cooling differs from that during separate heating or cooling operations, further influencing the performance coefficient.

IV. Conclusion

Through the study of the principles and application methods of simultaneous heating and cooling supply systems with heat pumps, combined with the analysis and comparison of system energy efficiency in the case study of the North China Electric Power University Sports Center project, the following conclusions are drawn:

1. When designing heat pump systems for building heating and cooling, a detailed analysis of the building's heating and cooling demands should be conducted. Where conditions permit, simultaneous heating and cooling supply systems with heat pumps should be adopted to save initial investment and operational costs.

2. The key to applying simultaneous heating and cooling supply systems lies in ensuring that the building's heating and cooling demands match the operational characteristics of the heat pump itself, thereby guaranteeing stable system performance.

3. When designing simultaneous heating and cooling supply systems, reasonable system configurations should be selected to achieve significant economic benefits.

4. Currently, the potential for improving the energy efficiency of heat pump systems operating solely in heating or cooling modes is limited. In comparison, simultaneous heating and cooling supply systems exhibit a substantially higher coefficient of performance. This approach represents an important measure and research direction for further unlocking the energy and saving potential of heat pump systems.

Xishan Forest Farm Management Office Renovation Project

Author: Wang Xuezhi

I. Project Overview

The Xishan Forest Farm Management Office is located in the Xishan Mountain Forest Park, Haidian District, Beijing, with a total floor area of 3,600 square meters. The building functions as an office space. The original heating (cooling) system was constructed in 2012 and utilized a ground heat exchanger + cooling tower heat pump system, with indoor fan coil units. The cold and heat source room was equipped with one YSSR-200AG and one HT200A/2 geothermal heat pump unit.

Due to prolonged operation, the pipeline system has severely aged, and some of the ground heat exchanger vertical borehole energy collection devices have malfunctioned. As these components are beyond repair, the system can no longer meet the heating (cooling) demand. Additionally, aging equipment has led to frequent system failures and high operational noise, significantly disrupting daily office activities.

II. Technical Solution

1. Given the limited available space and layout constraints, it was not possible to install sufficient ground heat exchanger vertical borehole energy collection devices in the area. Therefore, the construction party opted for the HYY Geothermal Energy Heat Pump Environmental System, which is suitable for centralized urban heating. This system employs HYY's proprietary Single-well-circulation heat exchange System with 100% groundwater recharge, offering land efficiency, high performance, and environmental friendliness. Based on the project's geographical location and geological conditions, four sets of CJXH-80 Single-well-circulation heat exchange System with 100% groundwater recharge were installed in the green space behind the office building. Each system has an energy collection capacity of 80 kW and a circulating water flow rate of 16 m^3/h.

2. The outdoor cooling tower and its ancillary equipment were dismantled to resolve issues related to noise and water loss.

3. Based on a system evaluation, outdated equipment such as heat pump units and circulating water pumps were identified for replacement. New, energy efficient, and reliable equipment was selected to achieve system upgrades.

4. An advanced intelligent control system was implemented to enable precise control and optimized operation of heat pump units, water pumps, valves, and other components. Remote monitoring functionality was integrated to facilitate real-time system supervision and management, achieving a control system upgrade.

5. Vibration dampers were installed for water pumps and other equipment, soundproofing materials were added inside the equipment room, soundproof doors were installed, and gaps and openings in the equipment room were sealed.

III. Project Implementation

The project commenced on March 15, 2025, and was completed on April 23, 2025, with a construction period of 40 days.

The renovated system began cooling operation on May 20, 2025, and has been running stably for nearly 120 days. Based on multiple days of on-site observation, the following operational results were achieved:

1. Indoor temperatures were maintained between 23–25℃.

2. Noise levels outside the equipment room did not exceed 50 dB, while indoor noise levels at the endpoints remained below 39 dB, eliminating disruptions to daily office work.

