ISSN:2309845 7

2023 年 6 月
第 38 期

半年刊

中國地熱能

CHINA GEOTHERMAL ENERGY

承印人：中国地热能出版社有限公司　　地址：香港中环干诺道中 62-63 号中兴商业大厦 8 楼　　售价：人民币 20 元

中节能咨询有限公司
CECEP Consulting Co.,Ltd.

绿色产业智库 | Green Industry Think Tank

中节能咨询有限公司是中国节能环保集团公司所属专业从事节能环保综合性咨询服务的全资子公司，同时也受集团公司委托，承担“中国节能环保集团公司产业研究中心”这一产业智库的建设任务。公司自 2002 年底成立伊始，就肩负着在节能环保领域为包括中央和各级地方政府提供咨询服务的使命，同时也面向国内外各类企事业单位、国际机构提供优质专业化咨询服务。

近年来，公司完成数百项各级政府及国际机构委托的政策、课题及规划研究项目，同时在火电热电、市政热力燃气、城市固废处理、污水处理、生态建设和环境工程、工业节能、建筑节能和新能源等领域开展了大量项目咨询。

公司累计开展咨询服务 6500 余项，项目涉及投资额超过 9000 亿元，在中国节能环保领域具有很高知名度和良好声誉，被誉为节能环保领域的“智库”。由于成绩显著，公司被发改委、财政部和环保部评为“十一五”节能减排先进单位。

自 2009 年起，公司受集团公司委托，具体承担国资委“中央企业节能减排监测中心”的建设、运维任务，对于我们的出色服务，国资委综合局每年都给集团致信表示感谢。

地址：北京市海淀区西直门北大街42号节能大厦A座16层
信箱：consulting@cecep.cn　　邮编：100082
电话：(010) 83052158　　传真：(010) 83052159
网址：www.consulting.cecep.cn

我们获得的荣誉 | Awards & Recognitions

- 《黑龙江紫金铜业有限公司铜冶炼项目节能评估报告》荣获“2017年度黑龙江省优秀工程咨询成果一等奖”
- 《蕉岭县生活污水处理设施全县捆绑PPP项目》荣获“2016-2017年度广东省优秀工程咨询成果一等奖”
- 《大观净水厂可行性研究报告技术审查报告》荣获“2016-2017年度广东省优秀工程咨询成果三等奖”
- 《湖北华电江陵发电厂一期工程项目申请报告评估报告》荣获“2016 年湖北省优秀工程咨询成果二等奖”
- 《大别山电厂二期2x660MW扩建工程项目申请报告评估报告》荣获“2016年湖北省优秀工程咨询成果优秀奖”
- 荣获国家开发银行信息科技局颁发的“2015年度优秀合作伙伴”
- 《基于环境管理战略转型的产业支撑能力案例评估》荣获“2015 年度北京市优秀工程咨询成果一等奖”
- 《绿色信贷节能环保效益评价系统》荣获“2015 年度北京市优秀工程咨询成果三等奖”

Scopes Of Business | 我们专注的业务

01	Policy and Research Analysis 政策与专题研究	受政府部门、国际机构及企事业单位委托,开展节能、环保、低碳、新能源等领域的政策法规、技术标准、行业规范的研究制定,以及行业现状、发展动态与趋势、投资机会、综合解决方案等方面的专题研究。
02	Planning Consulting 规划咨询	行业发展、区域节能环保、循环经济、低碳发展、新能源开发利用、热电联产、绿色发展、空间、环境、节水等专项规划的编制。
03	Green Financial Services 绿色金融服务	绿色金融政策研究、区域绿色金融体系规划、绿色信用评级体系和相关评估服务、绿色信用调查、绿色项目建设可行性研究、绿色项目管理咨询、绿色项目后评价、ESG 报告编制、金融机构绿色信贷统计管理整体解决方绿色项目后评价、金融机构绿色信贷统计管理整体解决方案构建、绿色项目第三方评估认证、绿色债券存续期跟踪评估。
04	Engineering Consulting 工程咨询	投资机会研究、项目建议书及可研的编制与评估、固定资产投资项目节能评估与审查、项目核准(资金)申请报告编制与评估、初步设计概算审查、融资方案咨询、项目后评价。
05	Third-party Services 第三方业务	作为政府和企业之间的独立第三方,提供包括能源审计、清洁生产审核、节能量审核、碳核查等在内的专业服务。
06	Technology Dissemination 技术推广	主要承担节能、低碳、环保技术推广政策咨询,行业共性技术市场研究,审核、碳核查等在内的专业服务。
07	Information System Services 信息系统开发	为各级政府部门、企业设计开发节能环保综合信息化管理系统,为金融机构开发绿色金融项目环境效益评估系统。

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

恒有源科技发展集团有限公司（简称恒有源集团），是中国节能环保集团公司旗下的中国地热能产业发展集团有限公司（香港上市号 8128.HK，简称中国地热能）在北京的科技实业发展总部。

Ever Source Science and Technology Development Group Co. Ltd. (HYY Group) is the Beijing Head Office for science and technology development owned by China Geothermal Industry Development Group Ltd. (HKEx: 08128, China Geothermal) which is subordinate to the China Energy Conservation and Environment Protection Group.

在京港两地一体化管理框架下，恒有源集团专注于开发利用浅层地能（热）作为建筑物供暖替代能源的科研与推广；致力于原创技术的产业化发展；实现传统燃烧供热行业全面升级换代成利用浅层地能为建筑物无燃烧供暖（冷）的地能热冷一体化的新兴产业；利用生态文明建设成果，促进传统产业升级换代；走出中国治理雾霾的新路子。

With integrated administrative framework of Beijing and Hong Kong offices, the HYY Group is fully engaged in the R&D and market promotion of using shallow ground source (heat) energy as the substitute energy source of heating for buildings; in industrialized development of its original technology; to the upgrading of traditional heating industry into a new industry of integrated combustion-free heating and cooling with ground source energy; and in pioneering ways to improve ecological construction and curb haze in China.

- **员工行为准则：**
  Code of Conduct :

  安全第一，标准当家
  With safety first, standard speaks

  扎扎实实打基础，反反复复抓落实
  To form a solid foundation, to make all strategies practicable

  负责任做每件事，愉快工作每一天
  All develop sense of responsibility,and achieve pleasure at work

---

- **我们的宗旨：** 求实、创新
  Our Mission: Pragmatism and Innovation
- **我们的追求：** 人与自然的和谐共生
  Our Pursue: Harmonious Coexistence of Human and Nature
- **我们的奉献：** 让百姓享受高品质的生活
  Our Dedication: Improve comfort level of the people's livelihood
- **我们的愿景：** 原创地能采集技术实现产业化发展——让浅层地能作为建筑物供暖的替代能源；进一步完善能源按品位分级科学利用；在新时期，致力推广利用浅层地能无燃烧为建筑物智慧供暖（冷）；大力发展地能热冷一体化的新兴产业。
  Our Vision: Work for greater industrialized development of the original technology for ground source energy collection, while promoting the use of shallow ground energy as the substitute energy of heating for buildings; furthering scientific utilization of energies by grades; propelling combustion-free intelligent heating (cooling) for buildings with ground source energy; and forcefully boosting the new industry of integrated heating and cooling with ground source energy.

中國地熱能

CHINA GEOTHERMAL ENERGY

主 办 / **Sponsor**
承 印 / **Printed by**
中国地热能出版社有限公司 / China Geothermal Energy Press Limited
地 址 / **Address**
香港中环干诺道中 62-63 号中兴商业大厦 8 楼 / 8/F., Chung Hing Commercial Building, 62-63 Connaught Road Central, Central, Hong Kong

协 办 / **Co-Sponsor**
北矿大（南京）新能源环保技术研究院 / Nanjing Institute For New Energy & Environmental Science And Technology
首都科技发展战略研究院 / Capital Institute of Science and Technology Development Strategy
北京节能环保促进会浅层地（热）能开发利用专业委员会 / Special Committee on Shallow Ground Source (Thermal) Energy Development and Utilization under Beijing Association to Promote Energy Conservation and Environmental
北京工业对外经贸促进会 / Beijing Industrial Association for the Promotion of Foreign Trade & Economic
中国地热与温泉产业技术创新战略联盟 / China's Geothermal and Hot-Spring Industry Union
中国热冷一体化清洁能源研究院 / China Integrated Heating and Cooling Clean Energy Research Institute

国际标准刊号 :23098457 / ISSN:23098457

发行部 / **Publishing Department**
纪少樱　张艳菲 / Kei Siu Ying, Zhang Yanfei
广告部 / **Advertising Department**
张艳菲 / Peng Fang, Zhang Yanfei
地址、联系电话 / **Address,Telephone**
北京市海淀区杏石口路 102 号　+8610-62592988 / Address: No.102,Xingshikou Road, Haidian District, Beijing +8610-62592988

目录

CONTENTS

本期焦点

CURRENT FOCUS

要实现无燃烧供暖就必须在获得浅层地热能的技术领域实现突破。大家都知道这是一个难度很大的技术创新的科研课题。恒有源公司决心承担这个课题，实现这个突破。用他们自己的话说就是，因为责无旁贷。

P14
论文海报
PAPER POSTER

P23
特别报道
SPECIAL REPORT

P30
热点资讯
HOTSPOT INFO

封面 / 目录图片 供图：张艳菲

中国地熱能
CHINA GEOTHERMAL ENERGY

2023 年 6 月
第 38 期
半年刊

CONTENTS

To realize non-combustion heating, it is necessary to achieve a breakthrough in the technical field of obtaining shallow geothermal energy. Everyone knew that this was a very difficult scientific research topic of technological innovation. Ever Source Company was determined to undertake this project and achieve this breakthrough. In their own words, they were duty-bound.

P45
PAPER POSTER

P57
SPECIAL REPORT

P69
HOTSPOT INFO

单井循环换热地能采集技术的发明和发展

——恒有源科技向世界浅层地热能供暖领域的献礼

INVENTION AND DEVELOPMENT OF SINGLE-WELL CIRCULATING HEAT EXCHANGE GEOTHERMAL ENERGY COLLECTION TECHNOLOGY

—— Ever Source Company's Gift to the Field of Shallow Geothermal Energy Heating in the World

作者：孙骥

1. 引言

打开百度地图搜索“中国地能恒有源示范小区”，可以在杏石口路 63 号院内看到一些用于实验的建筑物。在它的西南角有一片空地，地图上提示那里曾经是国家级恒有源技术中心的实验场地。单井循环换热地能采集技术就是从这里走向世界的。

上个世纪末北方供暖引起的大气污染问题愈演愈烈，冬天的雾霾天成为北方人无法回避的魔魇。数据显示北方冬季的燃烧供暖对雾霾的“贡献”最大，甚至超过了汽车尾气排放。为破解污染问题，一群有志于打破“供暖即污染”的人，集聚在恒有源，下决心改写供暖的故事，追求人与自然的和谐共生。

传统的供暖方式是燃烧供暖。就是说要得到热量，就必须烧点儿什么东西。例如燃煤取暖、燃气取暖，都是离不开燃烧的。但是燃烧在供给

我们需要的热量的同时，也带来了空气的污染、矿物质燃料的消耗和灰渣排放等问题。电采暖虽然在使用地没有污染问题，但是成本高、耗电量大。在当前我国仍以燃煤发电为主的情况下，用电量越多，燃煤发电带来的污染问题就越严重。

恒有源科技的创业者们早在上个世纪末就开始关注这个问题。认识到要解决这个矛盾必须另辟蹊径，结论是：必须做无燃烧的供暖。在当前技术条件下，利用热泵技术用低品位热源为建筑物供暖是最便捷的方案。问题是：这个低品位热源从哪里来？

从上世纪中叶人们开始关注浅层地下蕴藏的25 度以下的低品位热资源。用它来做无燃烧供暖的低品位热源应该是不二的选择。传统的取得浅层地热能的方式有两种：一种是用抽水井加回灌井方式；一种是用地下埋换热管的方式。这两种方式都有很大的局限性。第一种抽水井加回灌井方式，采用地下水作为热源，用热泵技术从水中取热，有简单、高效的优点。但是它难以克服的问题是回灌难，并且对地下水有污染。另一种地下埋管方式采用的是间壁式换热，换热效率低。每根地埋管的换热功率难以超过 5kW。因此占地面积很大，难以在城市建设中推广应用。要实现无燃烧供暖就必须在获得浅层地热能的技术领域实现突破。大家都知道这是一个难度很大的技术创新的科研课题。恒有源公司决心承担这个课题，实现这个突破。用他们自己的话说就是，因为责无旁贷。

工程师们利用周边许多废弃的农业灌溉水井进行了无数次的换热试验，建立了数据库；请进了北京市地质和水务专家做指导；邀请相关专业的院士和大学做地下温度场的实际测量的实验。在十几年的科研成果积累的基础上，一个全新的获得浅层地下热能的想法形成了，这就是单井循环换热浅层地能采集技术的原型。

所谓单井循环换热地能采集技术就是在浅层地下的一个有限的范围内，构造一个以大地为热的输入端的换热装置。换热介质是地下水。输出的热量供给热泵作为低品位热源使用。因为输入的热量直接来源于大地而换热的介质是就地取材的地下水，它直接浸润热源体，所以效率高、占地面积小。还从根本上规避了地下水污染、消耗和回灌难等问题。

2000 年 10 月，就在本文开头提到的实验小区内，第一个单井循环换热地能采集井投入实际运行。这是中国自主研发的科研成果，技术水平达到国际领先，我们拥有全部核心技术的自主知识产权。

20 多年过去了，单井循环换热地能采集技术与恒有源科技与时俱进，不断发展。2022 年已推广应用超过 2200 万㎡。相当于每年替代约 17 万吨标煤，减少二氧化碳排放约 45 万吨。在为亿万群众冬季送温暖，夏季送清凉的同时，节约了供暖的燃料消耗，显著减少了使用地域的空气污染排放量。

2. 基础工作

单井循环换热地能采集技术能不能保证地下水的安全？怎样制定它的设计标准？这两个问题的解决是基础性的工作。恒有源科技从创业伊始就投入大量的人力物力开展单井循环换热水资源检测和换热井周围温度场监测的相关研究工作，取得了丰富的成果。

从 2001 年起，恒有源公司选用“四博连工程师宿舍”和“西郊汽车配件城”这两个 2000 年和 2001 年开始投入运行的项目为试验点，委托北京市水环境监测中心对其采集井水进行连续 10 年的水质跟踪监测，委托北京市疾病预防控制中心进行连续 3 年的水质跟踪监测。截止

2010 年 9 月，得到检测报告 140 份，检测记录共计 3696 项。

北京市水务局和海淀区水务局组织有关专家召开了 3 次水质保护阶段成果评审会。结论是：单井循环换热技术较好地解决了移砂、地面不均匀沉降和水量损失的问题，较传统地下水源热泵技术有着突出的优点：北京市水环境监测中心的监测结果表明，水体质量 21 项指标在出水和回灌水中除水温外均没有明显的变化，单井循环换热回灌水未对地下水质量造成影响。“单井抽灌”这种浅层地能（热）提取方式是一种以水为介质的土壤换热装置而不是取水装置，与普通水冷系统相比彻底免除了水的蒸发损失，对节水有突出效果。北京市水环境监测中心和北京市疾病预防控制中心专家根据单井抽灌采集井的水质监测报告，得出结论：长期监测结果表明，在制冷、制热工况期间未出现出水和回灌水质有明显变化的情况，也未影响地下水质量。

2003 年 8 月 21 日和 2005 年 7 月 15 日北京市水务局和海淀区水务局组织的“单井抽灌”水资源保护成果评审会，专家评审意见为：单井抽灌能量采集技术是一个以水为介质的密闭循环的热量采集装置，是一种土壤源热泵系统，运行过程中没有水资源消耗，对区域地下水状态和地质结构无影响。

2006 年恒有源公司与哈尔滨工业大学等单位合作，开始了对单井循环换热井周围地下温度场的监测和研究。

单井循环地能采集井工作的过程中，采集井周围的岩土体的温度会发生变化，研究这些温度变化的规律对采集井的换热能力，包括最大换热功率和总的供热量和进出水的温度变化是十分重要的。恒有源科技从成立伊始就筹划建立企业技术中心进行这方面的研究工作，取得的成果对建立换热井的设计标准提供了数据支持，也为科研单位提供资料，支持专家对浅层地能开发利用的深层次的科研工作。

①在取热期间，地下温度场的变化规律

实际得到的测温曲线的构形极不规则，出现了较多的波折，这说明含水层在深度方向上的构造极不均匀，甚至存在分层。我们看到不同深度的地层由于地质结构不同，温度变化也不同，温度变化最大的，放出（或吸收）热量最多。改变采集井的内部结构重做上述实验，发现对不同的井内结构，岩土体温度变化的速度是不同的，由此我们可以找到对不同的地层，最适宜的井的结构，借助计算软件的帮助，我们可以得到相应的供应功率等计算数据。

②在恢复期间，地下温度场的变化规律

在供热季采集井周国的岩土体随着供热过程的持续，温度逐渐降低。在最冷季以后，温度开始回升。在停止供热以后的时间段，地下温度场的恢复过程对评价井周围岩土体的供热能力很重要，恢复过程快的，供热能力强。

③在采集井的周围岩土体内的温度场一年四季发生周期性的变化，最低温度发生在 2-3 月间，最高温度在 8-9 月间。实测结果表明，在采暖季结束之前，地下温度已开始回升；在制冷季开始之前已恢复到初始值。我们可以看到，对于设计正确的采集井在额定的供热功率和供热周期的条件下工作，地下温度场是周期变化的，并未发生有整体温度逐年降低的趋势。

3. 关键技术和创新

3.1 单井循环地能采集的关键技术

①井内液态密封技术和建立了采集系统地下水流态的数学模型。地下水多流态传热的数学模型。使用不同渗透条件地层的传热回填颗粒，局部改善地层增大渗透系数。和多含水层单井循环

的分层采集技术。

②农村分散式建筑的浅层地热能采集与末端散热及调控。

③与城镇供暖相匹配的高效电替煤供暖关键技术与产品。以单井循环换热采集技术为核心的系列化冷热源站。

④基于单井循环换热的热泵系统设计和评价方法。建立了基于谐波反应的地下换热量计算和系统优化方法。提出了基于多因素环套理论和层次分析法耦合的单井循环换热热泵系统综合性能评价方法。确定了单井循环换热热泵系统安全，节能及耐久等性能的指标值，实现了单井循环换热热泵系统综合性能评估标准化。

3.2 恒有源公司的四项技术创新

①首创能百分之百回灌的单井循环浅层地热能采集技术，获得 34 项国内外专利；

②利用浅层地热能为农村建筑供暖冷和热水的三联供技术与系列产品，获得 23 项国内外专利；

③城镇高效电替煤供暖技术，获得 10 项专利技术；

④单井循环换热热泵系统设计和评价方法。建立了相应的地方标准。

4. 成果与评价

4.1 据 2013 年国家发改委发文，在谈到单井循环换热地能采集技术的特点时强调：由恒有源公司自主研发的单井循环技术 (拥有发明专利)，实现了浅层地能采集技术的重大技术创新，为大规模利用浅层地能供热提供了有力的技术保障。经国务院原参事、中国工程勘察大师王秉忱领衔的专家组论证，该技术达到国际先进水平，应用前景广阔。

