Green Carbon-free Solar Drying R&D and Industrial Application of Agricultural Products Technology and Equipment

农业农村部规划设计研究院
CHINESE ACADEMY OF AGRICULTURAL ENGINEERING
中 国 农 业 工 程 研 究 设 计 院

Reporter: WANG Hai/Professor TEL: 010-59197315 ,13520492616

Cloud School
Sharing for Learning

CONTENTS

Unit and Team Introduction

Unit Introduce

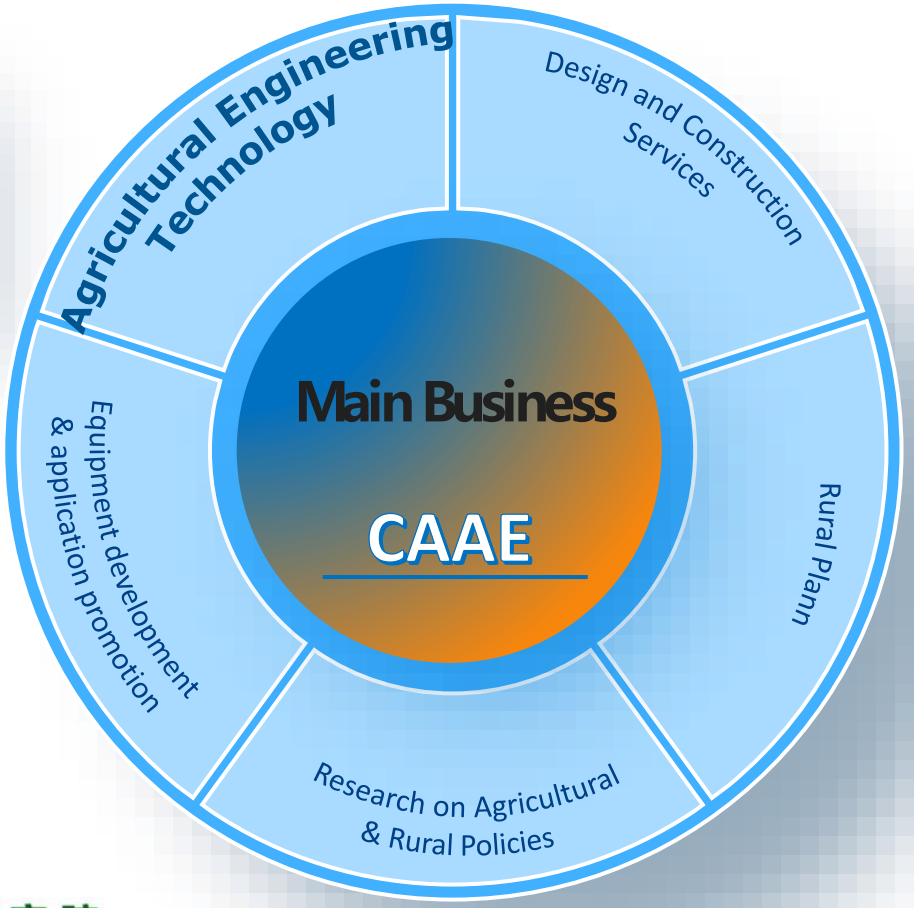
Academy of Agricultural Planning and Engineering, Ministry of Agriculture and Rural Affairs (MARA) of P. R. China

Directly affiliated bureau level public institution of MARA

328人	44人	80人	300余项	160余项
Staff	Regular Senior	Doctor of Philosophy	National & Provincial Projects	National & provincial rewards

Innovation Platform

- Biomass Engineering Center of the MARA
- National agricultural product processing technology and equipment research and development sub-center
- Key Laboratory of Resource Recycling Technology and Model of the MARA
- Key Laboratory for Primary Processing of Agricultural Products in the Production Areas of the MARA
- Key Laboratory of Primary Processing of agricultural products of the MARA
- Key Laboratory of Agricultural Waste Energy Utilization of the MARA



Introduction to Team Leader

Wang Hai

- **Second Level professor**
- **Ph.D Degree in Engineering**
- **Doctoral Supervisor**

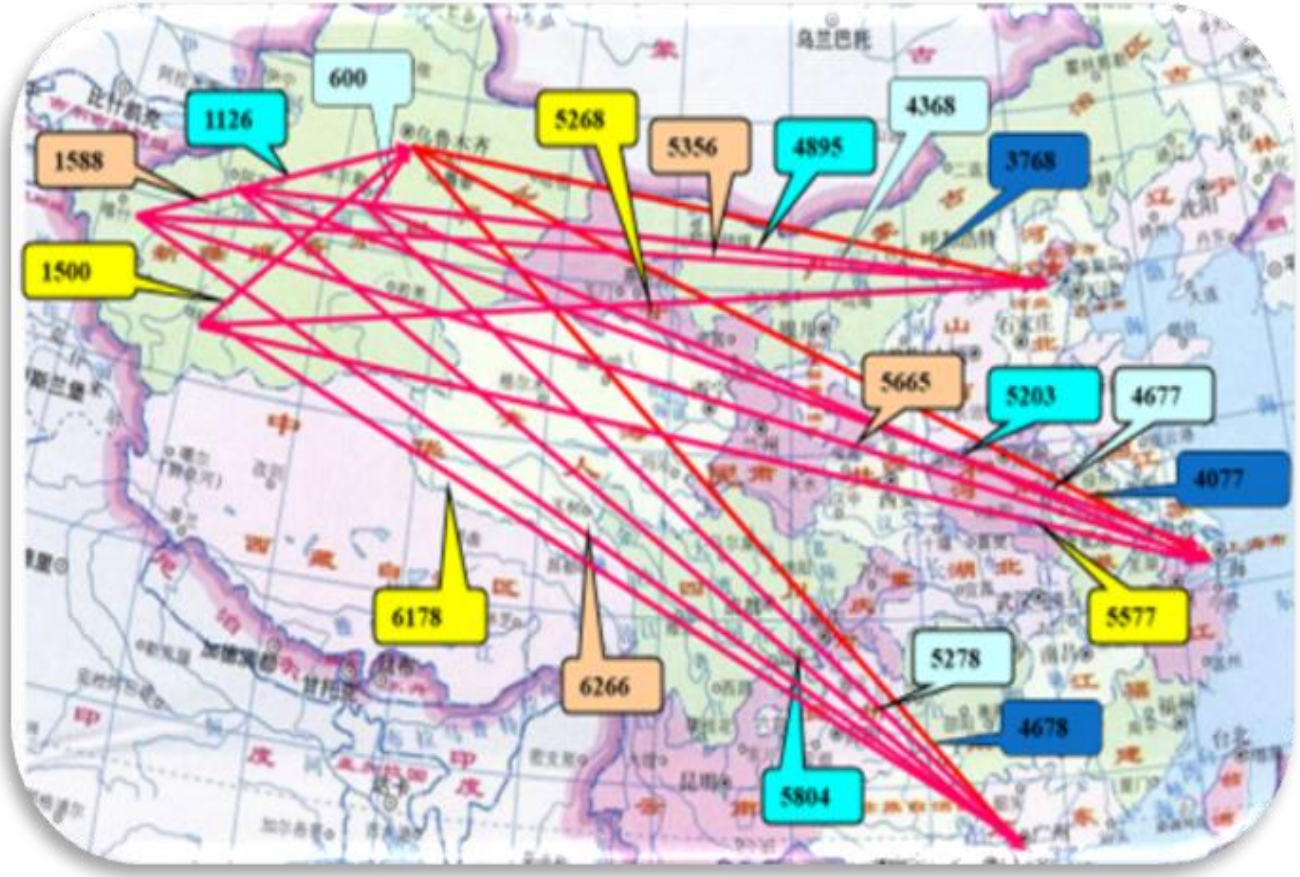
- Chief expert of fruit and vegetable drying technology and equipment innovation team of Planning and Design Institute of Ministry of Agriculture and Rural Areas
- Director of Chinese Society of Agricultural Engineering, Deputy Director and deputy Secretary General of Agricultural Products Processing and Storage Engineering Branch
- Chinese Society of Agricultural Machinery Agricultural and sideline products processing machinery branch standing member and packaging and food engineering branch member
- Director of the Leisure Food Processing Technology Branch of the Chinese Food Association
- Director of Beijing Food Association

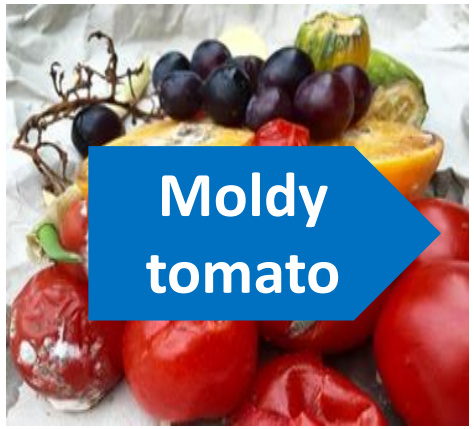
- The research on solar drying theory, solar collector and solar drying technology and equipment of agricultural products has made pioneering achievements, and the industrialization of solar drying of agricultural products is the first practice in China
- Led or participated in 27 national level projects, 12 ministerial level projects, and completed research on solar drying technology and quality control for over 20 agricultural products
- Formed over 30 research achievements and won 8 provincial and ministerial awards; Obtained 10 national invention patents; Develop 6 agricultural industry standards; Write 12 works; Published over 90 academic papers; Cultivate 5 young backbone students and 15 master's and doctoral students.

Project Background

- **Solar drying technology and equipment for agricultural products are the development direction to solve the problem of green, low-carbon, quality improvement, consumption reduction, cost saving, and efficiency enhancement**

- **The characteristics of large output, high water content, strong seasonality, perishability and so on, Xinjiang is far from the mainland, with high transportation costs and significant losses. Postharvest decay and deterioration can result in losses of up to 15% to 20%**





- **Drying is one of the best ways to solve the problem of severe loss of agricultural products**

Natural Drying

Advantages: Utilizing the heat of sunlight and natural wind power, the equipment is simple and the cost is low.
Disadvantages: Long cycle, limited by site and climate conditions, high labor intensity; Dust, mosquito and fly pollution, deterioration of quality, coupled with the spoilage of birds, mice, and poultry, increase losses, and reduce the rate of high-quality products.

Coal Drying

Advantages: mature technology, short cycle, and hygiene.
Disadvantages: high energy consumption, heavy pollution, poor quality, and high operating costs.
Limited use of coal in various parts of the country.

Heat Pump Drying

Advantages: Energy saving, environmental protection, controllable drying conditions.
Disadvantages: slow heating, small production capacity, expensive equipment, high energy consumption, and need for capacity expansion.

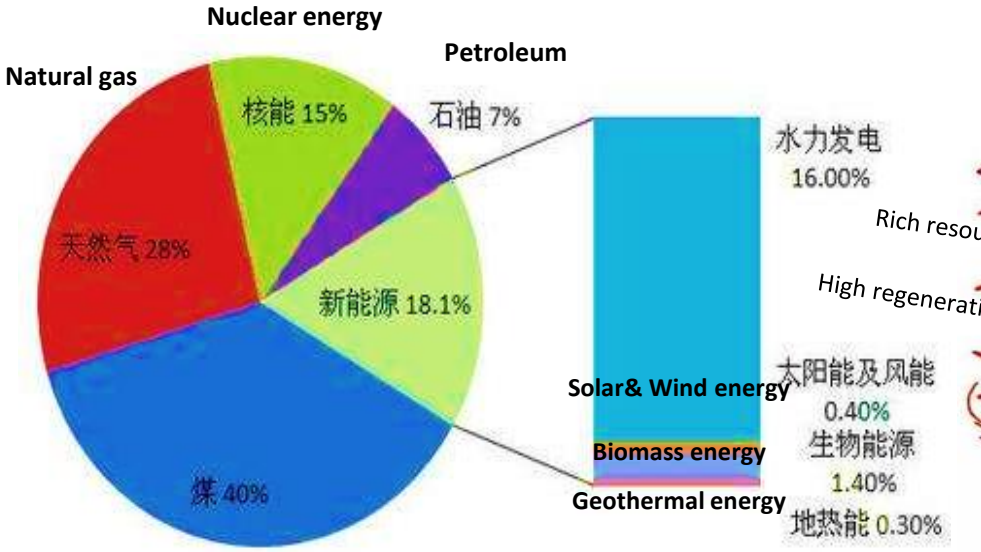
Advantages: Rich resources, free use, no need for transportation, environmentally friendly, and low operating costs
Disadvantages: Discontinuous and unstable, limited by meteorological conditions, traditional solar energy has low drying capacity, low temperature, and requires matching with other energy sources.

