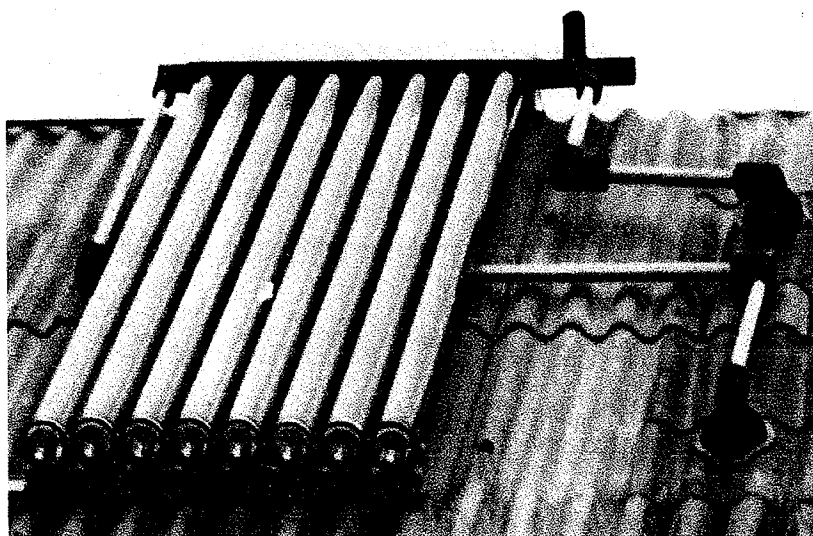


VAKUUMRØRSOLFANGERE FRA KINA

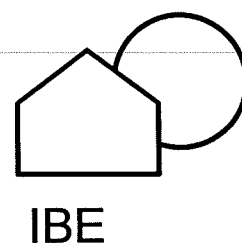
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Forord

Denne rapport afslutter projektet: "Vakuumsolfangere", j.nr. 51181/97-0064.
Projektet er finansieret af Energistyrelsen.

Ud over denne slutrapport er projektets foreløbige resultater beskrevet i paperet: "Solar Heating Systems with Evacuated Tubular Solar Collector", som blev præsenteret ved EuroSun'98 konferencen i Slovenien i september 98. Derudover er projektets foreløbige resultater beskrevet i artiklen: "Vakuumsolfangere – fremtidens solfangere?" i Vedvarende energi & miljø nr. 4/98 og i rapporten: "Kinesiske vakuumsolfangere", sagsrapport nr. SR-9825 fra Institut for Bygninger og Energi, november 1998, samt i rapporten: "Theoretical and Experimental Investigation of Chinese Evacuated Tubular Solar Collectors", sagsrapport nr. SR-9901, Institut for Bygninger og Energi, marts 1999.

Endelig blev projektets resultater præsenteret ved Solenergidagen den 20. maj 1999 på DTU.

Resumé

En række kinesiske firmaer har for nylig startet masseproduktion af vakuumrørsolfangere. I Kina har vakuumrørsolfangere i modsætning til Europa nået så lavt et prisniveau at det er blevet normalt at benytte disse højeffektive solfangere i mange forskellige typer solvarmeanlæg.

Fire forskellige vakuumrørsolfangere produceret af kinesiske firmaer er afprøvet i et lille forsøgssolvarmeanlæg til brugsvandsopvarmning. Forsøgsanlægget er afprøvet under realistiske betingelser i en prøvestand for solvarmeanlæg på DTU. Ved hjælp af afprøvningerne er der opstillet en simuleringsmodel for hver af de fire solfangere.

Med de opstillede modeller blev der gennemført beregninger af årsydelsen for forskellige danske solvarmeanlæg: Små og store solvarmeanlæg til brugsvandsopvarmning, solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning og solvarmecentraler. Beregninger blev gennemført med de fire undersøgte vakuumrørsolfangere og med almindelige plane solfangere.

Undersøgelserne viste at ydelsen af solvarmeanlæg forøges ved at benytte vakuumrørsolfangere i stedet for almindelige plane solfangere og at solfangerarealet for et solvarmeanlæg med en bestemt ydelse kan reduceres væsentligt ved at benytte vakuumrørsolfangere i stedet for almindelige plane solfangere. Jo højere dækningsgraden og driftstemperaturen er des større er den ydelsesmæssige fordel ved vakuumrørsolfangerne. For solvarmeanlæg til brugsvandsopvarmning og for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning med typiske dækningsgrader kan solfangerarealet reduceres ca. 2-3 gange hvis den bedst egnede vakuumrørsolfanger benyttes i stedet for en almindelig plan solfanger.

Prisniveauet for de kinesiske vakuumrørsolfangere eksporteret til Europa er forholdsvis højt. Med disse priser er der mulighed for at forbedre pris/ydelses-forholdet for solvarmecentraler med høje driftstemperaturer. For øvrige solvarmeanlæg er der ikke mulighed for at forbedre pris/ydelses-forholdet ved at anvende vakuumrørsolfangere i stedet for plane solfangere med mindre solvarmeanlæggets dækningsgrad er usædvanlig høj.

Da priserne for solfangerne solgt i Kina er meget lave er det imidlertid ikke utænkeligt at priserne for eksporterede kinesiske solfangere kan presses så langt ned at de kan blive attraktive i flere typer anlæg.

Summary

Recently a number of Chinese companies started mass production of evacuated tubular solar collectors. Contrary to Europe, in China the evacuated tubular solar collectors have reached such a low price level that it has become normal to use these high-efficient solar collectors in many different types of solar heating systems.

Four different evacuated tubular solar collectors produced by Chinese companies have been tested in a small solar domestic hot water test system. The test system has been tested under realistic conditions in a test facility for solar heating systems at DTU. By means of the tests a simulation model has been developed for each of the four solar collectors.

With the developed models calculations of the yearly thermal performance of different Danish solar heating systems were carried out: Small and large solar domestic hot water systems, combined solar domestic hot water and space heating systems and solar heating plants. Calculations were carried out with the four investigated evacuated tubular solar collectors and with ordinary flat-plate collectors.

The investigations showed that the thermal performance of solar heating systems is increased by using evacuated tubular solar collectors instead of ordinary flat-plate collectors and that the solar collector area of a solar heating system with a fixed thermal performance can be reduced considerably by using evacuated tubular solar collectors instead of ordinary flat-plate collectors. The higher the solar fraction and the operation temperature are the greater the advantage of using the evacuated tubular solar collectors will be. For solar domestic hot water systems and for combined space heating and domestic hot water systems with typical solar fractions the solar collector area can be reduced about 2-3 times if the best suitable evacuated tubular solar collector is used instead of an ordinary flat-plate collector.

The price level of the Chinese evacuated tubular solar collectors that are exported to Europe is relatively high. With these prices it will be possible to improve the price/performance-ratios for solar heating plants with high operation temperatures. For the other solar heating systems it is not possible to improve the price/performance-ratios by using evacuated tubular solar collectors instead of flat-plate collectors unless the solar fraction of the solar heating system is unusually high.

As the prices of the solar collectors sold in China are very low, it is not unthinkable, however, that the prices of exported Chinese solar collectors can be reduced so that they can become attractive in several types of solar heating systems.

1. Indledning

Vakuumsolfangere har været markedsført i Europa og USA i mange år. Da der er vakuum i glasrørene, er varmetabet fra absorberne, som er placeret inde i glasrørene, på grund af konvektion og varmeledning meget lille. Varmetabskoefficienten for vakuumsolfangere er derfor meget mindre end varmetabskoefficienten for almindelige plane solfangere. Derfor kan et solvarmeanlægs ydelse forbedres ved at bruge vakuumsolfangere. Imidlertid udgør solvarmeanlæg der bruger vakuumsolfangere stadig kun en meget lille del af det samlede antal installerede anlæg. Dette skyldes at vakuumsolfangere er relativt dyre. For at forbedre denne situation har fabrikanterne bestræbt sig på at reducere omkostningerne og forbedre vakuumsolfangernes ydelse.

I det sidste årti er mange kinesiske firmaer begyndt at masseproducere forskellige typer vakuumsolfangere. Prisen for vakuumsolfangere er faldende på det kinesiske marked. Sammenlignet med vakuumsolfangere produceret i Europa, er disse solfangere relativt billige. Der er i denne rapport foretaget en undersøgelse af fire kinesiske solfangere for forskellige typer solvarmeanlæg. Laboratorieundersøgelserne blev først foretaget for de forskellige vakuumsolfangere. Endvidere blev den årlige ydelse for forskellige typer solvarmeanlæg med vakuumsolfangere bestemt ved hjælp af computersimuleringer for danske vejrforhold.

2. Undersøgte vakuumsolfangere

2.1 Indledning

Der er forskellige udformninger af kinesiske vakuumsolfangere. Disse produkter kan egentlig klassificeres i to typer. Det er solfangere med enkeltlags-vakuumglasrør hvor absorberpladen er monteret indvendigt i vakuumet og solfangere med tolags-vakuumglasrør hvor vakuumet holdes mellem de to koncentriske glasrør. De sidstnævnte er belagt med en cylindrisk absorberoverflade på ydersiden af det indvendige glasrør. For hver type er der også små forskelle i designet. Som for eksempel solfangere med forskellig absorberform, forskellige glasrørsdiametre, forskellige afstande mellem glasrørene og med eller uden reflektorer.

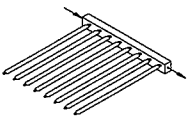
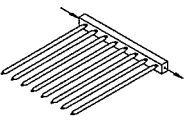
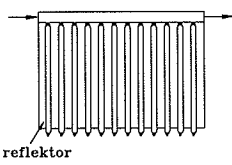
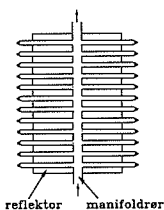
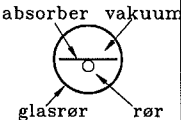
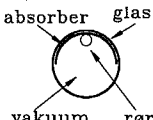
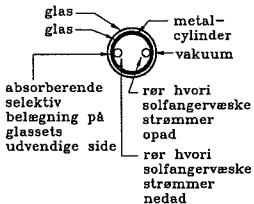
I den foreliggende rapport er der undersøgt fire vakuumsolfangere som repræsenterer de mest typiske kinesiske produkter. De grundlæggende informationer om disse solfangere er vist i Tabel 1. Den opgivne pris er eksklusive transportomkostninger og opgivet af de kinesiske firmaer i forbindelse med salget af 1000 solfangere i Danmark. Det bør nævnes at mange andre kinesiske firmaer markedsfører andre vakuumsolfangere, der er noget billigere end hvad der er opgivet i tabel 1.

2.2 De fire undersøgte solfangere

Solfangerne SEIDO1-8 og SEIDO 5-8 er baseret på heat pipe-princippet. Hver solfanger består af 8 vakuumsolfangere som er forbundet med en kondensator/varmeveksler-enhed. I hvert evakueret rør er absorberpladen med selektiv belægning godt fastgjort til et evakueret kobberrør der indeholder en lille mængde vand som varmeoverførende medium. Det varme-

overførende medium fordamper ved et lavt temperaturniveau når absorberen opvarmes af solstrålingen. Dampen i røret bevæger sig opad til kondensatoren hvor dampen kondenserer

Tabel 1. Data for de afprøvede solfangere.

Skematisk skitse af solfanger				
Tværsnit af glastrør				
Opvarmnings-princip	Heat pipe princip & varmeveksling til solfangervæske	Heat pipe princip & varmeveksling til solfangervæske	Solfangervæske opvarmes i rørene i glasset	Solfangervæske opvarmes i direkte kontakt med glasset
Reflektor?	Nej	Nej	Ja	Ja
Solfangertype	SEIDO 1-8	SEIDO 5-8	2 x SLU-1500/12	SLL-1200/24
Producent	Beijing Sunda Solar Energy Technology Co. Ltd	Beijing Sunda Solar Energy Technology Co. Ltd	Tsinghua Solar Co.	Tsinghua Solar Co.
Tværsnitsareal for glastrør	1,52 m ²	1,52 m ²	1,60 m ²	1,24 m ²
Solfanger-bruttoareal	2,00 m ²	2,00 m ²	2,44 m ²	2,50 m ²
Pris	\$590	\$615	\$630	\$487
Pris per m² tværsnitsareal for glastrør	\$388	\$404	\$394	\$393

og derved overfører varme til solfangervæsken der pumpes igennem kondensator/varmeveksler-enheden. Det varmeoverførende medium kondenserer i kondensatoren og strømmer ned til bunden af røret hvor det fordamper igen når temperaturen er høj nok hvorefter processen gentages. Den eneste forskel mellem disse to solfangere er at SEIDO 1-8 solfangeren er forsynet med en plan absorber mens SEIDO 5-8 solfangeren bruger en halvcylindrisk absorberplade. Denne absorberform bevirker at solfangeren er specielt højeffektiv når indfaldsvinklen på tværs af glastrørene er stor.

Solfangerne SLU-1500/12 og SLL-1200/24 er baseret på konstruktionen med tolags-glasrør hvor mellemrummet mellem glastrørene er evakueret. Fordelen ved denne konstruktion er at risikoen for ødelæggelse af evakueringen på grund af mangel på metal ved tætningsdelen er reduceret. Det indvendige glastrør har en selektiv belægning på den udvendige overflade og fungerer som absorber. I solfangeren SLL-1200/24 er de indre glastrør fyldt med solfangervæske. Solfangervæsken føres ind i bunden af et manifoldrør hvortil de vandrette glastrør er koblet. Solfangervæsken strømmer, når solen skinner, på grund af de naturlige drivkræfter fra

manifoldrøret ud i bunden af glastrørene hvorefter væsken stiger op til toppen af glastrørene hvorfra væsken returnerer til manifoldrøret. Solfangervæsken er i rørene i direkte kontakt med det inderste glastrør. Fra toppen af manifoldrøret forlader solfangervæsken solfangeren. I solfangeren SLU-1500/12 er de inderste glastrør forsynet med en metalcylinder med to rør hvori solfangervæsken opvarmes. Solfangervæsken pumpes fra et fordelerrør oven over glastrørene ned igennem det ene rør til bunden af glastrørene og herfra opad igennem det andet rør til et samlerør hvorfra solfangervæsken forlader solfangeren. Der anvendes en plan aluminium-reflektor til begge dobbeltglastrør-solfangerne.

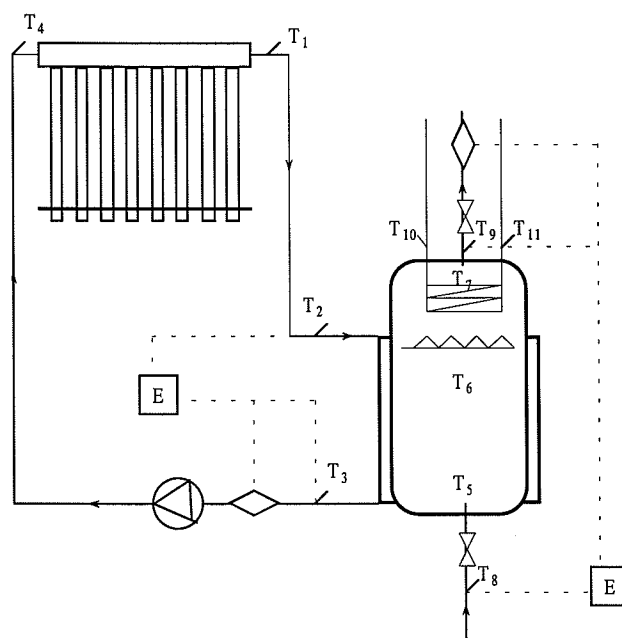
2.3 Definition af solfangerareal

I modsætning til hvad der er gældende for den plane type solfanger, er der stor forskel på en vakuumrørsolfangers transparente og totale areal. Derfor er definitionen af solfangerarealet for vakuumrørsolfangere meget vigtig. I denne undersøgelse bruges to definitioner af solfangerarealet. Den ene er tværsnitsarealet for glastrør bestemt ved hjælp af glastrørens længde og ydre diameter, den anden er bruttoarealet bestemt som produktet af solfangerens maksimumhøjde og -bredde. Reflektor og kondensator/varmeveksler eller fordelerrør medregnes når disse højder og bredder bestemmes. Følgelig er bruttoarealet det areal der kræves for at kunne montere solfangeren.

3. Laboratorieundersøgelse og modelverifikation

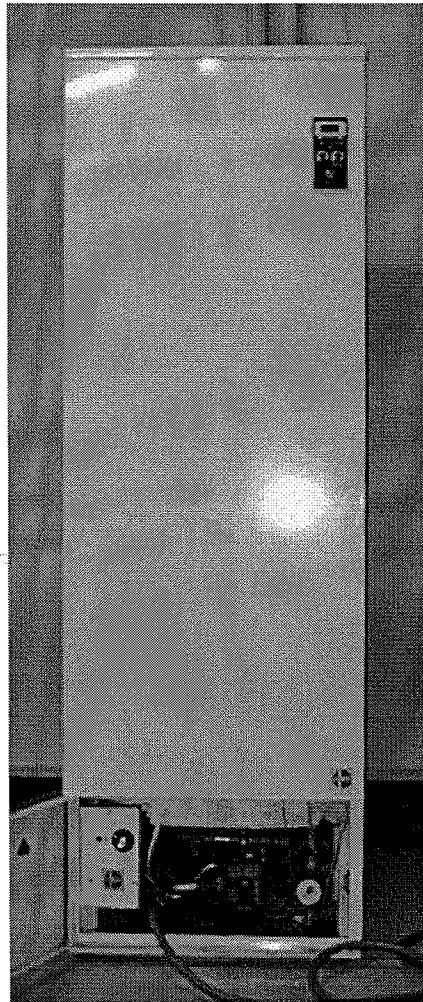
3.1 Design af forsøgsanlæg

For at undersøge vakuumrørsolfangeres ydelse blev der i en prøvestand foretaget laboratorieundersøgelser for disse solfangere med et lille solvarmeanlæg til brugsvandsopvarmning [2]. Fig.1 viser en principskitse af det afprøvede anlæg med målepunkterne. Anlægget består grundlæggende af solfanger, varmelager, styresystem og cirkulationspumpe. Den afprøvede solfanger er placeret på en sydvendt, 45° hældende flade, og der er brugt en glykol/vand-blanding som solfangervæske. Volumenstrømmen er ca. $0,2 \text{ l/min} \cdot \text{m}^2$ når solfangerkredsen er i drift. Alle fire solfangere afprøves i rækkefølge i det samme solvarmeanlæg til brugsvandsopvarmning. Baseret på målingerne er der udviklet og efterprøvet detaljerede simuleringsmodeller for anlægget og for hver afprøvet solfanger. Anlægget med en almindelig plan solfanger er også blevet undersøgt tidligere [7].



Figur 1. Principskitse af anlægget med målepunkter.

Anlæggets lagertank er en kappebeholder (Danlager 2000) med et totalt brugsvands-volumen på 265 l (+16 l i kappen). Der er to supplerende energianlæg indbygget i tanken. Varmevexlerspiralen er placeret i den øvre del af tanken, og elpatronen med effektafgivelsen 1180W er placeret under varmevexlerspiralen. I løbet af testperioden for disse vakuumrørsolfangere var det kun elpatronen der blev brugt som supplerende energikilde. Tanken er velisoleret med 65 mm og 50 mm polyurethanskum på toppen og siden. Et foto af tanken er vist i Figur 2, og databladet for tanken er vist i bilag 1.



Figur 2. Solvarmeanlæggets varmelager.

3.2 Forsøgsbetingelser

Der blev foretaget målinger for anlægget med de fire vakuumrørsolfangere fra april til oktober 1998. Temperaturerne i solfangerkredsen og lagertanken blev målt med termoelementer af typen kobber/konstantan (TT). Fig. 1 viser anlægget med målepunkterne.

Flowene i solfangerkredsen og tappekredsen måles ved hjælp af Clorius Combimeter energi- og flowmetre. Energimængden der blev overført fra solfangeren til lagertanken bestemmes ud

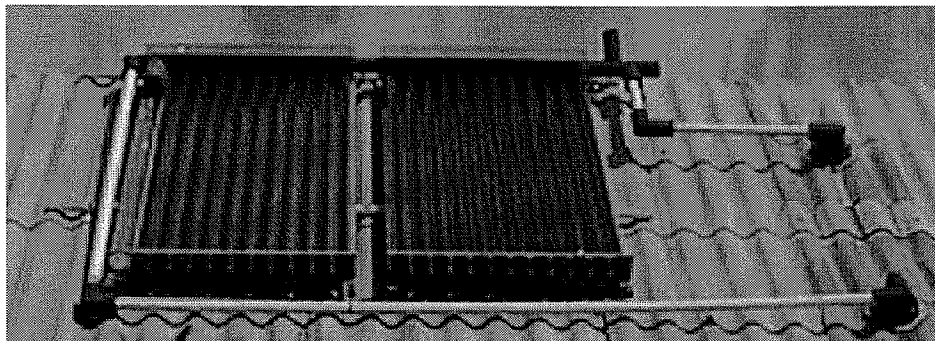
fra de målte flow i solfangerkredsen og forskellen på fremløbstemperaturen og returtemperaturen for kappen. På samme måde beregnes den energi der tappes fra lagertanken ud fra tappeflowet og temperaturforskellen mellem det tappede varme vand og det kolde fremløbsvand.

Udetemperaturen og solindfaldet på en sydvendt flade med en 45° hældningsvinkel er målt og registreret som 5, 10 og 60 minutters gennemsnitsstørrelser. Temperaturen i hallen hvor lagertanken er placeret er også registreret.

Under testperioden blev der tappet varmt vand 3 gange om dagen, kl. 7, kl. 12 og kl. 19. En energimængde på 2,44 kWh blev tappet ved hver tapning. Dette svarer til et dagligt forbrug på 160 l vand opvarmet fra 10°C til 50°C. Toppen af tanken opvarmes til 50°C af elpatronen i perioder hvor solfangeren ikke er i stand til at opvarme vandet til dette temperaturniveau. Elpatronens energiforbrug blev registreret med en kWh-måler.

3.3 Modelverifikation for anlæg med SLU-1500/12 solfanger

Undersøgelsen af SLU-1500/12 solfangeren blev foretaget i perioden fra 5. april til 8. juni 1998. Et foto af SLU-solfangeren er vist i Figur 3. To SLU-1500/12 solfangermoduler blev brugt i anlægget. Solfangernes bruttoareal er 2,44 m² og vakuumrørets tværsnitsareal er 1,53 m². Glasrørenes tværsnitsareal er mindre end det der er angivet i tabel 1 på grund af at et vakuumrør var gået i stykker og blev fjernet fra en af solfangerne. En 44% glykol/vandblanding er blevet brugt i solfangerkredsen som solfangervæske.



Figur 3. De to afprøvede SLU-1500/12 solfangere.

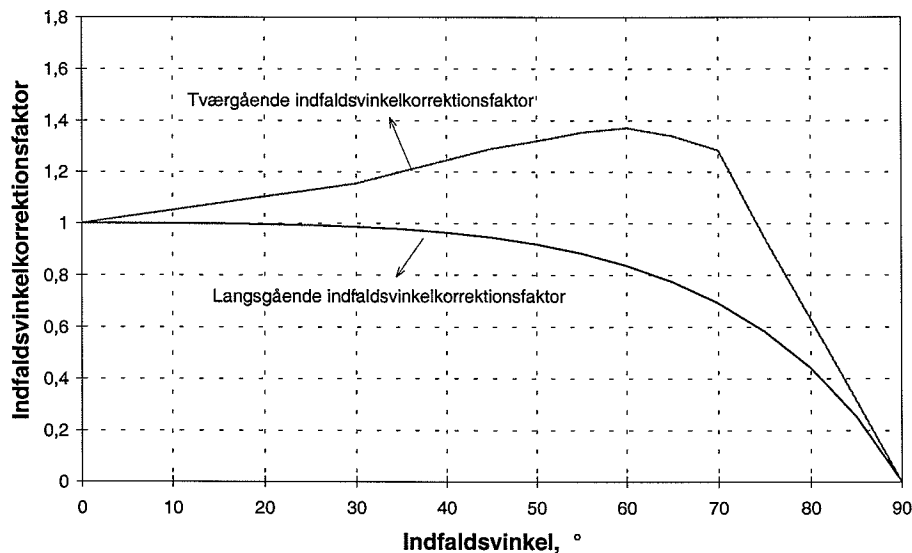
Solfangermodel

Målinger og beregninger viste at solfangerens varmekapacitet var 13400 J/m² K baseret på tværsnitsarealet for glasrørene. Baseret på testresultaterne er solfangerens effektivitet blevet bestemt. Solfangerens effektivitet er også baseret på glasrørenes tværsnitsareal. Solfangerens effektivitet kan udtrykkes som:

$$\eta = 0,81 - 1,81 \cdot (T_m - T_a) / G$$

Hvor,	η	solfangereffektivitet	—
	T_m	solfangervæskens gennemsnitstemperatur	°C
	G	bestrålingsstyrke på solfangerens overflade	W/m ²
	T_a	udelufttemperatur	°C

Til forskel fra en plan solfanger er effektivitetens indfaldsvinkelkorrektionsfaktor for en rør-solfanger også påvirket af indstrålingens retning. Baseret på målingerne blev indfaldsvinkelkorrektionsfaktoren for SLU-1500/12 solfangeren bestemt ved undersøgelsen, og resultaterne er vist i Figur 4.