单井循环技术采用封闭的、稳定的地能循环采集系统，单井内上部为加压回水区，下部为抽水区，地下水从抽水区被抽至井口换热器中，与热泵中的低温水换热，地下水热量释放后，再由同一口井返回到加压回水区。在一般采暖工程中，每口地能采集井（如砾石地质），可负担约 10000 平方米建统面积的供热量。与传统抽水井和土壤埋管技术相比，单井循环技术工程成本相当，但技术优势明显：避免了抽水井技术取水易、回灌难，地下水位下降和交叉污染等问题，不会引发潜在的地质灾害；相比土壤理管技术，换热效率高、占地面积小、维护便利、地质条件适用广。

采用单井循环技术供热与直接用电转化为热能供热相比，可实现节能 50%—70%；与传统的区城燃煤锅炉房供热相比，工程投资和运行费用相当，可直接实现节能约 15%—20%，并可显著减少区城内燃煤产生的大气污染物排放。由于该技术一套装置冬季可供热、夏季可供冷，对有夏季冷源需求的建筑，只相当于中央空调制冷工程投资，节省了供热系统投资，经济效益更好。

4.2 单井循环换热地能采集技术从 2001 年到 2012 年已推广应用超过 800 万平方米，因为该项技术不消耗、不污染地下水，受到社会各界的支持和欢迎。为规范管理，有必要确定什么是单井循环换热地能采集技术，应当符合哪些条件才可以认定为单井循环换热地能采集技术。2013 年北京节能环保促进会组织编写《单井循环换热地能采集井工程技术规范》，该标准对井的结构设计，换热功率、施工组织设计、验收的条件等，引用了恒有源公司的企业标准。该标准在引言中说明：单井循环换热地能采集井技术是一项我国原创的、先进的、适用于多种地质条件的浅层地能采集技术。它以循环水为介质采集浅层地下的温度低于 25 度的热能、可以实现地下水就地同层全部回灌。不消耗也不污染地下水，对地下水是安全的。

单井循环换热地能采集井的关键结构是井内

的密封装置。正确设计和使用密封装置是确保正常换热的关键，这是恒有源公司核心技术之一，公司申请相应的专利设立了技术壁垒，为加大单井技术的推广速度，恒有源公司最终同意放弃因实施该标准而产生的相应专利的专利权。

4.3 2017 年由北京建研院顾问总工吴德绳教高、清华大学教授王光谦院士、中国科学院地质所汪集旸院士、中国北科院胡春宏教高、北京大学倪晋仁教授、中国矿业大学教授武强院士、中国城建院许文发教授和国网湖南防灾中心陆佳政教高等组成的“基于单井循环换热的浅层地热能开发关键技术及工程应用”技术成果评价鉴定会专家组对单井循环换热技术进行评审，并得到鉴定评价意见：

①单井循环换热地热能采集技术是恒有源公司发明的适用于多种地质条件的浅层地能采集技术，它以地下水为介质采集浅层地下的热能，实现地下水就地同井 100% 回灌，不消耗也不污染地下水，对地下水和地质结构是安全的，实现浅层地能的安全、高效、环保、循环利用。

②与国内外传统的开发利用浅层地热能的“抽水井＋回灌井”技术相比，单井循环换热地热能采集技术具有十分突出的优势。它不消耗、不污染地下水、不破坏地下水的自然状态：单井换热量可达 500kW。

③单井循环换热地热能采集技术已在建筑界推广应用超过 1600 万平方米建筑的供暖，包括国家大剧院等标志性建筑的特殊供热。工程应用发展迅速，经济效益和社会效益显著。与燃煤采暖相比，在用工程每年可替代建筑供暖燃煤 14 万吨，和减少相应的二氧化碳排放量。

鉴定评价专家一致认为：项目成果具有原创性，达到国际领先水平。

4.4 2017 年中科院文献情报中心出具《科技查新报告》2017-649 号，得出结论：

该查新项目提出在单井循环换热地能采集过程中，井水实现就地 100% 同井同层回灌的技术工艺，在国内外公开文献中未见有相关报道。

该查新项目提出在单井循环换热地能采集过程中，单井供热功率达到 500kW，在国内外公开文献中未见有超过该数值的相关报道。

4.5 2003 年在世界地热资源委员会（GRC）墨西哥大会上，恒有源科技总经理徐生恒先生应邀与瑞士苏黎世大学吕贝克教授联合发表论文《浅层地能资源的利用—单井循环技术的实例研究》获大会最佳论文奖。

论文中提到：所谓浅层低温地热指的是在地表以下某一深度内（如 100 多米以内）所蕴藏的热量。在中国的大部分地区，上述深度处于恒温带，即温度基本不受四季变化的影响，保持在 10°C—20°C之间。开发和利用这部分低温地热为建筑物供暖、制冷和提供生活用水，一次性投入和运行成本都比传统的方式低。但是，由于浅层低温地热能量密度小，大面积开发技术难度较大。本文以在中国北京的一个工程实例——北京市海淀外国语实验学校来介绍以“单井抽灌系统”的运行原理。在这一工程实例中，浅层低温地热被用来在冬季为建筑物提供热源，在夏季则将热量排入地下。

浅层低温地热是一个巨大的冷热源，分布广且蕴藏丰富，极有开采利用价值。

单井抽灌技术是开发和利用浅层地下低温地热的捷径。它以地下水为介质与土壤换热，初始投资和运行成本都比较低。

本文所论述的系统是全部封闭的，在运行过程中不排放任何气态、固态和液态的污染物。

广泛采用这一系统不但大大提高了能源的利用率，而且节约了可观的环保投资。

4.6 2023 年由国家发展改革委员会下属单位国家节能中心组织的“第三届重点节能技术应用

典型案例”评选中，恒有源科技发展集团有限公司上报的海淀外国语实验学校京北校区地能热泵环境系统项目，经过初评、答辩、现场核查等多个环节筛选，最终入选。

4.7 在 2023 年世界地热大会即将在中国召开之际，国家地热能源开发利用研究及应用技术推广中心与能源行业地热能专业标准化技术委员会为展示中国地热产业的成就，促进中国地热产业高质量发展，开展了地热能开发利用示范项目评选活动。在评选活动中，恒有源集团“雄安市民服务中心综合能源项目”荣获地热能开发利用示范项目称号。雄安市民服务中心是雄安新区设立以来第一个基础设施项目，它是未来雄安缔造智慧城市、绿色城市的缩影，具有十分重要的样板意义。雄安市民服务中心综合能源系统采用“浅层地热能 + 再生水源 + 冷热双蓄”的综合能源供应系统，设置地热能热冷一体化能源站。能源站以浅层地热能为主，充分利用中水等可利用能源，结合低谷电进行冷热双蓄，打造供暖、制冷、生活热水一体化供应形式，形成了地热能无燃烧为建筑物智慧供暖（冷）系统，满足了项目 10 万平米建筑冷暖供应需求，实现了建筑物供暖（冷）总能耗的 60% 以上是浅层地热能等清洁能源，为地热能开发利用做出了示范，为新区建设起好了带头作用。

5. 我们的期待

第七届世界地热大会即将在北京召开，这是世界地热界的盛会，对此我们满怀期望。

仅以此文介绍我们的工作和想法，欢迎您的批评指正。期待以文会友，与国内外地热界朋友沟通和交流。尊敬的各位同仁，我们在北京恒有源科技发展集团有限公司恭候您的光临！

编者言

“论文海报”栏目是本期期刊为九月的世界地热大会专设的栏目，是本期期刊的一大亮点。 该栏目中的文章是三篇论文的简要概述，论文的详细内容将在今年的世界地热大会上发布。

本刊特在此隆重推出，谨以此栏目向为实现双碳目标不竭奋斗的专业人士和关注全球高质量发展的公益热心人士作预告，希望引起有关各界的关注，期待与各界友人沟通交流，共同促进地热产业乘风破浪，再创佳绩！

请关注今年九月在北京举办的世界地热大会，同时预祝大会圆满成功。

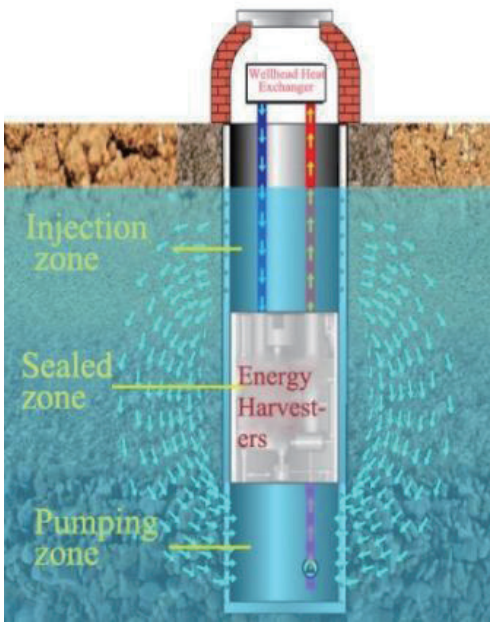
单井循环地热采集系统渗流与温度特性耦合模拟

COUPLING SIMULATION OF SEEPAGE AND TEMPERATURE CHARACTERISTICS OF SINGLE WELL CIRCULATING GEOTHERMAL COLLECTION SYSTEM

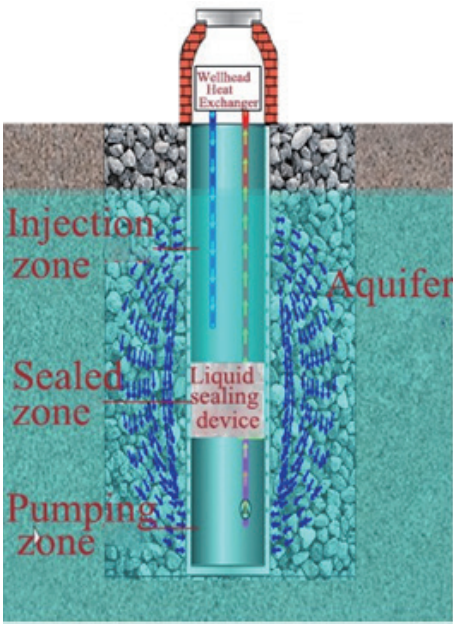
作者：徐生恒　武强

作者采用理论研究与数值模拟相结合的方法，探讨了单井循环系统运行对地下水渗流和温度场的影响。含水层的渗透系数影响地下循环水的流动，当隔板段含水层渗透率较差时，注入水被阻断流向抽水区，从而显著降低抽水温度的波动，保持稳定的换热温差。

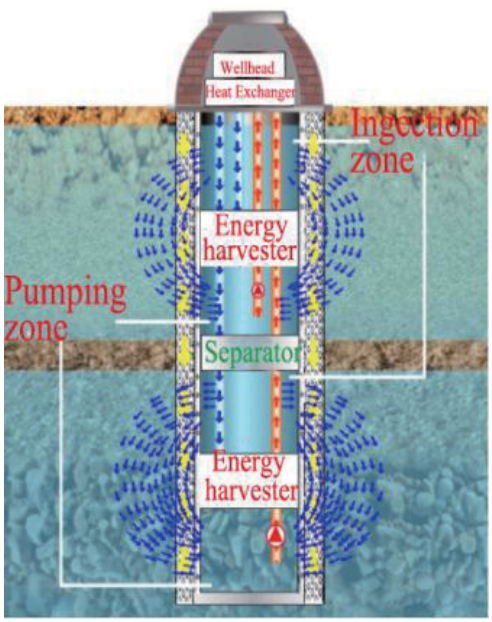
1. 单井循环集热系统简图



无传热回填型



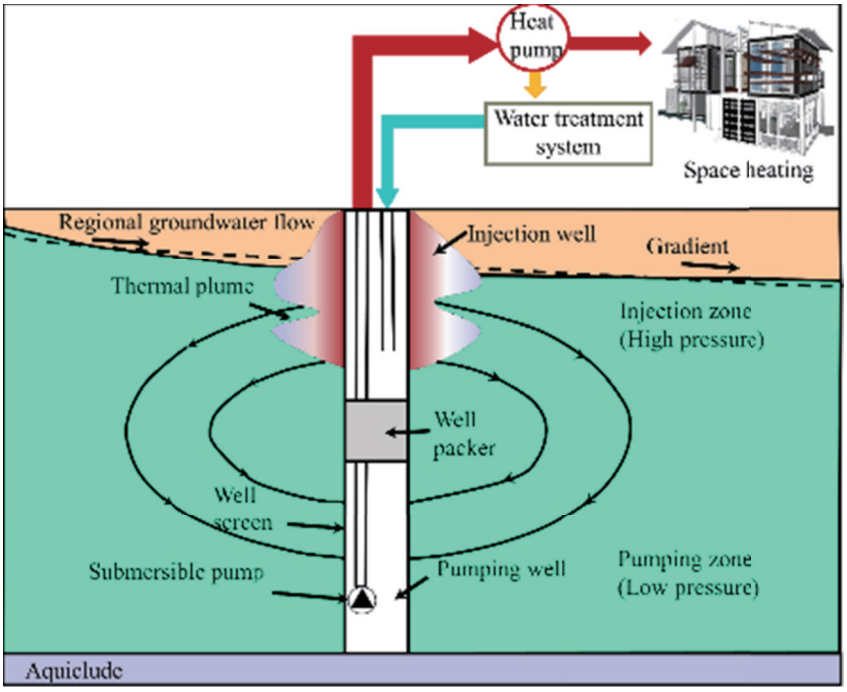
有传热回填型

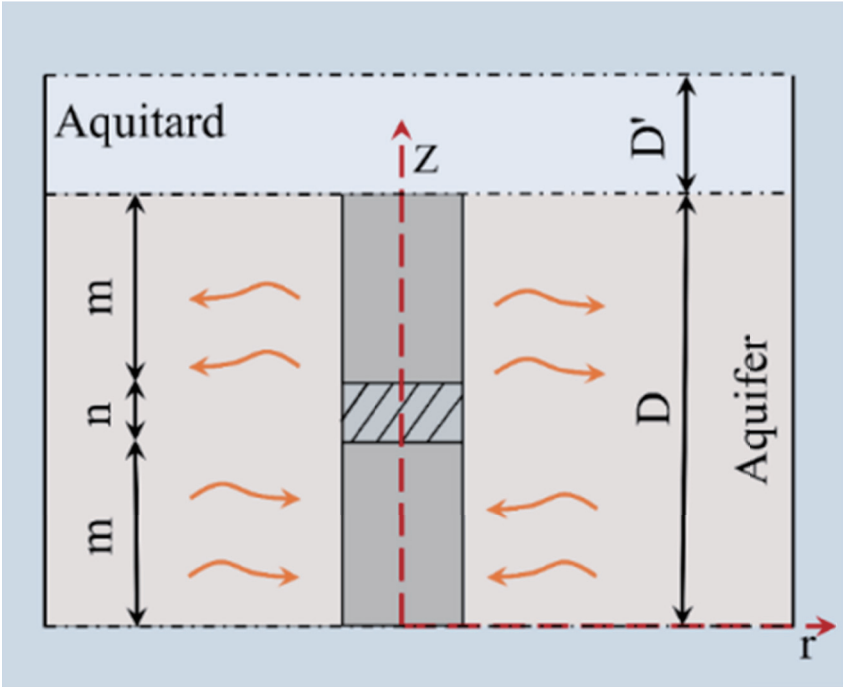


单井循环分层集热

2. 单井循环数学模型

同一均质含水层的定流量单井循环系统的抽灌单井被视为深度为 2m+n 的抽水完整井和 2 个非完整井 .





3. 渗流场与温度场动态变化

北京市某单井循环集热工程项目总热负荷为 3450 kW，总冷负荷为 3600 kW，项目所在地富水性较强，单井出水量达到 5000 m^3/d。设计含水层厚度 (d) 分别为 100 m 和 64 m 时单井循环地热采集系统，利用 Feflow 软件地下水模块和热迁移模块进行水热耦合数值模拟。模型运行时间以北京地区冬季供暖 (11.15-3.15)+ 夏季制冷 (6.1-9.15)+ 过渡期 (137d) 进行设计。

模型设置参数如下表：

Zone	Hydraulic conductivity (m/d)		Porosity	Specific weight	Thermal capacity (MJ/(m^3 · ℃)	Thermal conductivity W/(m · ℃)
	Kxx=Kyy	Kzz	n	μ	c	λ
I	1.00	1.20	0.29	0.01	1.50	1.87
I I	1.35	1.35	0.30	6×10^{-3}	1.50	1.87
III	5.8×10^{-3}	0.3	0.25	5×10^{-4}	1.50	1.87
IV	1.8×10^{-4}	1.8×10^{-4}	0.27	5×10^{-4}	1.30	1.35
V	1.3	1.3	0.31	1×10^{-4}	1.50	1.87
VI	5.01	5.01	0.35	1×10^{-4}	1.50	1.87

模拟结果显示：

①系统运行地下水降深：存在边界效应，含水层厚度越小，近热源井处绝对降深值高。

②不同运行模式下抽水温度仅冬季供暖的冬季运行模式长期运行下，抽水温度不断呈现“降低 - 恢复”的动态变化过程，温度自然恢复程度小于全年运行模式。仅夏季制冷的夏季运行模式抽水温度整体呈现上升趋势。夏季供冷模式下第一个制冷季结束，热源井抽水段已发生热贯通，随着运行年限增加，热贯通程度加剧且单井循环系统的热响应半径延伸扩大。

③渗透系数对渗流场影响

抽水段含水层温度分布变化受中间含水层渗透系数影响较大，当渗透系数较小时，灌水段与抽水段水力联系被削弱，回注水垂向流入抽水段的比例减少，降低了热贯通发生时间与程度。

4. 结论

①单纯制冷或加热方式不利于系统运行，出水温度总体演变趋势呈现上升（仅制冷）或下降（仅取热），发生能量衰减。在长期运行年度模式（冷却和加热）下，抽水温度稳定，满足系统可持续性的要求。

②含水层渗透系数对含水层渗流场和温度场的影响更为显著。当中间含水层 K 较小形成有效隔水层时，有利于减少回灌水越流补充抽水区，延缓热突破的发生和强度，保证了单井循环运行性能。

首个浅层地热能 + 太阳能发电多能互补分户式供暖(冷)示范项目——义合堡村

FIRST SHALLOW GEOTHERMAL ENERGY + SOLAR POWER GENERATION MULTI-ENERGY COMPLEMENTARY HOUSEHOLD-BASED HEATING (COOLING) DEMONSTRATION PROJECT —— Yihepu Rural

作者：刘宝红　李艳超

义和堡村位于奥运廊道张家口市怀来县，全年平均气温 5.5--6.5℃，冬季供暖设计温度 -13.6℃，属寒冷 A 区。太阳能年总辐射量 5700-6100 MJ/㎡，属第二类资源区。项目以浅层地热能 + 太阳能发电多能互补为农村建筑分户供暖(冷)。至 2023 年，该项目已稳定运行 7 年。

1. 方案配置

义和堡村建筑均为单层建筑，外墙为 370mm 红砖墙，无保温，门窗为单层木质或单层铝合金材料。每户东西长 13.2m，南北长 7.8m，供暖面积约 100 ㎡。整村共计 265 户，分东、西两个区域。

每户恒有源地能热宝设备为 1 套一拖二和 1 套一拖一机组，每户太阳能发电采用 20 块光伏组件。多能互补供电系统采用 1 台光伏逆变器，接入 220V 线路送入家庭原有室内进户配电箱，再经由 220V 线路与室内低压配电网进行连接。

2. 改造前后供暖对比

改造前农户各家烧燃煤炉取暖，每天人工添

村民家中新安装的地能热宝室内机

太阳能光伏并网箱

加煤块和清除煤渣。每户一个采暖季烧散煤 2.5-3.5t（散煤热值取 5000kcal/kg），折合标煤 1.79-2.5t。有 75% 的家庭供暖房间温度≤ 16℃，房间温度随加煤频率变化大，供暖温度不稳定。改造后农户遥控器控制室内机启停，操作方便。用户反馈供暖房间室温达标，部分用户反馈超过国家供暖标准，同时地能热宝系统夏季可以制冷。用户普遍认为使用舒服和方便。