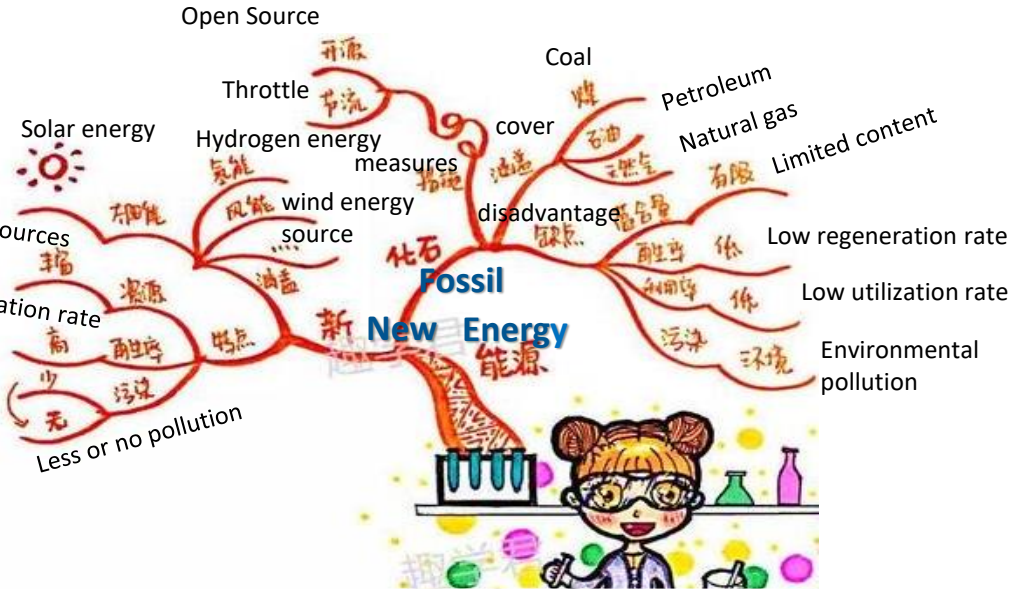
Solar Drying

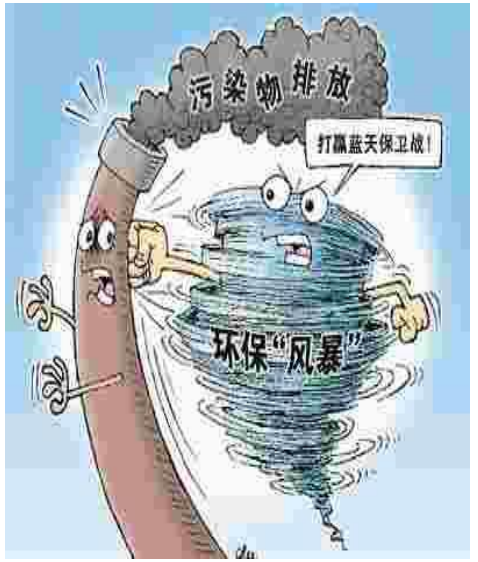
Reasonable design, temperature and flow rate can meet industrial requirements

It can avoid pollution and decay caused by dust, flies, and insects during outdoor exposure; It can save energy consumption from traditional drying methods such as coal burning, reduce costs, and reduce pollution emissions.

- **Drying is an energy consuming industry, accounting for approximately 12% of energy consumption.**
- **Global energy supply faces severe challenges**



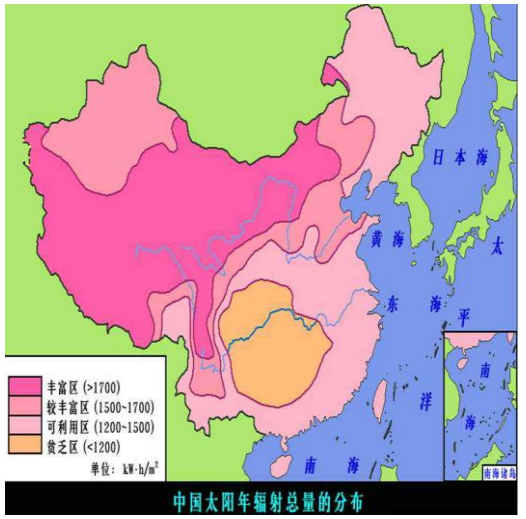




Proved recoverable reserves of fossil energy per capita in the world and China

Varieties	Unit	China	World	China/World
Coal	t	85.8	122.7	69.90%
Petroleum	t	1.5	27	5.60%
Natural gas	M^3	1840	27843	6.60%

In response to the technical bottlenecks of high energy consumption, heavy pollution, and poor quality in traditional agricultural product drying in China, combined with the natural resources of agricultural products, solar energy, air, and other resources in Xinjiang, Ningxia, Yunnan, Gansu, Hebei, and other regions, we will carry out research on solar energy drying technology and equipment for agricultural products.

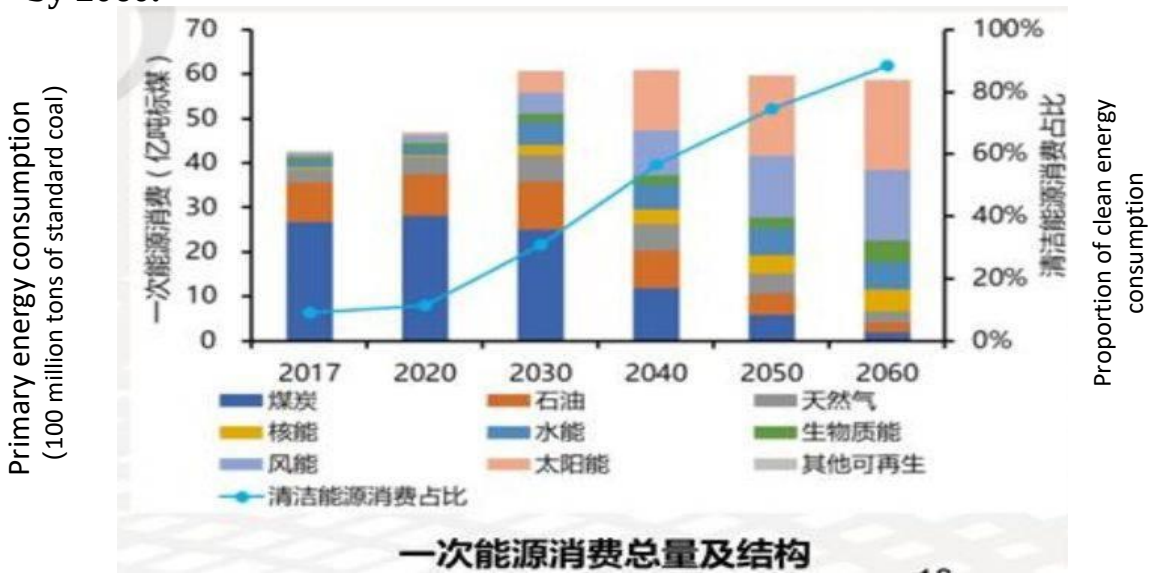


China actively participates in world climate change

- In 2015, Xi Jinping Chairman attended the Paris Conference on Climate Change and delivered an important speech.
- In September 2016, Xi Jinping Chairman personally deposited the legal instrument of China's ratification of the Paris Agreement.
- In December 2020, Xi Jinping Chairman further announced a series of new goals for China's carbon dioxide emissions reduction, non fossil energy development, and forest stock increase by 2030 at the Climate Ambition Summit.
- In October 2021, Xi Jinping Chairman attended the 15th Summit of the Conference of the Parties to the Convention on Biological Diversity and delivered a keynote speech, emphasizing that in order to promote the achievement of carbon peaking and carbon neutrality goals, China will successively release implementation plans and a series of supporting measures for carbon peaking in key areas and industries, and build a "1+N" policy system for carbon peaking and carbon neutrality.

China implements a national strategy to actively respond to climate change

- National Climate Change Adaptation Strategy
- Action Plan for Urban Adaptation to Climate Change
- National Climate Change Adaptation Strategy 2035
- China's Policies and Actions to Address Climate Change (2021)
- Proposed the development goals of "carbon peaking and carbon neutrality": achieving carbon peaking by 2030 and carbon neutrality by 2060.



Total and Structure of Primary Energy Consumption

- **China has abundant solar energy resources, with a theoretical reserve of 1700 billion tons of standard coal per year. Solar energy is both a primary energy source and a renewable energy source. It is rich in resources and can be used for free without transportation, without any pollution to the environment.**

According to the amount of solar radiation received, China can be roughly divided into five types of regions

Region type	Annual sunshinehours(h/a)	Annual total irradiationAmount(MJ/m².a)	Standard coal requiredfor equal amount of heat(Kg)	Including major regions	Notes
Class I	3200-3300	6680-8400	225-285	**Northern Ningxia& Gansu, Southern Xinjiang, Western Qinghai & Tibet**	The most abundant region
Class II	3000-3200	5852-6680	200-225	**Northwest Hebei,Northern Shanxi,Southern Inner Mongolia & Ningxia，Central Gansu，Eastern Qinghai，southeast tibet**	Relatively rich regions
three categories	2200-3000	5016-5852	170-200	**Shandon，Hena，Southeast Hebei，Southern Shanxi，Northern Xinjiang，Jilin，Liaonin，Yunnan，northern shaanxi，Southeast Gansu，Southern Guangdong**	Medium region
Four categories	1400-2200	4180-5016	140-170	**Hunan，Guangxi，Jiangxi，Zhejiang，Hubei，Northern Fujian &Guangd，southern shaanxi & Anhui**	Poor areas
Five categories	1000-1400	3344-4180	115-140	**Sichuan，Guizhou**	Worst Region

Low efficiency of solar energy resources

The development level of solar energy utilization is theoretically feasible and technically mature. But some solar energy utilization devices have low efficiency.

Instability of solar energy resources

Due to the limitations of natural conditions such as day and night, season, geographic latitude, and altitude, as well as the influence of random factors such as sunshine, shade, clouds, and rain, the solar irradiance reaching a certain ground is both intermittent and extremely unstable, which adds difficulty to the large-scale application of solar energy.

Dispersion of solar energy resources

Although the total amount of solar radiation reaching the Earth's surface is large, the energy flow density is very low. On average, near the Tropic of Cancer, in clear summer weather, the irradiance of solar radiation is highest at noon, with an average of 1000W of solar energy received on an area of 1 square meter perpendicular to the direction of sunlight; If the annual daily and night average is used, it will only be 200w. In winter, it is only about half, and on cloudy days it is only about 1/5, indicating a very low energy flow density.

Multiple project funding support

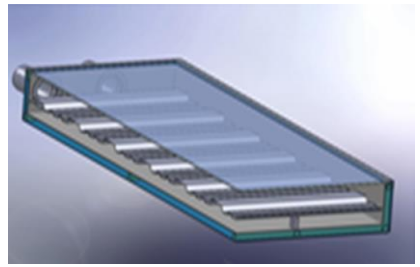
Pilot Demonstration of Hybrid Solar Multifunctional Fruit and Vegetable Drying Complete Equipment	MOST
Research on Solar Energy Multifunctional Seedless White Grape Drying Equipment，the 11th Five Year Plan	MOST
Research and Development and Integration Demonstration of Key Technologies and Equipment for Quality Preservation and Energy Conservation of Characteristic Melons and Fruits，the 12th Five Year Plan	MOST
Research on Solar Nano Phase Change Heat Storage，National Key R&D Plan for the 13th Five Year Plan	MOST
Research and Demonstration of Greenhouse Solar Energy Storage and Utilization Devices，the 12th Five Year Plan	MOST
Integration and Demonstration Promotion of Solar Drying Technology for Agricultural Products，National Spark Technology Program	MOST
Solar Energy Drying Agricultural Product Technology Equipment Promotion Demonstration Project，Ministry of Agriculture Finance Special Project	MoA finance division
Demonstration Project for East West Cooperation of Township Enterprises，The Ministry of Agriculture's Agricultural Product Promotion Plan	MoA Processing Bureau
Promotion and Demonstration of Low Carbon Technology for Drying Agricultural Products in the Western Region，The Ministry of Agriculture's Agricultural Ecological Environment Protection Project	MoA Department of Science and Education
Research and demonstration of key technologies and equipment for solar drying of scallops and prawns ， the marine public welfare industry	State Oceanic Administration Department of Science and Education
Research on Key Technologies and Equipment Development and Demonstration of Solar Energy Storage and Heat Release Drying of Southern Xinjiang Red Dates，The Innovation and Development Support Plan for Key Industries in Southern Xinjiang	Xinjiang Corps Department of Science and Education

Project Innovation

1. Development of A Multi Ventilation Dual Heat Exchange Flat Solar Collector

Structural Design and Material Selection of Heat Collectors

- From the engineering perspective of processing technology, production cost, convenient transportation, easy installation, and strength, the flat panel solar air collector has an area of 2 m^2 and an overall structure of 2010x930x150mm.
- Determine that the insulation material of the collector is polyurethane.
- Determine whether the heat absorbing material of the collector is a black chromium selective absorption coating.



Structural Optimization Test of Heat Absorber Ripple

- Comparative experiments were conducted on collectors using three different types of heat absorbers: flat non corrugated, longitudinal corrugated, and transverse corrugated.The other structures were consistent, and the optimal corrugated structure was determined.