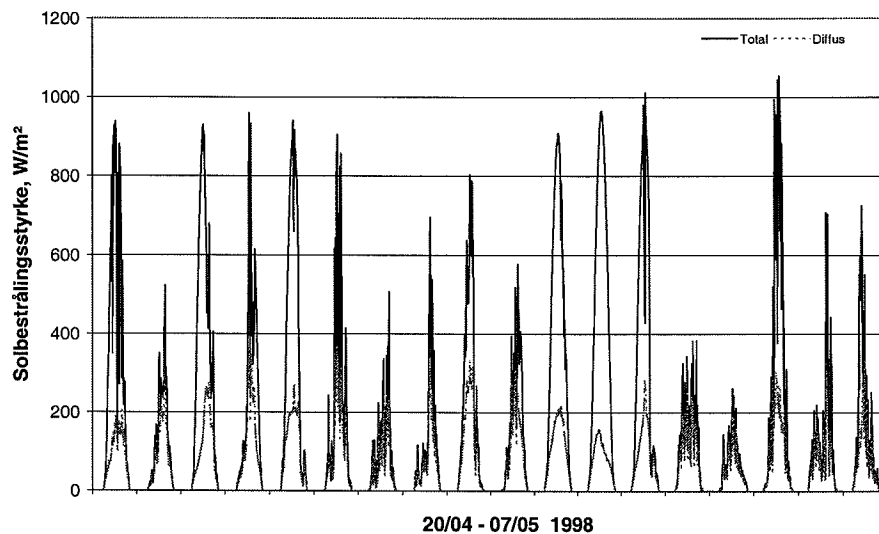


Figur 4. Indfaldsvinkelkorrektionsfaktorer for SLU-1500/12 solfangeren.

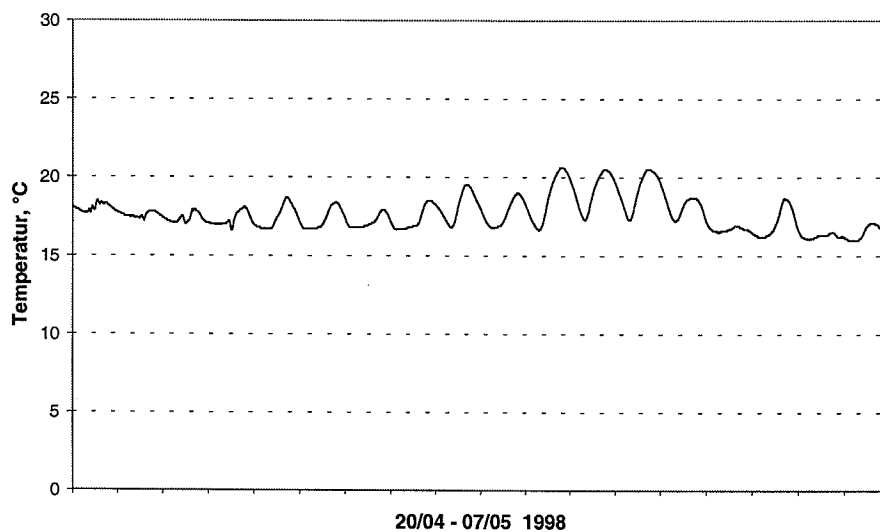
Sammenligning af resultater fra simuleringer og undersøgelser

Med designparametrene for anlægget og den ovenfor angivne model udføres simuleringer for perioden 20/4 til 7/5 1998. Anlæggets computermodel efterprøves med målte energi- og temperaturdata. Sammenligning af simuleringresultater og målinger er udført for de vigtigste parametre, såsom solenergi tilført tanken, supplerende energi til elpatron, energi tappet fra tanken, nettoydelse og temperaturer i solfangerkreds og lagertank. Her defineres nettoydelsen som energien tappet fra lagertanken minus den supplerende energi tilført tanken.

For at sammenligne simuleringresultaterne med målingerne, bruges den målte solindstråling, udelufttemperaturen, brugsvandets fremløbstemperatur til tanken og tappeflowet som simuleringssindata. Solindstrålingen på solfangerpladen og udelufttemperaturen i simuleringssperioden er vist i Figur 5 og 6.

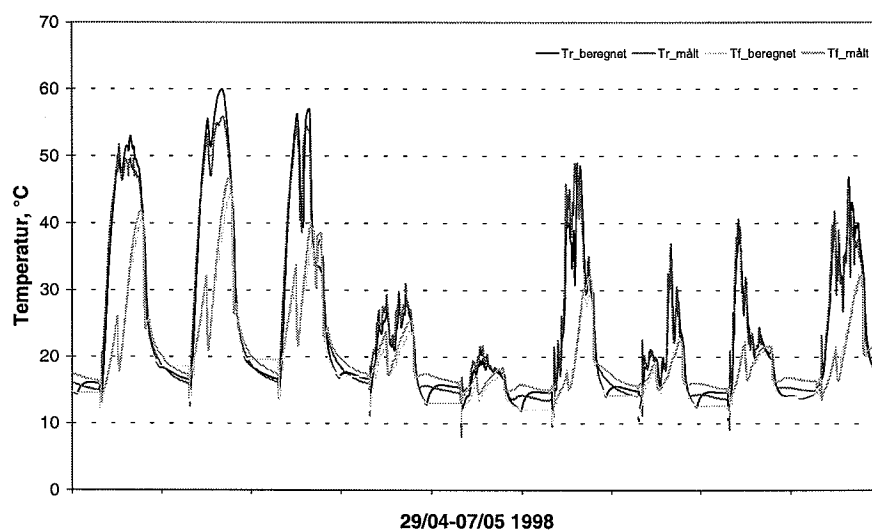
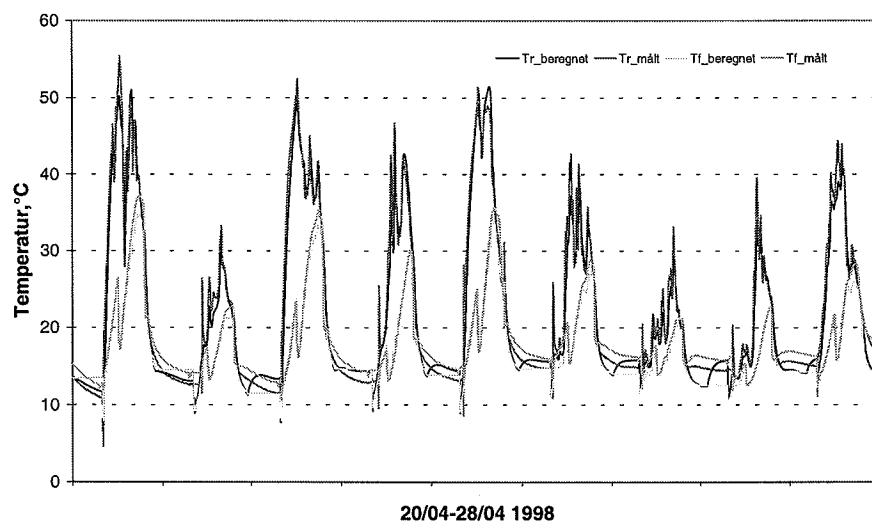


Figur 5. Solindstråling på solfangeren i perioden 20/4 – 7/5 1998.

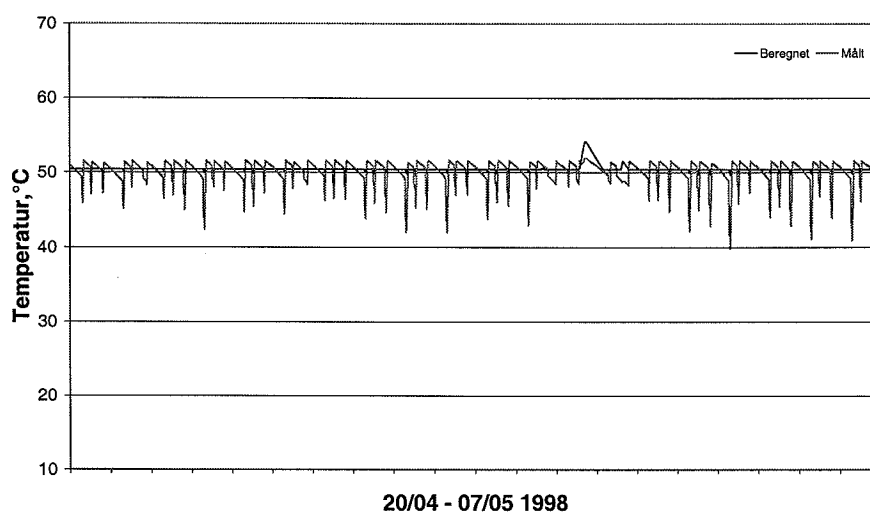


Figur 6. Den omgivende lufts temperatur i perioden 20/4 – 7/5 1998.

En sammenligning af målt og simuleret temperatur for solfangervæsken til og fra solfangeren er vist i Figur 7. Den vandrette linie indikerer at solfangerkredsen ikke var i drift. Ud fra Figur 7 kan det ses at der er en god overensstemmelse mellem målte og beregnede temperaturer.



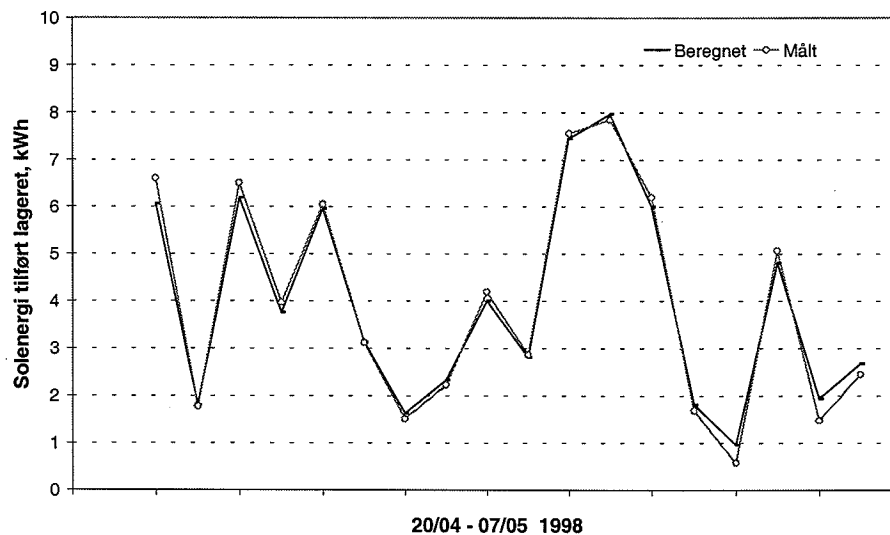
Figur 7. Fremløbs-og returtemperatur for solfangeren.



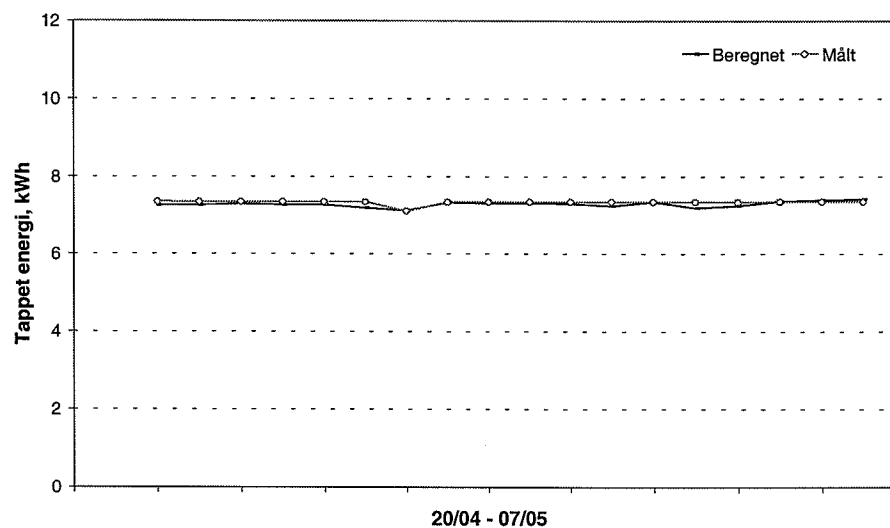
Figur 8. Temperaturen i toppen af lagertanken under simuleringsperioden.

Den målte og simulerede temperatur i toppen af lagertanken er vist i Figur 8. Den simulerede temperatur ligger omtrent konstant på 50,4°C, medens den målte temperatur svinger mellem 48°C og 51°C.

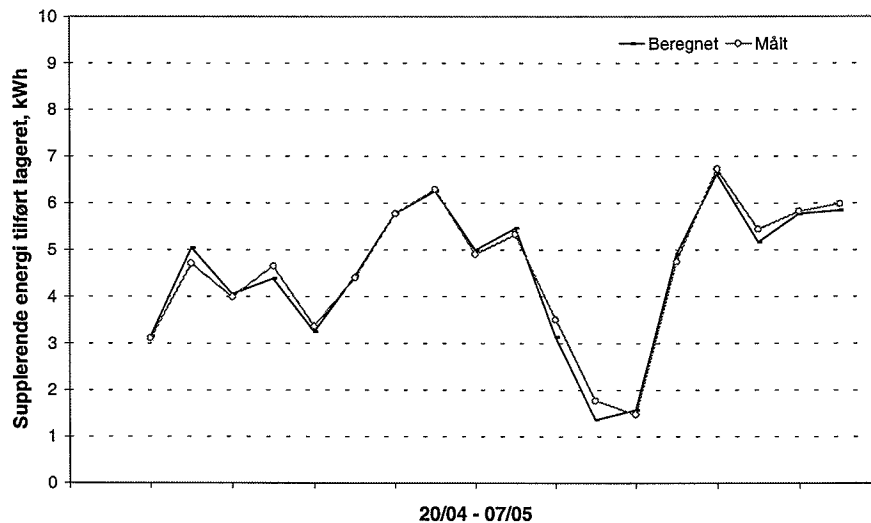
Sammenligningen af de målte og simulerede daglige værdier af energi tilført lagertanken fra solfangeren er vist i Figur 9, og den målte og simulerede daglige energimængde tappet fra lagertanken er vist i Figur 10. På lignende måde illustrerer Figur 11 den målte og beregnede daglige tilførsel af supplerende energi til lagertanken. Sammenligningen af den målte og beregnede nettoydelse er vist i Figur 12. Det fremgår at der er en god overensstemmelse mellem de målte og simulerede energimængder.



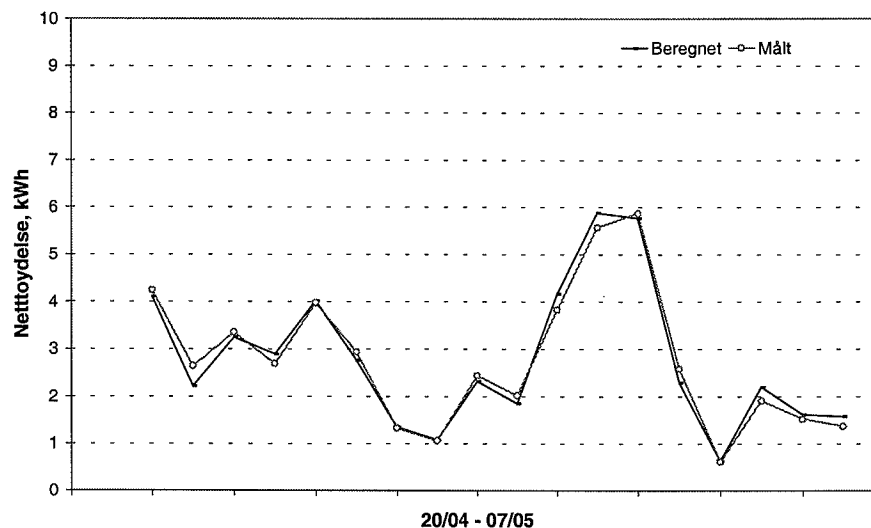
Figur 9. Solenergi tilført tanken under simuleringsperioden (daglige værdier).



Figur 10. Energi tappet fra tanken under simuleringsperioden (daglige værdier).



Figur 11. Supplerende energi tilført tanken under simuleringsperioden (daglige værdier).



Figur 12. Nettoydelse under simuleringsperioden (daglige værdier).

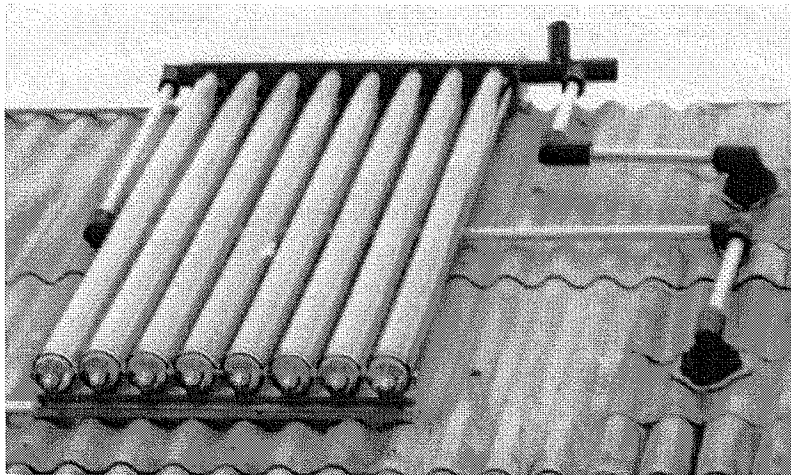
Tabel 2 viser summen af energimængderne igennem simuleringsperioden og afvigelsen mellem de simulerede og målte værdier. Det ses at afvigelserne er små og simuleringsresultaterne er acceptable.

Tabel 2. Energimængder under simuleringsperioden.

Periode 1998 20/04-07/05	Solenergi til tanken (kWh)	Benyttet supple- rende energi (kWh)	Tappet energi fra tank (kWh)	Nettoydelse (kWh)
Målt	71,7	81,9	131,9	50,0
Beregnet	71,3	81,1	131,1	50,0
Afvigelse %	-0,6	-1	-0,6	0

3.4 Modelverifikation for anlæg med SEIDO 1-8 solfanger

SEIDO 1-8 solfangeren blev testet i perioden 12. juni til 26. juli 1998. Et foto af solfangeren er vist i Figur 13. Et SEIDO 1-8 solfangermodul med et bruttoareal på 2,00 m² og et tværsnitsareal for glasrørene på 1,52 m² blev brugt til anlægget. En 44% propylenglycol/vandblanding blev brugt i solfangerkredsen som varmetransporterende væske.



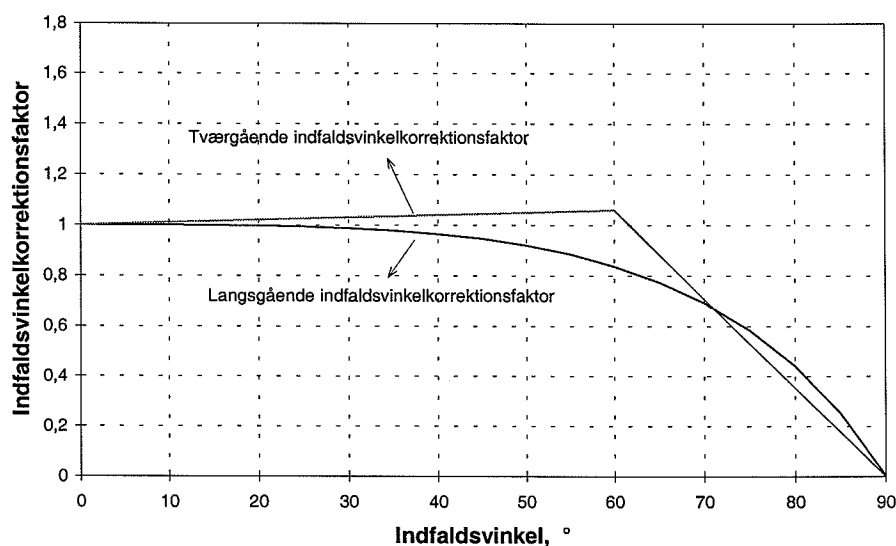
Figur 13. Den afprøvede SEIDO 1-8 solfanger.

Solfangermodel

Baseret på [3], [4] og målingerne, er SEIDO 1-8 solfangerens varmekapacitet, effektivitet og indfaldsvinkelkorrektionsfaktor blevet bestemt. Her er solfangerens varmekapacitet og effektivitet baseret på tværsnitsarealet for glasrørene. Solfangerens varmekapacitet er 2300 J/m²K, og effektiviteten kan udtrykkes som:

$$\eta = 0,675 - 2,13 \cdot (T_m - T_a) / G$$

Indfaldsvinkelkorrektionsfaktoren er vist i Figur 14.

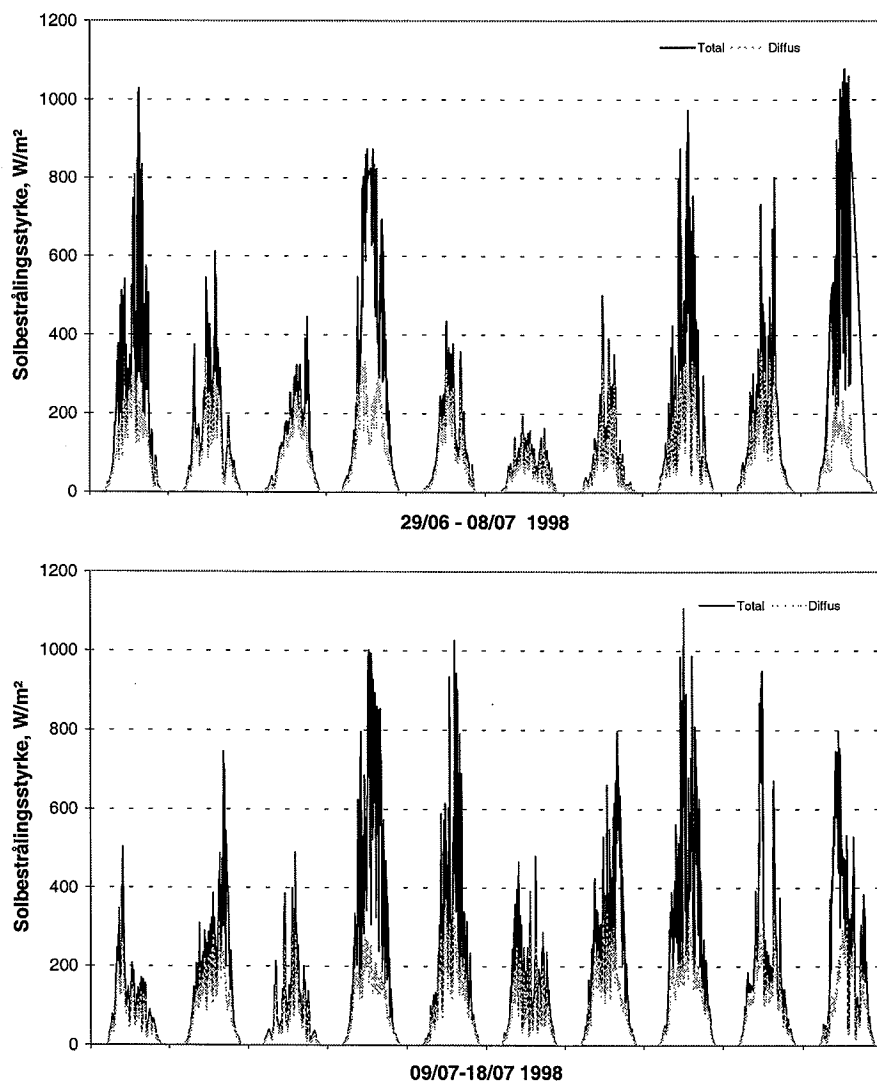


Figur 14. Indfaldsvinkelkorrektionsfaktor for SEIDO 1-8 solfangeren.

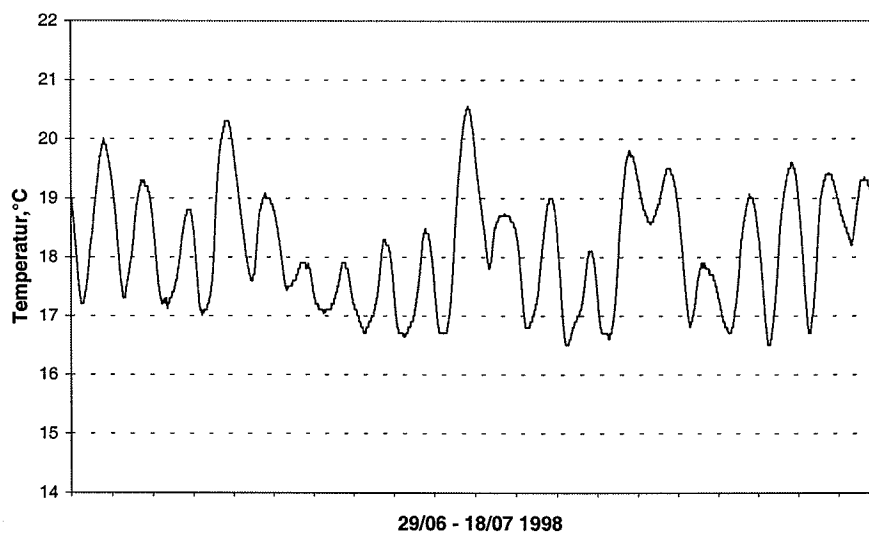
Sammenligning af resultater fra simuleringer og undersøgelser

Med designparametrene for anlægget og den ovenfor angivne model udføres simuleringer for perioden 29. juni til 18. juli 1998. Anlæggets computermodel efterprøves med målte energi- og temperaturdata. Sammenligning af simuleringresultater og målinger er udført for de vigtigste parametre, såsom solenergi tilført tanken, supplerende energi til elpatron, energi tappet fra tanken, nettoydelse og temperaturer i solfangerkreds og lagertank.