3. All equipment operated normally without any failures during the operation period.

4. The system achieved Single-well-circulation heat exchange System with 100% groundwater recharge.

Additionally, the construction of the energy collection wells utilized HYY's proprietary one-time well completion technology, where well pipes were directly installed to the design depth (72 meters) using a drill bit. Compressed air was used to remove rock debris from the borehole, replacing traditional drilling fluid. This method eliminated the need for mud wall protection and filter material filling, improved the permeability coefficient of the surrounding formation, protected the surrounding environment, and addressed the challenge of limited construction space.

IV. Project Completion Photos

The energy collection system occupies a small area

The energy collection system is hidden among the greenery

Install sound insulation materials in the computer room

Replace the water pump in the computer room and install shock-absorbing pads

Chinese Scientists Discover Full-Temperature-Range Barocaloric Effect in KPF6, Potentially Revolutionizing Heating/Cooling Industry

Comprehensive Report by the Editorial Department

In the evolution of heating and cooling technologies, scientists have continuously explored innovations to overcome the limitations of conventional methods. In August this year, a research team from the Institute of Metal Research, Chinese Academy of Sciences, achieved a major breakthrough: they observed, for the first time, a full-temperature-range barocaloric effect in the inorganic plastic crystal potassium hexafluorophosphate (KPF6). This discovery is not only of great significance in fundamental scientific research but also brings new prospects for the development of the heating and cooling industry.

I. Barocaloric Effect: A New Hope for Cooling Technology

Traditional heating/cooling units employ heat pump technology, which transfers heat through gas compression and expansion. Although widely used, this technology suffers from high energy consumption, emissions of harmful gases, and efficiency limitations due to the complexity of gas cycle systems. As the world places increasing emphasis on energy conservation, emission reduction, and environmental protection, there is an urgent need to develop new, efficient, and eco-friendly heating and cooling technologies.

Solid-state phase-change heat transfer technology has emerged as a promising alternative. Its core principle lies in utilizing solid materials that undergo internal structural changes (i.e., phase transitions) when subjected to external "fields" (such as magnetic, electric, or pressure fields). This process absorbs or releases heat, enabling cooling or heating. Depending on the applied field, these effects are categorized as magnetocaloric (controlled by magnetic fields), electrocaloric (controlled by electric fields), elastocaloric (controlled by mechanical stress), or barocaloric (controlled by pressure).

However, these solid-state phase-change methods have historically faced a common critical bottleneck: traditional solid-state phase-change materials only exhibit pressure-induced phase transitions within an extremely narrow temperature range near room temperature, severely limiting their applicability. To achieve continuous heating/cooling across a broader temperature range, scientists had to cascade multiple materials with different phase transition temperatures, forming multi-stage heat transfer devices. This approach significantly increased system complexity, posing numerous challenges in design, manufacturing, and maintenance.

II. Major Breakthrough: Full-Temperature-Range Barocaloric Effect in KPF6

Through in-depth research, the team at the Institute of Metal Research, Chinese Academy of Sciences, made a groundbreaking discovery in the inorganic plastic crystal KPF6. They observed, for the first time, a "full-temperature-range barocaloric effect", meaning that under applied pressure, KPF6 can exhibit the barocaloric effect across an extremely wide temperature range–from room temperature (around 25°C) down to liquid helium temperatures (-269°C). KPF6 has thus become the only known solid-state phase-change material capable of full-temperature-range heating and cooling.

From a microstructural perspective, KPF6 exhibits a face-centered cubic structure at room temperature and atmospheric pressure, with its internal hexafluorophosphate (PF6) molecular groups rotating freely and randomly. As the temperature decreases, it undergoes two internal structural changes, or phase transitions, transforming into different monoclinic structures. Applying pressure to these different structures causes them to transition into another rhombohedral structure. These rich and ordered phase transition processes, accompanied by significant endothermic or exothermic effects, enable KPF6 to achieve extremely broad heating and cooling temperature coverage.