Comparison test results of different ripples on the surface of the heat absorbing body

Ripple shape	Average inlet temperature/℃	Average irradiance/(w/m^2)	Average temperature difference between inlet and outlete/℃	Average efficiency of collector/%
Transverse ripple	22.16	870.60	20.51	84.53
No ripple	24.29	818.61	14.46	66.05
Longitudinal ripple	25.51	874.00	18.78	74.93

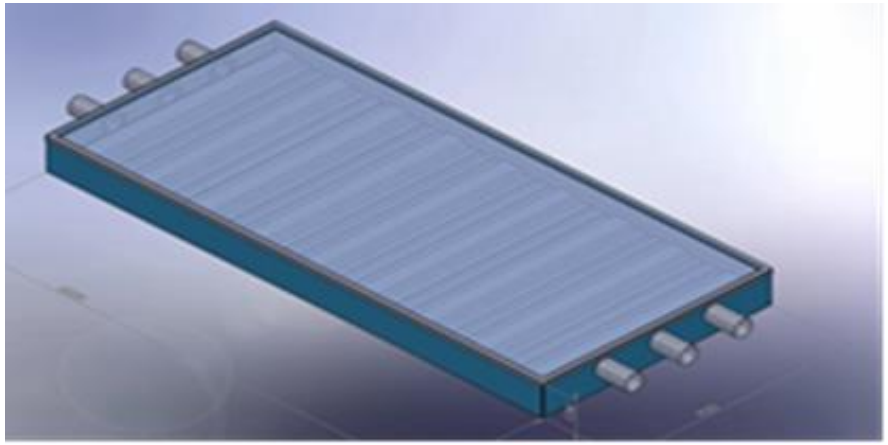
Optimization experiment on the number of import and export channels

Number of import and export groups	Average inlet temperature/℃	Average outlet temperature/℃	Average temperature difference between inlet and outlete/℃	Average irradiance/(w/m^2)	Flow/(kg/s)	Average efficiency of collector/%
1	34.83	78.89	44.20	884.92	0.02	67.40
3	34.69	82.96	48.13	892.68	0.02	84.58

Using pipes with a diameter of 80mm as the inlet and outlet, measure the collector efficiency when the inlet and outlet quantities are one in, one out, and three in, three out

1. Development of A Multi Ventilation Dual Heat Exchange Flat Solar Collector

- This key technical equipment solves the problem of efficient conversion of light and heat by studying the structural parameters and positioning methods of the collector plates in solar collecters. The research and development of three in three out ventilation and double-sided heat exchange wavy collector plates and other structural measures have reduced the dead angle of the working fluid flow, increased the heat exchange area between the working fluid and the collector plate, enhanced the turbulence of the working fluid flowing through the collector plate, increased the heat exchange between the working fluid and the collector plate, **improved the heat transfer efficiency, and increased the light to heat conversion rate from 75% to 89%. In the presence of the sun, the temperature increases by 36.4 to 43.0 ℃ compared to the environment.**



证书号第1556108号

实用新型专利证书

实用新型名称：多通风双换热平板式太阳能集热器

发 明 人：王海;苏海泉;刘瑜;张慧娟;郭雪霞;姚妙

专 利 号：ZL 2009 2 0278420.0

专利申请日：2009年11月13日

专 利 权 人：农业部规划设计研究院

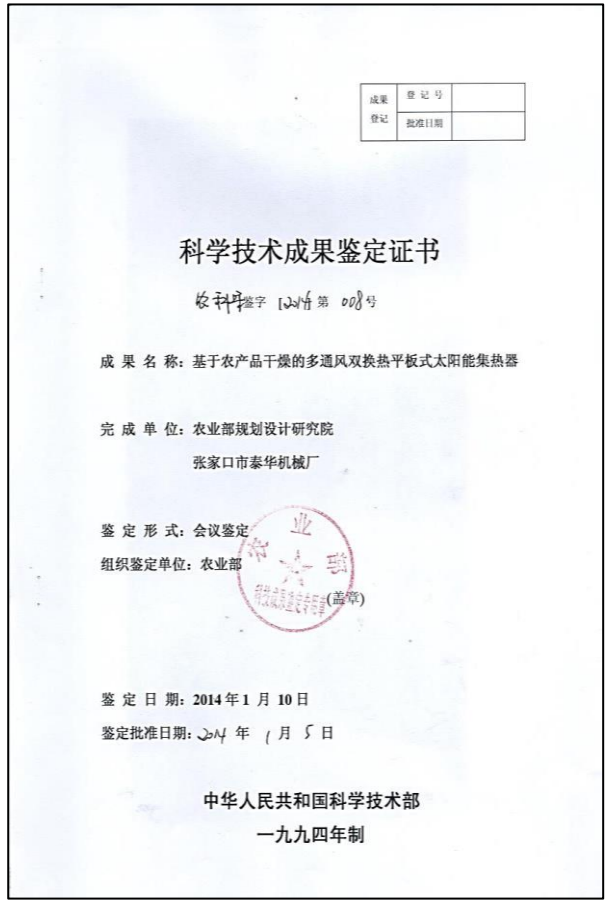
授权公告日：2010年10月06日

局长 田力普

2010年10月06日

第1页（共1页）

Patent: Multi ventilation dual heat exchange flat panel solar collector ZL 2009 2 0278420.0



科学技术成果鉴定证书

农科鉴字 [2014] 第 008 号

成果名称：基于农产品干燥的多通风双换热平板式太阳能集热器

完成单位：农业部规划设计研究院

张家口市泰华机械厂

鉴定形式：会议鉴定

组织鉴定单位：农业部

（盖章）

鉴定日期：2014年1月10日

鉴定批准日期：2014年1月5日

中华人民共和国科学技术部

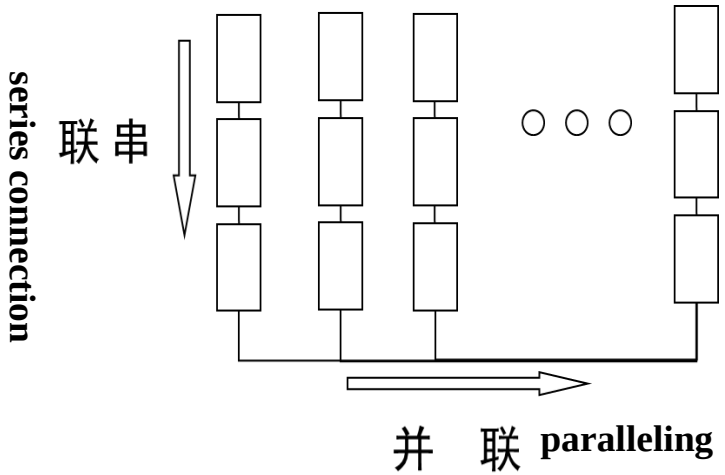
一九九四年制

Nongke Guojian Zi [2014] No. 008, expert opinion: The achievements have reached the international advanced level and are the first in China

2. Research and System Development of Hybrid Solar Energy Efficient Collecting Technology

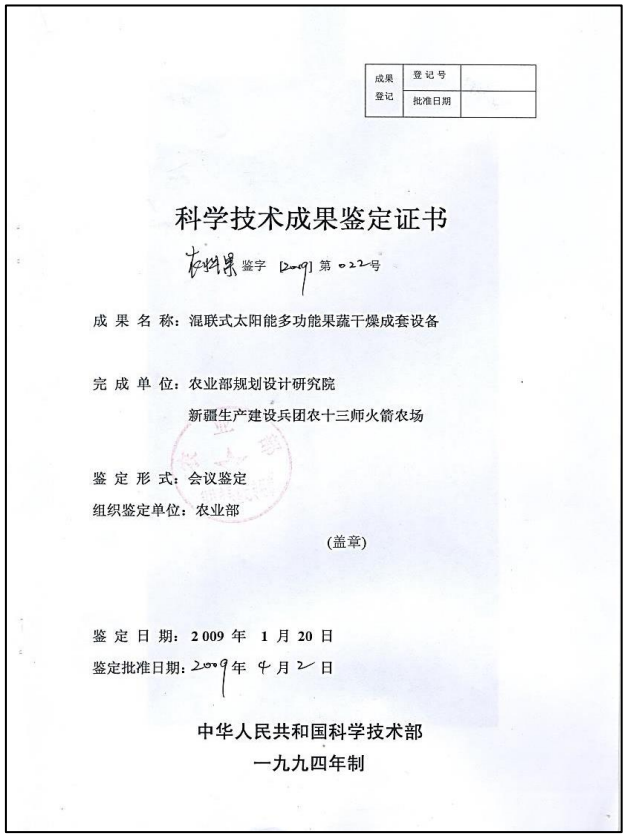
Research and System Development of Hybrid Solar Energy Efficient Collecting Technology

- The ability of a single collector to heat the working fluid is limited and cannot meet production needs, so the collector array will be arranged and used in production
- The series connection of collectors can heat the air multiple times, increasing the temperature of the hot air.
- Parallel connection of collectors can increase air flow to meet different flow requirements.
- Solved the temperature and production capacity of industrial production



2. Research and System Development of Hybrid Solar Energy Efficient Collecting Technology

- **The development of this key technology system aims to address issues such as solar instability and difficulty in achieving industrial drying. The solar collector plate adopts a series parallel hybrid structure combination, which increases the working fluid temperature and flow rate through series connection. It meets the drying, temperature, and air volume requirements for processing 1 ton, 2 tons, and 5 tons of fresh agricultural products in each batch; The working fluid adopts countercurrent to increase temperature; Equipped with an air filtration device to prevent dust from affecting the conversion of light and heat.**



成果登记 | 登记号 | | 批准日期 | |

科学技术成果鉴定证书

农科果鉴字 [2009] 第 022 号

成 果 名 称：混联式太阳能多功能果蔬干燥成套设备

完 成 单 位：农业部规划设计研究院
新疆生产建设兵团农十三师火箭农场

鉴 定 形 式：会议鉴定

组织鉴定单位：农业部

(盖章)

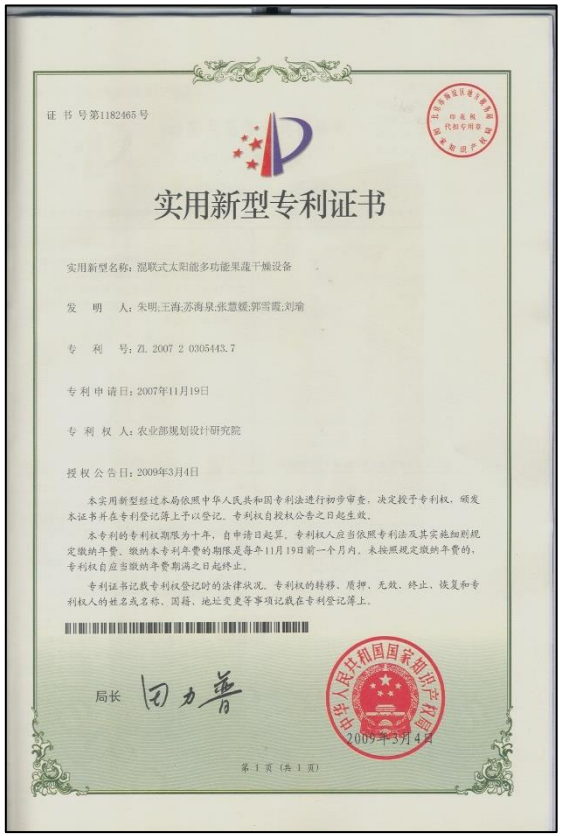
鉴 定 日 期：2009 年 1 月 20 日

鉴定批准日期：2009 年 4 月 2 日

中华人民共和国科学技术部

一九九四年制

Nongke Guojian Zi [2009] No. 022, expert opinion:The achievements have reached the international advanced level and are the first in China



证书号第1182465号

实用新型专利证书

实用新型名称：混联式太阳能多功能果蔬干燥设备

发 明 人：朱明,王海,苏海泉,张慧媛,郭雪霞,刘瑜

专 利 号：ZL 2007 2 0305443.7

专利申请日：2007年11月19日

专 利 权 人：农业部规划设计研究院

授权公告日：2009年3月4日

本实用新型经过本局依照中华人民共和国专利法进行初步审查，决定授予专利权，颁发本证书并在专利登记簿上予以登记。专利权自授权公告之日起生效。

本专利的专利权期限为十年，自申请日起算。专利权人应当依照专利法及其实施细则规定缴纳年费。缴纳本专利年费的期限是每个11月19日前一个月内。未按照规定缴纳年费的，专利权自应当缴纳年费期满之日起终止。

专利证书记载专利权登记时的法律状况。专利权的转移、质押、无效、终止、恢复和专利权人的姓名或名称、国籍、地址变更等事项记载在专利登记簿上。

局长 田力普

中华人民共和国国家知识产权局

2009年3月4日

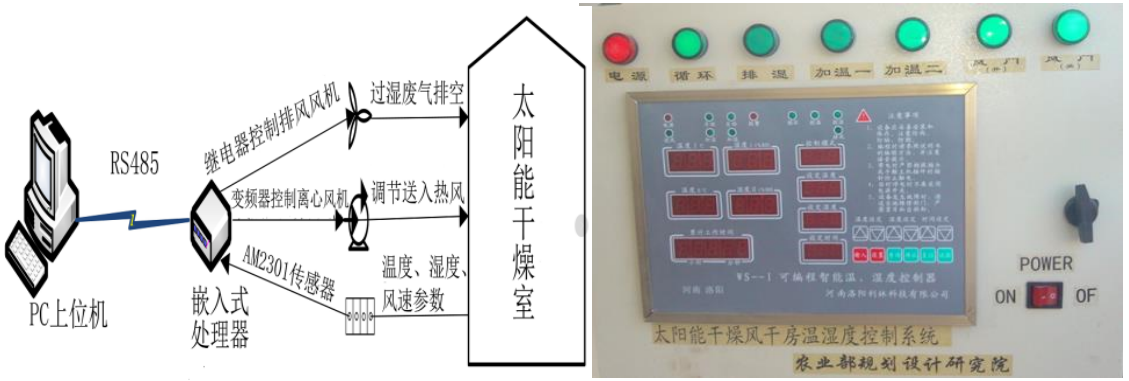
第 1 页（共 1 页）

Patent: Hybrid solar multifunctional agricultural product drying equipmentZL 2007 2 0305443.7