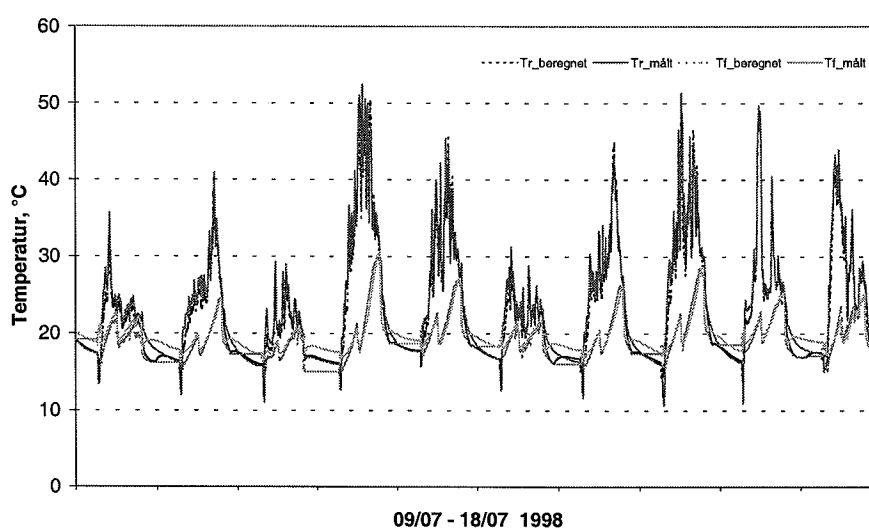
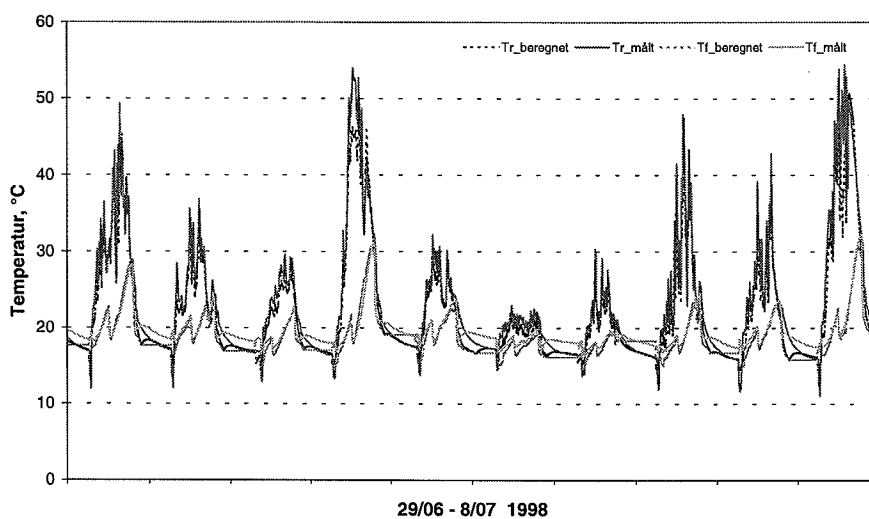
For at sammenligne simuleringresultaterne med målingerne, bruges den målte solindstråling, udelufttemperaturen, brugsvandets fremløbstemperatur til tanken og tappeflowet som simuleringssinddata. Solindstrålingen på solfangerpladen og udelufttemperaturen i simuleringssperioden er vist i Figur 15 og 16.



Figur 15. Solindstråling på solfangeren i perioden 29/6 –18/7 1998.

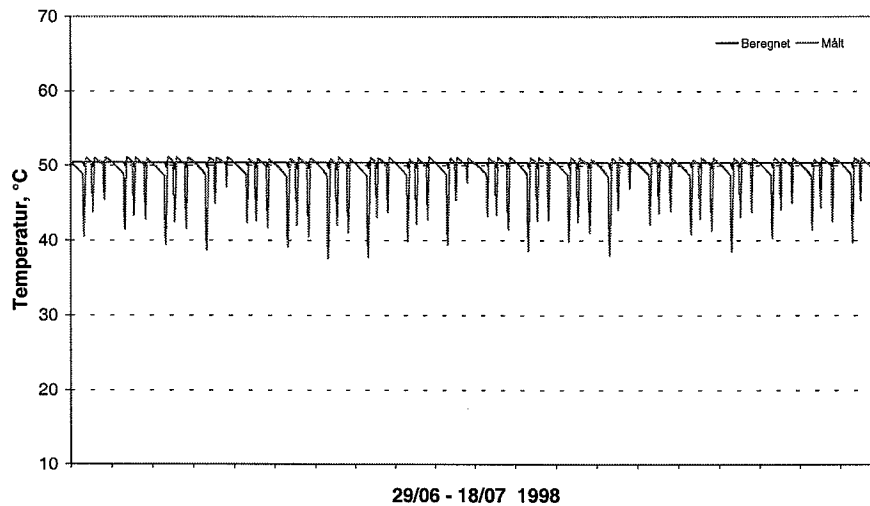


Figur 16. Den omgivende lufts temperatur i perioden 29/6 – 18/7 1998.



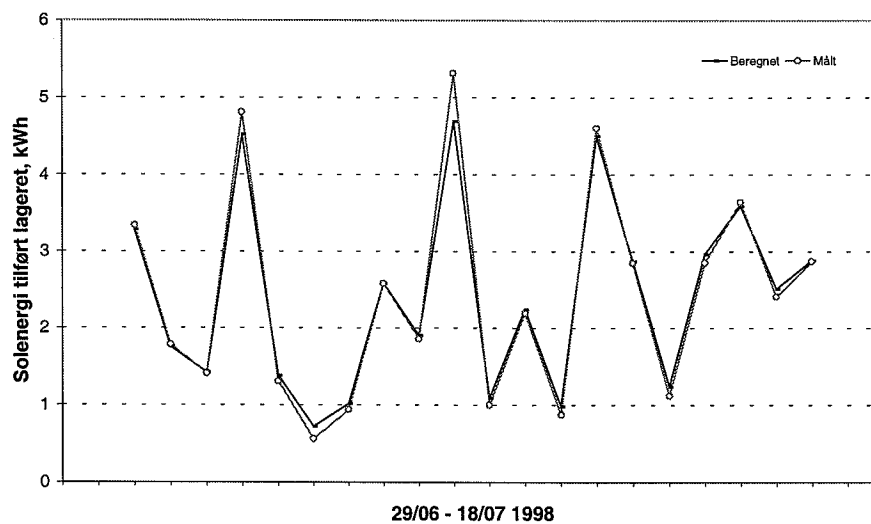
Figur 17. Fremløbs-og returtemperatur for solfangeren.

Figur 17 viser solfangerens målte og simulerede fremløbs- og returtemperatur. Den vandrette linie indikerer at solfangerkredsen ikke er i drift. Det kan ses ud fra Figur 18 at den simulerede fremløbs- og returtemperatur for solfangeren har korrekte dynamiske reaktioner.

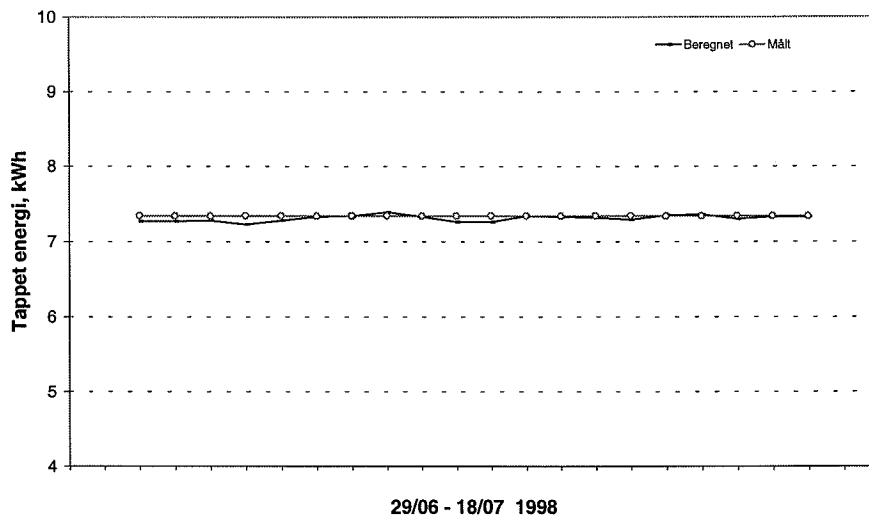


Figur 18. Temperaturen i toppen af lagertanken under simuleringsperioden.

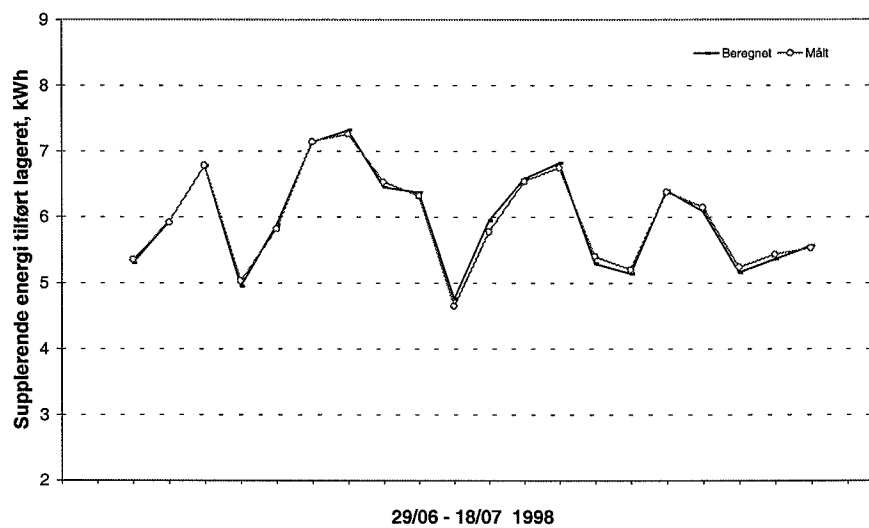
Den målte og simulerede temperatur i toppen af lagertanken er vist i Figur 18. Den simulerede temperatur ligger omtrent konstant på 50,1°C, medens den målte temperatur svinger mellem 48°C og 51°C.



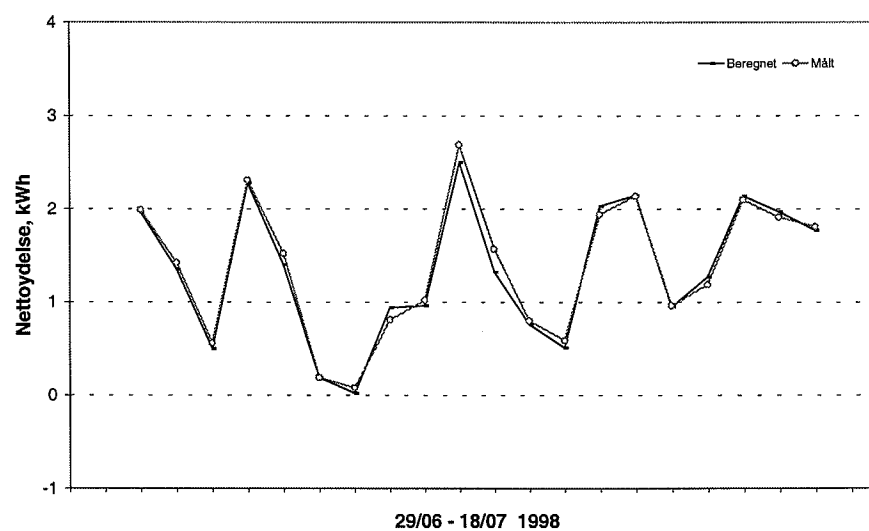
Figur 19. Solenergi tilført tanken under simuleringsperioden (daglige værdier).



Figur 20. Energi tappet fra tanken under simuleringsperioden (daglige værdier).



Figur 21. Supplerende energi tilført tanken under simuleringsperioden (daglige værdier).



Figur 22. Nettoydelse under simuleringsperioden (daglige værdier).

Sammenligningen af de målte og simulerede daglige energimængder i anlægget er vist i Figur 19-22. Figur 19 viser solenergi tilført lagertanken fra solfangeren, og Figur 20 viser den målte og simulerede energimængde tappet fra lagertanken. På lignende måde illustrerer Figur 21 den målte og beregnede tilførsel af supplerende energi til lagertanken. Sammenligningen af den målte og beregnede nettoydelse er vist i Figur 22. Det fremgår at der er en god overensstemmelse mellem de målte og simulerede energimængder.

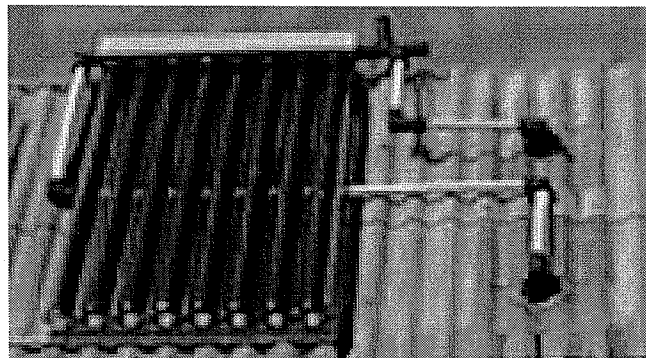
Tabel 3 viser summen af energimængderne igennem simuleringsperioden og afvigelsen mellem de simulerede og målte værdier. Det ses at afvigelserne mellem målte og beregnede energimængder er af et rimeligt begrænset omfang.

Tabel 3. Energimængder under simuleringsperioden.

Periode 1998 29/06-18/07	Solenergi til tanken (kWh)	Benyttet supple- rende energi (kWh)	Tappet energi fra tank (kWh)	Nettoydelse (kWh)
Målt	48,3	119,2	146,8	27,6
Beregnet	48,1	119,1	146,2	27,1
Afvigelse %	-0,4	-0,1	-0,4	-1,8

3.5 Modelverifikation for anlæg med SEIDO 5-8 solfanger

SEIDO 5-8 solfangeren blev testet i perioden 29. juli til 23. september 1998. Figur 23 viser et foto af den afprøvede SEIDO 5-8 solfanger. Et solfangermodul med et bruttoareal på 2,00 m² og et tværsnitsareal for glasrørene på 1,52 m² blev brugt i anlægget. I solfangerkredsen blev en 44% propylenglycol/vand-blanding brugt som varmetransporterende væske.



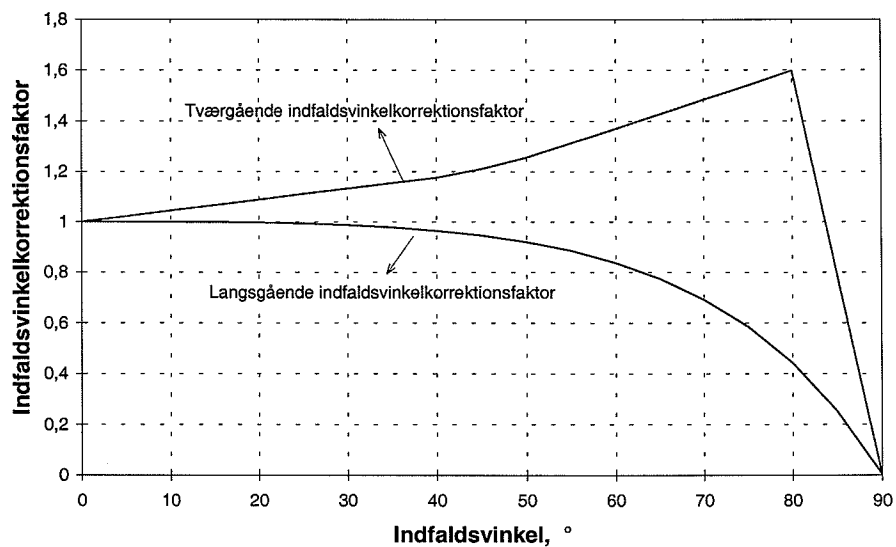
Figur 23. Den afprøvede SEIDO 5-8 solfanger.

Solfangermodel

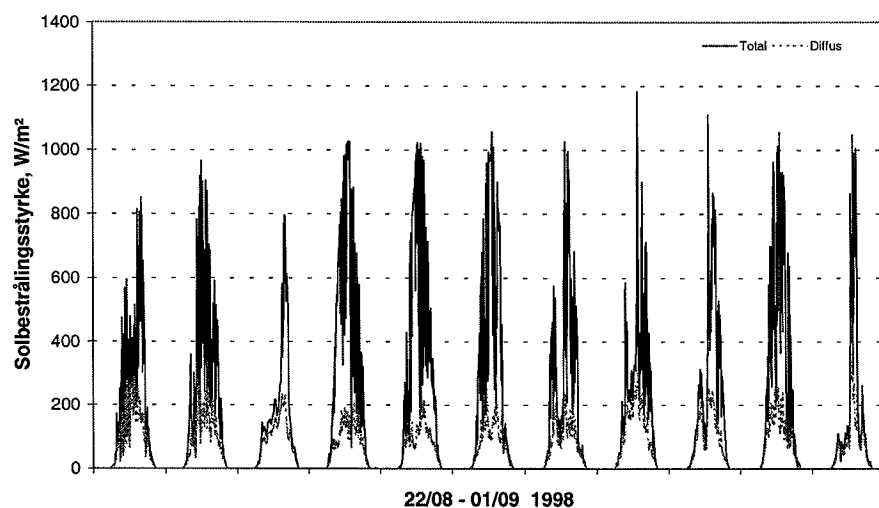
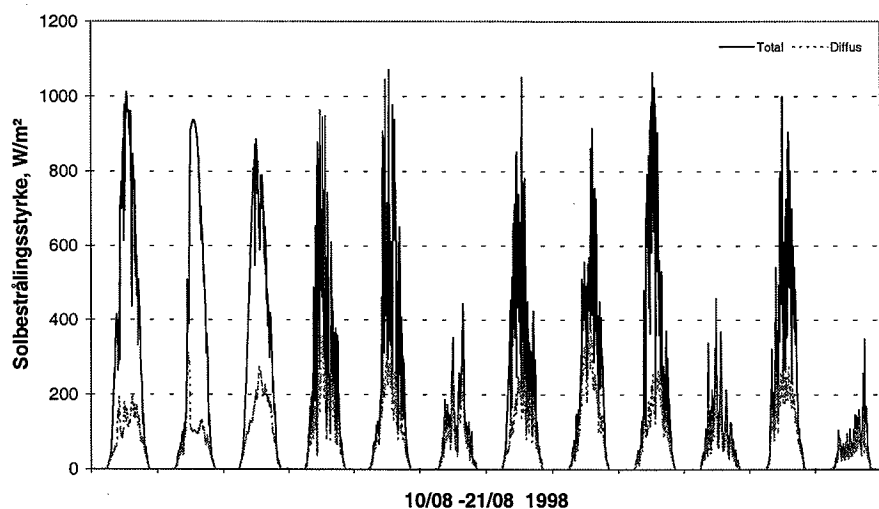
Baseret på [3], [4] og målingerne, er SEIDO 5-8 solfangerens varmekapacitet, effektivitet og indfaldsvinkelkorrektionsfaktor blevet bestemt. Her er solfangerens varmekapacitet og effektivitet baseret på tværsnitsarealet for glasrørene. Solfangerens varmekapacitet er 1500 J/m²K, og effektiviteten kan udtrykkes som:

$$\eta = 0,633 - 2,05 \cdot (T_m - T_a) / G$$

Indfaldsvinkelkorrektionsfaktorerne er vist i Figur 24.



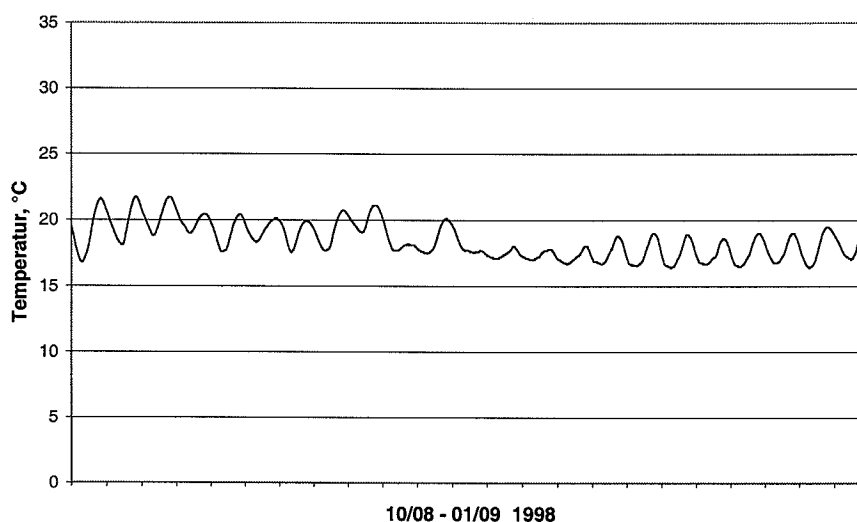
Figur 24. Indfaldsvinkelkorrektionsfaktorer for SEIDO 5-8 solfangeren.



Figur 25. Solindstråling på solfangeren i perioden 10/8 – 1/9 1998.

Sammenligning af resultater fra simuleringer og undersøgelser

Med designparametrene for anlægget og den ovenfor angivne model udføres simuleringer for perioden 10. aug. til 1. sep. 1998. For at lave en sammenligning, bruges den målte solindstråling, udelufttemperaturen, brugsvandets fremløbstemperatur til tanken og tappeflowet som simuleringsinddata. Solindstrålingen på solfangerpladen og udelufttemperaturen i simuleringsperioden er vist i Figur 25 og 26. Anlæggets computermodel valideres med målte energi- og temperaturdata.

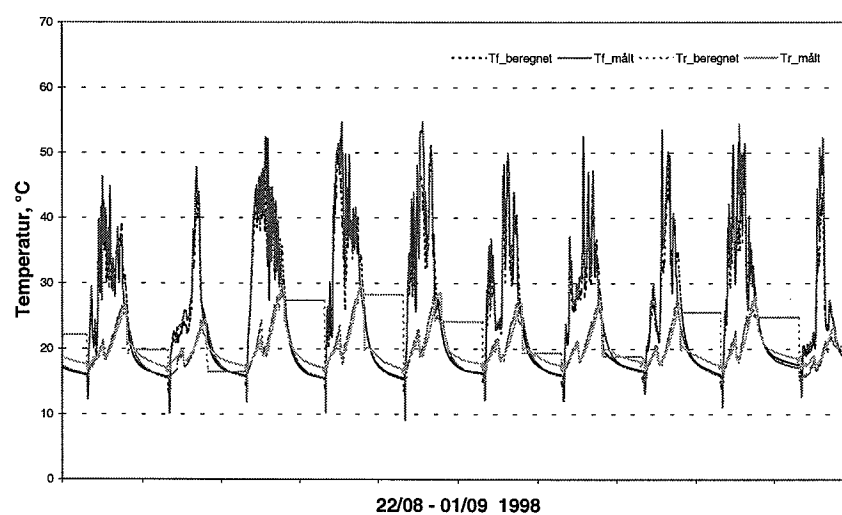
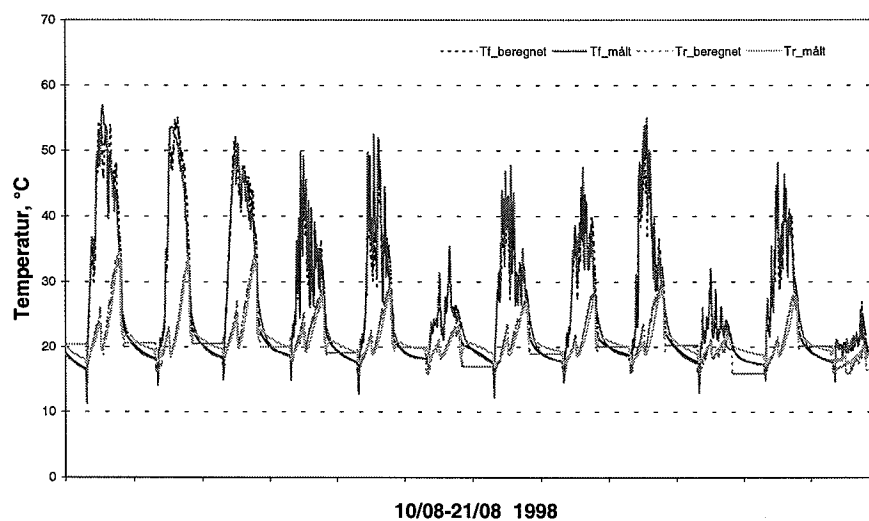


Figur 26. Den omgivende lufts temperatur i perioden 10/8 – 1/9 1998.

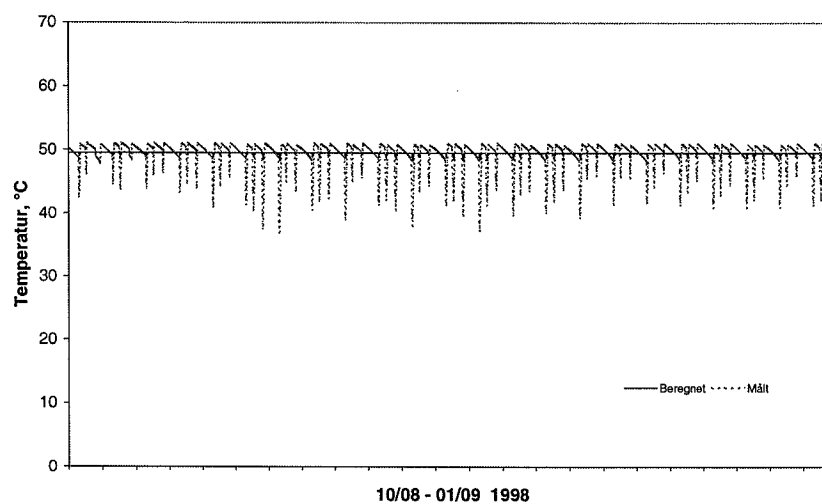
Figur 27 viser solfangerens målte og simulerede fremløbs- og returtemperatur. Den vandrette linie indikerer at solfangerkredsen ikke er i drift. Det kan ses ud fra Figur 27 at den simulerede fremløbs- og returtemperatur i solfangeren har korrekte dynamiske reaktioner.