3. 家庭每年经济收益

义和堡村张氏家庭 2020 年 8 月 1 日 -2021 年 7 月 31 日的多能互补系统收益情况：太阳能发电上网收益近 7000 元、市政电费不到 2500 元、家庭总收益近 4500 元。

地能热宝室外机、屋顶太阳能发电

4. 环境效益

环境效益主要有两部分来源，一部分为地能热宝系统替代燃烧散煤供暖带来的零污染、零排放环境效益，一部分为太阳能发电替代火电厂生产和输送带来的环境效益。改造后每年减少散煤燃烧约 800t，每年结余绿电超过 130 万 kWh。每年可减少二氧化碳排放 3101.69t、减少二氧化硫排放 14.13t、减少烟尘排放 12.36t，具有较好的环境效益。

5. 结论

义和堡村的浅层地热能 + 太阳能发电多能互补分户式供暖（冷）系统，利用浅层地热能为农村建筑分户供暖（冷），采用分房间调节和卧式结构的地能热宝设备，具有配电量小、操作简单、分间控制、温度舒适、高效节能等特点，解决了农村建筑供暖存在的问题；同时结合屋顶太阳能发电，每年能给农户增加经济收入；系统具有地热能 + 多能互补的创新性和实践意义。

北京市海淀外国语实验学校京北校区单井循环换热地能采集技术实例研究

A CASE STUDY ON SINGLE-WELL CIRCULATING HEAT EXCHANGE GEOTHERMAL ENERGY COLLECTION TECHNOLOGY IN JINGBEI CAMPUS OF BEIJING HAIDIAN FOREIGN LANGUAGE SHI YAN SCHOOL

作者：徐生恒　汪集旸

恒有源科技发展集团有限公司发明的“单井循环换热地能采集技术”是高效安全采集浅层地热能为建筑物提供稳定热源的一种方式。本文介绍了北京海淀外国语实验学校 20 年来应用此技术持续供暖的成果。2019 年起该校在位于北京冬奥会张家口赛区的京北新校区项目上扩大应用，满足新校区 13.7 万㎡建筑包括各种冬季运动场馆的供暖、制冷及全年提供生活热水的需求。使可再生能源利用率达 60% 以上，年减排二氧化碳超过 1976t。本项目应用“单井循环换热地能采集技术”获取可再生浅层地热能，不消耗不污染地下水，实现区域零碳排放。针对校区建筑分散和使用功能的特点，设置为集中采能、分布式设置冷热源站的水环热泵系统，进一步实现系统节能。利用季节蓄能实现热能的夏储冬用，供暖及制冷都达到了高能效运行。本文是 2003 年国际地热大会徐生恒和 Ladislaus Rybach 发表的《浅层地能资源利用——单井抽灌技术的实例研究》一文的延续。长期持续稳定的运行证明了单井循环换热地能采集技术的可靠性并具有简单

可复制性及广泛的适应性，是建筑供暖领域实现“碳中和、碳达峰”目标的一种优选的技术方案。

1. 引言

浅层地热能是指蕴藏于地表以下约 200 米以内的热能，温度低于 25 度。浅层地热能具有分布广、埋深浅、储量大和开发利用成本低等特点，是地热能家族中的重要组成部分。采用先进的单井循环换热地能采集技术能够大规模、低成本稳定地开发利用浅层地热能。结合热泵技术实现其热能品位（温度）的提升，使其成为建筑供暖的替代能源，是解决建筑供暖的便捷的低碳路径。2003 年徐生恒先生和瑞士苏黎世大学吕贝克教授以北京海淀外国语实验学校为实例联合发表了《浅层地能资源利用——单井抽灌技术的实例

张家口室外气象参数

台站位置	北纬	40° 47′
	东经	114° 53′
	海拔（m）	723.9
大气压力（mbar）	冬季	938.9
	夏季	924.4
年平均温度°C		7.8
室外计算 (干球) 温度 (°C)	冬季	-15
	夏季	31.6
室外计算 (湿球) 温度 (°C)		22.3
最热月平均温度 (°C)		23.2

应用》一文，首次介绍了利用单井循环换热地能采集技术开发利用浅层地热能为建筑物供暖、制冷的工程实例。由于采用单井循环技术从而避免了回灌难和地下水资源的污染、浪费等问题引起大会重视。此后也不断有业内人士问询，如今 20 多年过去了，海淀外国语实验学校先后完成了两次扩建，用于供暖的浅层地热能在中国也有了迅猛的发展，单井循环换热技术已经推广应用了超过 2000 万平方米建筑。本文以当年研究的样本工程——北京海淀外国语实验学校的供暖 / 冷系统最新进展为例，介绍了单井循环换热地能采集技术不断创新的成果和取得的经济效益及环境效益，以回应关心中国浅层地热能开发利用和单井循环换热技术的朋友们。

2. 海淀外国语实验学校概况

北京海淀外国语实验学校北校区工程为学校的一期工程，总建筑面积约 6 万㎡。北京海淀外国语实验学校南校区工程为学校的二期工程，总建筑面积约 4 万㎡。京北校区是学校的三期工程，位于冬奥之城张家口市，张家口地区属寒冷地区，其室外气象参数详见表 1。工程 2019 年开始建设，2022 年全部建成。京北校区建筑面积 13.7 万㎡，是新建的可容纳 5000 名学生 12 年一贯制国际化学校，包含教学楼、办公楼、科研中心、“海外”艺术学院、“海外”剧场、教职工食堂、学生公寓、教师公寓、室内外运动场馆等 10 栋建筑。

目前京北校区共有 10 栋建筑，由于校园面积比较大，具有建筑物分散、地表高程差比较大、使用时间及频率不一等特点，选用恒有源浅层地热能分布式冷热源系统，为建筑物供暖、制冷和生活热水。系统由单井循环换热地能采集井、浅层地热能集中换热站、分布式冷热源站及建筑物室内的末端系统组成。

项目设置多口单井循环换热地能采集井集中采集浅层地热能，将采集井连接到一起形成一次采集管网，利用一次采集管网将浅层地热能输送至集中换热站，由二次换热管网将浅层地热能分配至分布式冷热源站，分布式冷热源站内设置能量提升三次管网，提升至供暖或降低到制冷的温度品位，由四次管网输送至供暖冷建筑群，完成供暖冷。

3. 节能减排效果和主要技术进步和创新

项目供暖季总能耗为 259.03 万 kW.h 电能，折合 318t 标煤。与采用电直热式供暖比较，可节能约 800t 标煤，可再生能源利用率达 60%, 每年可减少 CO2 排放 1976t，减少 SO2 排放 16t，减少粉尘排放 8t。

20 年的时间里，单井循环换热浅层地热能供暖技术获得以下发展和创新：

①发明了有换热颗粒采集井，井水由置于隔热管底部抽水区的潜水泵抽出，进入热泵机组放热或吸热后，由热泵机组返回进入地能采集井的上部加压回水区内。水流在有换热颗粒的环形空间内向下流动至抽水区，透过隔热管下部的花管部分进入隔热管，再由潜水泵抽出。围绕井管周围置入换热颗粒，局部地改善地质环境，扩大高效率换热的范围，换热颗粒宜采用直径 10mm-100mm 的球形体，强度大于 50 兆帕。

②针对在多含水层地质结构中串层抽水的问题，研发了多水层无换热颗粒地能采集井技术，采用两个或多个井上下叠加及密封的结构，实现了多含水层地质结构的同层回灌。

③ 2012 年恒有源科技发展集团有限公司编制了《单井循环换热地能采集井工程技术规范》DB11/T 935-2012，为单井循环换热地能采集井的设计、施工提供了范本。

探访海外京北校区

——绿色海外京北校区伴浅层地热技术扬帆远航

A VISIT TO BEIJING HAIDIAN FOREIGN LANGUAGE SHI YAN SCHOOL

—— Green Jingbei Campus Sails with Shallow Geothermal Technology

作者：马晓芳（特约记者）

沿着京礼高速一路北上，驱车不久就能到达距离北京延庆冬奥村仅 20 多公里的北京海淀外国语实验学校京北校区（以下简称“京北校区”）。依苍山翠柏，临官厅水库，位于首都北部生态新区的京北校区森林覆盖率高，全年空气质量优良。早在 2019 年该校区就成为国家体育总局为奥运储备中国国少队人才的冰雪项目基地，并在 2021 年入选河北省第三批“北京 2022 年冬奥会和冬残奥

会奥林匹克教育示范学校”公示名单。

北京市海淀外国语实验学校在建校之初就与恒有源科技发展集团有限公司达成了合建环保低碳校园的共识，得益于此，京北校区在建设伊始便同恒有源联合设计研发，采用单井循环换热地能采集技术为全校师生冬季供暖、夏季制冷，同时保证学校游泳馆和生活 24 小时热水。二十余载四季轮回，恒有源集团独创的浅层地热能单井循环换热地能采集技术让师生们切身感受到了环保低碳的舒适，坚定了学校建设环保校园的决心，更为打造绿色低碳校园树立了典范。

绿色舒展的足球场，校内青山葱郁挺拔，四季恒温舒适的泳池，设施精良专业的综合体育中心，设备齐全的冰雪运动中心、滑雪练习场，舒适敞亮的海外剧场……走进京北校区，在温度适宜、明亮干净的教室内驻足，虽是炎炎夏日，但校内每个场馆都让人感觉舒爽惬意。一位初中学生告诉记者，自己在京北校区的学习和生活十分便捷舒适：“夏天早晚可以在校园内感受凉风，即便是酷暑教室内也凉爽宜人。我最爱冬天的游泳馆，那里始终温暖如春，水温恒定，可以放松大胆的游来游去。我们老师说，学校冬暖夏凉 24 小时热水都是浅层地热能技术提供的，真的很神奇，地热能让我们在绿色低碳校园学习生活。”

恒有源地能热泵为冬奥之城绿色发展做贡献

北京市海淀外国语实验学校京北校区位于冬奥之城张家口市，该校区是海淀外国语实验学校新建的 12 年一贯制国际化学校，是北京 2022 年冬奥会和冬残奥会奥林匹克教育示范学校及国家体育总局为奥运储备中国国少队人才的冰雪项目基地，也是集学习、运动、生活、休闲为一体的绿色生态校园。校区总规划建筑面积 30 万平方米，分为三期建设，截止目前一期、二期 10 栋建筑总计 14 万平米已经投入使用，三期正在建设中。

以“单井循环换热地能采集技术”为核心的恒有源地能热泵环境系统早在 2001 年就已经作为北京海淀外国语实验学校海淀校区的供暖冷系统投入运行，并达到了良好的使用效果。京北校区地处张家口市怀来县，空气清新，自然环境优越，但供暖期时间长，冬季气温低，为了保证项目正常供暖，并减少供暖系统的碳排放，达到清洁绿色供暖，项目继续采用了恒有源地能热泵环境系统作为项目的供暖系统，实现项目低碳、低成本供暖冷运行，为冬奥之城绿色发展做出贡献。

单井循环换热地能采集技术是一项我国原创的先进的适用于多种地质条件的浅层地热能采集技术。它以循环水为介质采集浅层地下的温度低于 25°C的热能，该技术实现了“取热不耗水”，能够安全、高效、省地、经济的采集浅层地热能，为大规模安全开发利用清洁可再生能源为建筑供暖提供了有利的技术支撑。

单井循环地源热泵系统以单井循环换热地能采集技术为核心，通过可再生的自然能源（浅层地热能）和热泵的结合，可以实现无燃烧、零碳排放的为建筑物供暖、制冷，使建筑物供暖总能耗的 60% 以上是可再生的浅层地热能。适用于新建、改扩建的各种公建、民建、农户等建筑的供暖冷，能够进一步促进建筑节能低碳运行，实现更高的经济效益和环境效益，助力“碳达峰、碳中和”的早日实现。

单井循环换热地能采集井由加压回水区、密封区、抽水区组成，以水为介质，从抽水区将采集到的热量进入换热器，将换热以后的介质通过加压回水区循环到抽水区，循环换热采集岩土体中的地热能。单井循环换热地能采集井按结构分为有换热颗粒地能采集井和无换热颗粒地能采集井两种形式。有换热颗粒地能采集井适用于弱透水地层，井深 40-100 米，单井地热能采集量 100-

300kW;无换热颗粒地能采集井适用于强透水地层，井深 60-100 米，单井地热能采集量 15-500kW。

地源热泵打造京北校区低碳校园

为了让京北校区方案达到最优，恒有源集团与学校设计建筑方进行了多次方案修改完善，最终采用恒有源分布式单井循环地源热泵系统作为项目的冷热源方案。该系统由单井循环换热地能采集井、浅层地热能集中换热站、分布式冷热源站及建筑内供暖冷末端组成。

单井循环地源热泵系统是一种利用可再生能源满足建筑物供暖冷需求的节能环保系统，系统运行没有污染物排放，能够和自然环境和谐共生，是京北校区供暖冷系统的首选方案。该系统采用单井循环换热采集技术，在海淀校区应用超过了20 年，经过多年应用证实该系统具有占地小、效率高、能耗低、运行稳定、控制方便等优点，一套系统就能够满足项目冬季供暖、夏季制冷、常年供应生活热水的需求。

京北校区项目建筑分布东西跨度超过 1000 米，南北跨度超过 800 米，地势高差超过 60 米，建筑周边采集井设置位置紧张，方案集中设置多套单井循环换热地能采集井集中采集浅层地热能，并在地能采集井附近设置浅层地热能集中换热站，利用采集井与换热站之间的一次采集管网将浅层地热能输送至浅层地热能集中换热站。然后再由换热站与分布式冷热源站之间的二次换热管网将浅层地热能分配至各个分布式冷热源站。分布式冷热源站按照建筑的分布设置，可一栋建筑设置一个，也可多栋建筑共用一个，分布式冷热源站内设置能量提升设备及三次管网，将末端循环水提

升至到达供暖冷需求的温度品位后由末端四次管网输送至各个建筑内供暖冷末端系统，由建筑内的末端设备完成供暖冷过程。

根据项目分期建设的需求，京北校区项目一期二期各设置一套分布式单井循环地源热泵系统。其中一期设置地能采集井 22 套，集中换热站 1 座，分布式冷热源站 4 个；二期设置地能采集井 28 套，集中换热站 1 座，分布式冷热源站 3 个。具体设置见下表：

<table>
<tr><th></th><th>系统序号</th><th>建筑物名称</th><th>分布式冷热源站配置</th><th>集中换热站配置</th><th>采集井配置数量</th></tr>
<tr><td rowspan="6">项目一期</td><td rowspan="6">恒有源分布式浅层地热能冷热源系统一</td><td>1# 小学部</td><td>1# 站</td><td rowspan="6">1 座</td><td rowspan="6">22 套</td></tr>
<tr><td>2# 中学部</td><td rowspan="2">2# 站</td></tr>
<tr><td>3# 海外剧场</td></tr>
<tr><td>4# 综合体育中心</td><td rowspan="2">3# 站</td></tr>
<tr><td>滑雪厅</td></tr>
<tr><td>5# 冰雪中心</td><td>4# 站</td></tr>
<tr><td>项目二期</td><td>恒有源分布式浅层地热能冷热源系统二</td><td>6# 国际部高中</td><td>5# 站</td><td>1 座</td><td>28 套</td></tr>
</table>

恒有源相关负责人介绍，分布式单井循环地源热泵系统应用于该项目有多个优势：

1、集中采集浅层地热能，实现按需供能

项目建筑的用能多少、使用频率等各不相同，采用集中采集浅层地热能的方式，通过设定采集井循环水回水的温度而调整其循环流量，实现按需取能，用多少、取多少、采多少，节约采集水泵电耗。

2、二次网闭式循环输送浅层地热能，降低输送能耗

项目建筑物分布高差达 60 米，若采用常规的地源热泵环境系统，需要将采集井的循环水直接输送至每个冷热源站中，每个采集水泵需要克服由于地势高差带来的 60 米静水压差，总采集水泵电功率需要 1250kw。方案采用设置集中换热站的方式后，每口采集井的循环水只需要输送至集中换热站即可，而集中换热站设置在地能采集井附近，大幅降低的了采集井需要克服静水压差，总采集水泵电功率只需 750kw。由于设置集中换热站，需要增加设置二次管网输送循环泵，循环泵总功率为 200kw，在扣除增加的二次管网输送循环泵功率后，总的采集系统电功率也较常规系统减少了 24%。

同时，二次管网输送循环泵采用变频控制，能够进一步的降低运行时的能耗。

3、二次管网输送低温地热能，减少热量损失

采用常规的地源热泵热泵系统时，地能采集井循环水的供水温度为 15℃，采用设置集中换热站的方式后，由集中换热站输送至每个冷热源站的二次水供水温度降至 13℃，按照管道埋深位置冬季土壤温度为 0℃计算，热量损失可减少 13%。

4、分布式冷热源站按需设置，与建筑冷热量需求高度贴合

根据每个建筑的冷热负荷情况，合理设置分布式冷热源站内热泵机组的装机容量，并考虑部分负荷时的运行情况，采用多台机组、每台机组多机头设置，能够实现建筑供能量与建筑需求量的高度贴合，避免大马拉小车情况的同时，进一步降低现系统运行能耗。

年减少 CO2 排放近两千吨 地源热泵绿色低碳保师生冬暖夏凉

京北校区项目采用单井循环地源热泵系统后，冬季供暖室内温度可达到 20℃以上，夏季制冷室内温度在 26℃左右，游泳池池水常年保持在 28℃，生活热水常年保障供应，满足了项目的冷热需求，完全达到了设计指标，提高了建筑的舒适度。教室内四季如春，低碳环保地保证了师生们冬暖夏凉。案例的实施证明，单井循环地源热泵系统完全能够替代传统燃烧供暖冷方式，实现全部供暖、制冷、生活热水的清洁能源供应，能够带来很好的经济效益和环境效益。

该项目一期 2021-2022 年的运行统计数据表明，供暖季总能耗为 259.03 万 kWh 电能，折合 318 吨标煤。与采用电锅炉供暖比较，可节能约 800 吨标煤，可减少 CO2 排放 1976 吨，减少 SO2 排放 16 吨，减少粉尘排放 8 吨，实现了较大的环境效益。

根据海淀校区多年的运行数据统计，系统全年供热、制冷和提供生活热水共耗电量为 52.66kW · h/ ㎡，按照居民电价 0.4886 元 / kW · h 计算，全年运行费用为 25.72 元 / ㎡（151 天供热，100 天制冷，200 天热水，365 天泳池加热），较北京市执行的北京市非居民供热价格项目 47 元 / ㎡节约 45% 以上。

系统在京北校区建成并实际投入运行后，经过了几个供暖季及制冷季的运行，统计数据显示京北校区全年供暖、制冷和提供生活热水总耗电量为 46.8kW · h/ ㎡，按照居民电价 0.52 元 / kW · h 计算，全年运行费用为 24.4 元 / ㎡（146 天供热，200 天热水，365 天泳池加热，90 天制冷），与项目所辖地张家口市的供暖收费标准 44.1 元 /（平米 * 供暖季）相比，节约 44%（其中还不包含夏季制冷及全年生活热水的费用）。实际运行数据进一步验证了选用该系统的正确性，解决了项目供暖制冷等需求的同时节省了运行费用，还带来了环境良好的环境利益，避免了环境污染，提升了校园与周边环境。