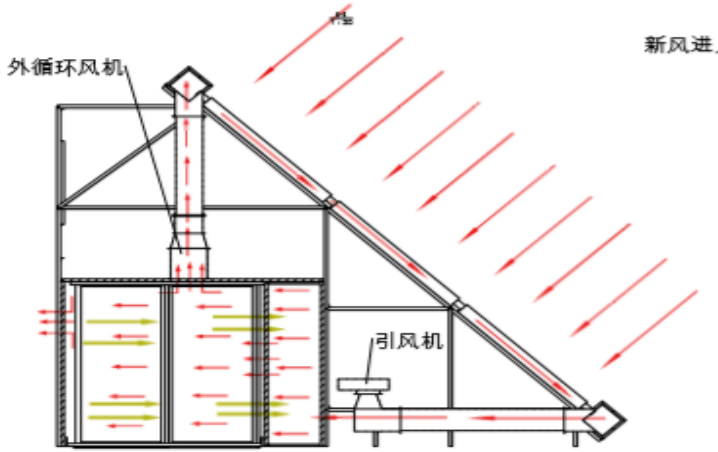
3. Matching and Complementing Solar Energy with Other Energy Sources

Matching solar energy with electricity

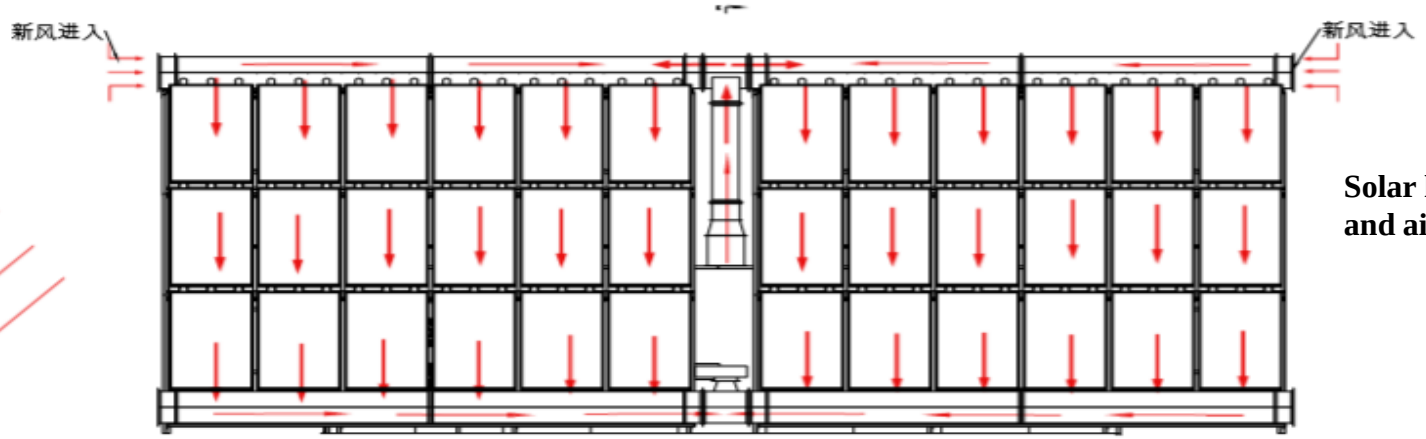
Matching solar energy with heat pumps



Structure diagram of real-time monitoring and control system for solar drying



Solar dual cycle: green represents internal cycle, and red represents external cycle



Dynamic control dual cycle solar drying equipment

Solar heating system and air flow conditions

4. Development of Solar Energy Heat Storage and Release Equipment

- **We have studied solar nano phase change heat storage and release materials. Studied the composition of nano phase change heat storage and release materials (PCM), including paraffin, high-density polyethylene, and expanded graphite; The mass ratio of paraffin(90%), high-density polyethylene(10%), and expanded graphite(5%); Leakage rate of nano phase change heat storage and release materials; Thermal conductivity and thermal stability of nano phase change heat storage and release materials.**

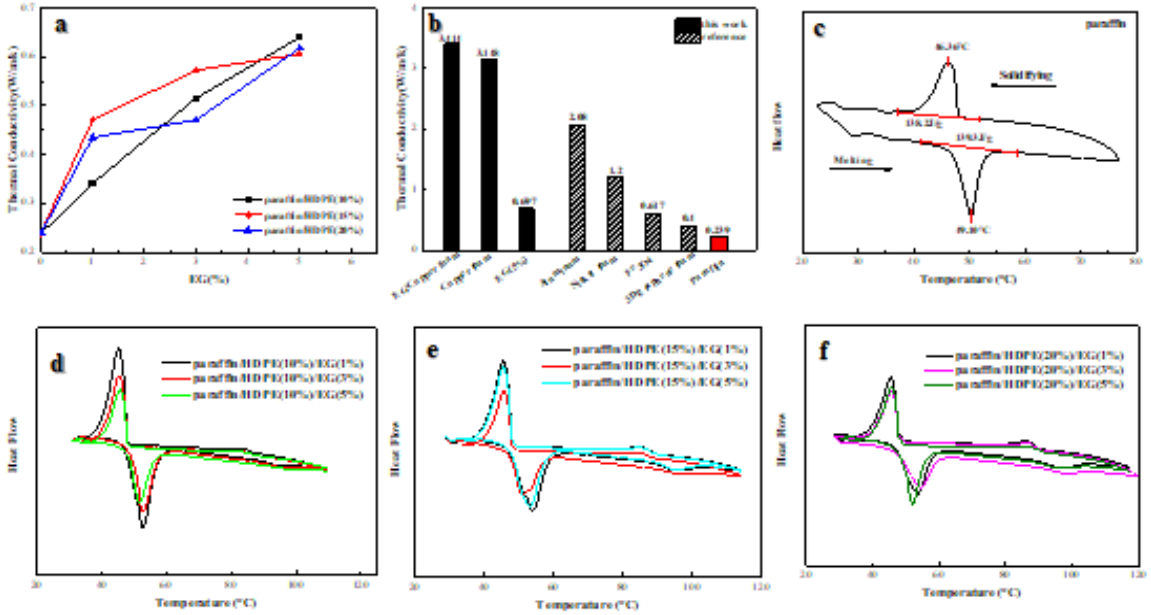


Fig. 2 (a) Thermal conductivity of paraffin/HDPE/EG composites. (b) Comparison of PCMs prepared in this study with some reported PCMs. (c)) DSC curves of paraffin. (d,e,f) DSC curves of paraffin/HDPE/EG composites.

Melting point and condensation point temperature and thermal conductivity of PCM10-5

Sample	Melting			Solidifying			Thermal conductivity
	onset (℃)	Peak (℃)	Latent heat (J/g)	Onset (℃)	Peak (℃)	Latent heat (J/g)	(W/m³/k)
paraffin/HDPE (5%)	48.46	51.73	126.7	47.79	45.32	126.3	0.641

PCM10-5 stores and releases heat

Melting			Solidifying		
onset(℃)	Peak(℃)	heat(kJ)	Onset(℃)	Peak(℃)	heat(kJ)
28.46	71.73	1400.7	71.79	28.32	1422.0

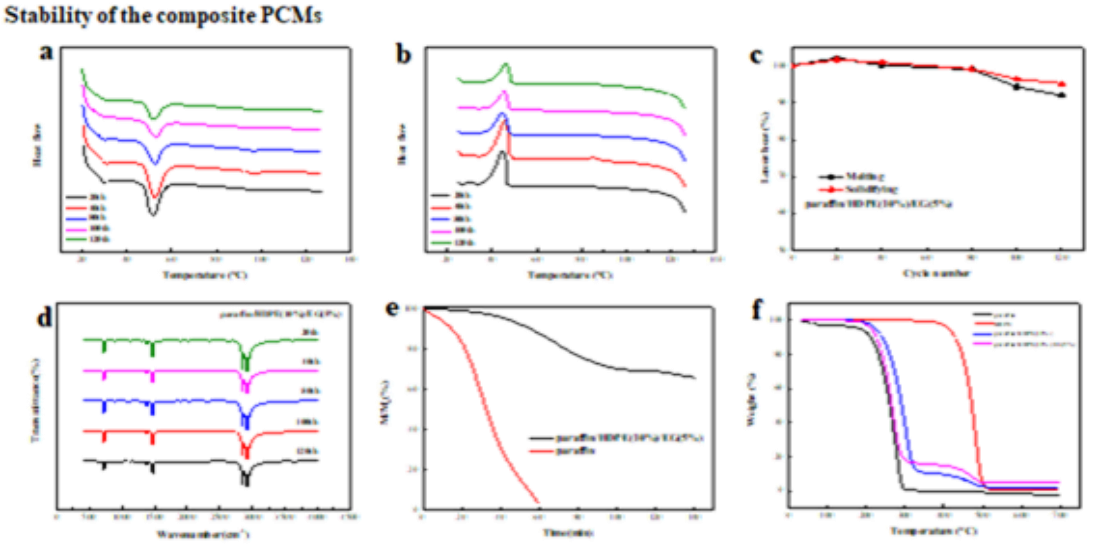


Fig. 4 (a,b) DSC curves of paraffin/HDPE(10%)/EG(5%) composites within different cycles. (c) cycling stability of the latent heat for paraffin/HDPE(10%)/EG(5%) composites. (d) FT-IR spectra of paraffin/HDPE(10%)/EG(5%) composites within different cycles. (e) Leakage test of paraffin/HDPE(10%)/EG(5%) composites. (f) TGA curves of PCMs.

4. Development of Solar Energy Heat Storage and Release Equipment

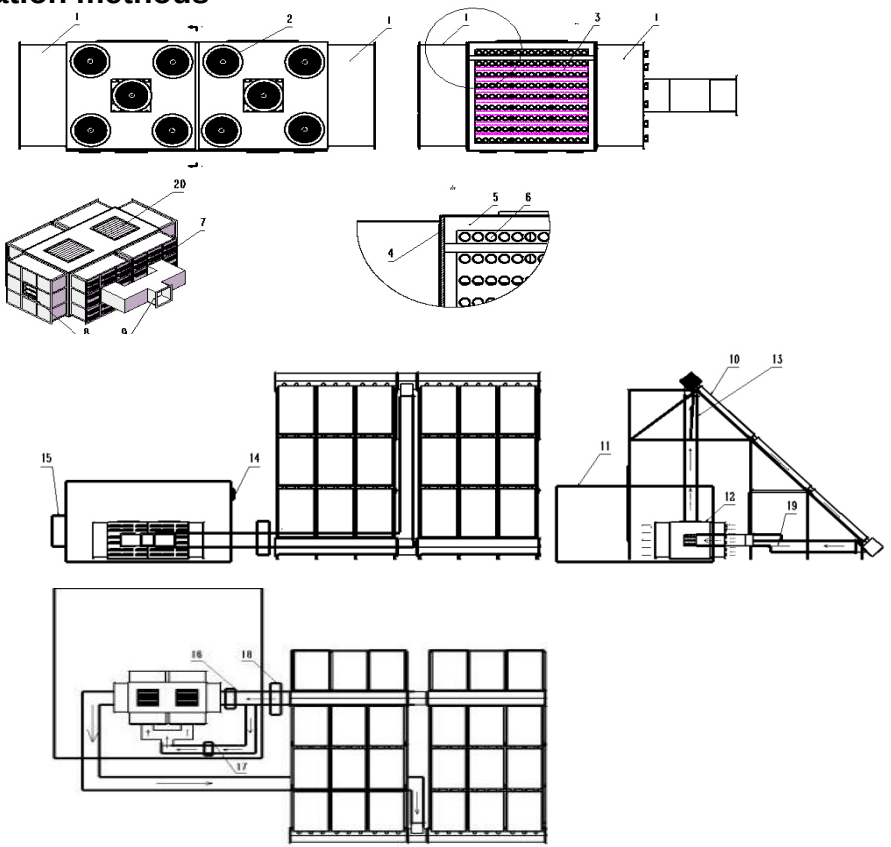
We have studied the solar nano phase change heat storage and release device.

Laboratory prototype

The conductive copper tube serves as a thermal fluid (cold fluid) heat storage and release channel, and is wrapped in a stainless steel plate shell outside the copper tube with fins to form a volume of nano heat storage material. 10kg of nano heat storage material - paraffin/high-density polyethylene (HDPE)/expanded graphite (PCM10-5). When a hot fluid is introduced into one end of the copper tube, the nano thermal storage material absorbs heat and melts through wall type heat exchange, resulting in phase change and storage of sensible and latent heat; When a cold fluid is introduced, the nano thermal storage material undergoes heat release and melting through inter wall heat exchange, resulting in phase change and the release of sensible and latent heat.

Laboratory prototype production drawings and experiments

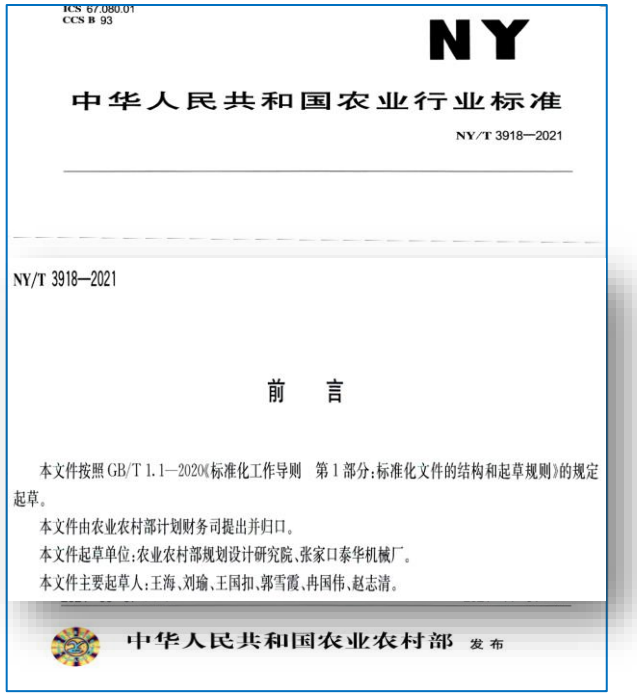
Innovative development of a production-oriented solar phase change heat storage and drying agricultural product heating system using hybrid solar energy collection, phase change heat storage and release in different paths, wall heat release, hot air heat storage cycle, cold air heating cycle, temperature and humidity control, and drying heat calculation methods



Solar thermal conversion, heat storage and drying system

5. Equipment Standard for Solar Drying Technology

- We have improved the construction of a solar drying standard system for agricultural products and formulated a series of solar drying agricultural product standards. Studied the terminology, process requirements, equipment system composition, installation of supporting components, drying equipment debugging, debugging precautions, safe operation, daily maintenance and upkeep, and other guarantee systems for solar drying of agricultural products. A standard formulation plan for solar drying technology terminology, technical regulations, facility design, and heat storage and release equipment for agricultural products has been proposed. With the approval of the National Standardization Management Committee and the Department of Quality and Safety Supervision of Agricultural Products of the Ministry of Agriculture and Rural Affairs, one national standard and two industry standards have been formulated, which can fill the gap in China's solar drying standards for agricultural products.