Den målte og simulerede temperatur i toppen af lagertanken er vist i Figur 28. Den simulerede temperatur ligger omtrent konstant på 49,0°C, medens den målte temperatur svinger mellem 48°C og 51°C.

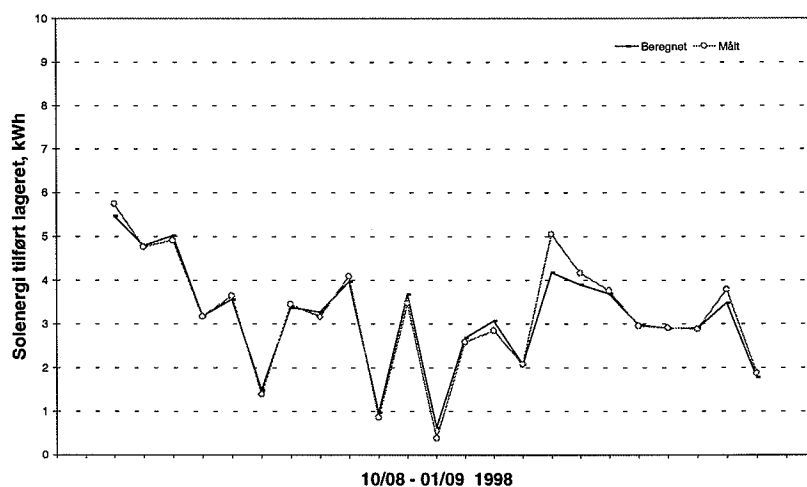
Sammenligningen af de målte og simulerede daglige værdier af energi tilført lagertanken fra solfangeren er vist i Figur 29, og den målte og simulerede daglige energimængde tappet fra lagertanken er vist i Figur 30. På lignende måde illustrerer Figur 31 den målte og beregnede daglige tilførsel af supplerende energi til lagertanken. Sammenligningen af den målte og beregnede nettoydelse er vist i Figur 32. Det fremgår at der er en god overensstemmelse mellem de målte og simulerede energimængder.



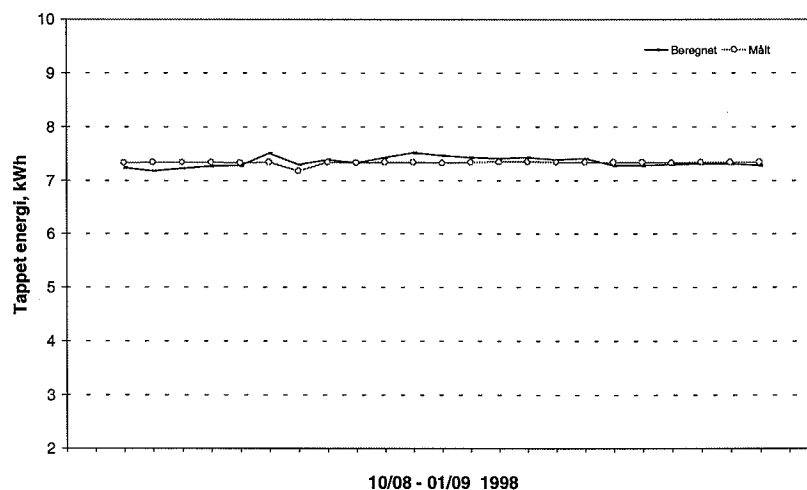
Figur 27. Fremløbs- og returtemperatur for solfangeren.



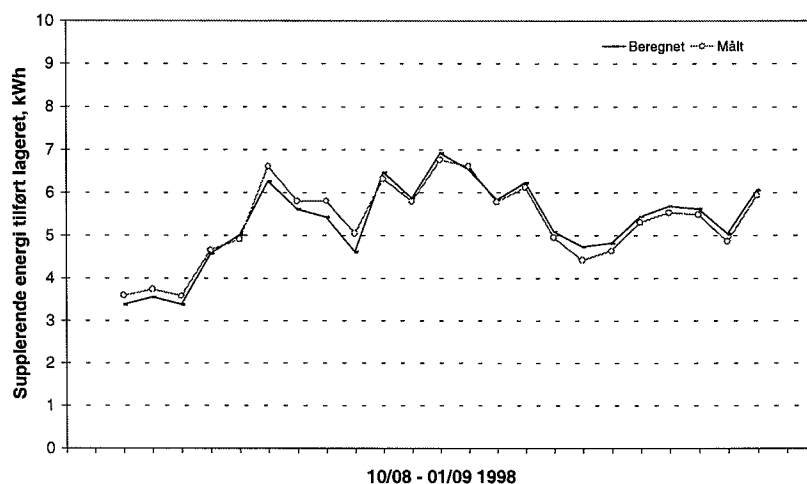
Figur 28. Temperaturen i toppen af lagertanken under simuleringsperioden.



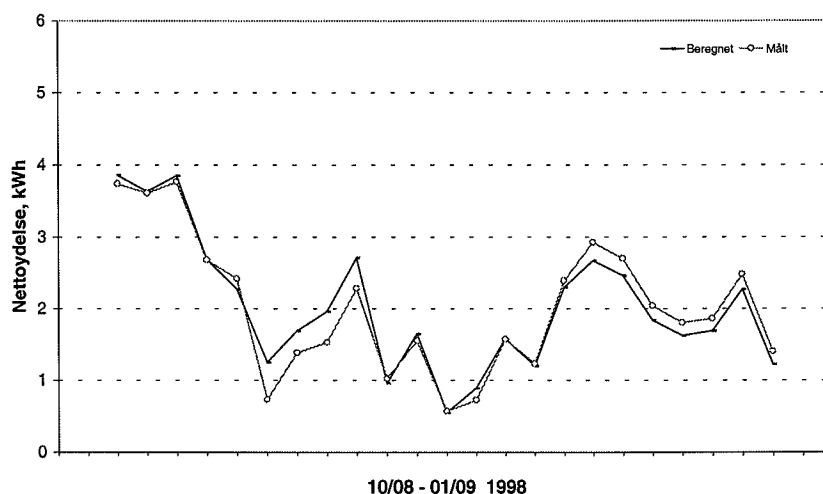
Figur 29. Solenergi tilført tanken under simuleringsperioden (daglige værdier).



Figur 30. Energi tappet fra tanken under simuleringsperioden (daglige værdier).



Figur 31. Supplerende energi tilført tanken under simuleringsperioden (daglige værdier).



Figur 32. Nettoyedelse under simuleringsperioden (daglige værdier).

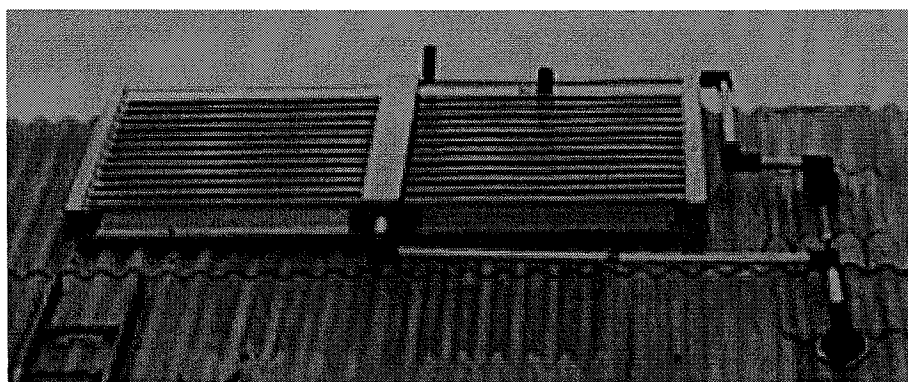
Tabel 4 viser summen af energimængderne igennem simuleringsperioden og afvigelsen mellem de simulerede og målte værdier. Det ses at afvigelserne mellem målte og beregnede energimængder er af et rimeligt begrænset omfang.

Tabel 4 Energimængder under simuleringsperioden.

Periode 1998 10/08-01/09	Solenergi til tanken (kWh)	Benyttet supple- rende energi (kWh)	Tappet energi fra tank (kWh)	Nettoyedelse (kWh)
Målt	73,9	122,3	169,0	46,7
Beregnet	73,0	122,2	168,6	46,4
Afvigelse %	-1,2	-0,1	-0,2	-0,6

3.6 Modelverifikation for anlæg med SLL-1200/24 solfanger

Undersøgelsen af SLL-1200/24 solfangeren blev foretaget i perioden fra 25. september til 21. oktober 1998. Fotos af SLL-1200/24 solfangeren er vist i Figur 33. Et solfangermodul med et bruttoareal på 2,50 m² og et tværsnitsareal for glasrørene på 1,24 m² blev brugt i anlægget. I solfangerkredsen blev en 22% propylenglykol/vand-blanding brugt som solfangervæske.



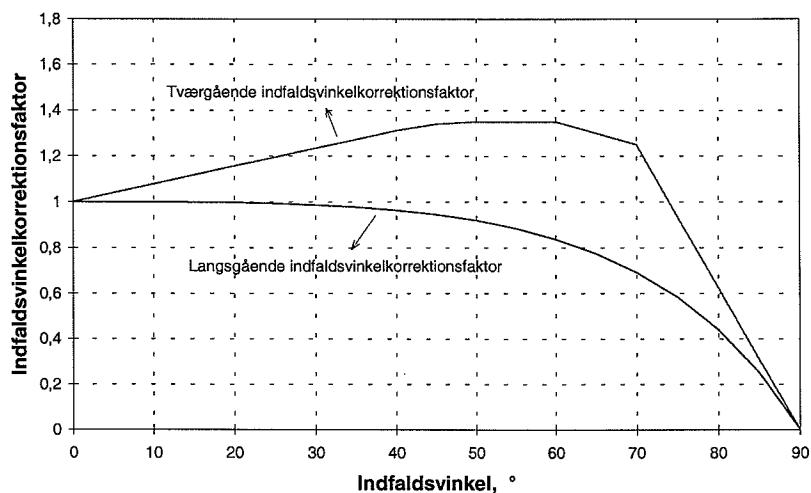
Figur 33. Den afprøvede SLL-1200/24 solfanger.

Solfangermodel

Baseret på [3], [4] og målingerne, er SLL-1200/24 solfangerens varmekapacitet, effektivitet og indfaldsvinkelkorrektionsfaktor blevet bestemt. Det blev konstateret at solfangerens varmekapacitet er $85800 \text{ J/m}^2 \text{ K}$. Denne overordentlig store varmekapacitet skyldes et stort indhold af solfangervæske i glasrørene. Her er både varmekapaciteten og solfangerens effektivitet baseret på glasrørenes tværsnitsareal. Solfangerens effektivitet kan udtrykkes som:

$$\eta = 0,735 - 1,82 \cdot (T_m - T_a) / G$$

Indfaldsvinkelkorrektionsfaktorerne er vist i Figur 34.

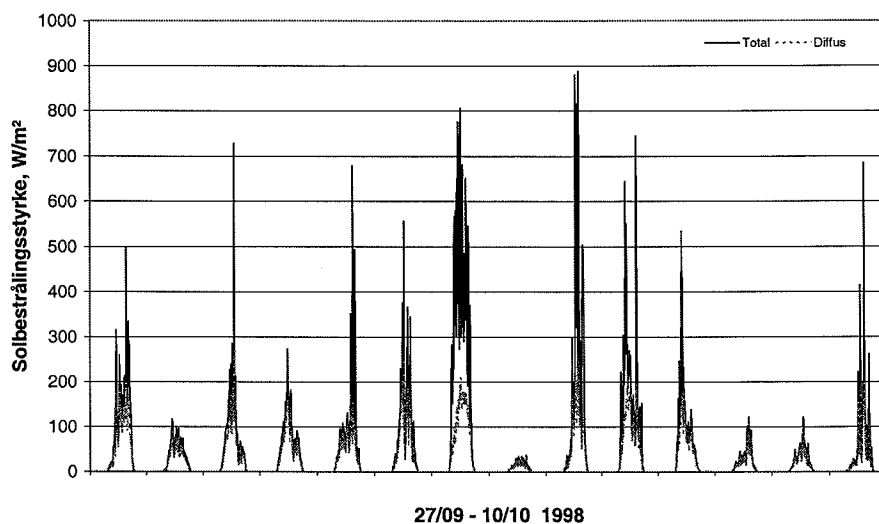


Figur 34. Indfaldsvinkelkorrektionsfaktorer for SLL-1200/24 solfangeren.

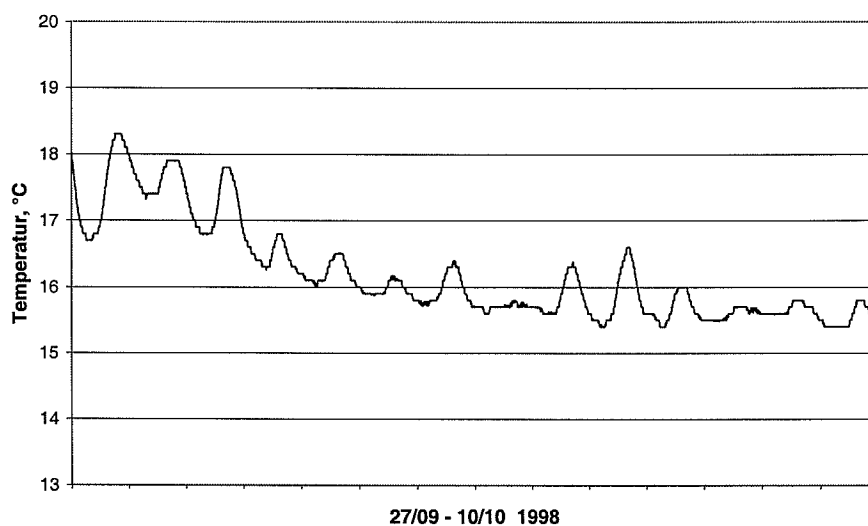
Sammenligning af resultater fra simuleringer og undersøgelser

Med designparametrene for anlægget og den ovenfor angivne model udføres simuleringer for perioden 27/9 til 10/10 1998. Anlæggets computermodel efterprøves med målte energi- og temperaturdata. Sammenligning af simuleringresultater og målinger er udført for de vigtigste parametre, såsom solenergi tilført tanken, supplerende energi til elpatron, energi tappet fra tanken, nettoydelse og temperaturer i solfangerkreds og lagertank.

For at sammenligne simuleringresultaterne med målingerne, bruges den målte solindstråling, udelufttemperaturen, brugsvandets fremløbstemperatur til tanken og tappeflowet som simuleringssindata. Solindstrålingen på solfangerpladen og udelufttemperaturen i simuleringssperioden er vist i Figur 35 og 36.



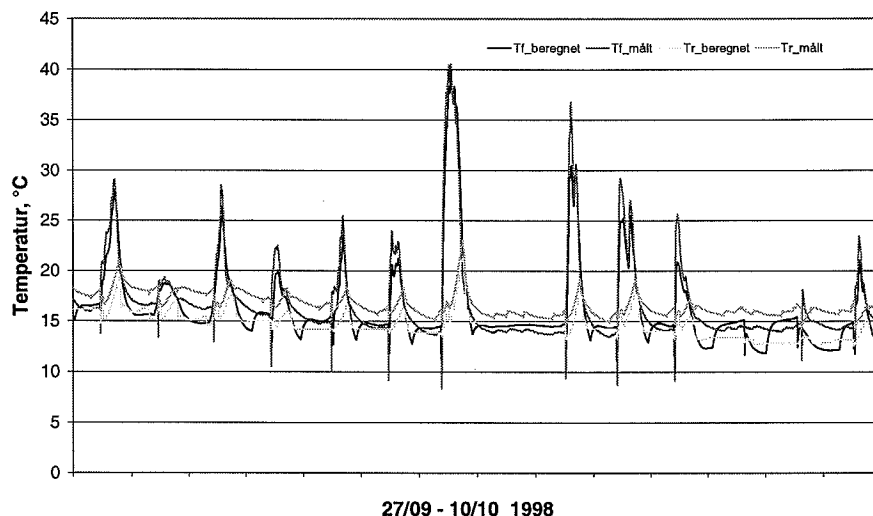
Figur 35. Solindstråling på solfangeren i perioden 27/9 – 10/10 1998.



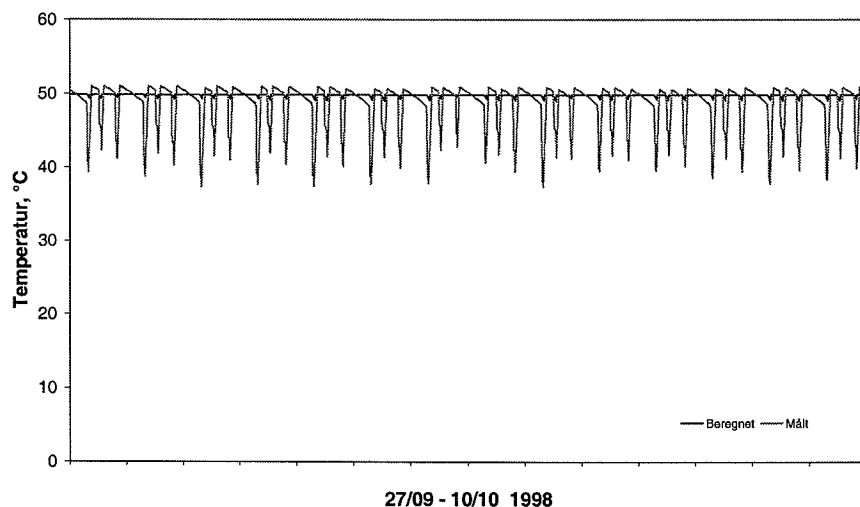
Figur 36. Den omgivende lufts temperatur i perioden 27/9 – 10/10 1998.

Figur 37 viser solfangerens målte og simulerede fremløbs- og returtemperatur. Den vandrette linie indikerer at solfangerkredsen ikke er i drift. Det kan ses ud fra Figur 37 at den simulerede fremløbs- og returtemperatur for solfangeren har korrekte dynamiske reaktioner.

Den målte og simulerede temperatur i toppen af lagertanken er vist i Figur 38. Den simulerede temperatur ligger omtrent konstant på 49,9°C, medens den målte temperatur svinger mellem 48°C og 51°C.

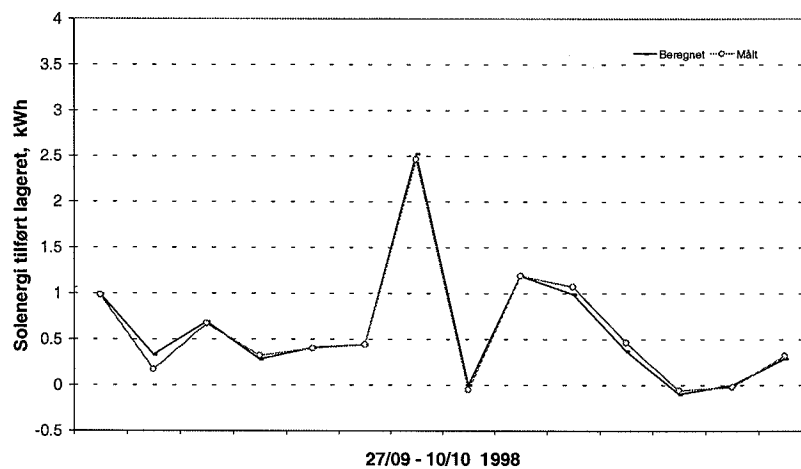


Figur 37. Fremløbs- og returtemperatur for solfangeren.

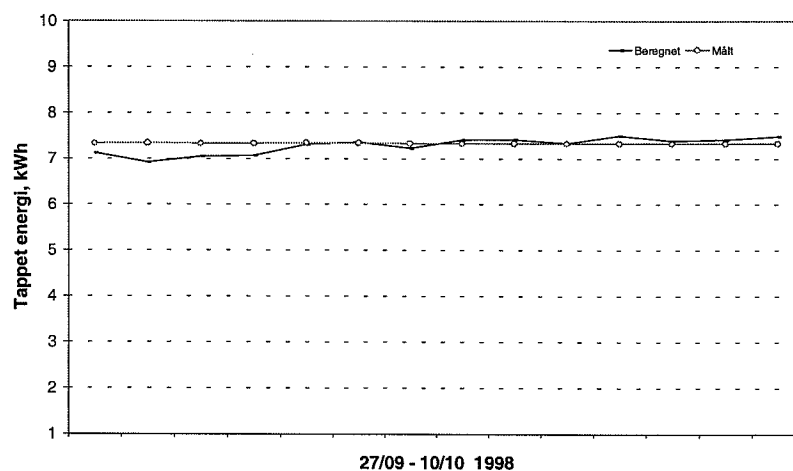


Figur 38. Temperaturen i toppen af lagertanken under simuleringsperioden.

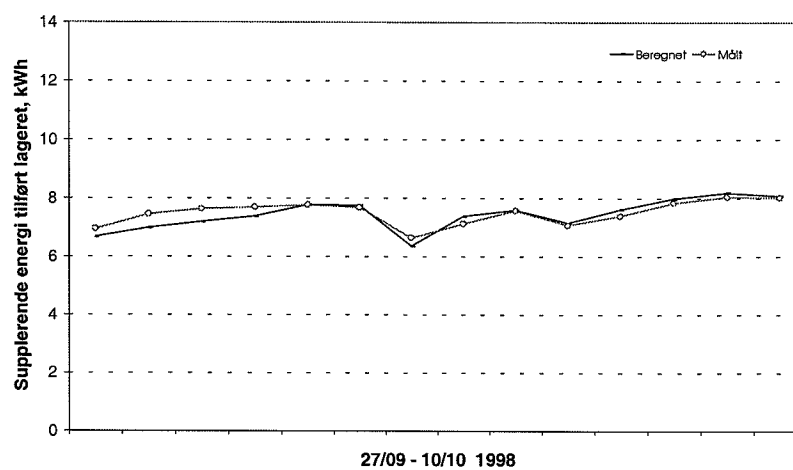
Sammenligningen af de målte og simulerede daglige værdier af energi tilført lagertanken fra solfangeren er vist i Figur 39, og den målte og simulerede daglige energimængde tappet fra lagertanken er vist i Figur 40. På lignende måde illustrerer Figur 41 den målte og beregnede daglige tilførsel af supplerende energi til lagertanken. Sammenligningen af den målte og beregnede nettoydelse er vist i Figur 42. Det fremgår at der er en god overensstemmelse mellem de målte og simulerede energimængder.



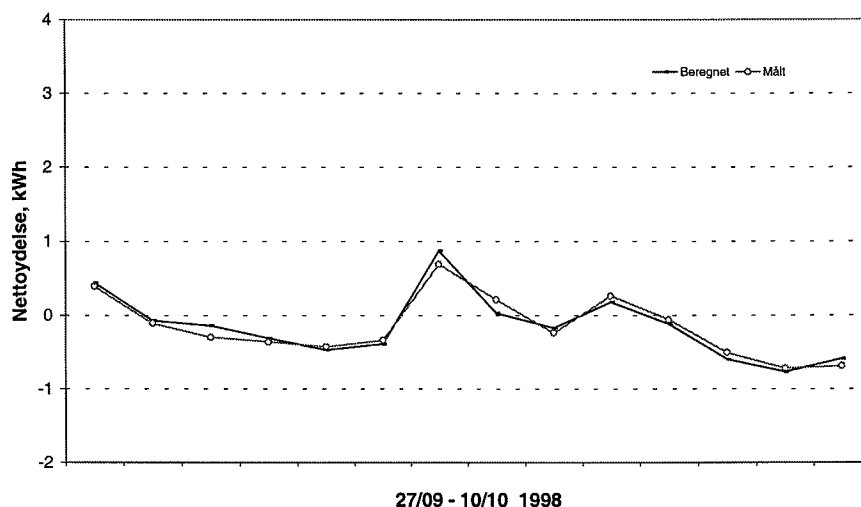
Figur 39. Solenergi tilført tanken under simuleringsperioden (daglige værdier).



Figur 40. Energi tappet fra tanken under simuleringsperioden (daglige værdier).



Figur 41. Supplerende energi tilført tanken under simuleringsperioden (daglige værdier).



Figur 42. Nettoyedelse under simuleringsperioden (daglige værdier).

Tabel 5 viser summen af energimængderne igennem simuleringsperioden og afvigelsen mellem de simulerede og målte værdier. Det ses at afvigelserne mellem målte og beregnede energimængder er af et rimeligt begrænset omfang.

Tabel 5. Energimængder under simuleringsperioden.