项目采用单井循环地源热泵系统，很好解决了供暖冷、常年泳池水维持温度和提供生活热水的需求，同时大幅降低了的系统的运行能耗。系统运行没有任何污染物的排放，与项目优越的自然环境形成了统一，保持了项目的环境优势。根据项目建筑分散、地形高差大、建筑用能需求差异性的特点，设计采用了分布式单井循环地源热泵系统的方式，体现了系统的可设计性强的特点，实现了按需供能，按需取能，用多少、取多少、采多少，节约运行能耗。

单井循环换热地能技术非常先进

恒有源地能热泵在在海外本部校区和京北校区的绿色实践不仅有利显示出单井循环换热低能

采集的技术优势，也展现了这一绿色环保技术的巨大未来空间。

单井循环换热地能采集井是我国原创的自主知识产权技术，经中科院文献情报中心国内外双向查询为原创技术，具有多项国际发明专利，省部级鉴定国际先进水平。2008 年 12 月获得全国工商联颁发的科技进步一等奖。国际发明是可再生能源领域唯一输出美国的中国原创技术。美国项目获当地政府颁发“能源之星”认定。

2012 年 12 月，由恒有源科技发展有限公司参编的北京市地方标准《单井循环换热地能采集井工程技术规范》（DB11/T935-2013）被北京市质量技术监督局批准发布。经过多年的推广实施，已经应用至超过 2100 万平方米建筑的供暖冷工程中，成为降低建筑运行碳排放的重要技术措施。

单井循环换热地能关键技术及创新点

1、高效：单井循环换热地能采集井是以地下水为介质，采用与地下土壤砂石直接换热的方式采集浅层地热能，提高了换热井的供水温度，从而提高了整个地源热泵系统的能效；

2、安全环保：地热能采集利用全过程不消耗也不污染地下水，对地下水是安全的，避免了潜在地质灾害；

3、省地：其换热效率为传统土壤源方式的 20-100 倍，单井成井后地面仅占一个检修井盖面积，占地面积为传统方式的 1/（20-100），为浅层地热能在土地紧张建筑密集的城市中心区应用提供了技术支持；

4、适用性广：单井循环换热地能采集井分为有蓄能颗粒地能采集井和无蓄能颗粒地能采集井，可适用于不同地质情况，可设计性强，适用范围广；

5、施工周期短：根据项目冷热量需求设定采集井数量，单井施工周期 3-7 天，可实现多井同步施工，可大大缩短工期。

单井循环换热技术为中国独创

单井循环换热技术是我国的独创，恒有源公司拥有其全部自主的知识产权。该技术运行过程中没有水资源消耗，对区域地下水状态和地质结构无影响，具有原创性，已达到国际领先水平。目前，该项技术已走出国门，在美国等国家推广应用并获得成功，为大规模安全开发利用浅层地热能提供了可靠的技术保障。

单井循环地源热泵系统可设计性强，可以根据项目的规模、建筑分布特点、使用规律等进行专项的设计，与建筑物的需求实现完美的契合。京北校区的案例充分证明了浅层地热能完全可以作为供暖冷的替代能源，该系统实现了项目全部供暖、制冷、生活热水的清洁能源供应，起到了很强的典型示范作用。

在未来新建建筑及老旧建筑改造时，应大力推广应用单井循环换热技术，不仅能够为系统使用方节省运行费用，还能大幅降低系统的碳排放，为建设低碳社会贡献力量。

恒有源科技发展集团有限公司（以下简称恒有源）成立于 2000 年，2009 年在香港上市，2012 年中国节能环保集团成为第一大股东。在京港两地一体化管理模式下，恒有源以“让可再生的浅层地热能作为传统燃烧供暖的替代能源”为目标，利用浅层地热能无燃烧清洁供暖，完善发展可再生能源热冷一体化新兴产业是集团的主营业务，实现了原创浅层地热能采集换热技术的产业化发展。在与热泵技术相结合后，让低品位的浅层地热能（温度低于 25°C）成为建筑物供暖的替代能源。在北方供暖地区原有的传统燃烧、单一供暖的基础上，将供暖和制冷两个领域进行融合，发展成为新时期地能热冷一体化的新兴产业。

在规划与设计、可再生浅层地热能供给、智能制造、工程建设与管理、运行与维护五个产业板块的有力支撑下，恒有源已发展成为集投、建、运于一体的清洁、智慧供暖的系统服务商，为北方智慧供暖开拓出了一条无燃烧、零排放、有效防治雾霾的新路子。

恒有源以原创的国际领先的“单井循环换热地能采集技术”为核心，安全、高效、省地、经济的采集浅层地热能，实现了“取热不耗水”，为大规模开发利用浅层地热能提供了有力的技术支撑。大量的与浅层地热能采集相关的专利技术，以及建筑机电安装工程专业承包壹级资质，使公司具备了“系统交钥匙工程”的能力，为客户提供“一站式”清洁供暖（冷）服务。

大力发展浅层地热能供暖同时，恒有源也始终专注无燃烧清洁供暖方式的差异化需求研究与推广，在低温空气源供暖领域取得了长足的发展，形成了以“高效供热 / 省电节能设计技术、低噪音设计技术、宽范围 / 多功能设计技术、高可靠性运行设计技术”为核心的产品技术体系。空气源供暖（冷）作为无燃烧清洁能源供暖（冷）的重要组成部分，与浅层地热能供暖多能互补，同样发挥了及其显著的作用。

恒有源以低温热源（浅层地热能、空气能）作为供暖替代能源，做到了让百姓采暖成本低于传统的直接燃煤采暖。截止到 2022 年，恒有源集团已推广可再生能源替代供暖（冷）项目 2107 万平米，其中集中供暖（冷）项目 1878 万平米，分户供暖（冷）项目 116 万平米（11466 户）、分户空气能供暖（冷）项目 113 万平米（9360 户）。所推广项目可实现年节能量 15.5 万吨标煤，实现供暖常规能源替代量 25.9 万吨标煤，年实现清洁供暖二氧化碳减排量 64 万吨。目前恒有源集团直接负责供暖营运的项目有 50 项，涉及建筑面积 279 万平米，年实现清洁供暖二氧化碳减排量 8.5 万吨。

恒有源集团在多年的科研与经营实践中，始终秉承着“求实、创新”的企业宗旨，追求人与自然的和谐共生。以提高百姓生活品质为目标，全力打造地能热冷一体化的新兴产业链。新时期，恒有源集团将一如既往，携手社会各界共担当保护碧水蓝天的勇士，为实现北方清洁智慧供暖、零排放的梦想继往开来、砥砺前行。

风光储氢协同发展获突破

BREAKTHROUGHS IN COORDINATED DEVELOPMENT OF WIND POWER, PHOTOVOLTAIC POWER AND HYDROGEN ENERGY STORAGE

近日，全球最大光伏制氢生产项目——中国石化新疆库车绿氢示范项目 220 千伏变电工程投产送电。该项目是我国首个万吨级光伏绿氢示范项目，预计每年可减少二氧化碳排放 48.5 万吨，对推动绿氢产业链发展、推动我国能源产业转型升级、保障国家能源安全等具有重要意义。

该项目只是我国风光储氢协同发展的一个缩影。有测算显示，要实现碳达峰碳中和，风电、光伏发电装机容量预计将达到 50 亿千瓦左右。风光、氢能与储能将进一步融合发展。

示范意义显著

“在构建新型能源体系过程中，协调不同能源品类的定位、确保不同能源品类的平衡是个大课题。”在近日召开的 2023 电力新能源专题研讨会上，国能能源研究院院长张福龙说：“以政策为指导和引领，相关部门正积极尝试和探索，稳步推进风光储氢一体化项目。”

去年 3 月，国家发改委、国家能源局在《“十四五”新型储能发展实施方案》中明确提出“在东北、华北、西北、西南等地区充分发挥大规模新型储能作用，通过‘风光水火储一体化’多能互补模式，促进大规模新能源跨省区外送消纳，提升通道利用率和可再生能源电量占比。”此后，内蒙古、新疆、宁夏多地开展风光储氢示范项目建设，产业热度空前。

业内专家普遍认为，在“双碳”目标下，氢能既能解决能源问题，同时也是实现“双碳”目标的重要抓手。

中国电力科学研究院新能源研究中心资深专家丁杰认为，高能量密度固态储氢技术有利于解决风能、太阳能等新能源发电的稳定并网和弃风弃光问题，催生电力系统内氢能存储新业态。“电氢双向转换的热电联供系统，可以有效降低氮氧化物的排放，降低输送环节的损耗，实现冷、热、电的梯级利用和协同供应，是提升能源消费终端综合利用的重要手段。”

“用风、光发电，再采用电解水制氢，整个生

产过程都是绿色、纯生态的。因此，风光储氢一体化项目的示范意义显著。”丁杰说，示范后再大面积推广，一方面可以产出经济、无碳、环保的绿氢，另一方面将对电力电网的储能需求、灵活性供应及调控模式产生前所未有的积极作用。

减碳效果明显

目前氢能产业规模持续增长，对税收和就业的贡献将来可能超过风电、光伏，并形成万亿元级甚至十万亿元级市场。”隆基氢能科技有限公司副总裁王英歌说。

在江苏天合储能有限公司储能战略市场与产品管理总监李秉文看来，光伏发电、储能、氢能和智能电网是实现碳达峰碳中和的 4 个关键因素，而跨季节的长时储能需要氢能去解决。

那么，风光储氢项目究竟是如何“施展魔法”的？以中国石化新疆库车绿氢示范项目为例，该项目主要包括光伏发电、输变电、电解水制氢、储氢、输氢五大部分。项目建成投产后，将利用光伏发电进行电解水制氢，这些氢气将替代之前的天然气制氢，作为还原剂供应至中国石化塔河炼化有限公司，生产炼油装置。通过此模式，该项目每年可减少二氧化碳排放 48.5 万吨。

另外，据张福龙介绍，京能乌兰察布 150 万千瓦风光火储氢一体化大型风电光伏基地项目也

已于 4 月正式开工。该项目充分利用现有火电的灵活调峰能力，通过先进风力发电技术，将凉城县丰富的风资源优势转化为促进地方经济发展的动力。“项目建成后，每年可生产约 36.28 亿千瓦时绿色电能，节约标煤约 125.57 万吨，减少二氧化碳排放约 304.69 万吨。”

建议企业不要盲从

在多位与会专家看来，风光储氢协同发展是大势所趋。

李秉文认为这一市场会越来越大。他介绍，以风光储氢市场的一部分——光储融合为例，预计今年这一市场的规模将达到 84.9 吉瓦，到 2030 年市场占比将达到 55% 以上。随着西部大开发的持续推进，西北五省的风光新增装机量将超 170 吉瓦，到 2027 年，新增电化学储能规模预计可达 55 吉瓦时。

张福龙称：“风光火储氢一体化示范项目建设的推进，一定会带动上下游一批项目投资方、设计方、设备提供方、运维方等不同环节的企业进入，让产业链各环节企业变得更加活跃。”

“地方政府和能源央企、国企依然是风光储氢项目建设的主导者和推动者，他们承担着引领能源转型的重任。对于其他相关企业来说，这是一个最好的发展机遇期，也是大家可以获得更大收获的时期。”张福龙说，“但是，我们呼吁企业要理性看待这一市场的发展趋势和变化，不要盲目追随，而要掌握适合自己公司发展的业务和节奏。”

张福龙同时提醒：“无论是风电、光伏，还是储能、氢能，都要考虑怎么让它们互相配合，怎么让清洁能源份额变得更大、更稳，而不能让各能源品类之间造成无谓的内耗。”

（来源：中国能源报）

徐锭明：大力发展地热产业 携手共建地热强国

XU DINGMING: VIGOROUSLY DEVELOP THE GEOTHERMAL INDUSTRY AND JOIN HANDS TO BUILD A GEOTHERMAL POWER

前不久，国家能源专家咨询委员会副主任、国家气候变化专家委员会委员徐锭明在“沣西能源·2023 第十三届中国国际地热高层论坛”期间召开的“新源谷·浅层地热清洁供暖技术与应用创新研讨会”分论坛上通过视频的形式分享了“十四五”地热行业发展思考，呼吁地热同仁要学习“数字经济”，他希望地热人要雄心壮志、携手打造数字时代的地热强国。

徐锭明认为中国要大力发展地热产业，要从七个方面来思考解决问题，助力地热产业高质量发展。一是能源革命中地热能的地位和作用；二是碳中和时代地热能地位和作用；三是构建新型电力系统中地热能地位和作用；四是构建现代工业体系中地热能地位和作用；五是构建现代农业体系中地热能地位和作用；六是构建现代社会体系中地热能地位和作用；七是构建现代民生体系

中的地热能地位和作用。

他表示，纵观人类社会发展的历史，人类文明的每一次重大进步都伴随着能源的改进和更替，这次能源的更替必定将把我们带入社会主义生态文明新时代。地热能作为清洁低碳能源，要在能源革命中认清地位、发挥作用，积极推动能源革命。

他在演讲中指出，科技决定未来能源，科技创造未来能源。从长远看，未来能源发展不取决于对能源资源的占有，而取决于能源高科技的突破。他表示，“十四五”能源一定要考虑科技发展，而数字化在能源革命中正扮演着越来越重要的角色。他指出，数字化将全面优化资源；数字化将整体提高效率；数字化将创新商业模式；数字化将重构能源市场；数字化要实现全生命周期价值最大化；数字化要推动新时代的数字经济；数字化要为新智慧经济奠定基础。

为此，他呼吁地热同仁，地热行业要实现高质量发展，必须数字化转型。数字经济具有高创新性、强渗透性、广覆盖性，不仅是新的经济增长点，而且是改造提升传统产业的支点，可以成为构建现代化经济体系的重要引擎。

他表示，真正改变世界的是生态系统而不是某一项技术，生态系统可提供综合解决方案，解决复杂困难问题，绝非单一技术可为，系统合作大于竞争，我们要推动行业有序发展，实现同体共享繁荣。“所以地热行业未来整个产业链都要融合在一起，形成一个地热的生态系统。”

工业时代能源强国是化石燃料。他介绍，工业时代经历了第一煤炭强国，第二石油强国，第三光电强国。进入数字化时代，未来的经济是绿色的数字经济，数字的绿色经济。他希望地热人雄心壮志、要携手打造数字时代的地热能强国。

（来源：地热能资讯）

INVENTION AND DEVELOPMENT OF SINGLE-WELL CIRCULATING HEAT EXCHANGE GEOTHERMAL ENERGY COLLECTION TECHNOLOGY

—— Ever Source Company's Gift to the Field of Shallow Geothermal Energy Heating in the World

Author: Sun Ji

1. Introduction

Open Baidu Map of BeiJing and search for “China Geothermal Ever Source Demonstration Communities”. You can see some buildings for experiments in No.63 Xingshikou Road. There is an open space in its southwest corner, which was once the experimental site of the National Ever Source Technology Center. It is from here that the single-well circulating heat exchange geothermal energy collection technology has gone to the world.

The air pollution caused by heating at the end of last century in northern China became more and more serious, and the smog in winter became an unavoidable nightmare for northerners. Data showed that combustion heating in northern China contributed the most to smog in winter, even exceeding automobile exhaust emissions. In order to solve the pollution problem, a group of people who were interested in breaking the stereotype that “heating is pollution” gathered in Ever Source and made up their minds to rewrite the story of heating and pursue the harmonious coexistence between man and nature.

The traditional heating method is combustion heating. That is to say, to get heat, you must burn something. For example, coal-fired heating and gas-fired heating are inseparable from combustion. However, combustion not only supplies the heat we

need, but also brings problems such as air pollution, mineral fuel consumption and ash emission. Although there is no pollution problem in the place where electric heating is used, it has high cost and large power consumption. At present, coal-fired power generation is still the main method in China, and the more electricity consumption, the more serious the pollution problem caused by coal-fired power generation.

Ever Source people began to pay attention to this problem as early as the end of last century. Recognizing that they must find another way to solve this contradiction, they came to a conclusion that they must do non-combustion heating. Under the current technical conditions, it is the most convenient scheme to use heat pump technology to heat buildings by low-grade heat sources. The question is: Where does this low-grade heat source come from?

From the middle of last century, people began to pay attention to the low-grade heat resources below 25 degrees centigrade in shallow underground. It should be the best choice to use those resources as a low-grade heat source for non-combustion heating. There are two traditional ways to obtain shallow geothermal energy: one is to use pumping wells plus recharge wells; and the other is to bury heat exchange tubes underground. Both methods have noticeable limitations. The first one uses underground water as heat source, and obtains heat from water with the heat pump technology, which has the advantages of simplicity and high efficiency. However, it is difficult to overcome the problem that recharge is difficult and pollutes underground water. The second one adopts partition heat exchange, which has low heat exchange efficiency. The heat exchange power of each buried tube is difficult to exceed 5kW. Therefore, it covers a large area and is difficult to popularize and apply in urban construction. To realize non-combustion heating, it is necessary to achieve a breakthrough in the technical field of obtaining shallow geothermal energy. Everyone knew that this was a very difficult scientific research topic of technological innovation. Ever Source Company was determined to undertake this project and achieve this breakthrough. In their own words, they were duty-bound.

Engineers carried out numerous heat exchange tests and established a database by using many abandoned agricultural irrigation wells around them, and invited Beijing geological and water experts to give guidance and academicians and universities of related majors to do experiments on actual measurement of underground temperature field. On the basis of more than ten years' scientific research achievements, a brand-new idea of obtaining shallow underground heat energy was formed, which is the prototype of single-well circulating heat exchange shallow geothermal energy collection technology.

The so-called single-well circulating heat exchange geothermal energy collection technology is to construct a heat exchange device with the earth as the input end in a limited range of shallow underground. The heat exchange medium is groundwater. The output heat is supplied to the heat pump as a low-grade heat source. Because the input heat comes directly from the earth and the medium of heat exchange is underground water readily available, which directly infiltrates the heat source body, so it features high efficiency and small occupied area. It also fundamentally avoids the problems of underground water pollution, consumption and difficulty in recharge.

In October, 2000, the first single-well circulating heat exchange geothermal energy collection well was put into practical operation in the experimental district mentioned at the beginning of this article. This was a scientific research achievement independently developed by China, and the technology has reached the international leading level. We had independent intellectual property rights of all core technologies.

More than 20 years have passed, and the single-well circulating heat exchange geothermal energy collection technology and Ever Source have kept pace with the times and developed continuously. In 2022, it has been popularized and applied over 22 million m^2, equivalent to replacing about 170,000 tons of standard coal every year and reducing carbon dioxide emissions by about 450,000 tons. While bringing warmth to hundreds of millions of people in winter and coolness in summer, it saves the fuel consumption of heating and significantly reduces the air pollution emissions in the areas of use.

2. Basic Work

Can single-well circulating heat exchange geothermal energy collection technology ensure the safety of underground water? How to formulate its design standards? The solution of these two problems is the basic work. From the beginning of its business, Ever Source has invested a lot of manpower and material resources to carry out the related research on single-well circulating heat exchange and temperature field monitoring around heat exchange wells, and achieved rich results.

Since 2001, Ever Source has selected “Sibolian Engineer Dormitory” and “Xijiao Auto Parts Town”, which were put into operation in 2000 and 2001, as test sites, and entrusted Beijing Water Environment Monitoring Center to track and monitor the water quality of the collected well water for 10 consecutive years, and Beijing Center for Disease Control and Prevention to track and monitor the water quality for three consecutive years. As of September 2010, 140 test reports and 3696 test records were obtained.