ICS 67.080.01
CCS B 93

NY

中华人民共和国农业行业标准

NY/T 3918—2021

NY/T 3918—2021

前　言

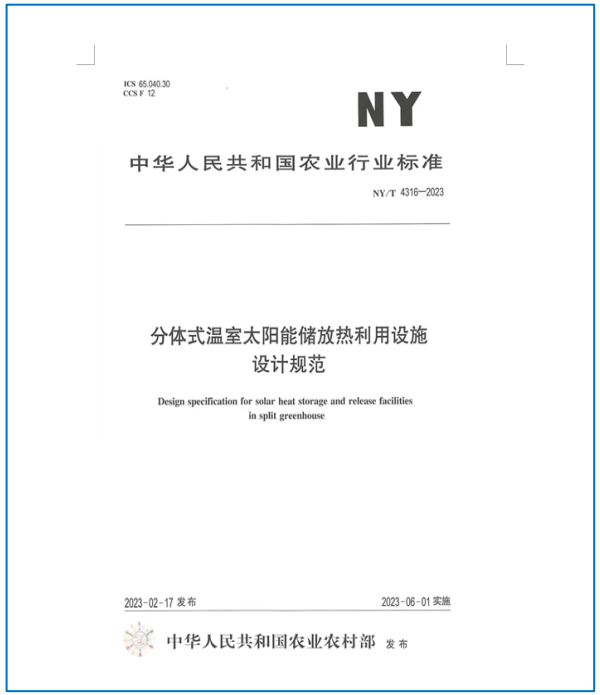
本文件按照GB/T 1.1—2020《标准化工作导则　第1部分：标准化文件的结构和起草规则》的规定起草。

本文件由农业农村部计划财务司提出并归口。

本文件起草单位：农业农村部规划设计研究院、张家口泰华机械厂。

本文件主要起草人：王海、刘瑜、王国扣、郭雪霞、冉国伟、赵志清。

中华人民共和国农业农村部　发布


ICS 65.040.30
CCS P 12

NY

中华人民共和国农业行业标准

NY/T 4316—2023

分体式温室太阳能储放热利用设施
设计规范

Design specification for solar heat storage and release facilities in split greenhouse

2023-02-17 发布　　2023-06-01 实施

中华人民共和国农业农村部　发布


ICS 67.080.01
X 26

GB

中华人民共和国国家标准

GB/T XXXX-XXXX

太阳能干燥果蔬生产技术规程

Technical regulations for the production of solar dried fruits and vegetables

（征求意见稿）

6. Intellectual Property

Apply for 13 patents, including 2 authorized national invention patents and 5 utility model patents

Published 40 scientific and technological papers, including 6 SCI papers, 11 EI papers, and 22 core journals

Forming equipment 1. Hybrid Dual Cycle Solar Energy Agricultural Product Drying Equipment

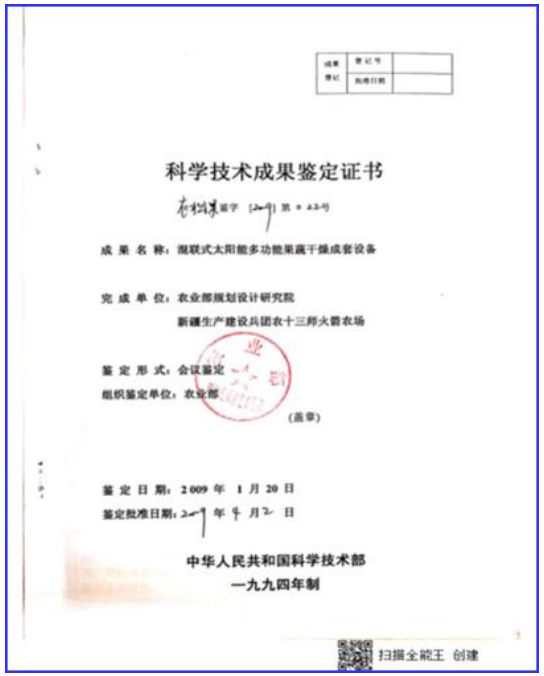
- This equipment uses solar energy as the heat source, utilizes heat transfer mechanism, and heats air through forced convection to dry agricultural products in the form of hot air. Adopting the hot air temperature control drying technology route, a hybrid solar collector is used to collect heat, and the heat is sent to the agricultural product drying system in the form of dual circulation hot air through a fan to achieve agricultural product drying.

- With the support of the National Support Plan for the 11th and 12th Five Year Plans and the scientific and technological tasks of relevant departments and bureaus of the MARA, **the fifth generation equipment has been improved.**

- This equipment has **1 ton, 2 tons, and 5 tons** of dried fresh fruits per batch. **Nearly 20 sets** have been promoted in provinces and regions such as Xinjiang, Ningxia, Yunnan, Gansu, and Hebei. Can dry agricultural products such as grapes, dates, goji berries, walnuts, lilies, mushrooms, cauliflower, prawns, scallops, etc.

Forming Facilities 2. Productive and Efficient Solar Collector Box Type Agricultural Product Drying Room

- This facility uses solar energy as the heat source and based on the drying characteristics of agricultural products and the mechanism of hot air drying, a technical transformation is carried out on the traditional air-drying room in Xinjiang. It adopts a box structure design, introduces forced natural uniform air exhaust technology and foldable dual heat exchange technology.
- The main technical performance indicators: **the drying temperature inside the facility is 12.5 ℃ higher than outside; The moisture content of raisin products is 14.2%; Increase the green grade rate of raisins by 48%; The drying time has been shortened from 45-120 days in traditional natural drying rooms to 20 days.** Can be used for agricultural product processing, traditional Chinese medicine processing enterprises, farm farmers, etc.



科学技术成果鉴定证书

成 果 名 称：微联式太阳能多功能果蔬干燥成套设备

完 成 单 位：农业部规划设计研究院
新疆生产建设兵团农十三师火箭农场

鉴 定 形 式：会议鉴定
组织鉴定单位：农业部

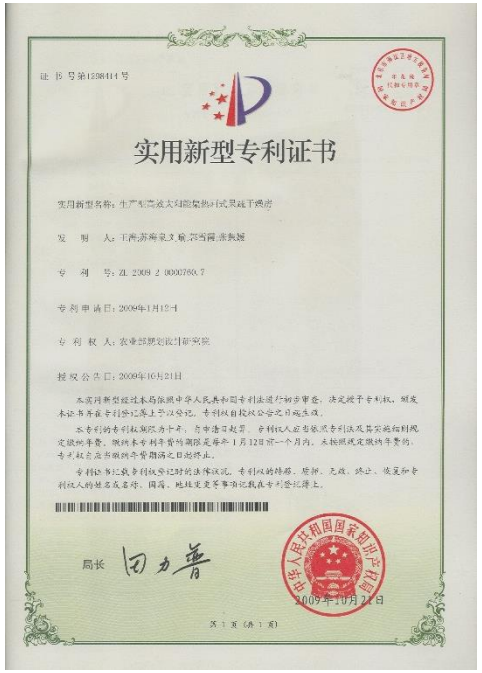
（盖章）

鉴 定 日 期：2009 年 1 月 20 日
鉴定批准日期：2009 年 1 月 21 日

中华人民共和国科学技术部
一九九四年制

扫描全能王 创建

Nongke Guojian Zi [2009] No. 021, expert opinion:The achievements have reached the international advanced level and are the first in China



实用新型专利证书

局长

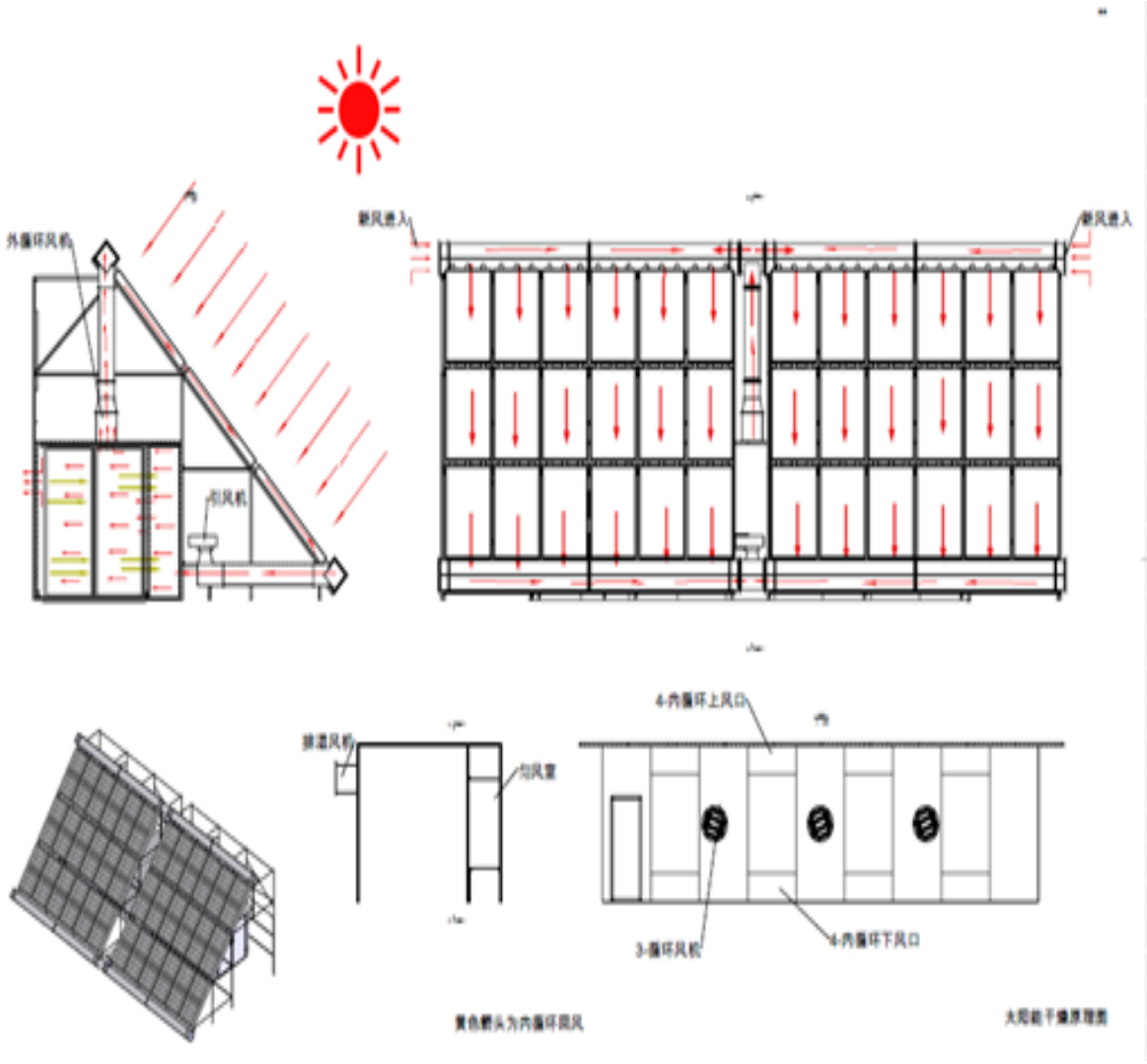
2009年10月21日

Patent: Production type high-efficiency solar collector box drying room ZL 2009 2 0000760.7

Forming Equipment 3. Development of Dual Cycle Solar Drying Equipment

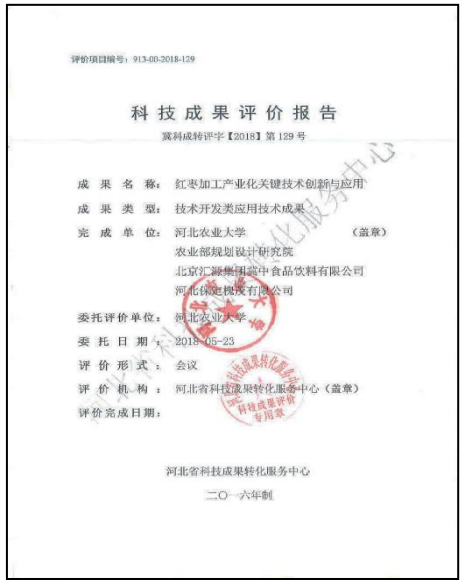
- Internal circulation: The air drying medium is introduced from the uniform air chamber by a circulating fan on the partition of the drying chamber. Dry air passes through the wet material in the drying chamber and returns to the opposite box board equipped with a dehumidification fan. It then passes through the wet material and returns to the uniform air chamber through the upper and lower return air louvers on the partition, forming an internal circulation in the drying system. The circulation air flow is parallel to the tray, and this circulation is opened from beginning to end as long as the drying is in progress.