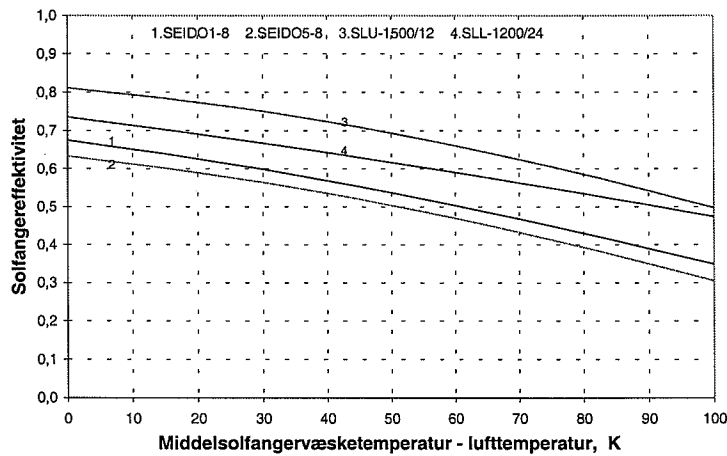
Periode 1998 27/09-10/10	Solenergi til tanken (kWh)	Benyttet supple- rende energi (kWh)	Tappet energi fra tank (kWh)	Nettoyedelse (kWh)
Målt	8,4	104,9	102,7	2,2
Beregnet	8,4	104,1	102,0	2,1
Afvigelse %	0,0	-0,8	-0,7	-4,5

3.7 Resumé af testresultater

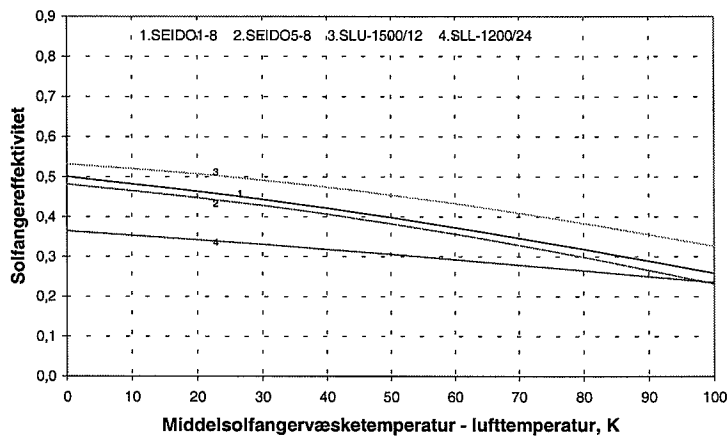
Fire typer vakuumrørsolfangere produceret af kinesiske firmaer er blevet undersøgt. Baseret på laboratorieundersøgelser er simuleringsmodeller for solfangerne blevet udviklet og efterprøvet. Solfangereffektiviteten for de fire vakuumrørsolfangere, baseret både på tværsnitsarealet for glastrørene og bruttoarealet, er vist i Figur 43 og 44. Indfaldsvinkelkorrektionsfaktorerne for de fire solfangere er vist i Figur 45. Varmekapaciteten for de fire solfangere bestemt af undersøgelserne er vist i Tabel 6.

Tabel 6. Varmekapaciteten for de undersøgte vakuumrørsolfangere.

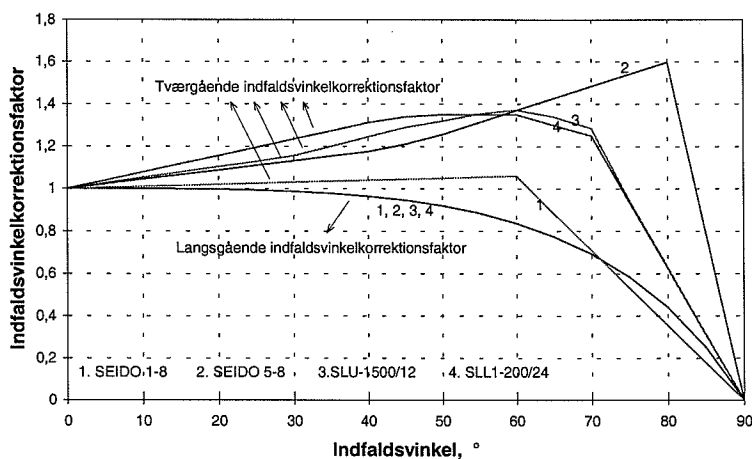
Solfangertype	Varmekapacitet (baseret på tværsnitsarealet for glastrørene) J/m ² K	Varmekapacitet (baseret på bruttoarealet) J/m ² K
SEIDO 1-8	2300	1700
SEIDO 5-8	1500	1100
SLU-1500/12	13400	8800
SLL-1200/24	85800	42600



Figur 43. Solfangereffektivitet for fire kinesiske vakuumrørsolfangere for indfaldsvinklen 0° og bestrålingsstyrken 800 W/m^2 . Effektiviteterne er baseret på tværsnitsarealet for glastrørene.



Figur 44. Solfangereffektivitet for fire kinesiske vakuumrørsolfangere for indfaldsvinklen 0° og bestrålingsstyrken 800 W/m^2 . Effektiviteterne er baseret på solfangerbruttoarealet.



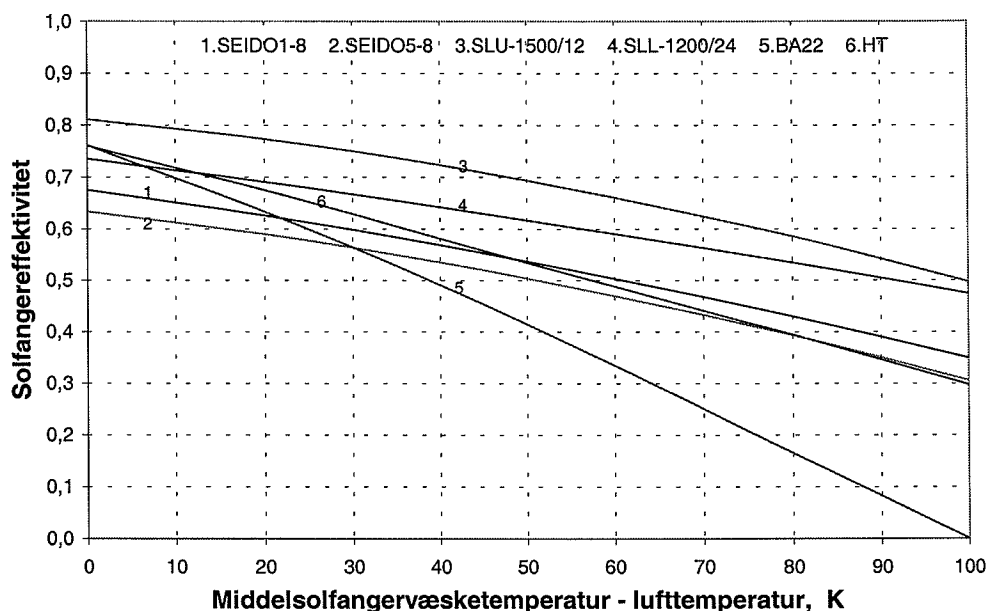
Figur 45. Indfaldsvinkelkorrektionsfaktorer for de afprøvede vakuumrørsolfangere.

4. Solvarmeanlæg med vakuumrørsolfangere

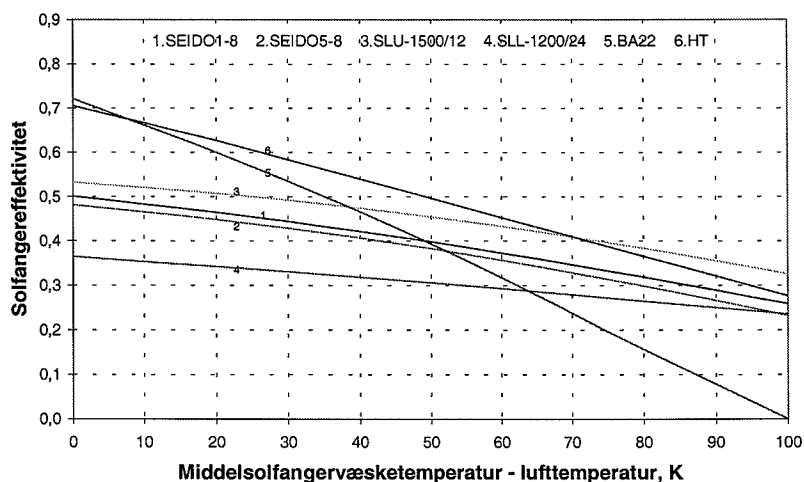
Undersøgelserne af de 4 afprøvede vakuumrørsolfangere er beskrevet i afsnit 3, hvor de udviklede og efterprøvede solfangermodeller også er beskrevet. For bedre at forstå hvordan vakuumrørsolfangere påvirker anlægsydelsen, udføres simuleringer under danske vejrforhold for forskellige typer solvarmeanlæg med de afprøvede vakuumrørsolfangere. For at foretage en sammenligning med traditionelle solfangere blev der også udført simuleringer for anlæg med almindeligt brugte plane solfangere. To typer plane solfangere (BA22 fra Batec A/S og HT fra Arcon Solvarme A/S), som typisk bruges i solvarmeanlæg til brugsvandsopvarmning og solvarmecentraler i Danmark, blev brugt som referencer.

Som tidligere nævnt, er der for vakuumrørsolfangernes vedkommende en stor forskel på glasrørenes tværsnitsareal og bruttoarealet. Begge disse arealer kan være af stor betydning for udformningen af solvarmeanlæg. Derfor vises ydelser for solvarmeanlæg baseret på begge arealer.

Baseret på de to arealer viser Figur 46 og 47 effektivitetskurverne for de fire kinesiske vakuumrørsolfangere og de to plane reference-solfangere ved en bestrålingsstyrke på 800 W/m^2 og en indfaldsvinkel på 0° . Det kan ses af Figur 46 at effektiviteten for vakuumrørsolfangerne er stor når glasrørenes tværsnitsareal benyttes. Dette gælder især for solfangere der er forsynet med reflektorer. Effektiviteten for solfangerne baseret på bruttoarealet er vist i Figur 47. Det er tydeligt at vakuumrørsolfangernes effektivitet er relativt lav når bruttoarealet benyttes. Årsagen er at en del af det totale areal ikke udnytter solstrålingen aktivt. Dette gælder f.eks. for mellemrummet mellem glasrørene, kondensatoren / varmeveksleren og fordelerrøret.

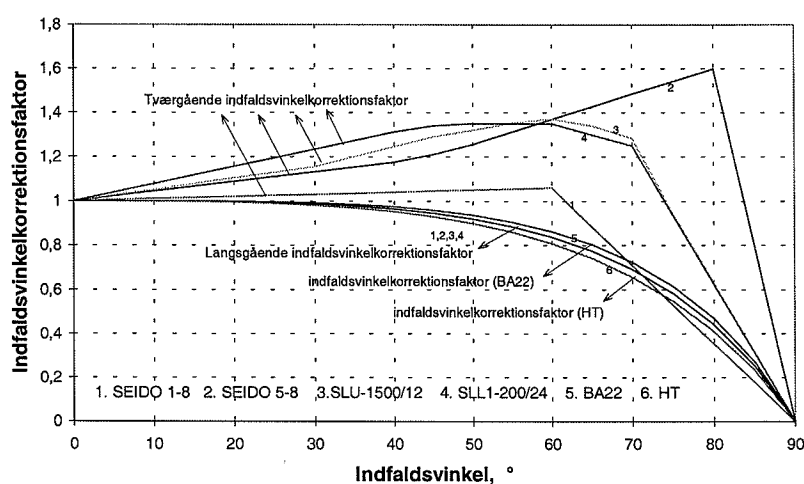


Figur 46. Solfangereffektivitet for indfaldsvinklen 0° og bestrålingsstyrken 800 W/m^2 . Effektiviteterne er baseret på tværsnitsarealet for glasrørene/det transparente areal.



Figur 47. Solfangereffektivitet for indfaldsvinklen 0° og bestrålingsstyrken 800 W/m^2 . Effektiviteterne er baseret på solfangerbruttoarealet/det udvendige areal.

Figur 48 viser indfaldsvinkelkorrektionsfaktorer for de fire vakuumrørsolfangere og BA22 og HT solfangerne. Det bemærkes at i den langsgående retning ligner indfaldsvinkelkorrektionsfaktoren for vakuumrørsolfangerne de plane solfangeres indfaldsvinkelkorrektionsfaktor, men i den tværgående retning varierer indfaldsvinkelkorrektionsfaktoren for vakuumrørsolfangerne fra solfanger til solfanger for forskellige indfaldsvinkler. For en indfaldsvinkel i intervallet fra 0° til 60° øges indfaldsvinkelkorrektionsfaktoren i tværgående retning. Denne stigende tendens består for SEIDO 5-8 solfangeren indtil indfaldsvinklen kommer op på 80° . Dette skyldes at SEIDO 5-8 solfangeren bruger en halvcylindrisk absorberudformning. Det er tydeligt at indfaldsvinkelkorrektionsfaktoren for en vakuumrørsolfanger er stærkt påvirket af mange designfaktorer, såsom glasrørets diameter, afstanden mellem glasrørene, absorberformen og tilstedeværelsen af eller manglen på en reflektor, etc.



Figur 48. Indfaldsvinkelkorrektionsfaktorer for de afprøvede vakuumrørsolfangere og plane solfangere.

Varmekapaciteten for de fire vakuumrørsolfangere og de plane reference-solfangere er vist i Tabel 7.

Tabel 7. Solfangernes varmekapacitet.

Solfangertype	Varmekapacitet (baseret på tværsnitsarealet for glasrørene) J/m ² K	Varmekapacitet (baseret på bruttoarealet) J/m ² K
SEIDO 1-8	2300	1700
SEIDO 5-8	1500	1100
SLU-1500/12	13400	8800
SLL-1200/24	85800	42600
BA22	5300	5000
HT	6900	6400

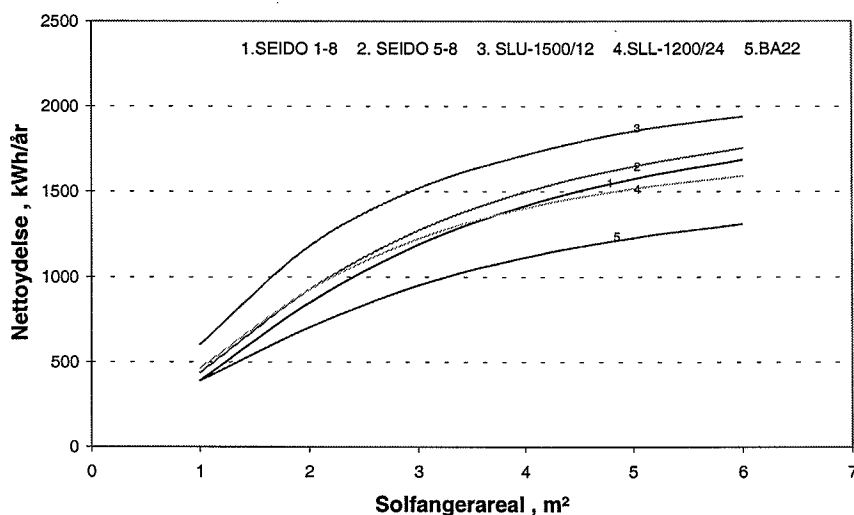
4.1 Små solvarmeanlæg til brugsvandsopvarmning

Ved hjælp af computersimuleringer undersøges ydelsen af små solvarmeanlæg til brugsvandsopvarmning med de fire vakuumrørsolfangere samt en plan reference-solfanger. Til simuleringen benyttes et typisk udformet solvarmeanlæg til brugsvandsopvarmning, med et solfangerareal på 3 m² og en 195 l kappebeholder, som referenceanlæg. I dette anlæg opvarmes den øverste halvdel af vandet i tanken til 50,5°C af en supplerende energikilde. Det daglige forbrug af vand fra anlægget er 160 l opvarmet fra 10°C til 50°C, svarende til et årligt energiforbrug på 2690 kWh. En tredjedel af det samlede daglige varmtvandsforbrug tages dagligt kl. 7, 12 og 19. Det Danske Design Referenceår, DRY's vejrdata, bruges i beregningerne. Beregningerne udføres med simuleringsprogrammet beskrevet i [6].

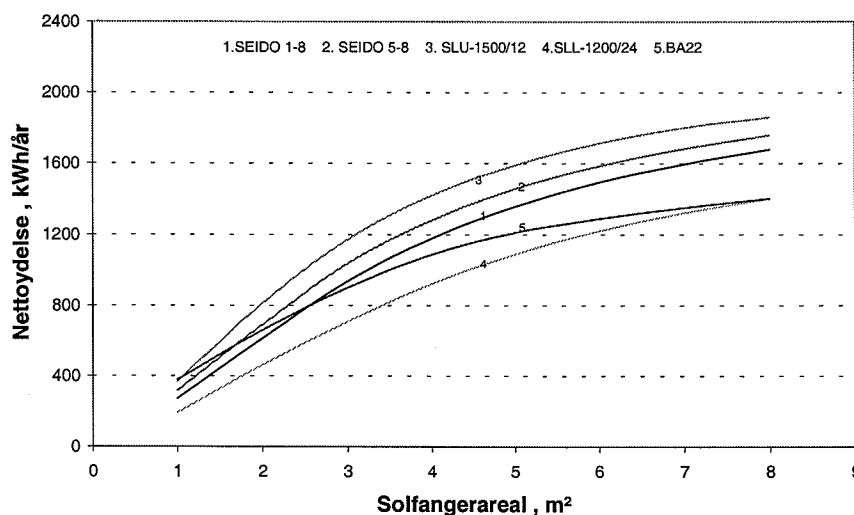
For at kunne foretage en sammenligning af anlæg med de forskellige typer solfangere er det vigtigt at sikre at simuleringen udføres under optimale driftsforhold for hvert enkelt anlæg. Først blev et antal simuleringer udført for at undersøge den effekt volumenstrømmen i solfangerkredsen har på anlægsydelsen. Simuleringerne var baseret på den antagelse at solfangereffektiviteten ikke er påvirket af volumenstrømmen. Resultaterne viser at den maksimale ydelse opnås når volumenstrømmen er ca. 0,2 l/min.m² solfanger for alle anlæg.

Baseret på de optimale driftsforhold for hvert anlæg blev der foretaget en undersøgelse af solfangerarealets effekt på anlægsydelsen. Nettoydelsen som funktion både af glasrørenes tværsnitsareal/det transparente areal og solfangerens bruttoareal er vist i Figur 49 og Figur 50. Her er nettoydelsen defineret som energi tappet fra anlægget minus den supplerende energi tilført tanken. Det kan ses at nettoydelsen øges betydeligt når den almindelige plane solfanger erstattes af en vakuumrørsolfanger, specielt når solfangerarealet er stort. Forøgelsen afhænger af typen af vakuumrørsolfanger. Med hensyn til anlægsydelse er fordelene ved at benytte vakuumrørsolfangere i stedet for plane solfangere størst når glasrørenes tværsnitsareal/det transparente areal benyttes. Nettoydelsen for 6 m² anlæggene med vakuumrørsolfangere er 22% - 48% større end nettoydelsen for anlæggene med en almindelig plan solfanger baseret på

glasrørenes tværsnitsareal/det transparente areal. Der er ingen fordele for anlæg med et lille solfangerareal ved at benytte en vakuumrørsolfanger i stedet for en plan solfanger.



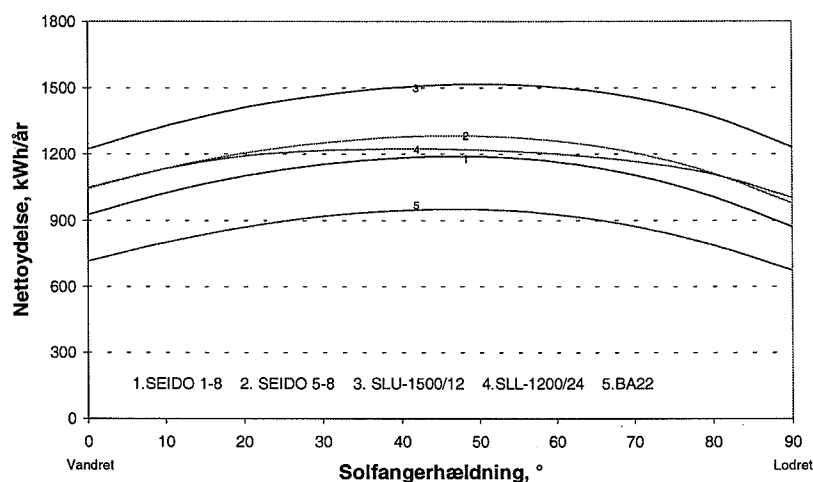
Figur 49. Nettoydelse for standardanlæg til brugsvandsopvarmning som funktion af solfangerarealet for forskellige solfangere. Solfangerarealerne er tværsnitsarealet for glasrørene/det transparente areal.



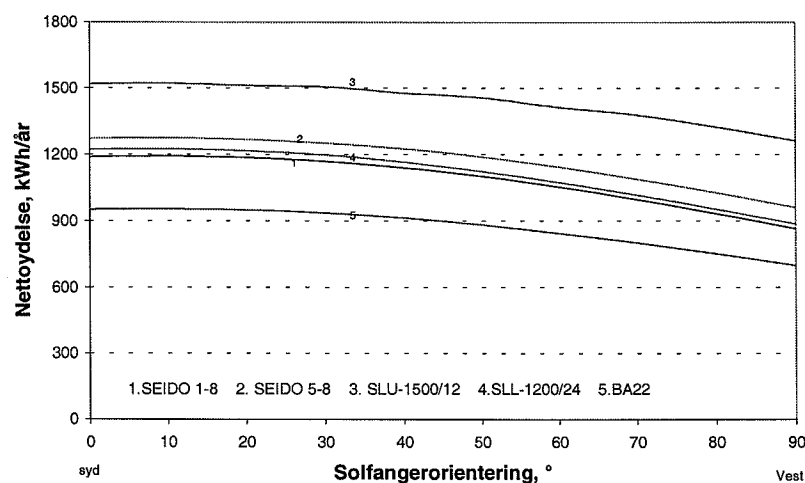
Figur 50. Nettoydelse for standardanlæg til brugsvandsopvarmning som funktion af solfangerarealet for forskellige solfangere. Solfangerarealerne er bruttoarealet/det udvendige areal.

Simuleringer blev også udført for at undersøge den effekt solfangerens hældning og orientering har på anlægsydelsen. Figur 51 og 52 viser den beregnede årlige nettoydelse for anlæggene med en 3 m² solfanger (tværsnitsareal for glasrørene/det transparente areal) som funktion af solfangerhældning og orientering. Det kan ses at anlæggets nettoydelse er størst når solfangerne vender mod syd og når solfangerens hældning er mellem 40° og 55°. Det kan også ses at anlægsydelsen for den alminde-

lige plane solfanger procentmæssigt er reduceret mere end for vakuumrørsolfangerne når solfangerens orientering og hældning ændres fra det optimale udgangspunkt: Sydvendt solfanger og ca. 45° hældning af solfangeren. Følgelig er der særlige ydelsesmæssige fordele ved vakuumrørsolfangere når det ikke er muligt at installere solfangeren optimalt.



Figur 51. Beregnede nettoyielder for 3 m² standardanlæg til brugsvandsopvarmning som funktion af solfangerhældningen for forskellige sydvendte solfangere.



Figur 52. Beregnede nettoyielder for 3 m² standardanlæg til brugsvandsopvarmning som funktion af solfangerorienteringen for forskellige solfangere med solfangerhældningen 45°.

Ud fra de ovenfor viste simuleringresultater kan det ses at ydelsesforøgelsen for små solvarmeanlæg til brugsvandsopvarmning der benytter vakuumrørsolfangere i stedet for plane solfangere er forskellig under forskellige driftsforhold. Jo større nettoyielden fra et anlæg er, desto større vil fordelene være ved at bruge vakuumrørsolfangere. For reference-anlægget med årlige nettoyielder på 750 kWh, 1000 kWh og 1300 kWh, vises det krævede solfangerareal for vakuumrørsolfangerne og BA22-solfangeren i Tabel 8. Det kan ses at for at nå en nettoyield på 1300 kWh, behøves

en 5,9 m² BA22-solfanger eller en 2,3 m² SLU-1500/12 solfanger. Her er der regnet med glastrørsarealet/det transparente areal. Dette resultat viser at fra et økonomisk synspunkt bør prisen pr. m² solfanger for en SLU-solfanger ikke være mere end 2,6 gange prisen for en BA22-solfanger for et solvarmeanlæg med en årlig nettoydelse på 1300 kWh.

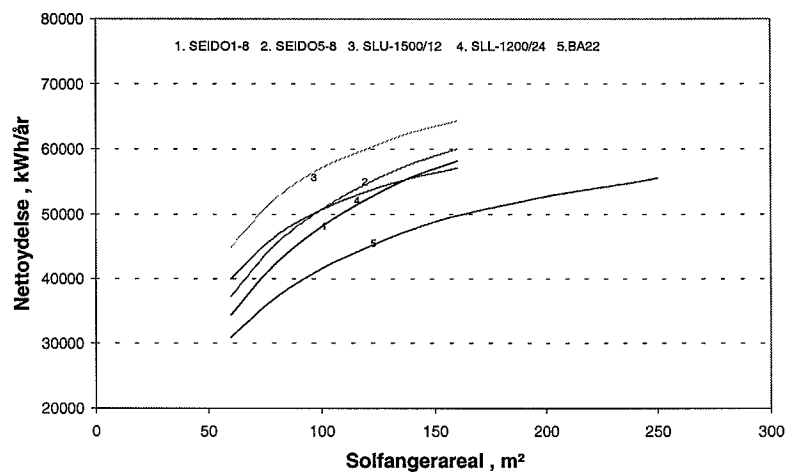
Tabel 8. Det krævede solfangerareal for forskellige årlige nettoyielder.