Beijing Water Affairs Bureau and Haidian District Water Affairs Bureau organized relevant experts to hold three review meetings on the results of water quality protection. The conclusion was that the single-well circulating heat exchange technology could solve the problems of sand removal, uneven ground settlement and water loss, and had outstanding advantages over the traditional underground water geothermal heat pump technology. The monitoring results of Beijing Water Environment Monitoring Center showed that there was no obvious change in 21 indexes of water quality except water temperature in effluent and recharge water, and the single-well circulating heat exchange recharge water had no influence on underground water quality. “Single-well pumping and recharge”, a shallow geothermal energy (heat) extraction method, is a soil heat exchange device with water as medium instead of a water intake device. Compared with ordinary water-cooling system, it completely avoids the evaporation loss of water and has an outstanding effect on water conservation. According to the water quality monitoring report of single-well pumping, recharge and collection well, experts from Beijing Water Environment Monitoring Center and Beijing Center for Disease Control and Prevention came to the conclusion that the long-term monitoring results showed that there was no obvious change in effluent and recharge water quality in cooling and heating conditions, and the underground water quality was not affected.

On August 21, 2003 and July 15, 2005, Beijing Water Affairs Bureau and Haidian District Water Affairs Bureau organized the “Single-well Pumping and Recharge” Water Resources Protection Achievement Review Meeting. The review opinion of experts was that the single-well pumping, recharge and energy collection technology as a closed circulation heat collection device with water as the medium, was a ground source heat pump system, which caused no water resources consumption during operation and had no influence on regional underground water state and geological structure.

In 2006, Ever Source cooperated with Harbin Institute of Technology and other entities to monitor and study the underground temperature field around the single-well circulating heat exchange well.

In the operation process of the single-well circulating geothermal energy collection well, the temperature of rock and soil around the collection well will change. It is very important to study the law of these temperature changes for predicting the heat exchange capacity of the collection well, including the maximum heat exchange power, the total heat supply and the temperature changes of inlet and outlet water. Since its establishment, Ever Source has planned to set up a corporate technology center to carry out research work in this field. The results obtained have provided data support

for the establishment of design standards for heat exchange wells, and also data for scientific researchers to support their research on the development and utilization of shallow geothermal energy.

① Variation law of underground temperature field during heat collection period

The actual thermometry curve is very irregular, and there are many twists and turns, which shows that the aquifer structure in the depth direction is extremely uneven, and there are even layers. We can see that the temperature changes of strata with different depths are different due to different geological structures, and those with largest temperature changes emit (or absorb) the most heat. By changing the internal structure of the collection well and redoing the above experiment, it is found that the temperature change speed of rock and soil is different for different well structures, so we can find the most suitable well structure for different strata, and with the help of calculation software, we can get the corresponding calculation data such as supply power.

② Variation law of underground temperature field during the period of restoration,

In the heating season, the temperature of the rock body around the collection well gradually decreases with the continuous heating process. After the coldest season, the temperature began to rise. After stopping heating, the recovery process of underground temperature field is very important to evaluate the heating capacity of rock around the well. The recovery process is fast and the heating capacity is strong.

③ The temperature field in the rock and soil around the collection well changes periodically all year round, the lowest temperature occurs in February-March, and the highest temperature occurs in August-September. The measured results show that before the end of the heating season, the underground temperature has started to rise and returned to the initial value before the start of the cooling season. We can see that the underground temperature field changes periodically when the well is designed correctly and working under the condition of rated heating power and heating cycle, and there is no trend that the overall temperature decreases year by year.

3. Key Technologies and Innovations

3.1 The key technologies of single-well circulating geothermal energy collection include:

① Liquid sealing technology in the well and the mathematical model of underground water flow pattern in the collection system are established. Mathematical model of multi-flow pattern heat transfer of underground water. Using heat transfer backfill particles of formations with different permeability conditions, the formations can be locally improved and the permeability coefficient

can be increased. Multi-aquifer single-well circulation stratified collection technology.

② Shallow geothermal energy collection, terminal heat dissipation and control of rural decentralized buildings.

③ Key technologies and products of high-efficiency electricity instead of coal heating matching with urban heating. Serial cold and heat source stations with single-well circulating heat exchange collection technology as the core.

④ Design and evaluation method of heat pump systems based on single-well circulating heat exchange. The calculation method of underground heat exchange and system optimization based on harmonic response are established. A comprehensive performance evaluation method of single-well circulating heat exchange heat pump system based on multi-factor loop theory and analytic hierarchy process (AHP) is proposed. The performance index values of safety, energy saving and durability of the single-well circulating heat exchange heat pump system are determined, and the comprehensive performance evaluation standardization of the single-well circulating heat exchange heat pump system is realized.

3.2 The four technological innovations of Ever Source include:

① Has pioneered the single-well circulating shallow geothermal energy collection technology with 100% recharge, and obtained 34 patents at home and abroad;

② The triple supply technology and series products that use shallow geothermal energy to heat, cool and provide hot water for rural buildings have won 23 patents at home and abroad;

③ The urban high-efficiency electricity instead of coal heating technology has obtained 10 patents;

④ Has developed the design and evaluation method of the single-well circulating heat exchange heat pump system and established corresponding local standards.

4. Results and Evaluation

4.1 According to the official document issued by the National Development and Reform Commission in 2013, which emphasized, when talking about the characteristics of single-well circulating heat exchange geothermal energy collection technology, that the single-well circulating technology (with invention patent) independently developed by Ever Source was a major technological innovation in the shallow geothermal energy collection, which provided a strong technical guarantee for the large-scale use of shallow geothermal energy for heating. The expert group led by Wang Bingchen, a former counselor of the State Council and a Chinese engineering survey master, demonstrated that the technology has reached the international advanced level and has broad application prospects.

The single-well circulating technology

adopts a closed and stable geothermal energy circulation collection system. The upper part of the single well is a pressurized return water area, and the lower part is a pumping area. The underground water is pumped from the pumping area to the wellhead heat exchanger, to exchange heat with the low-temperature water in the heat pump. After the heat of the underground water is released, it is returned to the pressurized return water area via the same well. In general heating projects, each geothermal energy collection well (such as gravel geology) can afford about 10,000 square meters of heating capacity. Compared with the traditional pumping well and soil buried pipe technology, the engineering cost of the single well circulation technology is equivalent, but the technical advantages are obvious: it avoids the problems of easy water intake, difficult recharge, groundwater level drop and cross-pollution in the pumping well technology, and will not cause potential geological disasters; compared with the soil buried pipe technology, the heat exchange efficiency is high, the occupied area is small, the maintenance is convenient, and the technology is widely appliable for different geological conditions.

Compared with the direct conversion of electricity into heat energy for heating the single-well circulating technology, energy saving can be achieved by 50% to 70%; compared with the traditional heating from coal-firing boiler rooms, the engineering investment and operating costs are comparable, and energy saving can be directly achieved by about 15% to 20%, and air pollutant emissions caused by coal combustion in the district can be significantly reduced. Since a set of devices using this technology can provide heat in winter and cold in summer, for buildings with cooling demand in summer, it is only equivalent to the investment in central air-conditioning refrigeration works, which saves the investment in the heating system and has better economic benefits.

4.2 From 2001 to 2012, the single-well circulating heat exchange geothermal energy collection technology was popularized and applied to more than 8 million square meters, and was supported and welcomed by all sectors of society as it did not consume or pollute underground water. In order to standardize the management, it was necessary to determine what was the single-well circulating heat exchange geothermal energy collection technology, and what conditions should be met before it could be identified as the technology. In 2013, Beijing Energy Conservation and Environmental Protection Promotion Association organized the compilation of Technical Specifications for Single-well Circulating Heat Exchange Geothermal Energy Collection Wells, which quoted the corporate standards of Ever Source for well structure design, heat exchange power, construc-

tion organization design and acceptance conditions. In the introduction of the standards, it is stated that the single-well circulating heat exchange geothermal energy collection well technology is an original, advanced shallow geothermal energy collection technology suitable for various geological conditions in China. It uses circulating water as a medium to collect shallow underground heat energy with temperature lower than 25 degrees centigrade. It can realize all local recharge of underground water in the same layer, without consuming or polluting underground water and is safe for underground water.

The key structure of single-well circulating heat exchange geothermal energy collection well is a sealing device in the well. Correct design and use of sealing device is the key to ensure normal heat exchange, which is one of the core technologies of Ever Source. The company has applied for corresponding patents and set up technical barriers. In order to increase the popularization of the single-well technology, Ever Source finally agreed to give up the patent right of corresponding patents to facilitate the implementation of the standards.

4.3 In 2017, the expert group of “Key Technologies and Engineering Applications of Shallow Geothermal Energy Development Based on Single-well Circulating Heat Exchange”, composed of Professor-level Senior Engineer Wu Desheng, Consultant and Chief Engineer of Beijing Institute of Architectural Design, Professor Wang Guangqian from Tsinghua University, Academician Wang Jiyang from the Institute of Geology, Chinese Academy of Sciences, Professor-level Senior Engineer Hu Chunhong from Beijing Academy of Science and Technology, Professor Ni Jinren from Peking University, Academician Wu Qiang from China University of Mining and Technology, Professor Xu Wenfa from China Urban Construction Design & Research Institute, and Professor-level Senior Engineer Lu Jiazheng from State Grid Hunan Disaster Prevention Center, reviewed the single-well circulating heat exchange technology, and came up with the following opinions.

① The single-well circulating heat exchange geothermal energy collection technology is a shallow geothermal energy collection technology invented by Ever Source, which is suitable for various geological conditions. It collects shallow underground heat energy with underground water as a medium, and realizes 100% recharge of underground water in the same well, without consuming or polluting underground water. It is safe for underground water and geological structures, and realizes safe, efficient, environmentally friendly and recyclable use of shallow geothermal energy.

② Compared with the traditional technology of “pumping well + recharge well”, which exploits and utilizes shallow geothermal energy at home and abroad, the single-well circulating heat exchange geo-

thermal energy collection technology has outstanding advantages, as it does not consume, pollute and destroy the natural state of underground water. The heat exchange capacity of single well can reach 500kW.

③ The single well circulating heat exchange geothermal energy collection technology has been popularized and applied in the construction field to heat more than 16 million square meters of buildings, including the special heating of landmark buildings such as the National Grand Theater. The engineering application has developed rapidly, and the economic and social benefits are remarkable. Compared with coal-fired heating, the in-use projects can replace 140,000 tons of coal for building heating every year, and reduce the corresponding carbon dioxide emissions.

The appraisal and evaluation experts agreed that the project results were original and had reached the international leading level.

4.4 In 2017, the Documentation and Information Center of the Chinese Academy of Sciences issued the Science and Technology Novelty Search Report No. 2017-649: Novelty Search Conclusion:

This novelty project proposes a technical process of realizing 100% recharge of well water in the same well and layer in the process of single well circulating heat exchange geothermal energy collection, which has not been reported in the public literatures at home and abroad.

This novelty project proposes that the heating power of a single well reaches 500kW during the single-well circulating heat exchange geothermal energy collection process, and there is no relevant report exceeding this value in the public literatures at home and abroad.

4.5 At the Mexico Conference of the World Geothermal Resources Committee (GRC) in 2003, Mr. Xu Shengheng, General Manager of Ever Source,were invited to jointly publish the paper Utilization of Shallow Geothermal Energy Resources – A Case Study of Single-well Circulating Technology with Professor Rybach of the University of Zurich, Switzerland, which won the Best Paper Award of the conference.

The paper mentions: The so-called shallow low-temperature geothermal heat refers to the heat stored in a certain depth below the surface (such as within more than 100 meters). In most parts of China, the above-mentioned depths are in a constant temperature zone, that is, the temperature is basically not affected by the changes of the four seasons and remains between 10°C and 20°C. The development and utilization of this part of low-temperature geothermal heat for building heating, cooling and provision of domestic water has a lower one-time input and operating cost than traditional methods. However, due to the low energy density of shallow low-temperature geothermal heat, large-scale development technology is difficult to achieve. This pa-

per introduces the operation principle of a "single-well pumping and recharge system" based on an example in Beijing Haidian Foreign Language Shiyan School in Beijing China. In this case, shallow low-temperature geothermal heat is used to provide heat for buildings in winter and discharge heat into the ground in summer.

Shallow low-temperature geothermal heat is a huge cold and heat source, which is widely distributed and rich in reserves, and has great exploitation and utilization value.

Single-well pumping and recharge technology is a shortcut to develop and utilize shallow underground low-temperature geothermal energy. It uses groundwater as a medium to exchange heat with soil, and the initial investment and operation cost are relatively low.

The system discussed in this paper is completely closed, and does not discharge any gaseous, solid and liquid pollutants during operation.

Wide application of this system not only greatly improves the utilization rate of energy, but also saves considerable investment in environmental protection.

4.6 In the third appraisal and selection of "Typical Application Cases of the Key Energy Saving Technologies" organized by the National Energy Conservation Center under the National Development and Reform Commission in 2023, the geothermal heat pump environmental system project in Jingbei Campus of Haidian Foreign Language Shiyan School submitted by Ever Source Science and Technology Development Group Co., Ltd. was finally selected after preliminary evaluation, defense and on-site verification.

4.7 On the occasion of the upcoming World Geothermal Conference in 2023 in China, the National Technology Promotion Center for Geothermal Energy Development and Utilization Research and Application and the Geothermal Energy Professional Standardization Technical Committee of the Energy Industry launched the appraisal and selection activities for geothermal energy development and utilization demonstration projects in order to show the achievements of China's geothermal industry and promote the high-quality development of the industry. In the activities, Ever Source Group's "Comprehensive Energy Project of Xiong'an Citizen Service Center" won the title of Demonstration Project of Geothermal Energy Development and Utilization. Xiong'an Citizen Service Center is the first infrastructure project since the establishment of Xiongan New Area. It is the epitome of creating a smart city and a green city in Xiong'an in the future, and has very important model significance. The comprehensive energy system of Xiong'an Citizen Service Center adopts a comprehensive energy supply system of "shallow geothermal energy + reclaimed water source + cold and hot storage", and sets up a geothermal energy hot and cold

integrated energy station. The energy station mainly focuses on shallow geothermal energy, makes full use of available energy such as reclaimed water, and combines low-valley electricity for cold and hot storage, creates an integrated supply of heating, refrigeration and domestic hot water, forms a smart heating (cooling) system for buildings without combustion of geothermal energy, meets the demand for heating and cooling services of 100,000 square meters of buildings in the project, and realizes the objective that more than 60% of the total heating (cooling) energy consumption of buildings is clean energy such as shallow geothermal energy, which demonstrates the development and utilization of geothermal energy and plays a leading role in the construction of the new area.

5. Our Expectations

The 7th World Geothermal Congress to be held in Beijing soon is a grand conference of the world geothermal community, and we are full of expectations for it.

This article is an introduction of our work and ideas, and your criticism and correction are welcome. We look forward to communicating and exchanging with friends in geothermal circles at home and abroad. Dear colleagues, we are waiting for you in Beijing Ever Source Science & Technology Development Group Co., Ltd.!

Editor's word

The column "Paper poster" is a special column for the World Geothermal Congress in September, and is a highlight of this issue. The articles in this column are brief summaries of three papers, the details of which will be presented at this year's World Geothermal Congress.

The magazine is here to launch, This column is a preview to professionals who are committed to achieving the two-carbon goal and public welfare enthusiasts who are concerned about high-quality global development.

Hope to attract the attention of all walks of life, and look forward to communicating with friends from all walks of life to jointly promote the geothermal industry to ride the wind and waves and create new achievements!

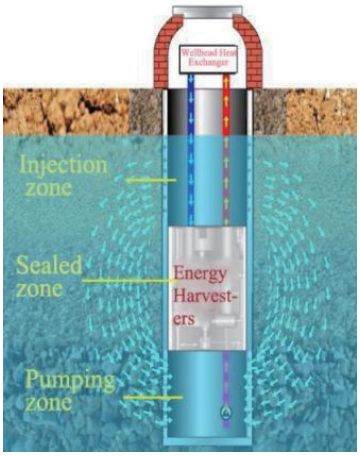
Please pay close attention to the World Geothermal Congress to be held in Beijing this September, and wish the conference a complete success.

COUPLING SIMULATION OF SEEPAGE AND TEMPERATURE CHARACTERISTICS OF SINGLE WELL CIRCULATING GEOTHERMAL COLLECTION SYSTEM

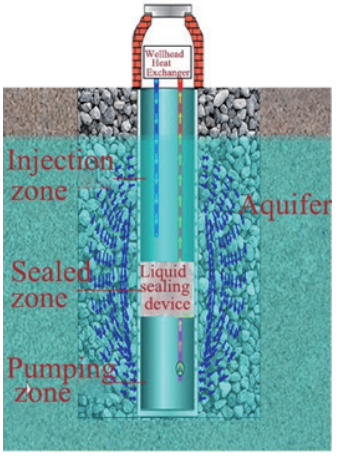
Author: Xu Shengheng, Wu Qiang

Using a combination of theoretical research and numerical simulation, the author discusses the influence of the operation of a single-well circulating system on groundwater seepage and temperature field. The permeability coefficient of the aquifer affects the flow of the underground circulating water. When the penetration rate of the aquifer in the baffle section is poor, the injected water is blocked from flowing to the pumping area, thereby significantly reducing the fluctuation of pumping temperature and maintaining a stable heat exchange temperature difference.

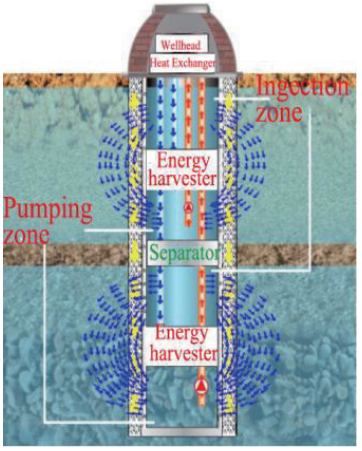
1. Sketch Diagram of Single-well Circulating Heat Collection System



No heat transfer backfill type

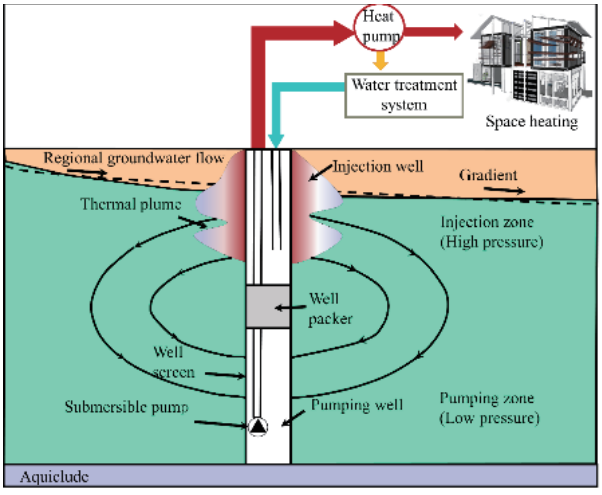


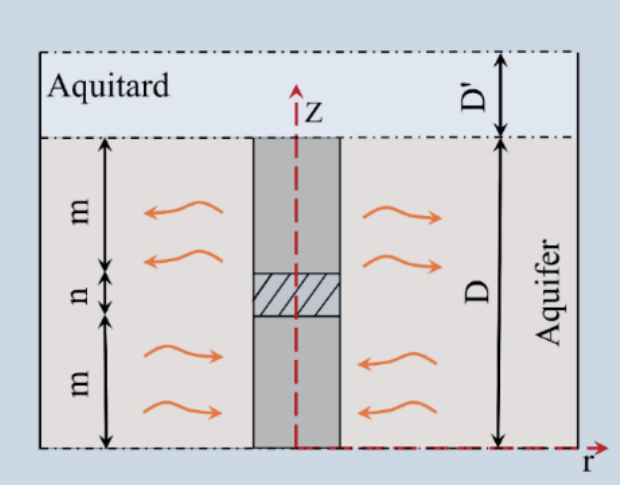
Heat transfer backfill type



Single–well circulation stratified heat collection

2.Mathematical Model of Single-well Circulating





The pumping and recharge single well of the constant flow single-well circulation system in the same homogeneous aquifer is regarded as a complete pumping well with a depth of 2m+n and two incomplete wells.