- External circulation: refers to the introduction of air drying medium from the uniform air chamber by the circulating fan on the partition of the drying chamber. Dry air passes through the wet materials in the drying chamber, enters the solar collector through the induced draft fan, induced draft duct, and inlet duct above the drying chamber, and is reheated by the solar collector system. It is then added to the uniform air chamber by the forced draft fan through the outlet duct and supply duct, and then re fed into the drying system through the circulating fan, forming an external circulation of the drying system, The direction of the circulating air flow is perpendicular to the tray.



Forming Equipment 3. Development of Dual Cycle Solar Drying Equipment

- This key technical equipment focuses on issues such as room temperature humidity, uneven flow field, and high drying energy consumption in drying equipment, and studies drying equipment that integrates solar energy internal circulation and external circulation.
- A uniform air chamber has been set up, and its internal circulation solves the problem that the drying cars are both the first and second cars of tunnel kiln drying, accelerating the drying rate and uniformity; The external circulation solves the high energy demand in the later stage of drying, reduces heat loss, and improves drying efficiency.



科技成果评价报告

冀科成转评字【2018】第129号

成果名称：红枣加工产业化关键技术创新与应用

成果类型：技术开发类应用技术成果

完成单位：河北农业大学（盖章）
农业部规划设计研究院
北京汇源集团定中食品饮料有限公司
河北钦定枣业有限公司

委托评价单位：河北农业大学

委托日期：2018-05-23

评价形式：会议

评价机构：河北省科技成果转化服务中心（盖章）

评价完成日期：

河北省科技成果转化服务中心

二〇一六年制

Ji Ke Cheng Zhuan Ping Zi [2018] No. 129, expert evaluation: The overall technology has reached the international leading level

证书号第2923335号

发明专利证书

发明名称：太阳能双循环农产品干燥设备及其在干燥农产品中的应用

发明人：王海；郭雪霞；刘瑜；冉国伟；张慧娟；赵志清；陈祥全；王伟华

专利号：ZL 2015 1 0609677.X

专利申请日：2015年09月22日

专利权人：农业部规划设计研究院

地址：100125 北京市朝阳区麦子店街41号

授权公告日：2018年06月15日　　授权公告号：CN 105115258 B

局长 申长雨

第1页（共1页）

Invention Patent: Solar Energy Dual Cycle Agricultural Product Drying Equipment and Its Application in Drying Agricultural Products 201510609677. X

河北省科学技术奖

证书

为表彰河北省科学技术奖获得者，特颁发此证书。

项目名称：红枣加工产业化关键技术创新与应用

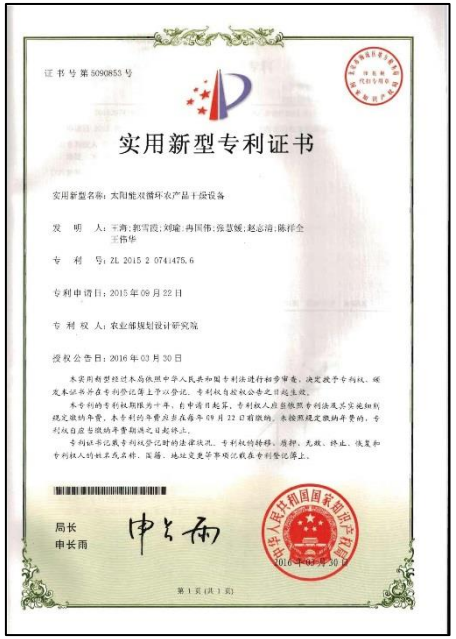
奖种类别：科学技术进步奖

奖励等级：二等

获奖者：王海

2018年度·证书编号：2018JB2076-4

Reward: Innovation and application of key technologies in the industrialization of jujube processing won the second prize of Hebei Province Science and Technology Progress Award in 2018



证书号第5090853号

实用新型专利证书

实用新型名称：太阳能双循环农产品干燥设备

发明人：王海；郭雪霞；刘瑜；冉国伟；张慧娟；赵志清；陈祥全；王伟华

专利号：ZL 2015 2 0741475.6

专利申请日：2015年09月22日

专利权人：农业部规划设计研究院

授权公告日：2016年03月30日

局长 申长雨

第1页（共1页）

Utility model patent: solar dual cycle agricultural product drying equipment

Third Party Evaluation

- According to the latest research conducted by the Science and Technology Literature Information Center of the CAAS, the main innovation points have not been reported domestically or internationally.
- Top Ten Technological Innovation Promotion Achievements in Agricultural Product Processing Industry in 2015

- Top Ten New Equipment of the 2019 China Agricultural and Rural Key New Technologies, New Products, and New Equipment by the Chinese Agricultural Association


科技查新报告

项目名称：太阳能集热干燥农产品技术装备研发与应用

委 托 人：农业农村部规划设计研究院

委托日期：2020 年 09 月 23 日

查新机构（盖章）：中国农业科学院科技文献信息中心

（国家一级科技查新咨询单位）

查新完成日期：2020 年 10 月 21 日

中华人民共和国科学技术部

二〇〇〇年制

六、查新结论

经与所查国内外文献比较分析，该项目的新颖性如下：


证 书

农业部规划设计研究院：

你单位的“太阳能农产品干燥设备”被推选为2015年度农产品加工业十大科技创新推广成果。

农业部农产品加工局

2015年11月30日


中国农学会文件

农学（学术）发〔2019〕14号

关于公布“2019中国农业农村重大新技术、新产品和新装备”遴选结果的通知

各有关单位，有关人员：

为及时反映我国农业农村科技应用领域最新进展，满足农业农村发展重大科技需求，创新引领农业农村科技发展，在农业农村部科技教育司的指导下，中国农学会组织开展了2019中国农业农村重大科技新成果遴选工作。期间，共收到来自199家单位的322项申报成果，经网络评审、会议复审、会议终审和征求部行业司局意见，产生2019中国农业农村重大新成果30项，其中新技术、新产品和新装备各10项。现公布如下：

— 1 —

Third Party Evaluation

- **It is a domestic initiative, with an overall international advanced level and some technical indicators leading internationally**

Multi ventilation dual heat exchange flat solar collector based on agricultural product drying

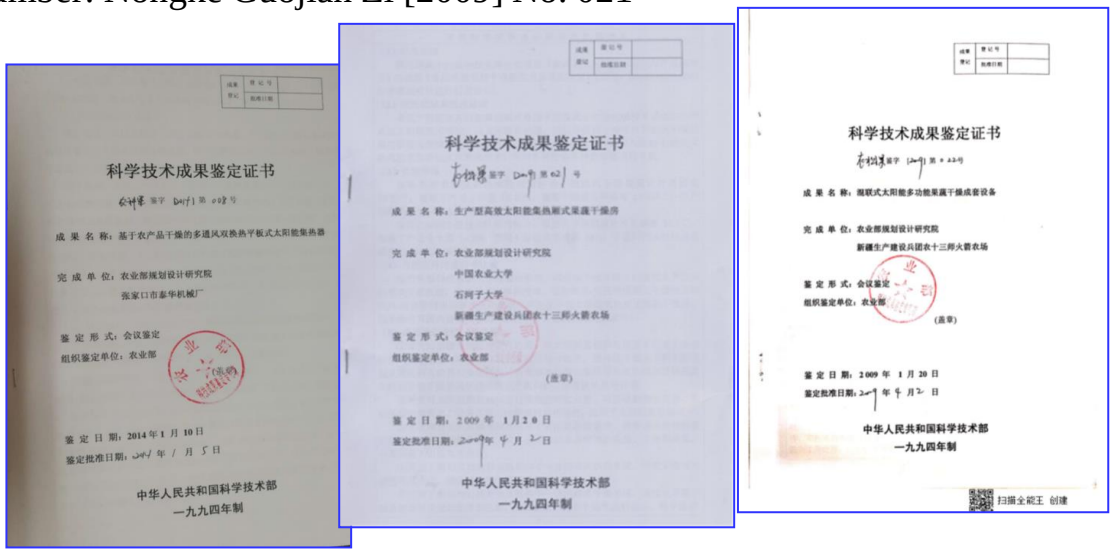
Organizational appraisal unit: Ministry of Agriculture, appraisal number: Nongke Guojian Zi [2014] No. 008

Hybrid solar powered fruit and vegetable drying equipment

Organizational appraisal unit: Ministry of Agriculture, appraisal number: Nongke Guojian Zi [2009] No. 022

Productive and efficient solar collector box style fruit and vegetable drying room

Organizational appraisal unit: Ministry of Agriculture, appraisal number: Nongke Guojian Zi [2009] No. 021

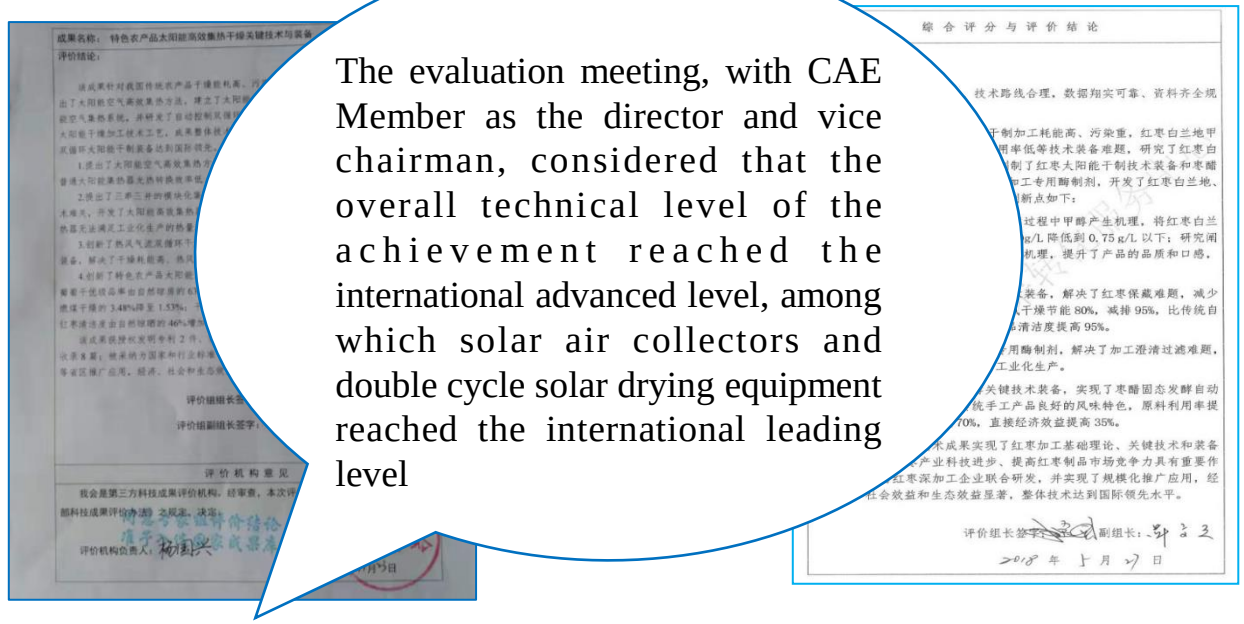


Key Technologies and Equipment for Solar Energy Efficient Collector Drying of Special Agricultural Products

Organizational appraisal unit: China Agricultural Society: Zhongnong (Evaluation) Zi [2020] No. 51

Innovation and Application of Key Technologies in the Industrialization of Red Date Processing

Organizational appraisal unit: Hebei Provincial Science and Technology Achievement Transformation Service Center: Ji Ke Cheng Zhuan Ping Zi [2018] No. 129



The evaluation meeting, with CAE Member as the director and vice chairman, considered that the overall technical level of the achievement reached the international advanced level, among which solar air collectors and double cycle solar drying equipment reached the international leading level

Third Party Evaluation

Result evaluation conclusion: This project proposes a high-efficiency solar air heat collection method, establishes a solar energy agricultural product drying model and theory, develops a large-scale solar energy air heat collection system, and develops an automatic control dual cycle solar energy drying equipment for agricultural products, optimizing the solar energy drying processing technology of agricultural products.