Årlig nettoydelse Solfangerareal m ²	750 kWh (dækningsgrad 28%)		1000 kWh (dækningsgrad 37%)		1300 kWh (dækningsgrad 48%)	
	rørareal /transparent areal	bruttoareal	rørareal /transparent areal	bruttoareal	rørareal /transparent areal	bruttoareal
BA22	2,1	2,2	3,2	3,4	5,9	6,2
SEIDO 1-8	1,7	2,3	2,4	3,2	3,3	4,4
SEIDO 5-8	1,5	2,0	2,1	2,8	3,1	4,2
SLL-1200/24	1,5	3,0	2,1	4,2	3,2	6,4
SLU-1500/12	1,2	1,8	1,6	2,4	2,3	3,5

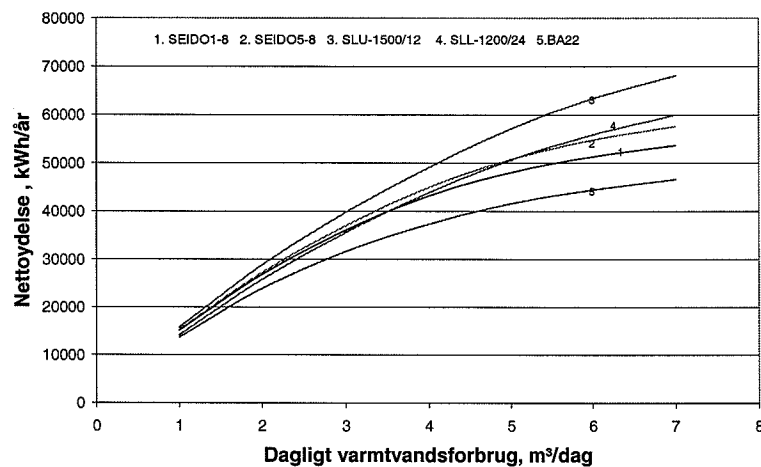
4.2 Store solvarmeanlæg til brugsvandsopvarmning

I det sidste årti er markedet for store solvarmeanlæg til brugsvandsopvarmning øget. Sammenlignet med små solvarmeanlæg til brugsvandsopvarmning for enfamiliehuse viser store solvarmeanlæg til brugsvandsopvarmning for mellemstore beboelsesejendomme en lav pris per kvadratmeter af solfangeranlægget. For at få en bedre forståelse af hvordan forskellige typer solfangere vil påvirke anlægsydelsen, er detaljerede simuleringer blevet udført for typisk udformede store solvarmeanlæg til brugsvandsopvarmning med de fire vakuumrørsolfangere og den plane BA22-solfanger. Reference-anlægget blev designet med en 100 m² solfanger og en 5000 l lagertank, som er en lodret cylindrisk tank med en indbygget varmevekslerspiral nederst i tanken og en supplerende energikilde i den øverste del. Cirka 1500 l vand i den øverste del af tanken opvarmes til 50,5°C af den supplerende energikilde. Det daglige forbrug af vand fra anlægget er 5000 l opvarmet fra 10°C til 50°C. Varmt vand tappes 5 gange om dagen, kl. 7, 8, 12, 19 og 20 og en femtedel af det daglige varmtvandsforbrug tappes ved hver aftapning. Beregningerne udføres med et simuleringsprogram udviklet i [5].

Figur 53 viser nettoyielden som funktion af solfangerarealet (glasrørens tværsnitsareal/det transparente areal). Det kan ses at med det samme solfangerareal viser de anlæg der benytter vakuumrørsolfangere en betydeligt bedre ydelse sammenlignet med de anlæg der benytter plane solfangere. For at opnå en nettoydelse på 50000 kWh, er det påkrævede solfangerareal, tværsnitsareal for glasrørene, 75 m² (svarende til et bruttoareal på 114 m²) for SLU-1500/12-solfangeren, eller et transparent areal på 160 m² (svarende til et bruttoareal på 169 m²) for BA22-solfangeren. For et forøget solfangerareal øges nettoyielden nogenlunde ens for de forskellige vakuumrørsolfangere med undtagelse af SLL-1200/24-solfangeren. Dette skyldes at SLL-solfangerens varmekapacitet er meget stor. Med årlige nettoyielder på 45000 kWh, 50000 kWh og 55000 kWh for reference-anlægget vises det påkrævede solfangerareal for vakuumrørsolfangerne og BA22-solfangeren i Tabel 9.



Figur 53. Nettoydelse for store solvarmeanlæg til brugsvandsopvarmning som funktion af solfangerarealet for forskellige solfangere. Solfangerarealerne er tværsnitsarealet for glastrørene/det transparente areal.



Figur 54. Nettoydelse for 100 m² solvarmeanlæg til brugsvandsopvarmning som funktion af solfangertypen og varmtvandsforbruget. Solfangerarealerne er tværsnitsarealet for glastrørene/det transparente areal.

Tabel 9. Det krævede solfangerareal for forskellige nettoydelse

Nettoydelse Solfangerareal m ²	45000 kWh (dækningsgrad 53%)		50000 kWh (dækningsgrad 59%)		55000 kWh (dækningsgrad 65%)	
	rørareal /transparent areal	bruttoareal	rørareal /transparent areal	bruttoareal	rørareal /transparent areal	bruttoareal
Solfangertype						
BA22	125	131	163	171	238	251
SEIDO 1-8	87	117	108	145	132	177
SEIDO 5-8	78	105	96	129	123	165
SLL-1200/24	75	151	96	193	132	266
SLU-1500/12	58	88	77	117	87	133

Figur 54 viser for forskellige solfangere hvordan nettoydelsen af et 100 m² solvarmeanlæg påvirkes af varmtvandsforbrugets størrelse. Her er det benyttede areal

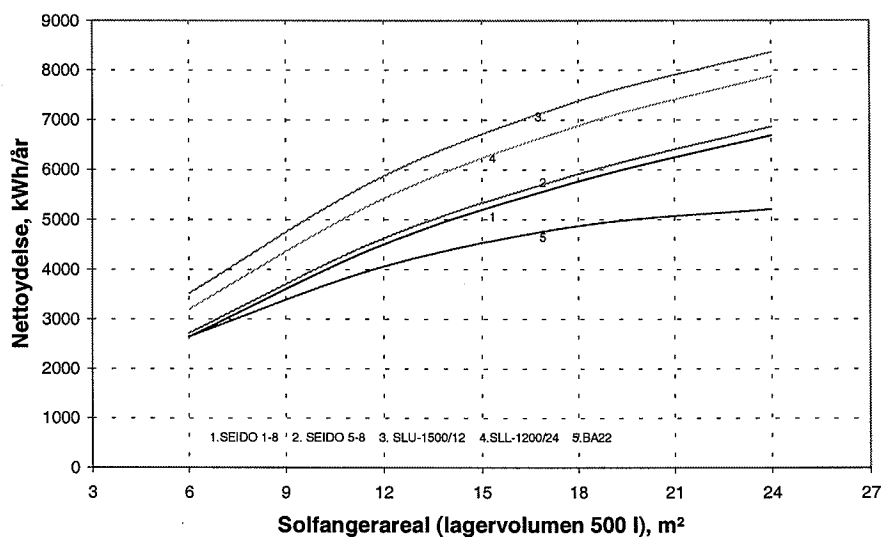
tværsnitsarealet for glasrørene/det transparente areal. Det fremgår at solfangertypen kun har en meget lille indflydelse på anlægsydelsen når det daglige varmtvandsforbrug er mindre end 40% af tankvolumenet. Jo større varmtvandsforbruget er, des større bliver nettoydelsen, og des større bliver den ydelsesmæssige fordel ved at benytte vakuumrørsolfangere.

4.3 Solvarmeanlæg til rumopvarmning og brugsvandsopvarmning

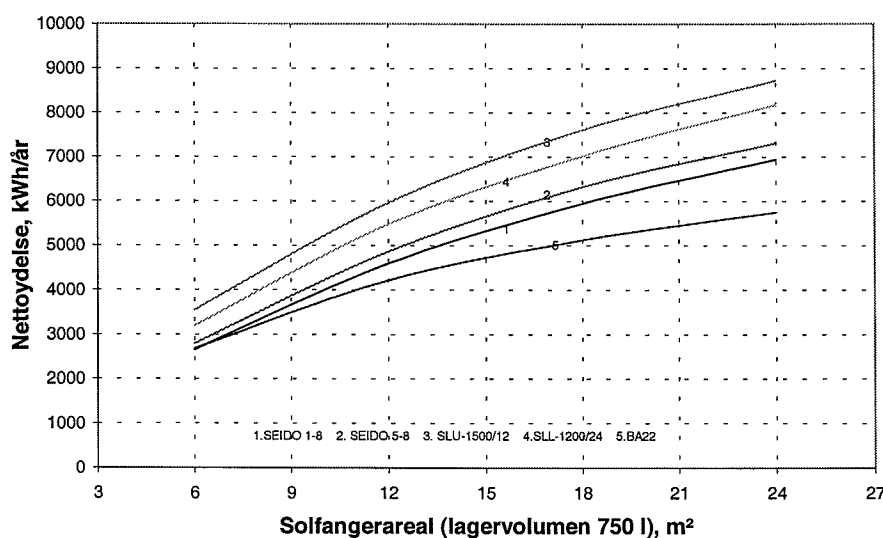
Undersøgelserne af vakuumrørsolfangernes indflydelse på anlægsydelsen for kombinerede varmtvands- og rumopvarmningsanlæg baseres på simuleringsprogrammet TRNSYS [8]. Beregninger foretages både med de fire vakuumrørsolfangere og med en plan solfanger, BA22.

To typisk udformede kombinerede brugsvands- og rumopvarmningsanlæg til en-familiehuse er valgt som reference-anlæg for undersøgelsen. Begge reference-anlæggene består af en 10 m² solfanger og en 500 l varmtvandsbeholder. Beholderen er udformet med 3 indbyggede varmevekslerspiraler i bunden, midten og den øverste del. Varmeveksleren i bunden er forbundet med solfangerkredsen, og den midterste benyttes af rumopvarmningskredsen. I den øverste del af tanken tilfører varmevekslerspiralen supplerende energi for at holde vandet i den øverste del af tanken på 50,5°C. De to reference-anlæg bruger forskelligt udformede rumopvarmningsanlæg. Det ene anlæg bruger gulvvarme, og den supplerende energi tilføres huset hver gang energien fra lagertanken ikke kan opfylde varmebehovet. Det andet anlæg benytter radiatorer i huset, og hele varmebehovet til rumopvarmning dækkes fra tanken. På grund af de forskellige udformninger af rumopvarmningsanlæggene placeres den supplerende varmevekslerspiral og varmevekslerspiralen for rumopvarmningskredsen i forskellige niveauer af tanken for de to anlæg. For anlæg der bruger gulvvarme, er suppleringsvarmevekslerspiralen placeret så den holder de øverste 150 l på 50,5°C og varmevekslerspiralen der er forbundet med varmekredsen er placeret under den supplerende varmevekslerspiral. For anlægget med radiatorerne opvarmes 200 l i toppen af tanken af den supplerende energikilde til 50,5°C, og varmevekslerspiralen der er forbundet med varmekredsen er placeret over den supplerende varmevekslerspiral. Det daglige varmtvandsforbrug fra tanken er 150 l og vandet opvarmes fra 10°C til 50°C. En tredjedel af det daglige varmtvandsforbrug tappes dagligt fra tanken kl. 7, 12 og 19. Varmetabet fra referencehuset er 211 W/K svarende til et varme-forbrug på 20000 kWh/år for at holde en rumtemperatur på 20°C året rundt. Husets varmekapacitet er 50 MJ/K.

Den årlige nettoydelse som funktion af solfangerarealet for anlægget med gulvvarme og med et tankvolumen på 500 l og 750 l er vist i Figur 55 og 56. Her er solfangerarealet tværsnitsarealet af glasrørene for vakuumrørsolfangerne og det transparente areal for den plane solfanger. Det ses at et øget solfangerareal vil give en forøgelse af anlæggenes nettoydelse uanset hvilken type solfanger og tankvolumen der bruges. Nettoydelsen vokser mest når solfangerarealet vokser når der er tale om vakuumrørsolfangere. Fordelen ved at bruge vakuumrørsolfangere er altså størst for anlæg med store dækningsgrader. Her er nettoydelsen defineret som energien tappet fra tanken som varmt brugsvand plus husets varmekonsum minus den supplerende energi der er brugt både i tanken og i huset.



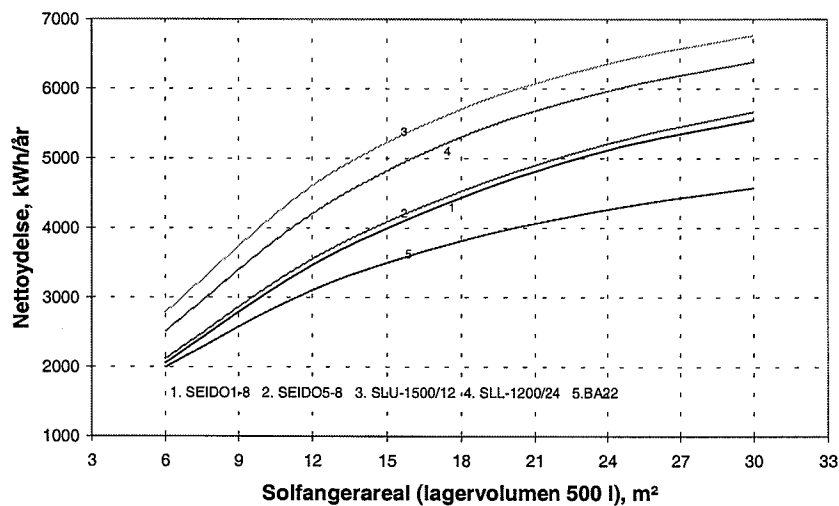
Figur 55. Nettoydelser for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning som funktion af solfangertypen og solfangerarealet. Solfangerarealerne er tværsnitsarealet for glasrørene/det transparente areal. Opvarmningssystemet er et gulvvarmesystem.



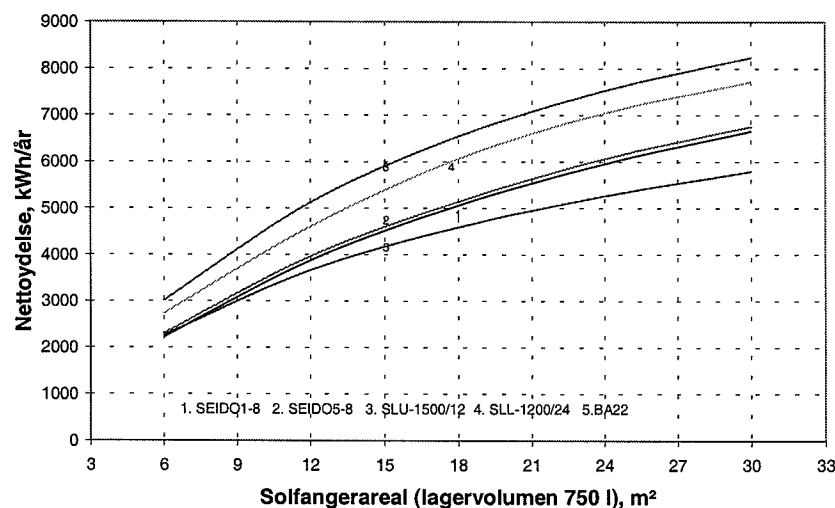
Figur 56. Nettoydelser for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning som funktion af solfangertypen og solfangerarealet. Solfangerarealerne er tværsnitsarealet for glasrørene/det transparente areal. Opvarmningssystemet er et gulvvarmesystem.

Den beregnede årlige nettoydelse som funktion af solfangerarealet for anlægget med radiatorer og et tankvolumen på 500 l og 750 l er vist i Figur 57 og 58. Som for anlægget med gulvvarme fører et øget solfangerareal til en forøgelse af anlæggets nettoydelse, som er forskellig for forskellige typer solfangere. Med det samme solfangerareal er nettoydelsen for anlægget med radiatorer mindre end nettoydelsen for

anlægget med gulvvarme. Dette skyldes forskellen i de to anlægs tankudformning og suppleringsstrategi. Driftstemperaturen for solfangerne er lavest i anlægget med gulvvarme.



Figur 57. Nettoydelse for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning som funktion af solfangertypen og solfangerarealet. Solfangerarealerne er tværsnitsarealet for glasrørene/det transparente areal. Opvarmningssystemet er et radiatorsystem.



Figur 58. Nettoydelse for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning som funktion af solfangertypen og solfangerarealet. Solfangerarealerne er tværsnitsarealet for glasrørene/det transparente areal. Opvarmningssystemet er et radiatorsystem.

Ud fra resultaterne vist i Figur 55, 56, 57 og 58, er det tydeligt at den ekstra ydelsesforøgelse for anlæg der benytter vakuumrørsolfangere i stedet for plane solfangere er forskellig for forskellige anlægsudformninger. For anlægget med gulvvarme og en 500 l lagertank vises i Tabel 10 det krævede solfangerareal for forskellige typer solfangere for nettoydelse på 3500 kWh, 4500 kWh og 5000kWh. Ligeledes vises i

Tabel 11 for anlægget med radiatorsystem og en 500 l lagertank det krævede solfangerareal for forskellige typer solfangere for nettoyieldser på 3500 kWh, 4000 kWh og 4500 kWh.

Tabel 10. Det krævede solfangerareal for forskellige nettoyieldser (anlæg med gulvvarme).

Nettoydelse Solfangerareal m ² Solfangertype	3500 kWh (dækningsgrad 15,5%)		4500 kWh (dækningsgrad 19,9%)		5000 kWh (dækningsgrad 22,1%)	
	rørareal	bruttoareal	rørareal	bruttoareal	rørareal	bruttoareal
BA22	9,5	10,0	14,9	15,7	19,8	20,9
SEIDO 1-8	8,6	11,6	12,0	16,2	14,0	18,9
SEIDO 5-8	8,3	11,2	11,5	15,5	13,5	18,2
SLL-1200/24	6,9	13,9	9,5	19,1	10,8	21,7
SLU-1500/12	6,0	9,2	8,4	12,8	9,7	14,8

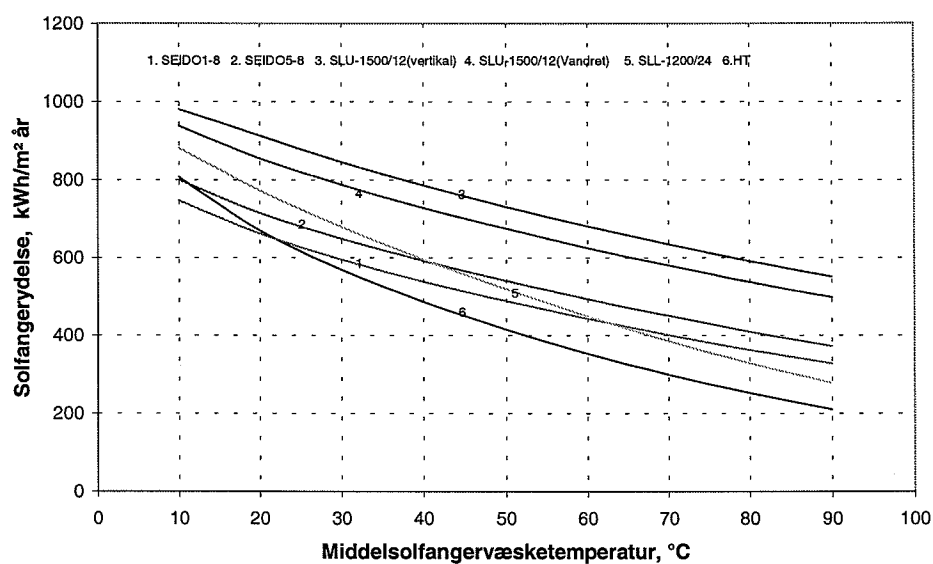
Tabel 11. Det krævede solfangerareal for forskellige nettoyieldser (anlæg med radiatorer).

Nettoydelse Solfangerareal m ² Solfangertype	3500 kWh (dækningsgrad 15,5%)		4000 kWh (dækningsgrad 17,7%)		4500 kWh (dækningsgrad 19,9%)	
	rørareal	bruttoareal	rørareal	bruttoareal	rørareal	bruttoareal
BA22	14,9	15,7	20,2	21,3	28,6	30,2
SEIDO 1-8	12,2	16,5	15,0	20,2	18,5	24,9
SEIDO 5-8	11,7	15,7	14,0	18,8	17,8	24,0
SLL-1200/24	9,4	18,9	11,3	22,8	13,5	27,2
SLU-1500/12	8,3	12,6	9,9	15,1	11,7	17,8

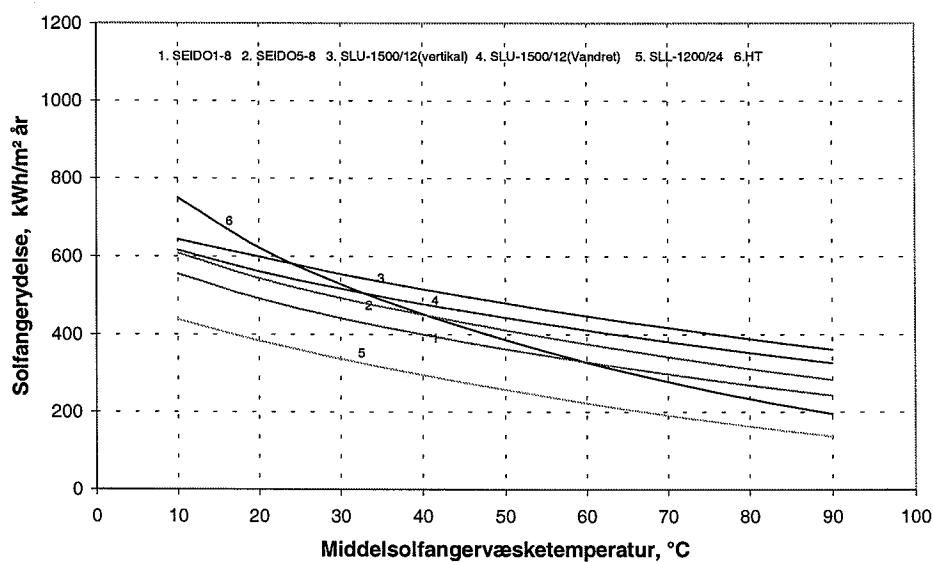
4.4 Solvarmecentraler

For at undersøge den årlige ydelse for forskellige solfangere i solvarmecentraler er der foretaget simuleringer for solfangerne med en konstant driftstemperatur igennem hele året. Figur 59 og 60 viser den beregnede årlige energiydelse per m² solfanger for de fire kinesiske vakuumrørsolfangere og for den plane solfanger HT fra Arcon Solvarme A/S som funktion af middelsolfangervæsketemperaturen. For SLU-solfangeren er der gennemført ekstra beregninger med glasrørene placeret vandret. Simuleringen er både baseret på tværsnitsarealet for glasrørene/det transparente areal og solfangerens bruttoareal. Simuleringerne er udført baseret på simuleringsprogrammet beskrevet i [6]. Der er regnet med sydvendte solfangere med en hældning på 45° og med vejrdata fra det danske referenceår DRY.

Det ses i Figur 59 at ydelsen fra solfangeren formindskes når driftstemperaturen øges. Jo højere temperaturen bliver desto større bliver ydelsesfordelen når vakuumrørsolfangere benyttes i stedet for den plane solfanger. For solvarmecentraler med lave driftstemperaturer er plane solfangere at foretrække, hvorimod vakuumrørsolfangere er bedst egnede for solvarmecentraler med høje driftstemperaturer. SLU-solfangeren yder bedst når glasrørene har den normale lodrette placering. Tabel 12 viser forholdet mellem vakuumrørsolfangerarealet (tværsnitsarealet for glasrørene) og det plane reference-solfangerareal (det transparente areal) svarende til samme ydelse under forskellige driftstemperaturer. Ved at sammenligne arealforholdene i Tabel 12 og priserne for de forskellige solfangere er det muligt at bestemme den bedst mulige solfanger for et bestemt temperaturniveau.



Figur 59. Årsydelse pr. m² solfanger som funktion af middelsolfangervæsketemperaturen. Solfangerarealerne er tværsnitsarealerne for glasrørene/det transparente areal.



Figur 60. Årsydelse pr. m² solfanger som funktion af middelsolfangervæsketemperaturen. Solfangerarealerne er bruttoarealet/det udvendige areal.

Tabel 12. Forholdet mellem vakuumrørsolfangerarealet og HT-solfangerarealet (tvær-snitsarealet for glasrørene/det transparente areal) resulterende i den samme årlige ydelse.

Solfangertype					
Driftstemperatur °C	HT	SEIDO 1-8	SEIDO 5-8	SLL-1200/24	SLU-1500/12
20	1	1,01	0,93	0,86	0,73
30	1	0,95	0,87	0,83	0,67
40	1	0,90	0,82	0,81	0,62
50	1	0,85	0,76	0,80	0,57
60	1	0,79	0,71	0,78	0,52
70	1	0,74	0,66	0,77	0,47
80	1	0,69	0,61	0,76	0,43
90	1	0,64	0,56	0,75	0,38

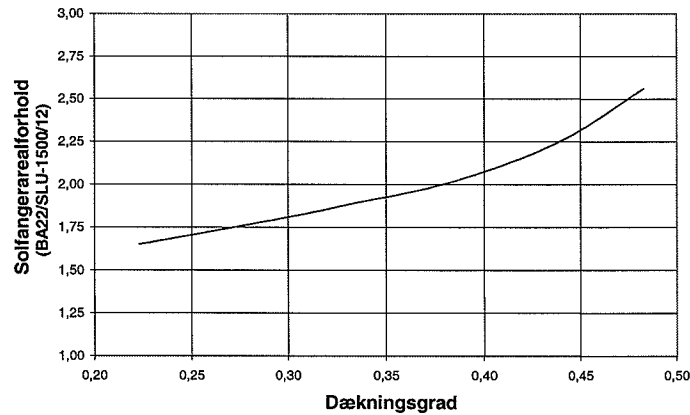
5. Sammenfatning og vurdering

I kapitel 4 er årlige ydelser beregnet for små og store solvarmeanlæg til brugsvandsopvarmning, for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning og for solvarmecentraler. Beregningerne er udført med de 4 undersøgte kinesiske vakuumrørsolfangere og med almindelige plane solfangere markedsført af danske solfangerfabrikanter.