3. Dynamic Changes of Seepage Field and Temperature Field

A single-well circulating heat collection project in Beijing has a total heating load of 3450 kW and a total cooling load of 3600 kW. The project site is rich in water, and the water output of the single well reaches 5000 m^3/d. A single-well circulating geothermal collection system is designed when the aquifer thickness (d) is 100m and 64m respectively, and the underground water module and heat transfer module of the Feflow software are used to carry out numerical simulation of hydrothermal coupling. The model running time is designed with heating in winter (11.15-3.15) + cooling in summer (6.1-9.15) + transition period (137d) in Beijing.

The model setting parameters are as follows:

The simulation results show:

① Underground water depth reduction in system operation: there is a boundary effect, the smaller the thickness of the aquifer, the higher the absolute depth reduction value near the heat source well.

② Under different operation modes and the long-term operation mode of winter operation in which the pumped water temperature is used only for heating in winter, the pumped water temperature continues to show a dynamic change process of “reduction-recovery”, and the extent of natural temperature recovery is smaller than that of the annual operation mode. The pumped water temperature in the summer operation mode with only summer cooling shows an overall

Zone	Hydraulic conductivity (m/d)		Porosity	Specific weight	Thermal capacity (MJ/(m^3 · ℃)	Thermal conductivity W/(m · ℃)
	Kxx=Kyy	Kzz	n	μ	c	λ
I	1.00	1.20	0.29	0.01	1.50	1.87
I I	1.35	1.35	0.30	6×10^{-3}	1.50	1.87
III	5.8×10^{-3}	0.3	0.25	5×10^{-4}	1.50	1.87
IV	1.8×10^{-4}	1.8×10^{-4}	0.27	5×10^{-4}	1.30	1.35
V	1.3	1.3	0.31	1×10^{-4}	1.50	1.87
VI	5.01	5.01	0.35	1×10^{-4}	1.50	1.87

upward trend. At the end of the first cooling season in the summer cooling mode, thermal breakthrough has occurred in the pumping section of the heat source well. With the increase of operating years, the extent of thermal breakthrough has intensified and the thermal response radius of the single-well circulation system has been expanded.

③ Influence of permeability coefficient on seepage field

The change of aquifer temperature distribution in the pumping section is greatly affected by the permeability coefficient of the intermediate aquifer. When the permeability coefficient is small, the hydraulic connection between the recharge section and the pumping section is weakened, the proportion of the re-injection water flowing vertically into the pumping section is reduced, and the time and extent of thermal breakthrough are reduced.

4. Conclusions

① The simple cooling or heating method is not conducive to the operation of the system. The overall evolution trend of the effluent temperature shows an increase (cooling only) or a decrease (heating only), and energy decay occurs. Under the annual long-term operation mode (cooling and heating), the pumped water temperature is stable, which meets the requirements of system sustainability.

② The permeability coefficient of the aquifer has a more significant effect on the seepage field and temperature field of the aquifer. When the K of the intermediate aquifer is small to form an effective aquifer, it is beneficial to reduce the overflow of the recharge water to replenish the pumping area, delay the occurrence and intensity of thermal breakthrough, and ensure the single-well circulating operation performance.

FIRST SHALLOW GEOTHERMAL ENERGY + SOLAR POWER GENERATION MULTI-ENERGY COMPLEMENTARY HOUSEHOLD-BASED HEATING (COOLING) DEMONSTRATION PROJECT

—— Yihepu Rural

Author: Liu Baohong, Li Yanchao

Yihepu Rural is located in Huailai County, Zhangjiakou City, the Olympic corridor. The annual average temperature here is 5.5-6.5 °C, and the winter heating design temperature is -13.6 °C. It belongs to the cold A region. The total annual solar radiation is 5700-6100 MJ/m^2, making it a Category II resource area. The project uses shallow geothermal energy + solar power generation multi-energy complementary to provide heat (cold) for rural buildings on a household basis. By 2023, the project has been in stable operation for 7 years.

1. Program Configuration

The buildings of Yihepu Rural are all single-storey buildings. The outer walls are 370mm red brick walls, with no thermal insulation, and the doors and windows are single-layer wood or single-layer aluminum alloy materials. Each household is 13.2m long from east to

Indoor unit of geothermal energy heater in a villager's home

Outdoor unit of geothermal energy heater, rooftop solar power generation

Solar photovoltaic grid connection box

west, 7.8m long from north to south, and has a heating area of about 100 square meters. There are 265 households in the whole Rural, divided into two areas: east and west areas.

The Ever Source heater in a household is one set of device composed of one outdoor unit and two indoor units and one set of device composed of one outdoor unit and one indoor unit. Each household solar power generation uses 20 photovoltaic modules. The multi-energy complementary power supply system adopts one photovoltaic inverter, which is connected to the 220V line to the original indoor distribution box of the home, and then connected to the indoor low-voltage distribution network through the 220V line.

2.Heating Comparison before and after Renovation

Before the renovation, each household burned coal stoves for heating, and manually put in coal and removed cinders every day. Each household burnt 2.5-3.5 tons of loose coal in one heating season (the calorific value of loose coal is 5000kcal/kg), equiv-

alent to 1.79-2.5 tons of standard coal. 75% of the home heating rooms had a temperature of ≤ 16 °C, and the room temperature changed greatly with the frequency of coal adding, and the heating temperature was unstable. After the renovation, the household controls with a remote control the start and stop of the indoor unit, which was easy to operate. The room temperature of the heating room reached the standard according to users' feedback, and some users' feedback exceeded the national heating standard, at the same time, the geothermal energy household heating system can be used as a cooling system in summer. Users generally believed that it was comfortable and convenient to use.

3. Annual Economic Income of the Household

The multi-energy complementary system income of Zhang's family in Yihepu Rural from August 1, 2020 to July 31, 2021: Solar power generation income is nearly 7000 RMB, the electricity purchased is less than 2500 RMB, and the total household net income is nearly 4500 RMB.

4.Environmental Benefits

There are two main sources of environmental benefits, one is the zero-pollution and zero-emission environmental benefits brought by the replacement of burning loose coal for heating by the geothermal energy heater system, and the other is the environmental benefits brought by the replacement of thermal power production and transmission by solar power generation. After the renovation, loose coal burning is reduced by about 800t per year, and green electricity saving is more than 1.3 million kW.h per year. Annual can reduce carbon dioxide emissions 3101.69t, reduce sulfur dioxide emissions 14.13t, reduce soot emissions 12.36t, with good environmental benefits.

5. Conclusions

The shallow geothermal energy + solar power generation multi-energy complementary household-based heating (cooling) system in Yihepu Rural use shallow geothermal energy to heat (cool) rural buildings on a household basis, and adopts the geothermal energy heater equipment with separate room adjustment and Floor-type lower air outlet structure, characteristic of small power distribution, simple operation, room-specific control, comfortable temperature, high efficiency and energy conservation, and solves the problems existing in rural building heating; at the same time, combined with roof solar power generation, the practice can increase farmers' economic income every year; the system is innovative and of great practical significance with geothermal energy + multi-energy complementary.

PAPER POSTER

A CASE STUDY ON SINGLE-WELL CIRCULATING HEAT EXCHANGE GEOTHERMAL ENERGY COLLECTION TECHNOLOGY IN JINGBEI CAMPUS OF BEIJING HAIDIAN FOREIGN LANGUAGE SHI YAN SCHOOL

Author: Xu Shengheng, Wang Jiyang

The “single-well circulating heat exchange geothermal energy collection technology” invented by Ever Source Technology Development Group Co., Ltd. is a way to efficiently and safely collect shallow geothermal energy to provide a stable heat source for buildings. This article introduces the achievements of Beijing Haidian Foreign Language Shi Yan School in applying this technology for continuous heating over the past 20 years. Since 2019, the school has expanded the application of the technology in the Jingbei New Campus Project located in Beijing Olympic Winter Games Zhangjiakou Division to meet the needs of heating, cooling and year-round provision of domestic hot water for 137,000 square meters of buildings in the new campus, including various winter sports venues. The utilization rate of renewable energy reach more than 60%, and the annual emission reduction of carbon dioxide exceeds 1976 tons. This project applies the “single-well circulating

heat exchange geothermal energy collection technology" to obtain renewable shallow geothermal energy, which does not consume or pollute underground water, and achieves regional zero carbon emission. According to the characteristics of the decentralized and use functions of the campus buildings, it is set up as a water loop heat pump system with centralized energy utilization and distributed cold and heat source stations to further realize system energy conservation. The use of seasonal energy storage realizes the storage of heat energy in summer for use in winter, and the heating and cooling services have achieved high energy efficiency operation. This article is a continuation of the article Shallow Geothermal Energy Resource Utilization - A Case Study of Single-Well Pumping and Recharge Technology published by Xu Shengheng and Ladislaus Rybach at the 2003 International Geothermal Congress. The long-term continuous and stable operation proves the reliability of the single-well circulating heat exchange geothermal energy collection technology, which features simple replicability and wide adaptability. It is an optimal technical solution to achieve the goal of "emissions peaking and carbon neutrality" in the field of building heating.

1. Introduction

Shallow geothermal energy refers to the thermal energy stored within about 200 meters below the surface, and its temperature is lower than 25 degrees. Shallow geothermal energy, characteristic of wide distribution, shallow burial depth, large reserves and low development and utilization cost, is an important part of the geothermal energy family. The use of advanced single-well circulating heat exchange geothermal energy collection technology can develop and utilize shallow geothermal energy on a large scale, at low cost and stably. Combined with the improvement of its thermal energy grade (temperature) in the implementation of heat pump technology, it has become an alternative energy source for building heating, and a convenient low-carbon path to solve building heating. In 2003, Mr. Xu Shengheng and Professor Rybach of the University of Zurich, Switzerland jointly published the article Utilization of Shallow Geothermal Energy Resources – A Case Study of Single-well Circulating Technology with the example of Beijing Haidian Foreign Language Shi Yan School, which for the first time introduced engineering cases in which single-well circulating heat exchange geothermal energy collection technology was used to develop and utilize shallow geothermal energy for building heating and cooling. As the use of single-well circulation technology eliminated problems such as difficult recharge and pollution

and waste of underground water resources, it received high attention from the congress. Since then, there have been inquiries from industry insiders. Now more than 20 years have passed, Haidian Foreign Language Shi Yan School has completed two expansions, and shallow geothermal energy for heating has also developed rapidly in China. The single-well circulating heat exchange technology has been popularized and applied to more than 20 million square meters

Outdoor meteorological parameters in Zhangjiakou

Station position	North latitude	40° 47′
	East longitude	114° 53′
	Altitude (m)	723.9
Atmospheric pressure (mbar)	Winter	938.9
	Summer	924.4
Annual average temperature °C		7.8
Outdoor calculation (dry bulb) temperature (°C)	Winter	-15
	Summer	31.6
Outdoor calculation (wet bulb) temperature (°C)		22.3
Warmest monthly average temperature (°C)		23.2

of buildings. Taking the latest progress of the heating/cooling system of Beijing Haidian Foreign Language Shi Yan School, a sample project studied that year, as an example, this article introduces the continuous innovation of single-well circulating heat exchange geothermal energy collection technology and the economic and environmental benefits obtained to respond to those who are concerned about the development and utilization of shallow geothermal energy in China and the single-well circulating heat exchange technology.

2. Overview of Haidian Foreign Language Shi Yan School

The Jingbei Campus Project of Beijing Haidian Foreign Language Shi Yan School is the first phase project of the school, with a total construction area of about 60,000 square meters. The South Campus Project of Beijing Haidian Foreign Language Shi Yan School is the second phase project of the school, with a total construction area of about 40,000 square meters. The Jingbei Campus is the third phase project of the school. It is located in Zhangjiakou City, the city of the Winter Olympic Games. Zhangjiakou is a cold region, and its outdoor meteorological parameters are shown in Table 1. Construction of the project started in 2019 and completed in 2022. The Jingbei Campus has a construction area of 137,000 square meters. It is a newly built 12-year international school that can accommodate 5,000 students, including ten buildings such as the teaching building, office building, scientific research center, academy of art, theater, faculty canteen, student apartment, teachers' apartment, indoor and outdoor sports venues.

At present, there are 10 buildings in the Jingbei Campus. Due to the large campus area, scattered buildings, relatively large surface elevation difference, and varied time and frequency of use, Ever Source shallow geothermal energy distributed cold and heat source system is selected for the building Heating, cooling and provision of domestic hot water. The system consists of a single-well circulating heat exchange geothermal energy collection well, a shallow geothermal energy centralized heat exchange station, a distributed cold and heat source station and an terminal system in the building.

The project sets up multiple single-well circulating heat exchange geothermal energy collection wells to centrally collect shallow geothermal energy, connects the collection wells together to form a primary collection pipe network, and uses the primary collection pipe network to transport shallow geothermal energy to the centralized heat exchange station. The secondary heat exchange pipe network distributes shallow geothermal energy to

the distributed cold and heat source station, which is provided with trinary pipe network to upgrade the energy to the temperature grade of heating or cooling, and then it is transported to the buildings for heating or cooling via the quartic pipe network to complete the heating or cooling task.

3. Energy Conservation and Emission Reduction Effects and Major Technological Progress and Innovations

The total energy consumption in the heating season of the project is 2.590,300 kWh of electric energy, equivalent to 318 tons of standard coal. Compared with the use of electric heating directly, it can save about 800 tons of standard coal, the utilization rate of renewable energy is 60%, and the annual CO_2 emission can be reduced by 1976 tons, SO_2 emission can be reduced by 16 tons, and dust emission by 8 tons.

In the past 20 years, the single-well circulating heat exchange shallow geothermal energy heating technology has achieved the following developments and innovations:

① A collection well with heat exchange particles has been invented. The well water is pumped out by a submersible pump placed in the pumping area at the bottom of the heat insulation pipe. After entering the heat pump unit to release or absorb heat, the water returns via the heat pump unit to the upper pressurized water return area of the geothermal energy collection well. The water flows down to the pumping area in the annular space with heat exchange particles, enters the heat insulation pipe through the floral tube at the lower part of the heat insulation pipe, and is then pumped out by the submersible pump. Heat exchange particles are placed around the well pipe to locally improve the geological environment and expand the range of high-efficiency heat exchange. The heat exchange particles should be spherical with a diameter of 10mm-100mm, and the strength is greater than 50 MPa.

② Aiming at the problem of pumping across multiple aquifers in the geological structure, the technology of multi-aquifer geothermal energy collection wells without heat exchange particles has been developed. Two or more wells are stacked up and down and sealed to realize the same layer recharge of the geological structure with multiple aquifers.

③ In 2012, Ever Source Science and Technology Development Group Co., Ltd. compiled the Engineering Technical Specification for Single-well Circulating Heat Exchange Geothermal Energy Collection Wells DB11/T 935-2012, which provides a model for the design and construction of single-well circulating heat exchange geothermal energy collection wells.

A VISIT TO BEIJING HAIDIAN FOREIGN LANGUAGE SHI YAN SCHOOL

—— Green Jingbei Campus Sails with Shallow Geothermal Technology

Author: Ma Xiaofang (special correspondent)

Along the Beijing-Chongli Expressway all the way north, you can drive to the Jingbei Campus of Beijing Haidian Foreign Language Shi Yan School (hereinafter referred to as the "Jingbei Campus"), which is only more than 20 kilometers away from Yanqing Winter Olympics Village in Beijing, very soon. The Jingbei Campus, adjacent to Guanting Reservoir and with the dark green mountain and bluish green cypresses as the background, is located in the New Ecological District in the north of the capital, known for a high forest coverage rate and excellent air quality throughout the year. As early as 2019, the campus became the ice and snow project base for the General Administration of Sport of China to reserve talents for the Chinese National Youth Team for the Olympic Games, and was selected into the third batch of publicized list of "Olympic Education Demonstration Schools for Beijing 2022 Olympic Winter Games and Winter Paralympic " in Hebei Province in 2021.

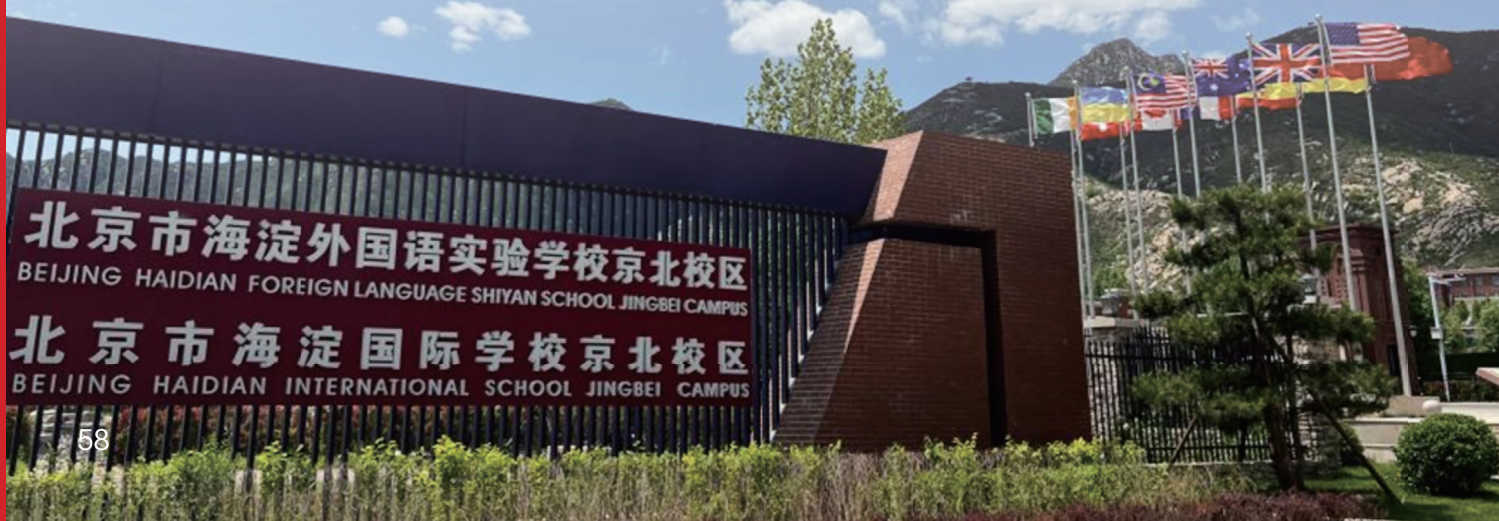
Beijing Haidian Foreign Language Shi Yan School reached a consensus with Ever Source Science & Technology Development Group Co., Ltd. to jointly build an environmentally friendly and low-carbon campus at the beginning of its establishment. Thanks to this, the Jingbei Campus jointly designed, developed, and adopted single-well circulating heat exchange geothermal energy collection technology to provide heating service to the teachers and students of the school in winter and cooling service in summer, while ensuring 24-hour hot water for the swimming pool of the school and daily campus life since the construction of the school. For more than 20 years, Ever Source Group's original shallow single-well circulating heat

exchange geothermal energy collection technology has allowed teachers and students to feel the comfort of environmental protection and low carbon, strengthened the school's determination to build an environmentally friendly campus, and set an example for building a green and low-carbon campus.