III. Significance of the Full-Temperature-Range Barocaloric Effect

This discovery fundamentally changes the traditional R&D approach for solid-state phase-change heating/cooling, which relied on "multi-material combinations". In the past, achieving wide-temperature-range heating/cooling required complex multi-stage devices that were not only costly but also difficult to optimize for efficiency. Now, KPF6 alone can cover the entire temperature range, greatly simplifying system design and construction. This is a milestone in advancing heating and cooling technologies, opening new doors for developing a new generation of efficient and environmentally friendly all-solid-state technologies.

Environmentally, traditional gas compression technologies often use refrigerants that contribute to greenhouse gas emissions, negatively impacting global climate change. As a solid-state material, KPF6 produces no greenhouse gas emissions during operation, addressing the environmental hazards of refrigerant leakage at the source and providing a practical solution for green, low-carbon heating and cooling.

From a theoretical energy efficiency perspective, the solid-state phase-change process directly absorbs heat, offering significantly higher theoretical energy efficiency compared to traditional heat pump technology. This promises substantial reductions in energy consumption for equipment, aligning with the global trend of energy conservation and emission reduction. This is undoubtedly positive news given the current energy constraints.

IV. Profound Impact on the Heating/ Cooling Industry

For the heating and cooling industry, the discovery of the full-temperature-range barocaloric effect in KPF6 is a timely breakthrough that will bring about a series of transformative changes.

First, in terms of product design and manufacturing, existing heating/cooling equipment relies on heat pump technology for heat transfer, requiring complex components such as compressors, condensers, and expansion valves. This results in bulky and intricate systems. In contrast, all-solid-state cooling/heating devices based on KPF6 utilize barocaloric technology for heat transfer, greatly simplifying the system. This paves the way for developing thinner, more compact heating and cooling products. This not only saves installation space but is also highly attractive for applications with strict spatial requirements, such as small apartments and precision instrument rooms. Additionally, it helps reduce manufacturing costs and maintenance complexities.

Second, in terms of energy efficiency and operating costs, as mentioned, the theoretical energy efficiency of solid-state phase-change cooling with KPF6 is higher. Future heating/cooling equipment applying this technology will consume less electricity during operation, reducing users' electricity expenses. For centralized heating/cooling systems in commercial buildings and large public spaces, the long-term energy-saving benefits will be substantial. This not only helps businesses lower operational costs but also enhances their social image by aligning with sustainable development principles.

Third, from an environmental compliance perspective, as global environmental standards become increasingly stringent, traditional heating/cooling equipment faces growing compliance pressures due to refrigerant issues. Products utilizing KPF6 all-solid-state technology, with no greenhouse gas emissions, will more easily meet environmental regulations and gain a competitive edge in the market.

Furthermore, the full-temperature-range barocaloric effect in KPF6 may spur new applications and product forms. For example, it could enable the development of specialized heating/cooling equipment capable of operating in extreme temperature environments, providing reliable temperature control solutions for aerospace, polar research, deep-sea exploration, and other specialized fields. It could also lead to personalized heating/cooling products with intelligent adjustment functions, dynamically responding to indoor conditions and user preferences to enhance comfort.

The discovery of the full-temperature-range barocaloric effect in KPF6 by the research team at the Institute of Metal Research, Chinese Academy of Sciences, presents unprecedented opportunities for the heating and cooling industry. Although transitioning from laboratory research to large-scale commercial application will require overcoming several engineering challenges, such as mass production of the material, optimization of high-pressure drive systems, and development of system integration technologies, this major breakthrough undoubtedly points the way forward for the industry. It is believed that in the near future, all-solid-state heating and cooling products based on KPF6 will become part of our daily lives, delivering greater efficiency, environmental sustainability, and comfort.

敬告读者

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We always strive to constantly improve the journal, so as to live up to the expectations of our readers. Undoubtedly, optimizing air quality, energy conservation and emission reduction, and smog control are significant challenges facing all Chinese people today. This journal, "China Geothermal Energy" is designed with the hope of making its contribution to overcoming these challenges.

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