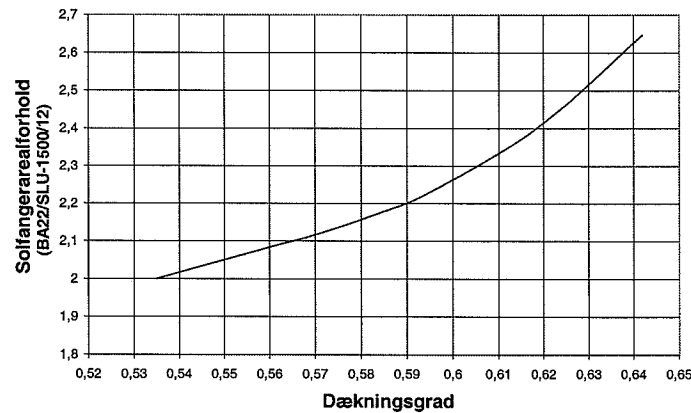
Beregningerne viste at for alle solvarmeanlæg med samme solfangerareal opnås de højeste ydelser hvis solfangeren SLU-1500/12 benyttes. Da prisen for de undersøgte vakuumrørsolfangere pr. m² næsten er ens for de undersøgte vakuumrørsolfangere, se Tabel 1, må det konkluderes at SLU-1500/12 solfangeren for alle typer anlæg er den bedst egnede af de undersøgte vakuumrørsolfangere. Derfor sammenlignes SLU-1500/12 solfangeren i det følgende med de almindelige plane solfangere BA22 og HT.

Figur 61 og 62 viser som funktion af den årlige dækningsgrad forholdet mellem solfangerarealet for BA22 solfangeren og solfangerarealet for SLU-1500/12 solfangeren som resulterer i samme årlige ydelse for hhv. et lille og et stort solvarmeanlæg til brugsvandsopvarmning. Jo større dækningsgraden er, des større bliver arealforholdet, dvs. at jo større dækningsgraden er, des større bliver den ydelsesmæssige fordel ved vakuumrørsolfangeren. Det ses også at arealforholdet for samme dækningsgrad vil være større for små solvarmeanlæg end for store solvarmeanlæg.

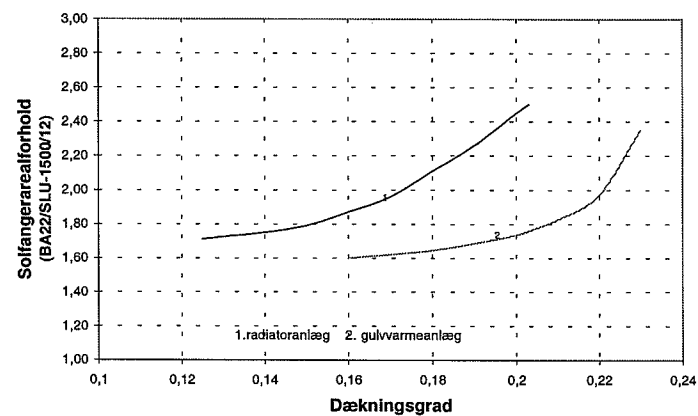
Figur 63 viser som funktion af den årlige dækningsgrad forholdet mellem solfangerarealet for BA22 solfangeren og solfangerarealet for SLU-1500/12 solfangeren som resulterer i samme årlige ydelse for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning, både for et hus med gulvvarme og for et hus med radiatorer. Jo større dækningsgraden er, des større bliver arealforholdet. Arealforholdet er større for huse med radiatorer end for huse med gulvvarme. Den ydelsesmæssige fordel ved vakuumrørsolfangeren er altså størst for solvarmeanlæg med høje dækningsgrader og i huse med radiatorer.



Figur 61. Solfangerarealforholdet mellem BA22 og SLU-1500/12 som resulterer i samme årlige ydelse for små solvarmeanlæg til brugsvandsopvarmning som funktion af den årlige dækningsgrad for solvarmeanlægget.

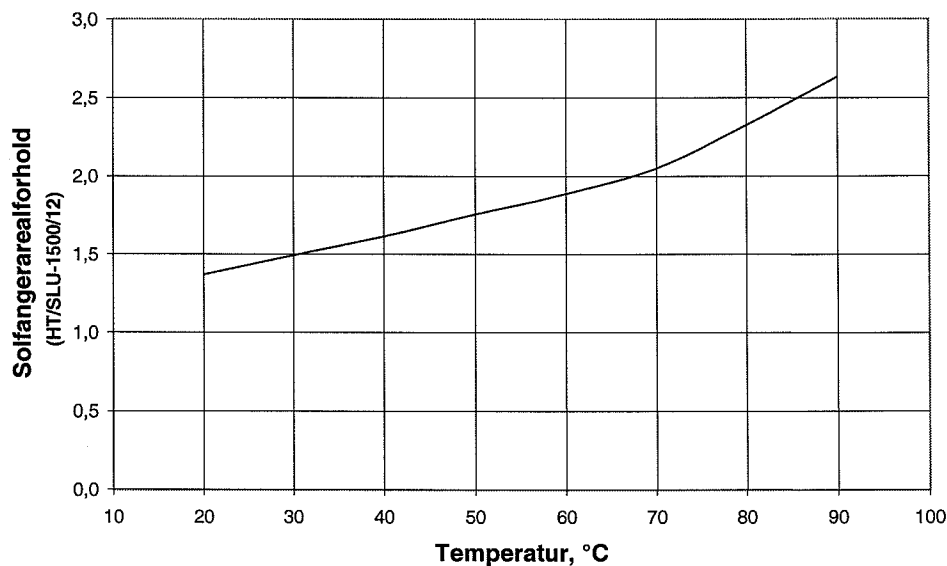


Figur 62. Solfangerarealforholdet mellem BA22 og SLU-1500/12 som resulterer i samme årlige ydelse for store solvarmeanlæg til brugsvandsopvarmning som funktion af den årlige dækningsgrad for solvarmeanlægget.



Figur 63. Solfangerarealforholdet mellem BA22 og SLU-1500/12 som resulterer i samme årlige ydelse for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning som funktion af den årlige dækningsgrad for solvarmeanlægget og varmeafgivelsessystemet.

Figur 64 viser forholdet mellem solfangerarealet for HT solfangeren og solfangerarealet for SLU-1500/12 solfangeren som resulterer i samme årlige solfangerydelse for en solvarmecentral som funktion af solfangervæsketemperaturen, som altid holdes konstant. Jo højere solfangervæsketemperaturen er, des større bliver arealforholdet. Den ydelsesmæssige fordel ved vakuumrørsolfangeren er altså størst når solfangervæsketemperaturen er høj. Det skal bemærkes at SLU-1500/12 solfangeren ikke er beregnet til solvarmecentraler. Der er derfor gode muligheder for at forbedre SLU-solfangerudformningen så den bliver specielt velegnet til solvarmecentraler.



Figur 64. Solfangerarealforholdet mellem HT og SLU-1500/12 som resulterer i samme årlige solfangerydelse for en solvarmecentral som funktion af solfangervæsketemperaturen.

Kan pris/ydelses-forholdet for solvarmeanlæg forbedres ved at benytte vakuumrørsolfangere? Spørgsmålet kan besvares ved hjælp af Figurerne 61-64 og priserne for SLU-1500/12 solfangeren og for almindelige plane solfangere. Med priserne anført i Tabel 1 synes der specielt at være mulighed for at forbedre pris/ydelses-forholdet for solvarmecentraler med høje driftstemperaturer hvis SLU-solfangeren videreudvikles så den bliver velegnet til solvarmecentraler. For de øvrige anlægstyper tyder det på at mulighederne er begrænsede så længe dækningsgraden ikke er usædvanlig høj. Det skal dog bemærkes at vakuumrørsolfangerne i Kina sælges til langt lavere priser end angivet i Tabel 1, at priserne fra Tabel 1 er eksportpriser oplyst af firmaerne i forbindelse med en studietur til Kina, at europæiske importører har gode muligheder for at forhandle priserne ned på et lavere niveau og at der er mange kinesiske firmaer der producerer vakuumrørsolfangere, se appendikset. Potentielle importører af vakuumrørsolfangere kan derfor vurdere om vakuumrørsolfangerne er attraktive til et givet anlæg ved direkte ud fra Figur 61-64 at bestemme hvad prisforholdet mellem vakuumrørsolfangeren og den plane solfanger højst må være for at vakuumrørsolfangeren skal være attraktiv til det pågældende anlæg.

6. Konklusion

Fire forskellige vakuumrørsolfangere produceret af kinesiske firmaer er afprøvet i et lille forsøgsanlæg til brugsvandsopvarmning. Forsøgsanlægget er afprøvet under realistiske betingelser i en prøvestand for solvarmeanlæg på DTU. Ved hjælp af afprøvningsne er der opstillet en simuleringsmodel for hver af de fire solfangere.

Med de opstillede modeller blev der gennemført beregninger af årsydelsen for forskellige solvarmeanlæg: Små og store solvarmeanlæg til brugsvandsopvarmning, solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning og solvarmecentraler. Beregninger blev gennemført med de fire undersøgte vakuumrørsolfangere og med almindelige plane solfangere.

Beregningerne viste at SLU-1500/12 solfangeren, som består af dobbeltglasrør med vakuum imellem rørene og med solfangervæsken cirkulerende gennem U-rør i de inderste glasrør, har en højere ydelse end de øvrige undersøgte vakuumrørsolfangere for alle typer solvarmeanlæg. Da de undersøgte vakuumrørsolfangere næsten har samme pris pr. m² solfanger, må det konkluderes at SLU-1500/12 solfangeren er den mest attraktive af de afprøvede vakuumrørsolfangere.

Undersøgelserne viste desuden at ydelsen af solvarmeanlæg forøges ved at benytte vakuumrørsolfangere i stedet for plane solfangere og at solfangerarealet for et solvarmeanlæg med en bestemt ydelse kan reduceres væsentligt ved at benytte vakuumrørsolfangere i stedet for almindelige plane solfangere. Jo højere dækningsgraden og driftstemperaturen er, des større er den ydelsesmæssige fordel ved vakuumrørsolfangere. De ydelsesmæssige fordele ved vakuumrørsolfangere er specielt store hvis solfangeren ikke kan installeres med en optimal orientering og hældning, dvs. hvis solfangeren ikke vender direkte mod syd og ikke har en solfangerhældning mellem 25° og 65°.

For solvarmeanlæg til brugsvandsopvarmning og for solvarmeanlæg til kombineret rumopvarmning og brugsvandsopvarmning med typiske dækningsgrader kan solfangerarealet reduceres ca. 2-3 gange hvis SLU-1500/12 solfangeren benyttes i stedet for en almindelig plan solfanger.

For solvarmecentraler kan solfangerarealet reduceres til det halve hvis SLU-1500/12 solfangeren benyttes i stedet for HT solfangeren hvis driftstemperaturen er 70°C.

Prisniveauet for de kinesiske vakuumrørsolfangere eksporteret til Europa er forholdsvis højt. Med de angivne eksportpriser er der for normale solvarmeanlæg ikke mulighed for at forbedre pris/ydelses-forholdet ved at benytte vakuumrørsolfangere i stedet for almindelige plane solfangere med mindre solvarmeanlæggets dækningsgrad er usædvanlig høj.

For solvarmecentraler kan der i afhængighed af driftstemperaturen opnås fordele ved at anvende vakuumrørsolfangere. Solvarmecentraler opbygges typisk med rækker af seriekoblede solfangere. Driftstemperaturen i starten af rækkerne er typisk lav, mens temperaturen i slutningen af rækkerne er høj. Der kan opnås fordel ved at anvende laveffektive billige plane solfangere i den første del af rækkerne og højeffektive

dyrere vakuumrørsolfangere i den sidste del af rækkerne. Desuden kan vakuumrørsolfangere i modsætning til de plane solfangere foruden strålingen forfra også udnytte den stråling som kommer bagfra. Det kan fx dreje sig om reflekteret stråling fra den bagved beliggende solfangerrække.

Der er dog behov for at videreudvikle vakuumrørsolfangerne før de kan benyttes i solvarmecentraler, idet de ikke i deres nuværende udformning er beregnet til solvarmecentraler som beskrevet ovenfor.

Det skal til slut nævnes at der er mange kinesiske producenter af vakuumrørsolfangere, og at prisniveauet for vakuumrørsolfangere solgt i Kina er meget lavt. Det er derfor ikke utænkeligt at priserne for eksporterede kinesiske vakuumrørsolfangere kan presses så langt ned at de kan blive attraktive i flere typer anlæg.

Referencer:

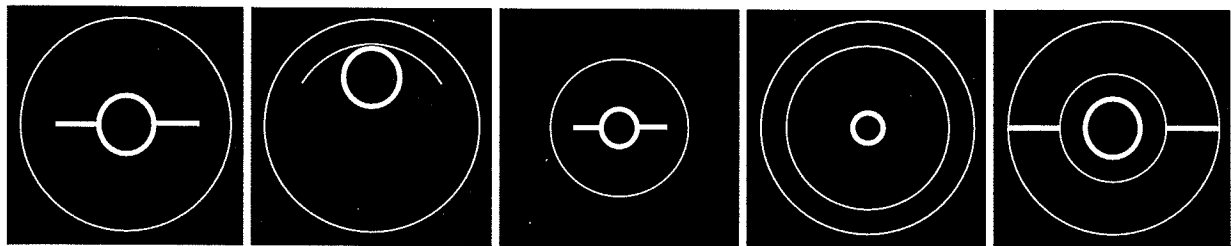
- [1]. He, Z.N. og Ge, H.C. (1997), *A comparison of optical performance between evacuated collector tubes with flat and semicylindric absorbers*, Solar Energy Vol. 60, No. 2, pp109-117.
- [2]. S. Furbo og L.J. Shah, *Laboratory tests of small SDHW systems*, North Sun'97 Proceedings, June 1997, Finland.
- [3]. SPF-Info, thermische Sonnenenergie 1998, SPF Solartechnik Prüfung Forschung, Ingenieurschule ITR, CD-ROM.
- [4]. Theunissen, P-H og Beckman, W.A., *Solar transmittance characteristics of evacuated tubular collector with diffuse back reflector*, Solar Energy, Vol. 35, No. 4 (1985), pp 311-320
- [5]. Furbo, S., *Varmelagring til solvarmeanlæg*, rapport nr. 162, (Sept. 1984), Laboratoriet for Varmeisolering, Danmarks Tekniske Universitet.
- [6]. Berg, P., *Højtydende solvarmeanlæg med små volumenstrømme*, Teoretiske undersøgelser. Rapport nr. 209, Laboratoriet for Varmeisolering, Danmarks Tekniske Universitet, Marts 1990.
- [7]. Andersen E. *Afprøvning af solvarmeanlæg til brugsvands-opvarmning for Solahart Scandinavia ApS*, rapport nr. SR-9726, Institut for Bygninger og Energi, Danmarks Tekniske Universitet.
- [8]. S.A.Klein, W.A.Beckman, *TRNSYS a transient system simulation program*, Solar Energy Laboratory, University of Wisconsin—Madison, July 1996.

Kinesiske firmaer der markedsfører vakuumrørsolfangere:

Firma	Adresse	Tlf./fax	Produkttype
Beijing Sunda Technology Co.	3 Huayuan Road, Haidian District, Beijing 100083, KINA	Tlf.: +86 10 62028646 Fax: +86 10 62374906	SEIDO 1-8 SEIDO 2-8 SEIDO 5-8
Tsinghua Solar Co.	Tsinghua University, Beijing 100084, KINA	Tlf.: +86 10 62780196 Fax: +86 10 62780198	SLU-1500/12 SLU-1200/12 SLL-1500/24(50) SLL-1200/24(50)
Beijing Tian-Pu Solar Energy Industry Co.	Daxing Lucheng Industry Zone Beijing 102600, KINA	Tlf.: +86 10 68222207 Fax: +86 10 69239666	Alle produkter baseret på dobbelt glastrør som SLL- og SLU-produkter.
Beijing TurboSun Technology Development Co.	No.8 East Huayuan Road, Haidian District, Beijing 100083, KINA	Tlf.: +86 10 62053580 Fax: +86 10 62047504	som SLL-solfangere
Xin-Ao Solar Energy Development LTD.	Xin-Ao solar Energy Development LTD. Huaxiang road, LangFang Economic & Technical development Zone, Hebei, KINA	Tlf.: +86 316 6089999-245 Fax: +86 316 6080999	som SLL-solfangere
Shandong Huangming solar energy group	North Hubing road, De Zhou 253023, Shandong KINA	Tlf.: +86 534 2340033 Fax: +86 534 2321808	som SLL-solfangere
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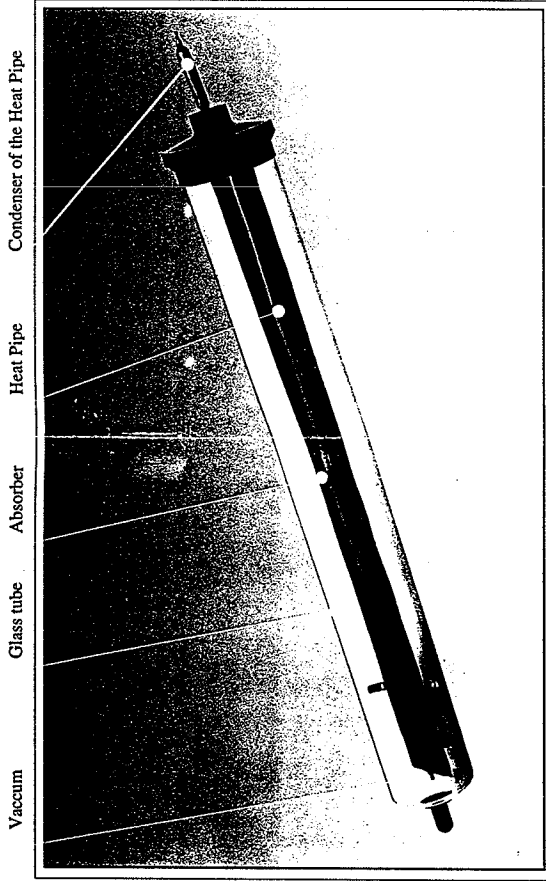
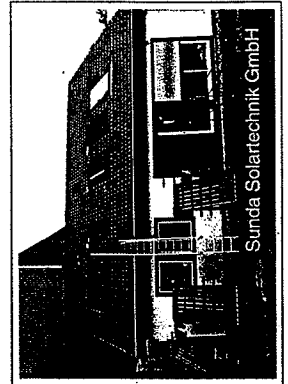
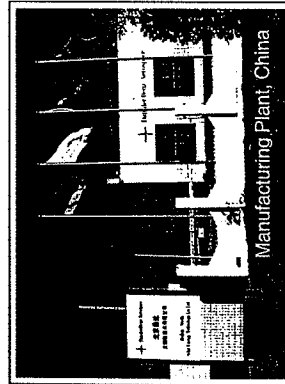
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www.beijingsunda.com.cn

Introduction

The Sino-German Joint Venture Sunda Solar Energy Technology Co. Ltd., was founded in 1995 by Daimler-Benz Aerospace AG and Beijing Sunpu Technical Co.. Both companies have a long-standing experience in the field of solar collectors and since 1985 jointly researched and developed the vacuum tube solar collector technology. This research and development work was supported by the German and the Chinese governments, the United Nations Development Program and Beijing Solar Energy Research Institute.

Sunda today manufactures a wide range of different vacuum tubes to serve the individual customer requirements. In 1996 Sunda opened a new enlarged manufacturing facility and established an overseas subsidiary company in Germany.



Responsibility and life

Using a high-tech vacuum tube solar collector covers the major part of the heat demand in your personal environment. The active use of solar energy does not only contribute to saving money, but also helps to conserve the Earth, since the substitution of fossil energy sources reduces the generation of harmful substances and carbon dioxide affecting the climatic equilibrium.

Sunda solar collectors are being proven efficient and reliable over a long lifetime. For the worldwide applications of solar collectors in the heating system, solar air-conditioning plants, solar powered process heat, desalination plants and other applications, the economic advantages go hand in hand with the sense of responsibility for the environment and future generation.

Technology

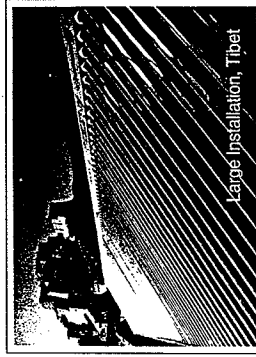
The vacuum tube solar collector with heat pipe is a breakthrough in solar technology. To achieve the highest efficiency the absorber is sputtered with an aluminium nitride selective coating, which transforms over 92 % of the incoming solar radiation into heat. The heat pipe transfers the heat into the heating circuit via a copper condenser. In order to prevent any heat loss the absorber and the heat pipe are mounted in a highly stable vacuum glass tube, which ensures a good insulation and protection in the long term against corrosion and other environmental influences.

The collector therefore combines a high efficiency of the absorber with the advantages of durability and a long lifetime. It is easy to install and guarantees optimal service, comfort and reliability.

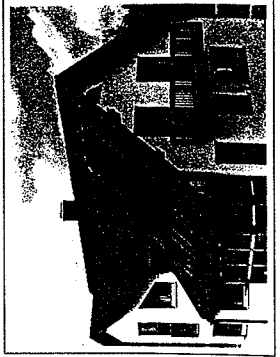
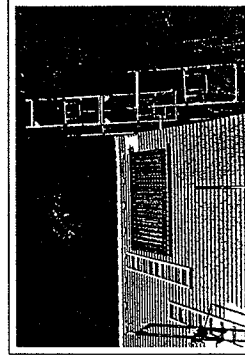
The product variations - heat pipe, direct flow, and storage type - help to find the best solution for the individual customer application. This is important for the engineering of large systems - also integrated into the building facade - as well as for the individual household.

All products are inspected and certified according to the German Industry Standard DIN 4757.

Our Research and Development team guarantees a regular progress in product technology and application.

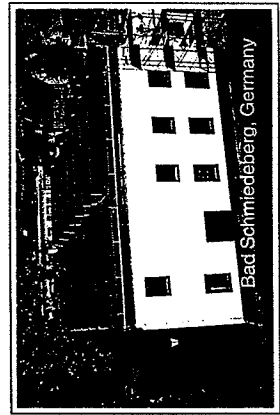


Large Installation, Tibet



Customer Service

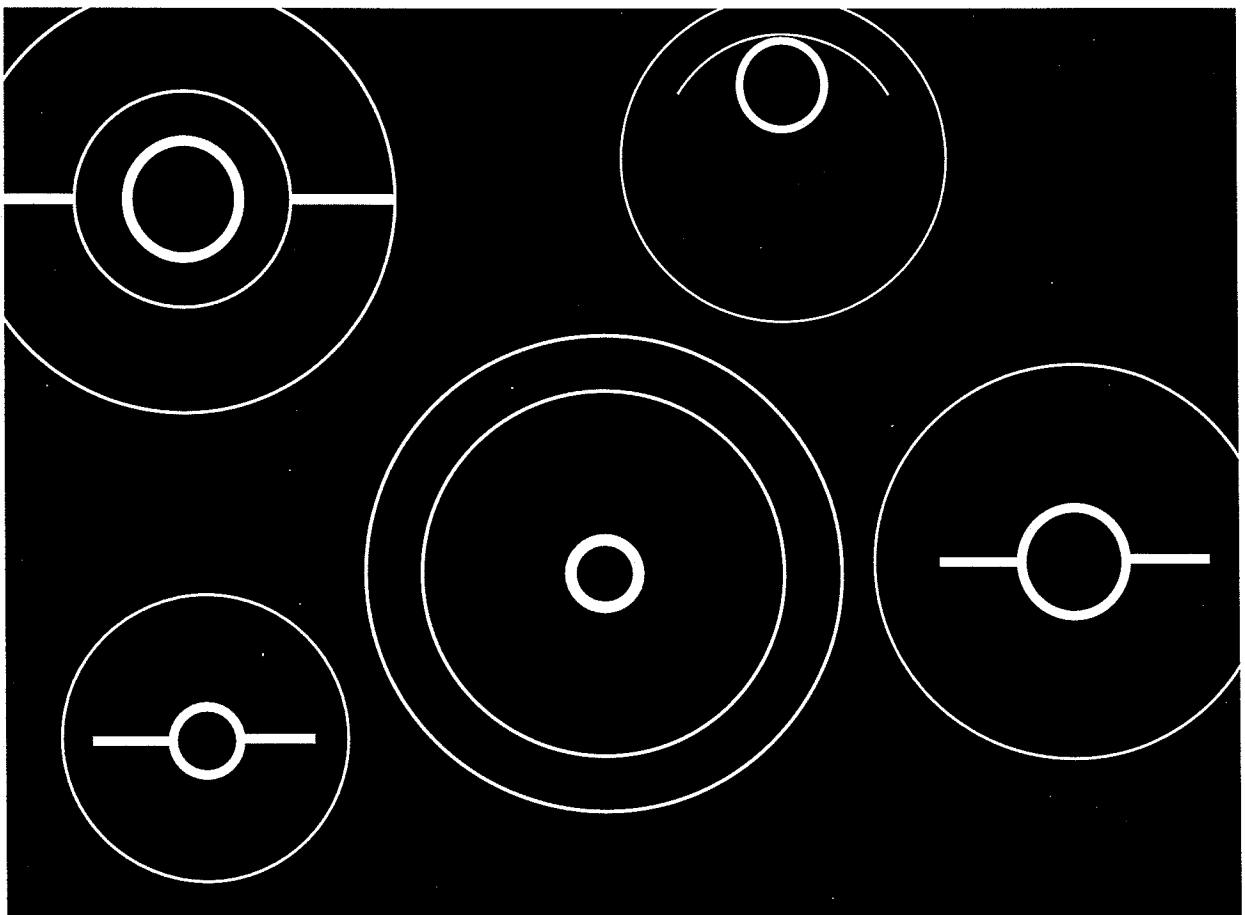
Sunda has well established experience out of numerous projects in order to give qualified support in planning, supervision and all technical questions. It is our objective to ensure a high level of customer satisfaction with our products, technology and service. We are happy to assist you in the planning, layout and calculation of the solar collector system designed according to the individual customer requirements.