The green and spacious soccer field, the lush green hills on campus, the comfortable swimming pool with constant temperature in all seasons, the comprehensive sports center with excellent and professional facilities, the well-equipped ice and snow sports center, the ski practice field, the comfortable and open overseas theater... walking into the Jingbei campus, and stopping in the classrooms with suitable temperature and bright and clean, although it is a hot summer day, every venue in the campus makes people feel comfortable and cozy. A junior high school student tells the reporter that his study and life at the Jingbei campus is very convenient and comfortable: "In summer, you can feel the cool breeze in the morning and evening on campus, and even in the hot summer the classrooms are cool and pleasant. I love the swimming pool in winter, where it is always warm and the water temperature is constant, so I can relax and swim around rest assured. Our teachers say that the school's 24-hour hot water in winter and summer is provided by shallow geothermal energy technology, which is really amazing, and geothermal energy allows us to study and live in a green and low-carbon campus."

Ever Source geothermal heat pumps contribute to the green development of the Winter Olympics City

Beijing Haidian Foreign Language Shi Yan School Jingbei Campus is located in Zhangjiakou City, the city of Winter Olympics. It is a newly built 12-year international school of Haidian Foreign Language Shi Yan School, an Olympic Education Demonstration School for Beijing 2022 Winter Olympics and Winter Paralympics, an ice and snow project base for General Administration of Sport of China to reserve Chinese national junior team talents for the Olympics, and a green ecological campus integrating study, sports, life



and leisure. The total planned construction area of the campus is 300,000 square meters, and it is divided into three phases. Up to now, 10 buildings in Phase I and Phase II have been put into use with a total area of 140,000 square meters, and Phase III is under construction.

As early as 2001, the Ever Source geothermal heat pump environmental system with “single-well circulating heat exchange geothermal energy collection technology” as the core has been put into operation as the heating and cooling system of Haidian Campus of Beijing Haidian Foreign Language Shi Yan School, and achieved good results. Jingbei Campus is located in Huailai County, Zhangjiakou City, with fresh air and superior natural environment, but the heating period is long and the temperature is low in winter. In order to ensure the normal heating of the project, reduce the carbon emissions of the heating system and achieve clean and green heating, the project continues to adopt the Ever Source energy heat pump environmental system as the heating system, realizes the low-carbon and low-cost heat and cold supply for the project and contributes to the green development of the Winter Olympics City.

Single-well circulating heat exchange geothermal energy collection technology is an original advanced shallow geothermal energy collection technology suitable for various geological conditions in China. It uses circulating water as a medium to collect shallow underground heat energy with temperature lower than 25 ℃. This technology, realizing “heat acquisition without water consumption”, can collect shallow geothermal energy safely, efficiently, and economically while saving land, and provides favorable technical support for large-scale safe development and utilization of clean and renewable energy for building heating.

Single-well circulating geothermal heat pump system takes single-well circulating heat exchange geothermal energy collection technology as the core. Through the combination of renewable natural energy (shallow geothermal energy) and heat pumps, it can realize heating and cooling for buildings without combustion and zero carbon emission, and more than 60% of the total heating energy consumption of buildings is made possible with renewable shallow geothermal energy. It is suitable for heating and cooling of various newly built, renovated and expanded public buildings, civil buildings, rural households and other buildings, which can further promote the energy-saving and low-carbon operation of buildings, achieve higher economic and environmental benefits, and help the early realization of “emissions peaking and carbon neutrality”.

The single-well circulating heat exchange geothermal energy collection well is composed of the pressurized backwater area, sealed area and pumping area. With water as the medium, and the collected heat enters the heat exchanger from the pumping

area, and the heat exchanged medium circulates to the pumping area through the pressurized return water area, so as to collect geothermal energy in rock and soil by circulating heat exchange. According to the structure, single-well circulating heat exchange geothermal energy collection wells can be divided into two types: the geothermal energy collection wells with heat transfer particles and the geothermal energy collection well without heat transfer particles. Geothermal energy collection wells with heat transfer particles are suitable for weakly permeable formations, with a well depth of 40-100 meters and a single well geothermal energy collection capacity of 100-300kW; geothermal energy collection wells without heat exchange particles are suitable for strong permeable formations, with a well depth of 60-100 meters and a single well geothermal energy collection capacity of 15-500kW.

Geothermal heat pumps help build a low-carbon Jingbei Campus

In order to optimize the scheme of the Jingbei Campus, Ever Source Group and the school designer and construction contractor revised and improved the scheme for many times, and finally adopted Ever Source distributed single-well circulating

geothermal heat pump System as the cold and heat source scheme of the project. The system consists of a single-well circulating heat exchange geothermal energy collection well, a shallow geothermal energy centralized heat exchange station, a distributed cold and heat source station and a heat and cold supplying terminal in the building.

The single-well circulating geothermal heat pump system is an energy-saving and environmentally friendly system that uses renewable energy to meet the heating and cooling needs of buildings. The system runs without pollutant emission and can coexist harmoniously with the natural environment. It is the first choice for heating and cooling systems in the Jingbei Campus. The system adopts the single-well circulation heat exchange collection technology, which has been applied in Haidian Campus for more than 20 years. After years of application, it has been proved that the system has the advantages of small land occupation, high efficiency, low energy consumption, stable operation and convenient control. One system can meet the needs of heating in winter, cooling in summer and supplying domestic hot water all the year round.

The buildings of Jingbei Campus Project are distributed with an east-west span of more than 1,000 meters, a north-south span of more than 800 meters, and a terrain height difference of more than 60 meters. The collection wells around the building are in tight position. In the scheme, multiple sets of single-well circulating heat exchange geothermal energy collection wells are set up to collect shallow geothermal energy centrally, and shallow geothermal energy centralized heat exchange stations are arranged near the geothermal energy collection wells. The primary collection pipe network between the collection wells and the heat exchange stations is used to transport shallow geothermal energy to the shallow geothermal energy centralized heat exchange stations. Then the shallow geothermal energy is distributed to each distributed cold and heat source station by the secondary heat exchange pipe network between the heat exchange station and the distributed cold and heat source station. Distributed cold and heat source stations arranged according to the distribution of buildings, can be arranged in one building or shared by multiple buildings. Energy lifting equipment and tertiary pipe network are arranged in distributed cold and heat source stations, and the terminal circulating water is lifted to the temperature grade required by heating and cooling, and then transported to the heating and cooling terminal system in each building by the terminal equipment to complete the heating and cooling process.

According to the requirements of phased construction of the project, a set of distributed single-well circulating geothermal heat pump system is set up respectively in Phase I and Phase II of Jingbei Campus Project. In the first phase, 22 sets of geothermal energy

collection wells, 1 centralized heat exchange station and 4 distributed cold and heat source stations are set up; in the second phase, 28 sets of geothermal heat collection wells, 1 centralized heat exchange station and 3 distributed cold and heat source stations are set up. See the following table for specific settings:

<table>
<tr><th></th><th>System No.</th><th>Building name</th><th>Configuration of distributed heat and cold source stations</th><th>Configuration of centralized heat exchange stations</th><th>Number of configured collection wells</th></tr>
<tr><td rowspan="6">Phase I of the project</td><td rowspan="6">Ever Source distributed shallow geothermal energy heat and cold source system I</td><td>Primary school department 1#</td><td>Station 1#</td><td rowspan="6">1 station</td><td rowspan="6">22 wells</td></tr>
<tr><td>Middle school department 2#</td><td rowspan="2">Station 2#</td></tr>
<tr><td>Campus theater 3#</td></tr>
<tr><td>Comprehensive sports center 4#</td><td rowspan="2">Station 3#</td></tr>
<tr><td>Skiing hall</td></tr>
<tr><td>Ice and snow center 5#</td><td>Station 4#</td></tr>
<tr><td>Phase II of the project</td><td>Ever Source distributed shallow geothermal energy heat and cold source system II</td><td>High school of international department 6#</td><td>Station 5#</td><td>1 station</td><td>28 wells</td></tr>
</table>

According to the relevant person in charge of Ever Source, the distributed single-well circulating geothermal heat pump system has many advantages when applied to this project:

1. Collection of shallow geothermal energy centrally to realize energy supply on demand

The amount of energy used by buildings and the frequency of use vary, so the centralized collection of shallow geothermal energy is adopted and the circulation flow rate is adjusted by setting the return water temperature of the circulating water from the collection wells to achieve energy extraction according to demand, and the electricity consumption of collection pumps is saved.

2. Shallow geothermal energy is transported by closed circulation of secondary networks to reduce transportation energy consumption

The height difference of the project buildings is 60 meters. If the conventional geothermal source heat pump environmental system is adopted, the circulating water of the collection well needs to be directly transported to each cold and heat source station. Each collection pump needs to overcome the hydrostatic pressure difference of 60 meters caused by the terrain height difference, and the total electric power of the collection pump needs 1250kw. After the scheme adopts the way of setting centralized heat exchange stations, the circulating water of each collection well only needs to be transported to the centralized heat exchange station set near the geothermal energy collection well, which greatly reduces the need to overcome the hydrostatic pressure difference of the collection well, and only 750kw are enough for the total electric power of the collection pump. Due to the arrangement of the centralized heat exchange station, it is necessary to introduce the secondary pipe network conveying circulating pump, and the total power of the circulating pump is 200kw. After deducting the increased power of the secondary pipe network conveying circulating pump, the total electric power of the collection system is also reduced by 24% compared with the conventional system.

At the same time, the secondary pipe network conveying circulating pump adopts a frequency conversion control, which can further reduce the energy consumption during operation.

3. The secondary pipe network transports low-temperature geothermal energy to reduce heat loss

When the conventional geothermal source heat pump system is adopted, the water supply temperature of circulating water in the geothermal energy collection well is 15 ℃ . After setting the centralized heat exchange station, the water supply temperature of secondary water transported from the centralized heat exchange station to each cold and heat source station is reduced to 13 ℃ . Calculated according to the soil temperature of 0 ℃ in winter at the buried depth of the pipeline, the heat loss can be reduced by 13%.

4. Distributed cold and heat source stations are set as needed, highly compatible with cold and heat requirements of buildings

According to the cooling and heating load of each building, the installed capacity of heat pump units in the distributed cooling and heating source stations is reasonably set, and the operation of partial load is taken into account, and multiple units and multiple engines per unit are used, which can

achieve a high fit between the building energy supply and demand, avoid the situation of insufficient power and at the same time, and further reduce the energy consumption of the present system operation.

Geothermal heat pumps reduce CO2 emissions by nearly 2,000 tons every year in a green and low carbon manner, and keep teachers and students warm in winter and cool in summer

After the single-well circulating geothermal source heat pump system is adopted in Jingbei Campus Project, the indoor temperature of heating in winter can reach above 20 ℃, the indoor temperature of cooling in summer is about 26 ℃, the temperature of the swimming pool is kept at 28 ℃ all the year round,and domestic hot water supply is guaranteed throughout the yearwhich meets the cold and hot demand of the project, completely satisfies the design indexes and improves the comfort of the building. The classrooms are like spring all the year round, which ensures that teachers and students are warm in winter and cool in summer in a low-carbon and environmentally friendly manner. The implementation of the case proves that the single-well circulating geothermal heat pump system can completely replace the traditional combustion heating and cooling mode, realize the clean energy supply of all heating, cooling and domestic hot water, and bring good economic and environmental benefits.

The operation statistics of the first phase of the project from 2021 to 2022 show that the total energy consumption in the heating season is 2.5903 million kWh of electricity, which is equivalent to 318 tons of standard coal. Compared with using electric boilers for heating, it can save about 800 tons of standard coal, reduce CO_2 emission by 1976 tons, SO_2 emission by 16 tons and dust emission by 8 tons, thus realizing greater environmental benefits.

According to the statistics of Haidian Campus's operation data for many years, the total power consumption of heating, cooling and providing domestic hot water in the whole year is 52.66 kW•h/m^2. According to the residential electricity price of 0.4886 yuan/kW•h, the annual operation cost is 25.72 yuan/m^2 (151 days of heating, 100 days of cooling, 200 days of hot water and 365 days of swimming pool heating), saving more than 45% compared with the 47 yuan/m^2, the non-resident heating price implemented in Beijing.

After the system was built and put into operation in Jingbei Campus, it has been operated in several heating seasons and cooling seasons. Statistical data show that the total power consumption of heating, cooling and providing domestic hot water in Jingbei Campus is 46.8 kW•h/m^2. According to the residential electricity price of 0.52 yuan/kW h, the annual operating cost is 24.4 yuan/

m^2 (146 days of heating, 200 days of provision of hot water, 365 days of swimming pool heating, 90 days of cooling). Compared with the heating charge standard of Zhangjiakou where the project is located, it saves 44% (excluding the cost of summer cooling and annual domestic hot water). The actual operation data further verify the correctness of the system, which meets the heating and cooling needs of the project, saves the operation cost, brings good environmental benefits, avoids environmental pollution, and improves the campus and surrounding environment.

The project uses a single-well circulating geothermal heat pump system, which well solves the needs of heating and cooling, maintaining the temperature of the pool water all year round and providing domestic hot water, while significantly reducing the energy consumption of the system operation. The system operates without any pollutant emission, which unifies with the superior natural environment of the project and maintains the environmental advantages of the project. According to the characteristics of the project's scattered buildings, large topographic height difference and the variability of building energy demand, the design adopts a distributed single-well circulating geothermal source heat pump system, which reflects the strong designability of the system and realizes the characteristics of supplying and taking energy on demand, saving operational energy consumption.

The single-well circulating geothermal heat exchange technology is very advanced

The green practice of Ever Source geothermal heat pumps in the headquarters and Jingbei Campus of Haidian Foreign Language Shi Yan School only shows the technical advantages of single-well circulating heat exchange and low energy collection, but also manifests the huge future space of this environmentally friendly technology.

The single-well circulating heat exchange geothermal energy collection well is an original independent intellectual property technology in China. It is an original technology according to two-way inquiries at home and abroad by the Literature and Intelligence Center of Chinese Academy of Sciences. It has many international invention patents and has been appraised as international advanced at provincial and ministerial assessment. In December 2008, the technology won the first prize of scientific and technological progress issued by the All-China Federation of Industry and Commerce. This international invention is the only Chinese original technology exported to the United States in the field of renewable energy. The American project was awarded "Energy Star" by the local government.

In December, 2012, Beijing local standard "Technical Specification for Single-well Circulating Heat Exchange Geothermal

Energy Collection Well Engineering" (DB11/T935-2013), which was compiled by Ever Source Science &Technology Development Group Co., Ltd., was approved and released by Beijing Municipal Bureau of Quality and Technical Supervision. After years of popularization and implementation, it has been applied to heating and cooling projects of more than 21 million square meters of buildings, and has become an important technical measure to reduce carbon emissions from building operation.

Key technologies and innovations of single-well circulating heat exchange geothermal energy

1. High efficiency: The single-well circulating heat exchange geothermal energy collection well takes groundwater as the medium and collects shallow geothermal energy by directly exchanging heat with underground soil sand and gravels, which improves the water supply temperature of the heat exchange well, and accordingly the energy efficiency of the whole geothermal heat pump system;

2. Safety and environmental friendliness: The whole process of geothermal energy collection and utilization does not consume or pollute underground water, which is safe for underground water and avoids potential geological disasters;

3. Land saving: its heat exchange efficiency is 20-100 times that of the traditional ground source method. After a single well is completed, only the area of one manhole is occupied, only 1/(20-100) of the traditional practice, providing technical support for the application of shallow geothermal energy in the central area of cities with tight land and dense buildings;

4. Wide applicability: Single-well circulating heat exchange geothermal energy collection wells are divided into geothermal energy collection wells with energy storage particles and geothermal energy collection wells without energy storage particles, which can be applied to different geological conditions, with strong designability and wide application range;

5. Short construction period: The number of collection wells is set according to the cold and heat requirements of the project, and the construction period of a single well is 3-7 days, which enables synchronous construction of multiple wells and greatly shortens the construction period.

The single-well circulating heat exchange technology is original in China

The single-well circulating heat exchange technology is an original creation in China, and Ever Source owns all the independent intellectual property rights. The technology has no water consumption during operation, no impact on regional underground water state and geological structure, it is original

and has reached international leading level. At present, the technology has been promoted and applied successfully in the United States and other countries, providing a reliable technical guarantee for the large-scale and safe development and utilization of shallow geothermal energy.

The single-well circulating geothermal heat pump system can be feasibly designed according to the scale of the project, building distribution characteristics, use rules and other factors, and achieve perfect fit with the needs of buildings. The case of Jingbei Campus fully proves that shallow geothermal energy can be used as an alternative energy for heating and cooling. The system realizes the clean energy supply of heating, cooling and domestic hot water in the project, and plays a typical role in demonstration.

In the future, when erect new buildings and renovating old buildings, we should vigorously promote the application of single-well circulating heat exchange technology, which can not only save operating costs for system users, but also significantly reduce the carbon emissions of the system and contribute to the construction of a low-carbon society.

Ever Source Science & Technology Development Group Co., Ltd. (hereinafter referred to as Ever Source) was established in 2000 and listed in Hong Kong in 2009. In 2012, CECEP became its largest shareholder. Under the integrated management mode in Beijing and Hong Kong, Ever Source aims at “making renewable shallow geothermal energy an alternative energy for traditional combustion heating”. It is the main business of the Group to use shallow geothermal energy for non-combustion clean heating and improve the development of renewable energy hot and cold integrated emerging industries, thus realizing the industrial development of original shallow geothermal energy collection and heat exchange technology. Combined with heat pump technology, low-grade shallow geothermal energy (temperature below 25 ℃) becomes an alternative energy for building heating. On the basis of traditional combustion and single heating in northern China heating areas, the two fields of heat and cold supply are integrated, and it has developed into a new industry integrating geothermal energy, heating and cooling in the new period.

Under the strong support of five industrial sectors: planning and design, renewable shallow geothermal energy supply, intelligent manufacturing, engineering construction and management, operation and maintenance, Ever Source has developed into a clean and intelligent heating system service provider integrating investment, construction and transportation, which has opened up a new way for intelligent heating in northern China with zero combustion, zero emissions and effective smog prevention.

Ever Source takes the original international leading “single-well circulating heat exchange geothermal energy collection technology” as the core, collects shallow

geothermal energy safely, efficiently, and economically while saving land, and realizes "heat extraction without water consumption", which provides strong technical support for large-scale development and utilization of shallow geothermal energy. A large number of patented technologies related to shallow geothermal energy collection, as well as the Grade I qualification for professional contracting of electromechanical installation works of buildings, enable the company to contract "system turnkey projects" and provide customers with "one-stop" clean heating (cooling) services.

While vigorously developing shallow geothermal energy heating, Ever Source has always focused on the research and promotion of differentiated demand of non-combustion clean heating mode, and has made great progress in the field of low-temperature air source heating, forming a product technology system with "high-efficiency heating/energy-saving design technology, low noise design technology, wide-range/multifunctional design technology and high-reliability operation design technology" as the core. Air source heating (cooling), as an important part of non-combustion clean energy heating (cooling), complements shallow geothermal energy heating, and plays a significant role.

Ever Source uses low-temperature heat sources (shallow geothermal energy and air energy) as alternative energy for heating, so that the heating cost of people is lower than that of traditional direct coal-fired heating. By 2022, Ever Source Group has promoted 21.07 million square meters of renewable energy alternative heating (cooling) projects, including 18.78 million square meters of central heating (cooling) projects, 1.16 million square meters of household heating (cooling) projects (11,466 households) and 1.13 million square meters of household air energy heating (cooling) projects (9,360 households). The promoted project can save 155,000 tons of standard coal per year, replace 259,000 tons of standard coal as conventional energy for heating, and reduce carbon dioxide emission by 640,000 tons per year for clean heating. At present, Ever Source Group is directly responsible for 50 heating operation projects, involving a building area of 2.79 million square meters, and achieving an annual carbon dioxide emission reduction of 85,000 tons for clean heating.