Serial Number	key technology	technical index		This achievement	Domestic	Abroad
1	Solar air high-efficiency collector	Photothermal conversion efficiency		89%	72%≦Photothermal conversion rate≦80%	72%≦Photothermal conversion rate≦80%
		heat transfer efficiency		91.85%	40%≦heat transfer efficiency≦55%（H_2O）	35%≦heat transfer efficiency≦48%（美）
2	Solar efficient heat collection system	Temperature rise compared to ambient temperature		36.4～43.0℃	10～25.0℃	15～30℃
		Wet material handling capacity		0.5～10t	0.1～0.2t	0.2～0.5t
3	Complete set of solar efficient heat collection and drying equipment for agricultural products	Drying cycle	Thompson seedless102.7/d	17d	No solar energy, air drying45d	Non seedless white grapes20d
			Gourd stick1827kg/h	5h	No solar energy, air drying24h、Coal 8h	Nothing
			Prawn428.1kg	3.1h	Electricity6h、Coal 4.5h	Solar energy4.5h
		Energy saving compared to coal-fired and electric heating	Thompson seedless	Coal saving rate100%	Air drying coal saving rate100%	Save 20% fuel（US）
			Gourd stick	Coal saving rate100%、power saving rate90%	Standard coal 2.25t、Electricity 414 degrees Celsius	Nothing
			Prawn	Energy saving compared to coal82.81%、Energy saving compared to electricity93.9%	Standard coal 1.0 t、Electricity 85 degrees Celsius	Save 30% to 40% of conventional energy
4	Standard	National standard	Solar dried agricultural products	Terminology and production technical regulations	Nothing	here is only a standard for hot water collection and no standard for dry agricultural products
		Industry standards	Solar powered drying of fruits and vegetables	Facility Design Specification	Only NB/T 34022-2015 General Technical Requirements for Solar Drying Systems	

Honors & Awards

- 2022 China Energy Research Association Energy Technology Innovation Second Prize
- Second Prize of the Science and Technology Award of the China Federation of Commerce in 2022
- 2021 China Patent Excellence Award
- Second Prize for Science and Technology Progress in Hebei Province in 2018
- Second Prize for Science and Technology Progress of Xinjiang Production and Construction Corps in 2010


中国能源研究会能源创新奖

获奖证书

为表彰能源创新奖获得者，特颁发此证书。

奖项名称：技术创新奖

获奖项目：太阳能干燥农产品技术装备创制与应用

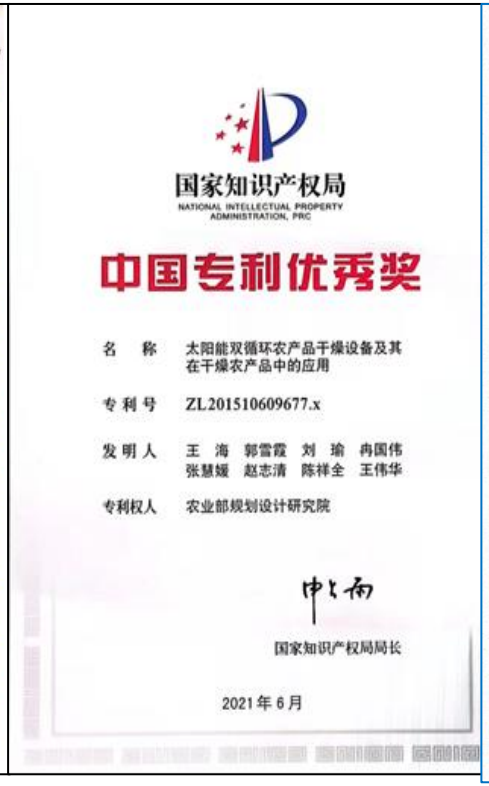
奖励等级：二等奖

获 奖 者：农业农村部规划设计研究院

获奖年度：2022年

发证机构：中国能源研究会

证书编号：2022-0285-J-2-26-D01


国家知识产权局

NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION, PRC

中国专利优秀奖

名 称 太阳能双循环农产品干燥设备及其在干燥农产品中的应用

专利号 ZL201510609677.x

发明人 王 海 郭雪霞 刘 瑜 冉国伟 张慧媛 赵志清 陈祥全 王伟华

专利权人 农业部规划设计研究院

国家知识产权局局长

2021年6月


国科奖社证字第0191号

2022年中国产学研合作创新与促进奖

产学研合作创新成果奖

获奖证书

为表彰在产学研深度融合中取得的重要科技创新成果，特颁发此证书。

项目名称：太阳能集热干燥农产品技术装备创新与应用

奖项等级：优秀奖

完成单位：农业农村部规划设计研究院
河北农业大学
石河子大学
张家口市泰华机械厂
宁夏回族自治区乡镇企业经济发展服务中心

主要完成人：王 海、郭雪霞、刘 瑜、王鑫磊、孙创锋、陈国刚、刘亚琼、冉国伟、周泽江、赵志清

证书号：20226353

中国产学研合作促进会

2025年2月


河北省科学技术奖

证 书

为表彰河北省科学技术奖获得者，特颁发此证书。

项目名称：红枣加工产业化关键技术创新与应用

奖种类别：科学技术进步奖

奖励等级：二等

获 奖 者：王海

2018年度-学-2-078JB2076-4


证 书

项目名称：食品高效节能干燥新技术与装备开发

获奖等级：新疆生产建设兵团科学技术进步奖 贰等奖

获奖人员：王 海 （名列第二）

获奖年度：2010年

证书编号：201021402

新疆生产建设兵团

二〇一一年一月


中国商业联合会科学技术奖

全国商业科技进步奖

获奖证书

获奖项目：农产品太阳能高效集热干燥技术装备创新与应用

获奖等级：二等奖

获 奖 者：农业农村部规划设计研究院

二〇二二年十二月

证书号：2022-2-64-D01

04

Promotion and Application

- **It can be used in agricultural and sideline product drying enterprises such as grains, fruits and vegetables, traditional Chinese medicine, and seafood (shrimp, kelp), especially suitable for small and medium-sized enterprises, farm farmers, etc**
- **The solar drying agricultural product molding equipment has a capacity of 0.5-5 tons.**

1 ton equipment

2-ton equipment

3-ton equipment

5-ton equipment

The application prospects are broad, and significant ecological, social, and economic benefits have been achieved

- **The project achievements have been promoted and applied in more than 20 enterprises in Xinjiang, Ningxia, Hebei, Gansu and other regions, including 14 enterprises. In the past two years, the accumulated dry agricultural products have reached 32800 tons, with an added output value of 1.932 billion yuan and a new profit of 299 million yuan. More than 4500 job opportunities have been created, indirectly benefiting 25000 people; Dry agricultural products require 24600 tons of water to evaporate (0.57 tons of standard coal to evaporate 1 ton of water), saving 14000 tons of standard coal, reducing 21000 tons of carbon dioxide, 168.3 tons of sulfur dioxide, 210 tons of smoke and dust, and 3646 tons of ash, saving 14 million yuan in funds. Compared to traditional drying technology, the hygiene indicators are improved by two orders of magnitude, and the rate of high-quality products is over 90%; Solar drying saves 82.81% energy, reduces emissions by 95%, and saves 93.9% energy compared to coal-fired hot air drying; Significant ecological, social, and economic benefits have been achieved.**

应用证明

项目名称	太阳能集热干燥农产品技术装备研发与应用
应用单位	中宁县建林红枣专业合作社
单位注册地址	宁夏回族自治区中卫市中宁县石空镇高山寺八队
应用起止时间	2014 年 8 月至 2019 年 12 月

经济效益（万元）

自然年	新增销售额	新增利润
2018	7015.00	1025.00
2019	8153.00	1072.00
累　计	15168.00	2097.00

所列经济效益的有关说明及计算依据：

新增销售额=新增销售量×平均销售价格，项目 2018 年 1 月至 2019 年 12 月止，累计新增干制销售红枣 1065.00t，平均销售价格 4.0 万元/t，累计新增销售额 4260.00 万元；累计新增干制销售枸杞 909.00t，平均销售价格 12.0 万元/t，累计新增销售额 10908.00 万元。新增利润=新增产品销售收入-新增产品成本。2018 至 2019 年 12 月止，累计新增产品销售收入 15168.00 万元，累计新增产品成本 13071.00 万元，累计新增利润 2097.00 万元。

具体应用情况：

由农业农村部规划设计研究院等单位共同完成的“太阳能集热干燥农产品技术装备研发与应用”项目，自 2014 年 8 月至 2019 年 12 月在我公司进行红枣、枸杞原料太阳能干制技术装备创新示范推广，利用该关键技术装备干制红枣、枸杞，比燃煤热风干燥节能 82%，减排 95%以上，比传统自然晾晒红枣、枸杞优级品率提高 72%，原料清洁度提高 95%以上，减少了采后损失，经济社会效益显著。

应用单位法定代表人签字：郝建林　2020 年 6 月 20 日　应用单位盖章　年　月　日

注：社会公益类项目如无经济效益，可不填经济效益相关栏目。

应用证明

项目名称	特色农产品太阳能高效集热干燥关键技术与装备
应用单位	宁夏乡镇企业经济发展服务中心
单位注册地址	银川金凤区北京中路 159 号
应用起止时间	2013 年 1 月至 2019 年 12 月

经济效益（万元）

自然年	新增销售额	新增利润
累　计		

所列经济效益的有关说明及计算依据：

具体应用情况：

2013 年 1 月起，我区采用农业农村部规划设计研究院等单位共同完成的太阳能空气高效集热方法、太阳能农产品干燥模型和理论、大型太阳能空气集热系统、自动控制双循环太阳能干制农产品装备及特色农产品太阳能干燥加工技术工艺等成果，在我区进行枸杞、红枣等太阳能干制示范推广，截止目前我区共建枸杞、红枣干燥示范工程中心几十处，我区约 15%枸杞、10%红枣采用该成果进行干制，相关企业均获得较好的经济效益。推广区域内解决了因干制引起的能耗高、污染重、品质差等问题，减少了采后损失，增加了农民收入，降低了环境污染，具有显著的经济、社会和生态效益。推广应用前景良好。

应用单位法定代表人签名：　2020 年 6 月 8 日　应用单位盖章　年　月　日

注：社会公益类和国家安全类项目如无经济效益，可不填经济效益相关栏目。

应用证明

项目名称	特色农产品太阳能高效集热干燥关键技术与装备
应用单位	新疆生产建设兵团农业农村局
单位注册地址	新疆维吾尔自治区乌鲁木齐市光明路 196 号
应用起止时间	2008 年 1 月至 2019 年 12 月

经济效益（万元）

自然年	新增销售额	新增利润
累　计		

所列经济效益的有关说明及计算依据：

具体应用情况：

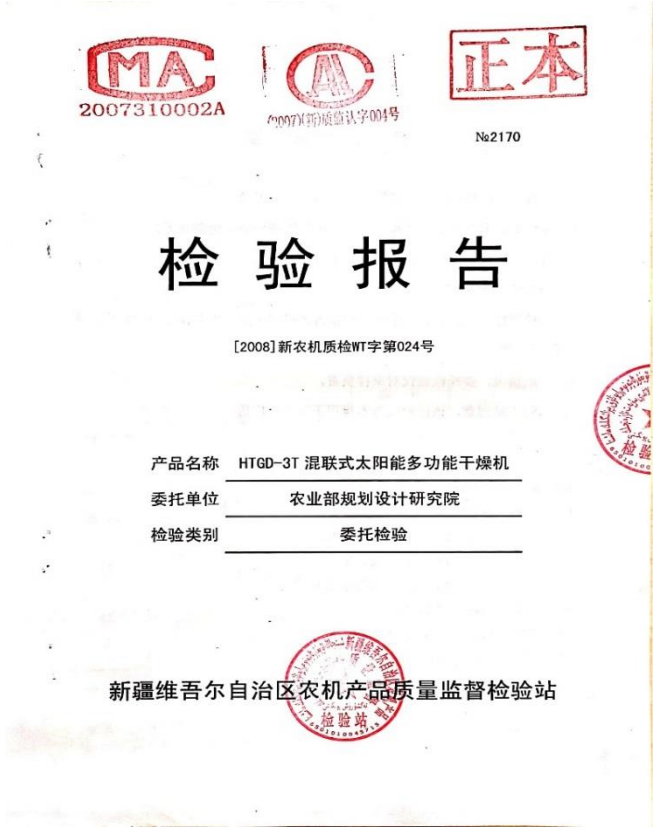
2008 年 1 月起，兵团三师、十师和七师先后采用农业农村部规划设计研究院等单位共同完成的太阳能空气高效集热方法、太阳能农产品干燥模型和理论、大型太阳能空气集热系统、自动控制双循环太阳能干制农产品装备及特色农产品太阳能干燥加工技术工艺等成果，开展葡萄、红枣、枸杞和核桃等农产品太阳能干制示范推广，截止目前，建设包括十三师火箭农场红枣和葡萄、十师 186 团核桃、七师 124 团枸杞等太阳能干燥示范工程十余处，示范推广区域内的 10%左右葡萄、红枣等农产品采用该成果技术进行干制，相关企业均获得较好的经济效益，一定程度解决了因干制引起的能耗高、污染重、品质差等问题，减少了采后损失，增加了职工收入，降低了环境污染，具有较为显著的经济、社会和生态效益，推广应用前景良好。

应用单位法定代表人签名：　2020 年 6 月 19 日　应用单位盖章　年　月　日

注：社会公益类和国家安全类项目如无经济效益，可不填经济效益相关栏目。

2021年度中华农业科技奖

- **In 2008, a hybrid solar box tunnel drying equipment was designed and manufactured at Xinjiang Rocket Farm. The solar energy collection area reaches 27m^2 and the processing capacity is 3t.**
- **When the drying capacity is 1827 kilograms per hour and the ambient temperature is 18.0~22.5 ℃, the maximum air temperature at the inlet of the drying chamber is 61 ℃, and the wind speed is 2.8 meters per hour**
- **The drying cycle is 5 hours, which can save 2.25 tons of standard coal and 414 kWh of electricity compared to coal-fired drying. The coal saving rate is 100% and the electricity saving rate is 90%.**



2007310002A

正本

№2170

检 验 报 告

[2008]新农机质检WT字第024号

产品名称	HTGD-3T 混联式太阳能多功能干燥机
委托单位	农业部规划设计研究院
检验类别	委托检验

新疆维吾尔自治区农机产品质量监督检验站

- **In 2009, a hybrid solar box drying tower was designed and manufactured in Lanzhou, Gansu. The solar energy collection area reaches 24m2 and the processing capacity is 1t.**

- **In June 2011, a set of solar drying equipment was built at Hebei Chengde Fengda Agricultural Development Co., Ltd. The solar energy collection area reaches 288m^2, and the processing capacity reaches 10t**
- **When the drying capacity is 1827 kilograms per hour and the ambient temperature is 18.0~22.5 ℃, the maximum air temperature at the inlet of the drying chamber is 61 ℃, and the wind speed is 2.8 meters per hour.**
- **The drying cycle is 5 hours, which can save 2.25 tons of standard coal and 414 kWh of electricity compared to coal-fired drying. The coal saving rate is 100% and the electricity saving rate is 90%.**

编号：122513

Inspection report

检 验 报 告

CNAS L0444

产品名称 果蔬太阳能干燥器

型号规格 GTG-10

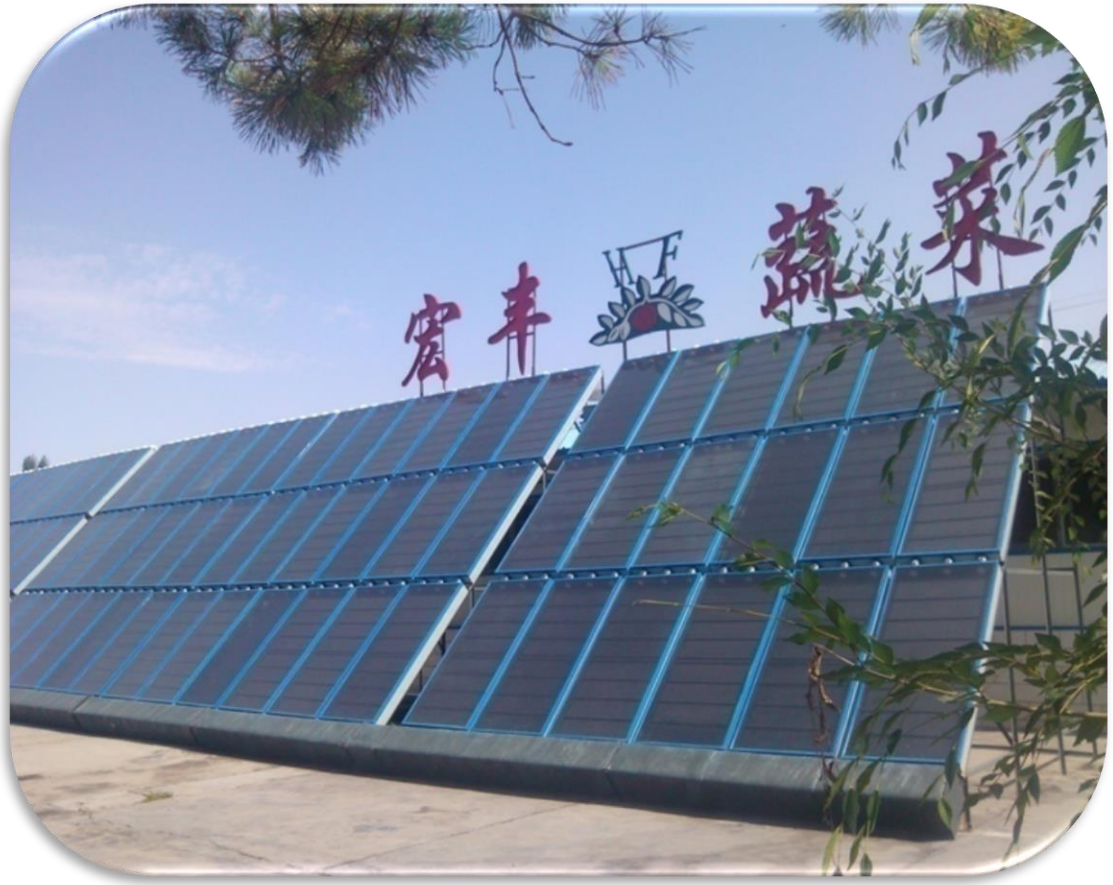
受检单位 农业部规划设计研究院

检验类别 委托检验

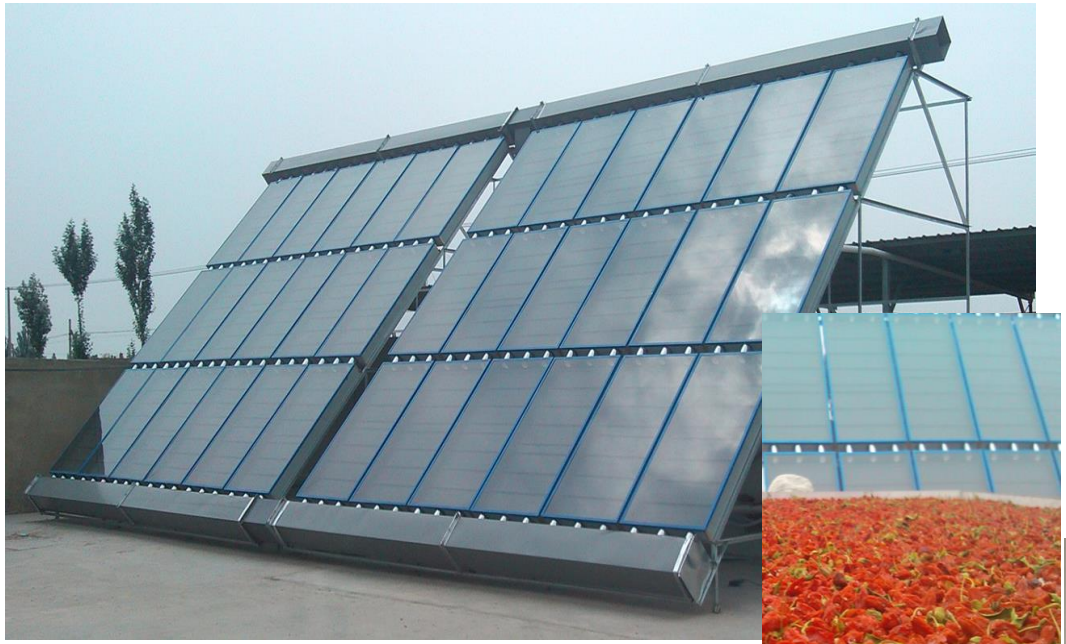
国家食品机械质量监督检验中心

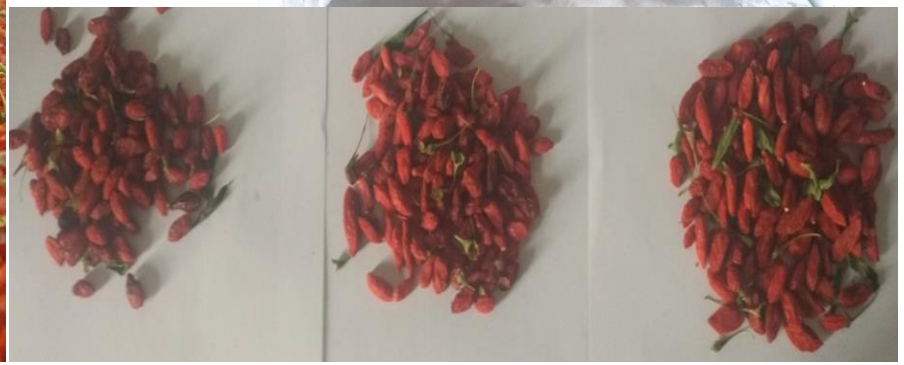
- **In 2011, a set of solar drying equipment was installed in the 184th Regiment of Xinjiang Agricultural 10th Division. The solar energy collection area is 192m^2, and the processing capacity is 3-5 tons.**

- **In 2012, a technical service cooperation agreement was signed with Gansu Gaotai County Hongfeng Dehydrated Vegetable Co., Ltd. to renovate the company's existing drying equipment and add a solar heating system with a heating area of 216m^2.**

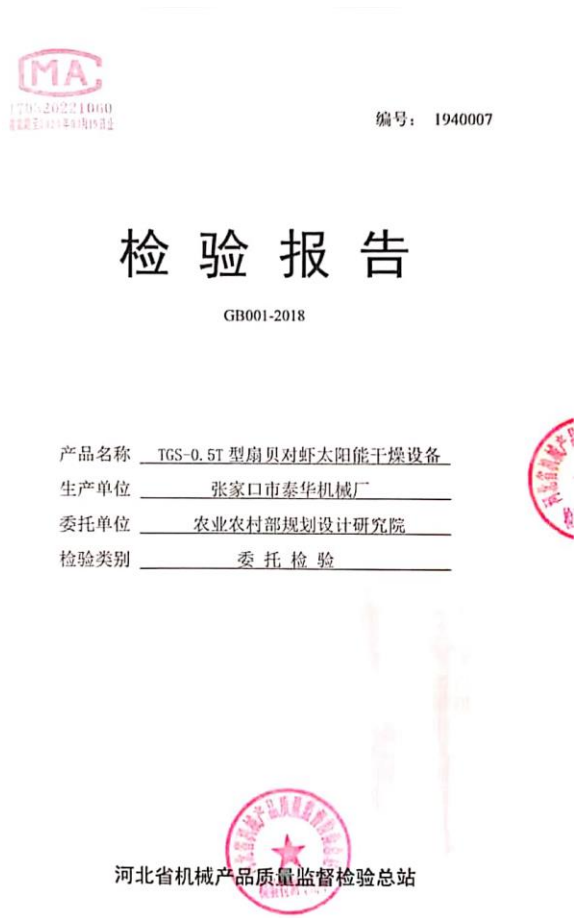


- In 2013, a set of 2t solar drying equipment was promoted at Ningxia Wansheng Biotechnology Co., Ltd.
- In 2014, a set of 2t solar drying equipment was promoted at Zhongli Goji Professional Cooperative in Zhongning County.
- In 2017, a set of 5t solar drying equipment was promoted at Ningxia Dadi Ecology Co., Ltd.





- **Hebei Tangshan Fengrui Aquatic Food Co., Ltd., with a batch of 428.1kg, saves 93.9% energy compared to electric drying, and a temperature rise of 36.4 ℃**
- **Realized green manufacturing of dried seafood**



编号： 1940007

检 验 报 告

GB001-2018

产品名称 TGS-0.5T 型扇贝对虾太阳能干燥设备

生产单位 张家口市泰华机械厂

委托单位 农业农村部规划设计研究院

检验类别 委 托 检 验

河北省机械产品质量监督检验总站

- Yunnan Midu Tiantian Rose Family Farm
- Yunnan Lanfuyuan Ecological Resources Investment Co., Ltd

- **In 2016, Guangquan Goji Farmers' Cooperative of Xinjiang Production and Construction Corps 124 Regiment**
- **In 2016, Guangquan Goji Farmers' Cooperative of Xinjiang Production and Construction Corps 124 Regiment**

编号：172275

检 验 报 告

产品名称 特色瓜果太阳能干燥设备

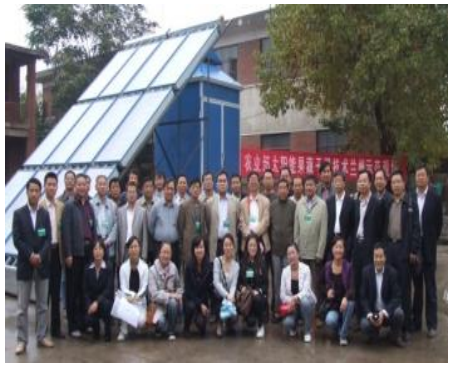
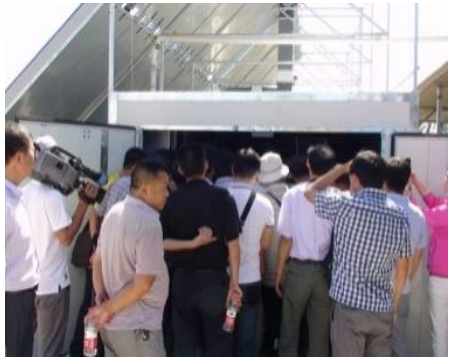
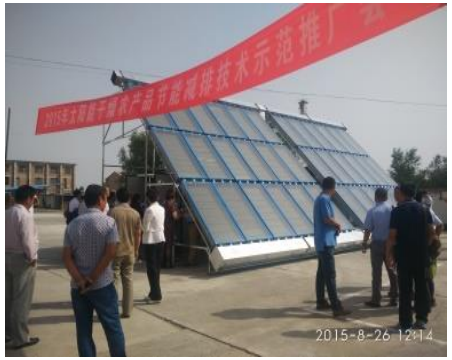
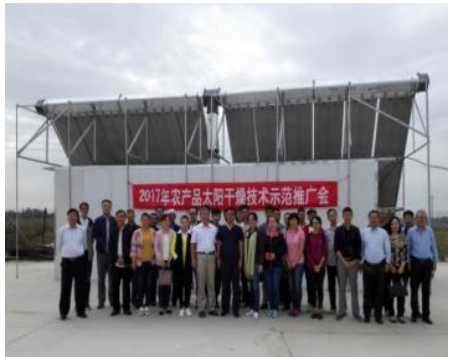
型号规格 ——

受检单位 农业部规划设计研究院

检验类别 委托检验

中国农业机械化科学研究院标准与质量检测中心

- **National training conference, training 3400 technical personnel.**

Hami, Xinjiang	Lanzhou, Gansu	184th Regiment,Xinjiang	Fengning, Hebei
			
Zhongning,Ningxia	**Zhongning,Ningxia**	**124th Regiment,Xinjiang**	**Zhongning,Ningxia**
			

The 2019 International Food Industry Exhibition

Conference promotion

The 18th National Drying Conference in 2021

The 2019 Annual Meeting of the Food Engineering Branch

The 2019 Annual Meeting of the Agricultural Products Processing and Storage Engineering Branch

WFP World Food Programme

2 ZERO HUNGER

Thank You

WFP-China SSC Knowledge Sharing Platform

Cloud School

Sharing for Learning