In many years of scientific research and business practice, Ever Source Group always adheres to the corporate tenet of "seeking truth and innovation" and pursues the harmonious coexistence between man and nature. With the goal of improving people's quality of life, we will make every effort to build a new industrial chain integrating energy, heating and cooling. In the new era, Ever Source Group will, as always, join hands with all sectors of society to act as warriors to protect clear water and blue sky, keep going and forge ahead into the future to realize the dream of clean and intelligent heating and zero emission in North China.

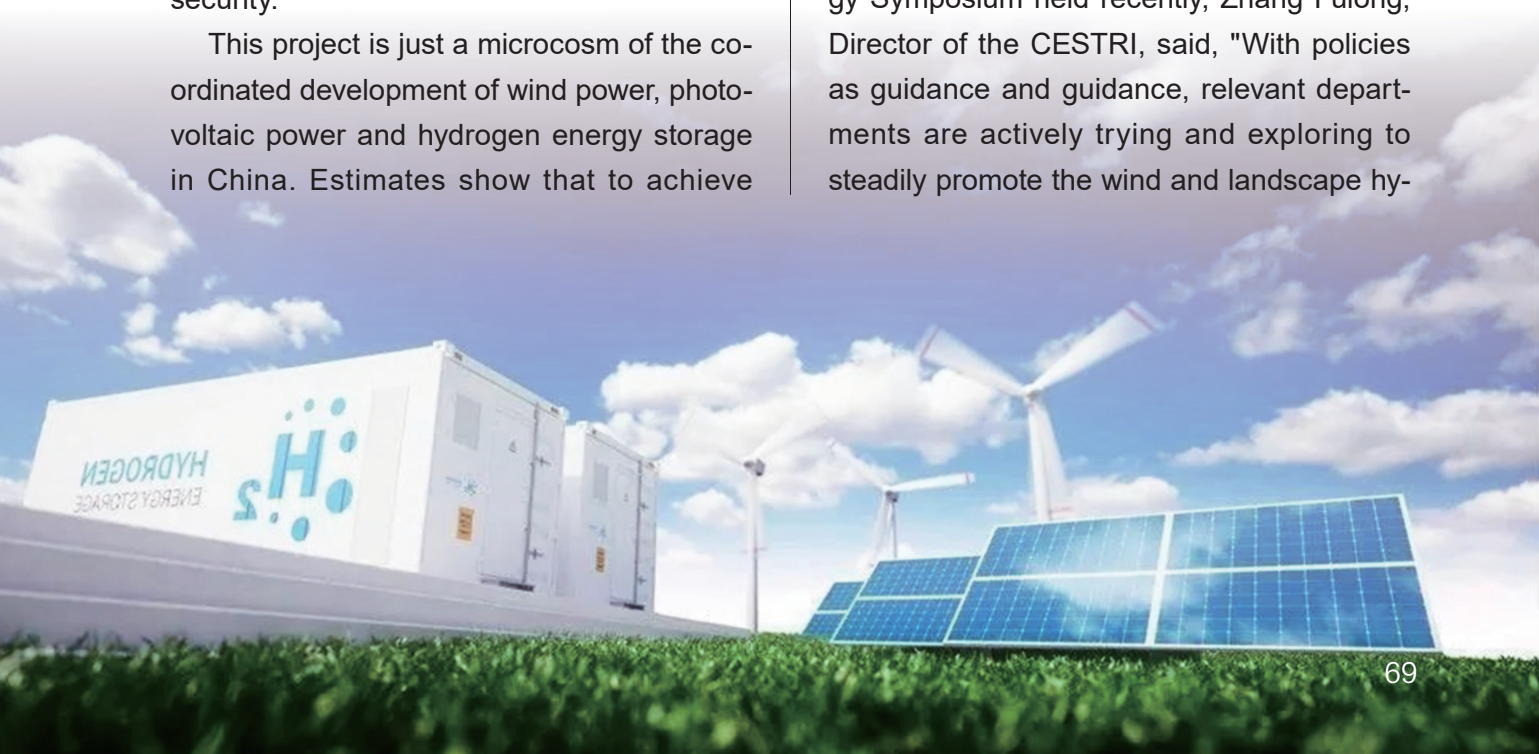
Breakthroughs in Coordinated Development of Wind Power, Photovoltaic Power and Hydrogen Energy Storage

Recently, the world's largest photovoltaic hydrogen production project - the 220 kV Power Transformation Project, a Sinopec Green Hydrogen Demonstration Project in Kuqa Xinjiang, was put into operation for power transmission. The project is the country's first 10,000-ton photovoltaic green hydrogen demonstration project, which is expected to reduce carbon dioxide emissions by 485,000 tons per year. It is of great significance to promoting the development of the green hydrogen industry chain, the transformation and upgrading of the country's energy industry, and ensuring national energy security.

This project is just a microcosm of the coordinated development of wind power, photovoltaic power and hydrogen energy storage in China. Estimates show that to achieve emissions peaking and carbon neutrality, the installed capacity of wind power and photovoltaic power generation is expected to reach about 5 billion kilowatts. Wind power, photovoltaic power and hydrogen energy storage will be further integrated and developed.

Noticeable demonstration significance

"In the process of building a new energy system, coordinating the positioning of different energy categories and ensuring the balance of different energy categories is a big issue." At the 2023 Electricity New Energy Symposium held recently, Zhang Fulong, Director of the CESTRI, said, "With policies as guidance and guidance, relevant departments are actively trying and exploring to steadily promote the wind and landscape hy-



drogen storage integration project."

In March last year, the National Development and Reform Commission and the National Energy Administration clearly proposed in the New Energy Storage Development Implementation Plan for the Fourteenth Five-Year that "full play will be given to the role of large-scale new energy storage in Northeast China, North China, Northwest China, Southwest China and other regions, new energy will be delivered and consumed across provinces in a large scale, and the utilization rate of channels and proportion of electricity from renewable energy will be increased through the complementary mode that integrates wind power, photovoltaic power, hydropower, coal-fired power and storage. Since then, Inner Mongolia, Xinjiang, Ningxia, and other places have carried out the construction of wind power, photovoltaic power, and hydrogen energy storage demonstration projects, bringing the industry unprecedented attention.

Experts in the industry generally believe that hydrogen can solve the energy problem under the goal of emissions peaking and carbon neutrality and is an important grip to achieve the target for emissions peaking and carbon neutrality.

Ding Jie, Senior Researcher at China Electric Power Research Institute's New Energy Research Center, claims that high-energy-density solid hydrogen energy storage technology has the advantage of solving the problems of wind and solar energy's stability in integration with the power grid and waste of wind and solar energy, and gives rise to the new business format of hydrogen energy storage in the electric power system. "The combined heat and power system with two-way conversion of electricity and hydrogen energy can effectively reduce the emission of nitrogen oxides, reduce the loss in the transmission link, and realize the cascade utilization and coordinated supply of cold, heat, and electricity. It is an important means to improve the comprehensive utilization at the terminal of energy consumption. "

"Green hydrogen production through the use of wind and photovoltaic electricity is an all-natural process. Therefore, the demonstration of wind, photovoltaic power and hydrogen energy storage integrated projects is of significant importance," says Ding Jie. After the demonstration, if it is further promoted on a large scale, it will not only produce eco-friendly, economical and zero-carbon hydrogen, but also have an unprecedented positive impact on the energy storage needs, flexibility and supply and control mechanisms of the power grid.

Obvious carbon reduction effect

As the hydrogen energy industry continues to grow, its contribution to tax revenue and employment is expected to surpass that of wind power and photovoltaics and form a market worth a thousand of billions or even ten thousand of billions of yuan," says Wang

Yingge, Vice President of Longi Hydrogen Energy Technology Co., Ltd. In the opinion of Li Binwen, Director of Strategic Storage Market and Product Management of Jiangsu Trinasolar Energy Storage Co., Ltd., the photovoltaic power generation, energy storage, hydrogen energy and intelligent power grid are the four key factors for achieving emissions peaking and carbon neutrality, and hydrogen energy is necessary for long-term storage beyond the season.

In that way, how does the wind power, photovoltaic power and hydrogen energy storage project "Cast magic"? Take Sinopec Green Hydrogen Demonstration Project in Kuqa Xinjiang as an example, the project mainly includes five major parts: photovoltaic power generation, power transmission and transformation, electrolytic water hydrogen production, hydrogen storage and hydrogen transmission. After the project is completed and put into operation, it will use photovoltaic power generation for electrolytic water hydrogen production, and the hydrogen will replace the previous natural gas hydrogen production and be supplied to Sinopec Tahe Refining and Chemical Co., Ltd. as a reducing agent to produce oil refining devices. Through this model, the project can reduce carbon dioxide emissions by 485,000 tons per year.

In addition, according to Zhang Fulong, Beijing Energy Ulanqab 1.5 Million Kilowatts Large-scale Wind Power/ Photovolta-

ic Power Base Project for Integrated Wind Power, Photovoltaic Power and Hydrogen Energy Storage has also officially started in April. The project makes full use of the flexible peaking capacity of existing thermal power and transforms Liangcheng County's abundant wind resource advantages into a driving force for local economic development through advanced wind power generation technology. "After the project is completed, it can produce about 3,628 million kWh of green electricity annually, save about 1,255,700 tons of standard coal and reduce carbon dioxide emissions by about 3,046,900 tons."

Enterprises should not follow blindly

In the view of many experts at the meeting, the coordinated development of wind power, photovoltaic power and hydrogen energy storage is an irresistible trend.

Li Bingwen believes that this market will become bigger and bigger. He says, taking the photovoltaic power and storage fusion, which is part of the wind power, photovoltaic power and hydrogen energy storage market, as an example, the scale of this market is expected to reach 84.9 GW this year, and the market share will reach more than 55% by 2030. With the continued development of West China, the new installed capacity of wind power and photovoltaic power in the five northwestern provinces will exceed 170 GW, and the scale of new electrochemical energy storage is expected to reach 55 GWh by 2027.

According to Zhang Fulong, "The promotion of the construction of wind power, photovoltaic power and hydrogen energy storage integration demonstration projects will definitely attract a number of upstream and downstream project investors, designers, equipment providers, operators and other enterprises in different links, so that enterprises in all links of the industry chain become more active."

"Local governments and central energy enterprises and state-owned enterprises are still the leading and driving force in the construction of wind power, photovoltaic power and hydrogen energy storage projects, and they bear the heavy responsibility of leading the energy transformation. For other related companies, it is the best period of development and a period when everyone can gain more." Zhang Fulong says, "However, we urge companies to take a rational view of this market development trend and changes, and not to blindly follow the trend, but to master the business and rhythm that suits their own development."

Zhang Fulong also reminds, "For wind power, photovoltaic power, or energy storage, hydrogen energy, we should consider how to make them cooperate with each other and how to make the share of clean energy become bigger and more stable, instead of making unnecessary internal friction between each energy category."

(Based on China Energy News)

Xu Dingming: Vigorously Develop the Geothermal Industry and Join Hands to Build a Geothermal Power

Not long ago, Xu Dingming, Deputy Director of the National Energy Administration Expert Advisory Committee and Member of the National Climate Change Expert Committee, shared his thoughts on the development of the geothermal industry in the "14th Five-Year Plan" at the subforum of "Xinyuanggu • Shallow Geothermal Clean Heating Technology and Application Innovation Seminar" during the "Fengxi Energy • 13th China International Geothermal High-level Forum in 2023" in the form of video, in which he called on geothermal colleagues to learn the "digital economy". He also hoped that geothermal people should be ambitious and work to-

gether to build a geothermal power in the digital age.

Xu Dingming believed that China should vigorously develop the geothermal industry, and should reflect on problems from seven aspects to help the high-quality development of the geothermal industry. First, the status and role of geothermal energy in the energy revolution; second, the status and role of geothermal energy in the era of carbon neutrality; third, the position and role of geothermal energy in constructing new power systemt; fourth, he position and role of geothermal energy in constructing modern industrial system; Fifth, the position and role of geothermal energy in the construction of modern agricultural system; The sixth is to construct the position and role of geothermal energy in modern social system; Seventh, the status and role of geothermal energy in building a modern people's livelihood system.

He said that throughout the history of the development of human society, every major progress of human civilization is accompanied by the improvement and replacement of energy, and this replacement of energy will definitely bring us into a new era of socialist ecological civilization. As a clean and low-carbon energy, It is necessary to recognize the position and play a role in the energy revolution and actively promote the energy revolution.

In his speech, Science and technology decide the future energy, and science and technology create the future energy. In the long run, future energy development does not depend on the possession of energy resources, but on breakthroughs in high technology of energy. He said that the "14th Five-Year Plan" for energy must consider technological development, and digitalization is playing an increasingly important role in the energy revolution. He pointed out that digitalization will comprehensively optimize resources; digitalization will improve efficiency as a whole; digitalization will innovate business models; digitalization will restructure the energy market; digitalization will maximize the value of the entire life cycle; digitalization will promote the digital economy in the new era; digitalization will Lay the foundation for a new smart economy.

To this end, he called on geothermal colleagues that digital transformation is necessary for the geothermal industry to achieve high-quality development. The digital economy is highly innovative, highly permeable, and widely covering. It is not only a new economic growth point, but also a fulcrum for transforming and upgrading traditional industries, and can become an important engine for building a modern economic system.

He said that it is the ecosystem rather than a certain technology that really changes the world. The ecosystem can

provide comprehensive solutions to solve complex and difficult problems, which is impossible for a single technology. Systematic cooperation, rather than competition, is the general trend. We must promote the orderly development of the industry and achieve shared prosperity. “Therefore, the entire industrial chain of the geothermal industry must be integrated as a whole to form a geothermal ecosystem.”

The energy that made a country strong in the industrial age was fossil fuels. He said, the industrial age has witnessed that coal, petroleum, and optoelectronics made a country strong and competitive successively in the industrial age. In the digital age, the future economy is a green digital economy and a digital green economy. He hoped that geothermal people will maintain great ambitions and join hands to build a geothermal energy power in the digital age.

(Based on Geothermal Energy News)

敬告读者

TO INFORM THE READER

《中国地热能》是由中国地热能出版社主办，北矿大（南京）新能源环保技术研究院、首都科技发展战略研究院、北京工业对外经贸促进会、北京节能环保促进会浅层地（热）能开发利用专业委员会、中国地热与温泉产业技术创新战略联盟、中国热冷一体化能源研究院协办的科技期刊，双语半年刊。我们的办刊宗旨是为政府制定能源政策提供参考建议；为地能开发企业提供宣传平台；为设计者、大众提供交流空间；推广浅层地热能利用经验，展示应用实例。

我们始终不忘读者的期待，用心用力办好期刊。毫无疑问，优化空气、节能减排、治理雾霾是当前摆在全体中国人民面前一个重大课题，我们期望《中国地热能》这本小小的期刊能够为攻克这一难题贡献微薄之力。

立足长远，着眼当前，在继承中创新，在变革中发展。自创刊以来，期刊一直得到了业内专家学者和广大读者的热情支持，在此致以我们的衷心感谢。大家的关注是我们的追求，大家的支持是我们的动力。让我们携手共进，共同打造《中国地热能》的美好明天。

《中国地热能》编辑部

投稿及广告联系人：张艳菲
电话：010-62599774
邮箱：journal@chyy.com.hk

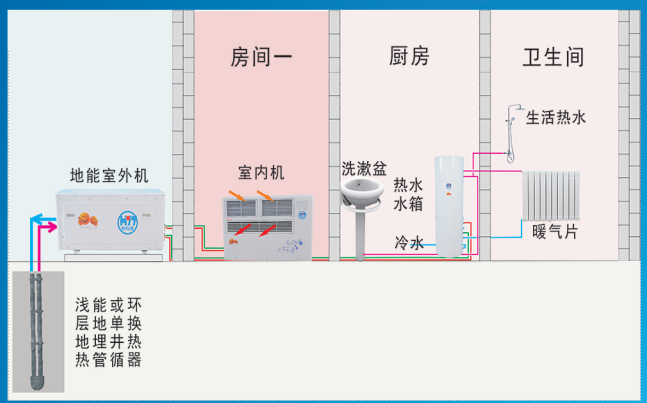
中國地熱能
CHINA GEOTHERMAL ENERGY


中國地熱能
CHINA GEOTHERMAL ENERGY
九年风雨兼程 九载始终如一
勇于开拓奋进 促地热能腾飞

地能热宝

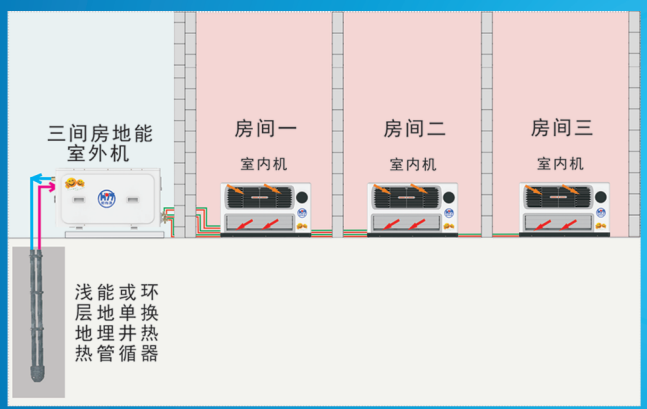
取代传统供热方式，更节能，更安全！

“地能热宝”系统是以浅层地热能作为供暖替代能源，可分间配热宝设备和分间计量，是高效电替煤自采暖系统。宏源地能热宝技术有限公司专注于农村建筑户式地能热冷机产品的开发、制造、系统集成和销售，旨在实现乡村清洁取暖，提高百姓生活品质。

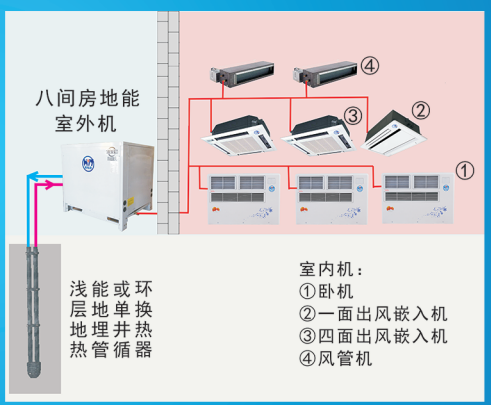


一间房暖冷及生活热水一体化地能热宝系统

两间房暖冷一体化地能热宝系统



三间房暖冷一体化地能热宝系统



八间房暖冷一体化地能热宝系统

特点：

低碳环保：无燃烧零排放，安全、干净、省心、省事；

操作简单：分间恒温控制，遥控器简单操作；

行为节能：能实现人在哪屋开哪儿设备，系统设计符合和继承了中国“省着用”的节俭传统；

初投资低：交钥匙工程300-350元/平米；

运行费用低：北京用户单位面积采暖费用约10元；

无需电增容：三间房暖冷一体化地能热宝系统配电仅为2.1kW（220V），相当于家用空调设备的配电量；

供暖有保证：浅层地热能温度相对恒定，不受室外恶劣天气影响。

宏源地能热宝技术有限公司

地址：四川省绵阳市涪城区金家林下街 29 号

联系电话：010-62592341 400-666-6168

传真：010-62593653

电邮：dnrb@hyy.com.cn

诚招各地区代理商

期待您的加盟

扫描二维码

获取更多地能知识