Bad Schmiedeberg, Germany

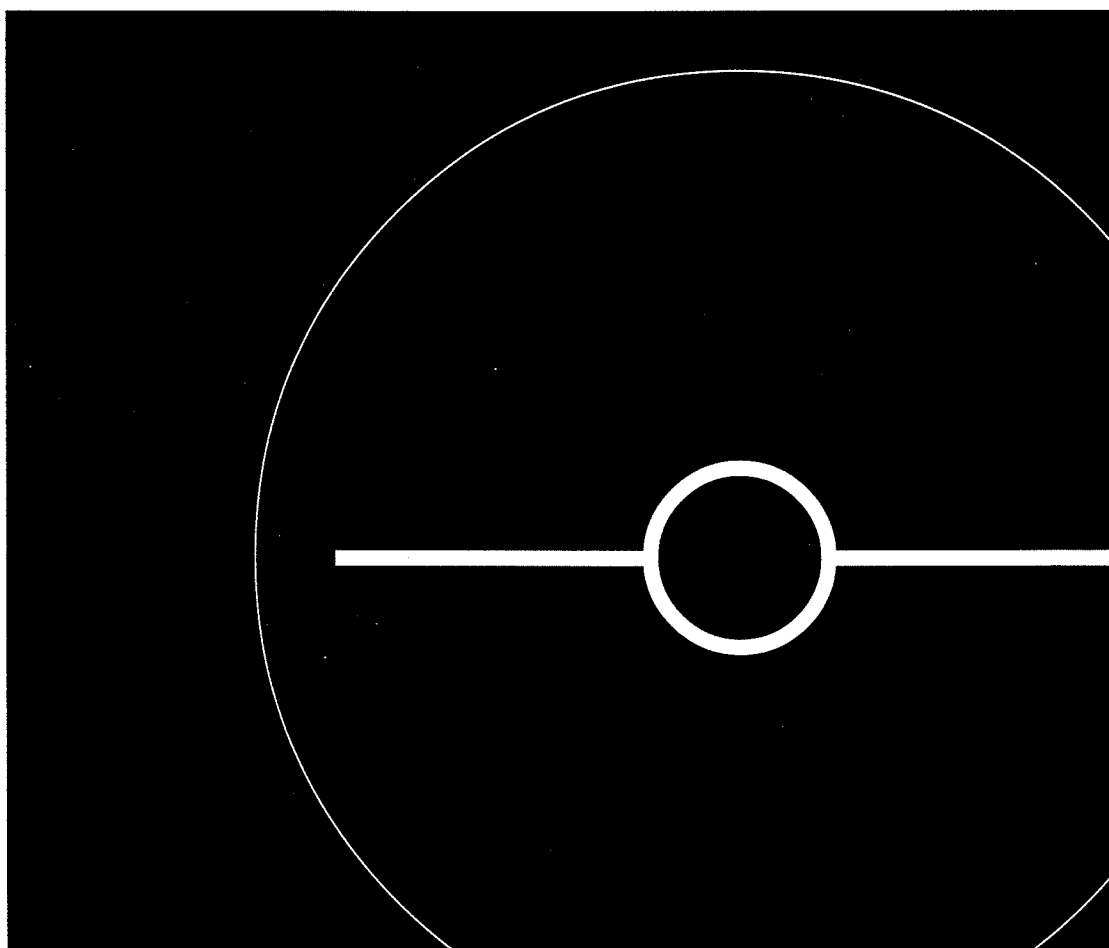
Beijing Sunda Solar Energy Technology Co. Ltd.

北京桑达太阳能技术有限公司



Product Sheet – Solar Collectors

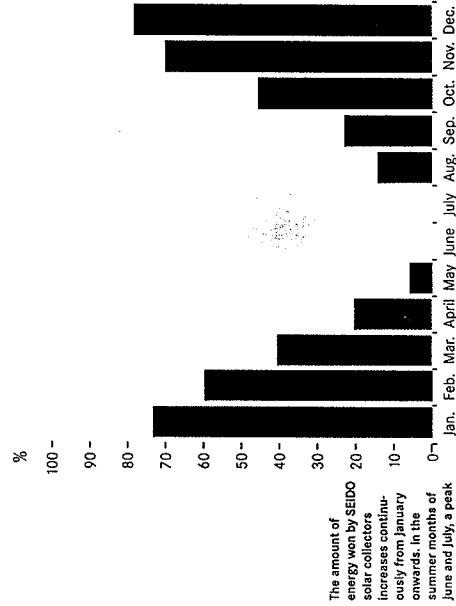
SEIDO ❶



Energy technology with convincing results

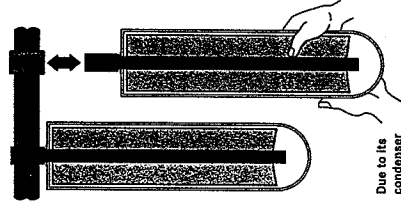
1

The sun provides us with an inexhaustible potential for energy which today can be usefully exploited by means of high technology. SEIDO solar collectors have been specially designed for the supply of hot water. They can obtain up to 70 per cent of the energy required for this purpose over one year. During the summer, they can practically cover 100% of the daily requirements and they still make an important contribution even in the relatively sunless months of winter. Given a correspondingly intense level of solar radiation, SEIDO solar collectors can cover a large part of our hot



SEIDO

2 A new type of solar collector



Due to its condenser plug-in system the vacuum glass tube of the SEIDO 1 solar collector is rotatable. This means the absorber can manually be directed towards the optimum position to the sun and maximum thermal energy is obtained.

The heart of the SEIDO solar collector is an aluminium nitride absorber plate. With its selective coating, the absorber transforms over 92 per cent of incoming solar radiation into heat. A 'heat pipe' transfers the heat and feeds this into the heating circuit via a copper condenser. The collector pipes and the heating circuit are separated from one another by means of dry connection. This means that individual pipes can easily be replaced at any time whenever necessary—without interrupting the operation of the system. In order to prevent the heat loss which usually occurs in solar collectors due to the circulation of air, the absorber and heat pipe are mounted in a highly stable vacuum glass tube. This stops energy from being lost due to air circulation and protects the absorber plate and heat pipe in the long term against corrosion or other environmental influences.

4 A concept to meet your own personal requirements

SEIDO solar collectors can be installed without difficulty on any kind of roof. There is enough room for them even on the smallest available area. Around three square metres are sufficient to cover about 70 per cent of the hot water needs of a household of four persons.

For the operation of larger systems too, such as industrial, hotel or sports facilities, SEIDO solar collectors are eminently suitable. With their enormous efficiency, they can provide enough energy

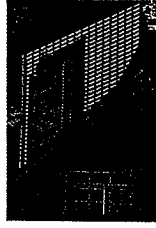
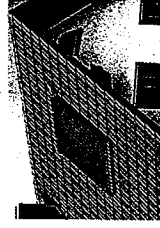
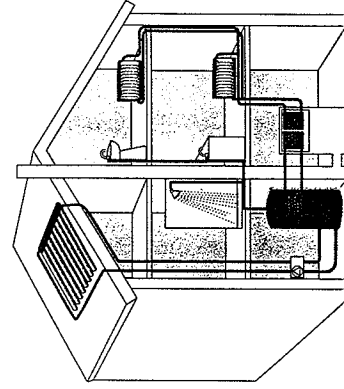
to meet even high demands for hot water. Individual planning is of decisive importance for the dimensioning and layout of the solar energy system. That is why factors such as climatic data, energy consumption and roof orientation and inclination are analysed and evaluated in specially developed computer programs. Thus SEIDO solar energy systems always fulfil specific requirements and guarantee optimal service, comfort and reliability.

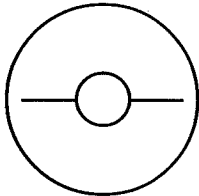
3 A circuit and a system

3

A self-contained heating circuit transports the heat from the collector to the inhouse hot-water storage tank (approx. 300 l). There the heat is passed on to the inhouse hot-water storage tank by a heat exchanger and the water for domestic use is heated. When the heat supplied by the collector is not sufficient to attain the desired temperature, a conventional heating system takes over and completes the heating process.

An electronic control unit constantly checks whether the temperature at the collector opening is greater than the temperature in the inhouse hot-water storage tank. In this case, the control unit switches on the heating circuit.





Technical data

Model type	SEIDO 1-8	SEIDO 1-16
Construction Certificate	Vacuum tube collector with heat pipe DIN 4757	
Number of collector pipes	8	16
Absorber surface	1.4 m ²	2.8 m ²
Length x width x height (mm)	2110 x 960 x 125	2110 x 1920 x 125
Weight	50 kg	100 kg
Pressure drop per module at 100 l/h	5 mbar	10 mbar
Fluid content	0.48 l	0.96 l
Glass material	High-quality borosilicate glass	
Glass tube diameter	100 mm	100 mm
Wall thickness	2.5 mm	2.5 mm
High vacuum, long-term stability	< 10 ⁻⁵ mbar	< 10 ⁻⁵ mbar
Absorber material	Aluminium Aluminium Nitride	
Coating		
Absorption coefficient	> 92 %	> 92 %
Emission coefficient	< 8 %	< 8 %
Angle of inclination	15 to 90 degrees	15 to 90 degrees
Test pressure	10 bar	10 bar
Permissible operating pressure	6 bar	6 bar
Max. temperature, } module	190° C	190° C
non-operating mode } pipe	247° C	247° C
Connection	Clamping ring	

Under normal circumstances: 1 m² collector surface per 100 l
water capacity or 0.7 m² per person

Consulting for planning of large-scale installation on request

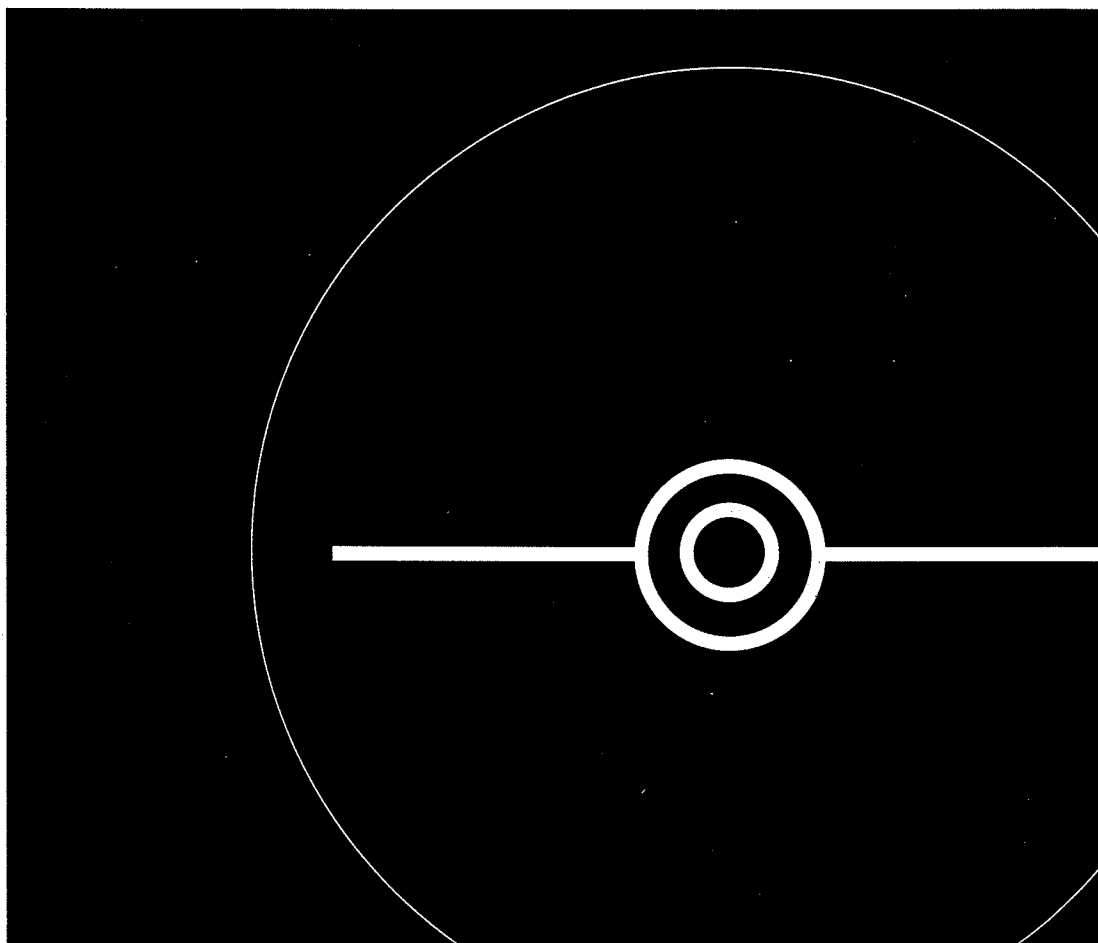
Sunda Solartechnik GmbH
An der Bundesstraße 31
88090 Immenstaad
Telefon: 0 75 45 - 8 34 83
Fax: 0 75 45 - 8 29 25

A Daimler-Benz Aerospace
Company

Retailer address

Product Sheet – Solar Collectors

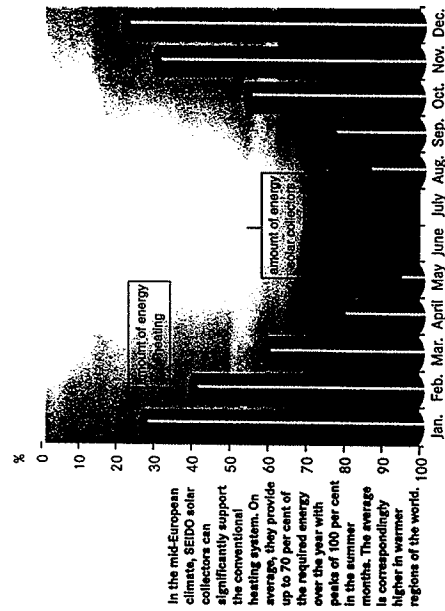
SEIDO ②



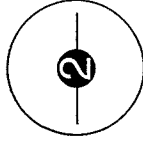
Energy technology with convincing results

1

The sun provides us with an inexhaustible potential for energy which today can be usefully exploited by means of technology. SEIDO solar collectors have been specially designed for the preparation of hot water. In the mid-European climate they can obtain on average up to 70 per cent of the energy required for this purpose over a year. During the summer, they can cover practically 100 per cent of our requirements and they make an important contribution even in the relatively sunless months of winter.

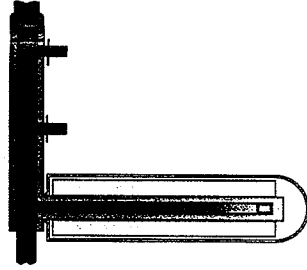


Given a correspondingly intense level of solar radiation, SEIDO solar collectors can cover a large part of our hot-water needs—even at temperatures of minus 15 degrees outdoors. These convincing results have been made possible by the use of tried-and-tested technology developed in the aerospace industry.



SEIDO

2 A new type of solar collector



A heat-transfer fluid flows through the SEIDO 2 solar collectors. This fluid flows past the inner surfaces of the absorber, where it picks up thermal energy. The yield of energy is maximised by this direct exchange of heat between the absorber and the transfer fluid.

The heart of the SEIDO solar collector is an aluminium nitride absorber. With its selective coating which is stable in the long term, it transforms over 92 per cent of incoming solar radiation into heat.

The transfer of heat collected by the absorber takes place immediately in the collector pipe. A heat transfer fluid is led directly along the surface of the absorber and is heated up.

This fluid then flows into an isolated heating circuit with high-quality insulation and carries the energy on to the thermal storage tank.

In order to prevent the heat loss which usually occurs in solar collectors due to the circulation of air, the absorber is mounted in a highly stable vacuum glass tube. This stops energy from being lost due to air circulation, and the absorber is protected in the long term against corrosion and other environmental influences.

A concept to meet your own personal requirements

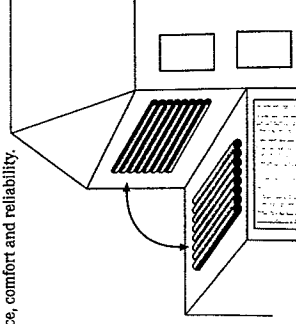
4

SEIDO solar collectors open up new perspectives for a design-oriented, open type of architecture which incorporates the most modern technology with functionality and style. Because of their usable angle of inclination of 0-90 degrees, the collectors can be easily integrated into facades, whether horizontally or vertically. Thus they give residential, hotel, office and industrial buildings and facilities an aesthetically sophisticated appearance.

For high-rise buildings and housing estates too, SEIDO solar collectors provide a high-tech, environmentally friendly solution for hot-water supply. Their enormous capacity means that they can provide sufficient energy,

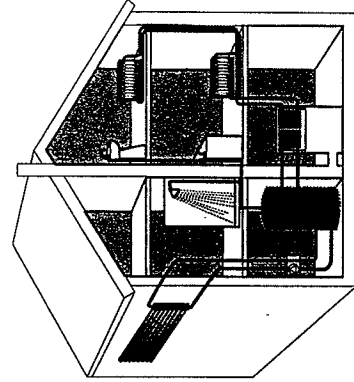
even when hot-water needs are greater than usual. So all it takes is about three square metres to cover around 70 per cent of the yearly hot-water requirements of a household of four persons.

Individual planning is of decisive importance for the dimensioning and laying out of the solar energy system. That is why factors such as data concerning climate, energy consumption, roof orientation and inclination is analysed and evaluated in specially developed computer programmes. Thus SEIDO solar energy systems always fulfil specific requirements and guarantee optimal service, comfort and reliability.



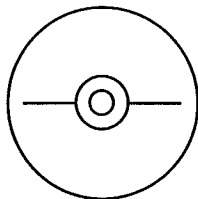
A circuit and a system

3



A self-contained heating circuit which is isolated and highly insulated conveys the heat from the collector to the inhouse hot-water storage tank. There, the heat is passed on to the thermal storage tank by means of a heat exchanger and the water is heated for domestic use. Whenever the heat supplied by the collector is not sufficient to attain the desired temperature, a conventional heating system takes over and completes the heating process. An electronic regulator constantly checks whether the temperature at the collector opening is greater than the temperature in the thermal storage tank. Whenever this is the case, the control unit switches on the heating circuit.

Technical data



Model type	SEIDO 2-4
Construction Certificate	Vacuum tube collector, flow-through DIN 4757 with qualification approval
Number of collector pipes	4
Absorber surface	0.7 m ²
Total surface	1.1 m ²
Length x width x height (mm)	2110 x 490 x 125
Weight	28 kg
Pressure drop per module at 50 l/h	<30 mbar
Fluid content	0.65 l
Glass material	High-quality borosilicate glass
Glass tube diameter	100 mm
Wall thickness	2.5 mm
High vacuum, long-term stability	< 10 ⁻⁵ mbar
Absorber material	Aluminium
Coating	Aluminium nitride
Absorption coefficient	>92%
Emission coefficient	<8%
Angle of inclination	0 to 90 degrees
Max. operating pressure	10 bar
Max. temperature, } module	190 °C
non-operating mode } pipe	247 °C
Connection	Clamping ring

Under normal circumstances: 1 m² collector surface per 100 l
water capacity or 0.7 m² per person

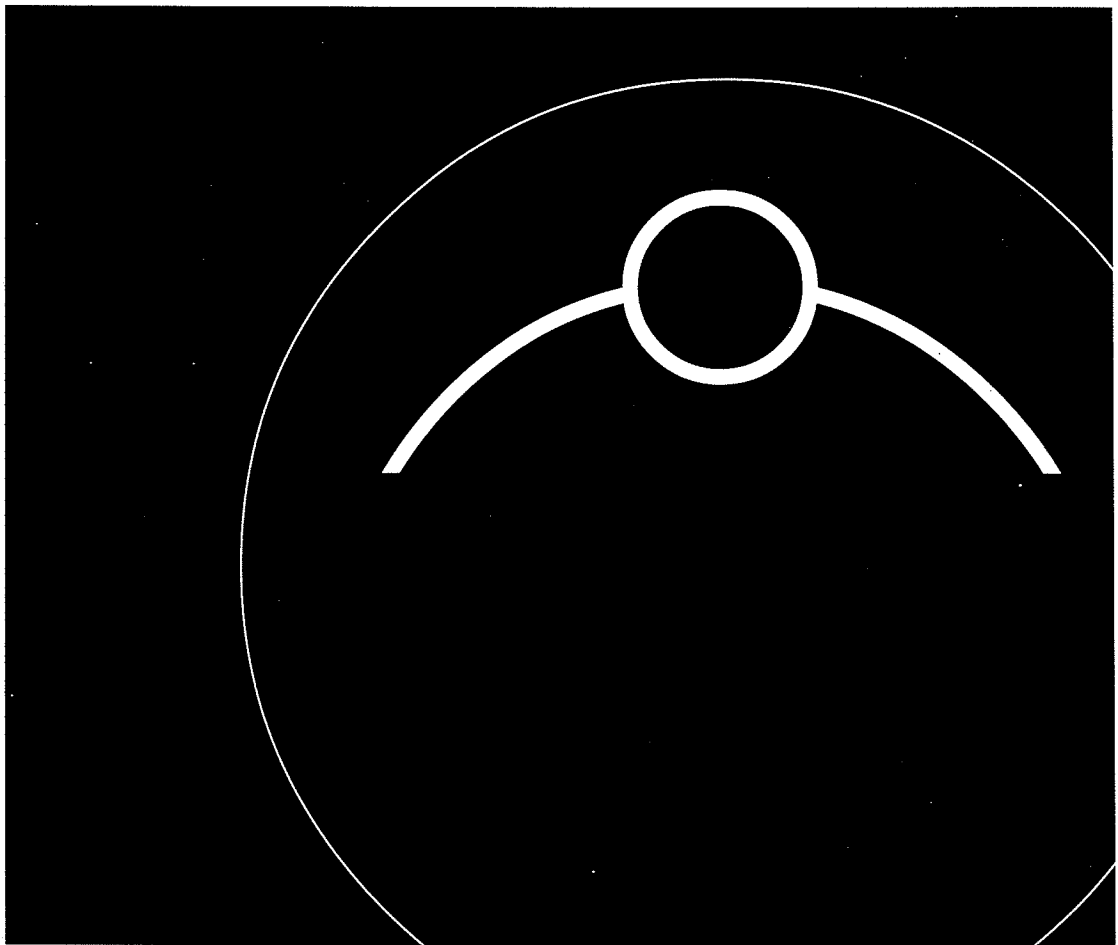
Consulting for planning of large-scale installation on request

Beijing Sunda Solar Energy
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Fax:0086-10-62374906
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Retailer address

Product Sheet – Solar Collectors

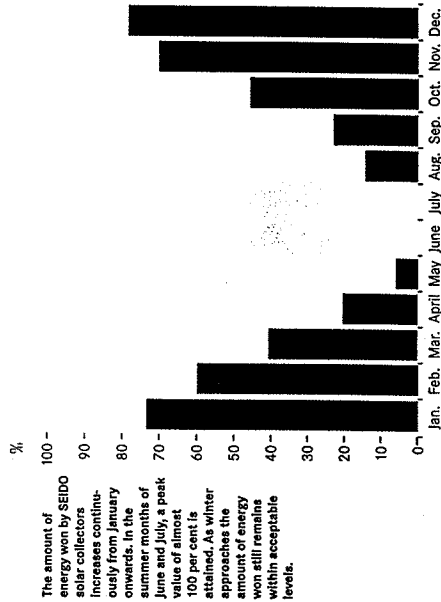
SEIDO 5



Energy technology with convincing results

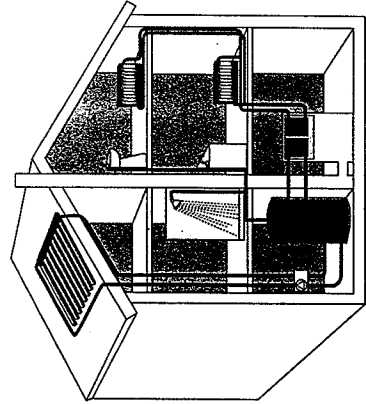
1

The sun provides us with an inexhaustible potential for energy which today can be usefully exploited by means of high technology. SEIDO solar collectors have been specially designed for the supply of hot water. They can obtain up to 70 per cent of the energy required for this purpose over one year. During the summer, they can practically cover 100% of the daily requirements and they still make an important contribution even in the relatively sunless months of winter. Given a correspondingly intense level of solar radiation, SEIDO solar collectors can cover a large part of our hot water needs – even at outdoor temperatures of minus 15 degrees centigrade. The convincing results were accomplished through the use of tried-and-tested technology developed in the aerospace industry.



3 A circuit and a system

A self-contained heating circuit transports the heat from the collector to the inhouse hot-water storage tank (approx. 300 l). There the heat is passed on to the inhouse hot-water storage tank by a heat exchanger and the water for domestic use is heated. When the heat supplied by the collector is not sufficient to attain the desired temperature, a conventional heating system takes over and completes the heating process. An electronic control unit constantly checks whether the temperature at the collector opening is greater than the temperature in the inhouse hot-water storage tank. In this case, the control unit switches on the heating circuit.



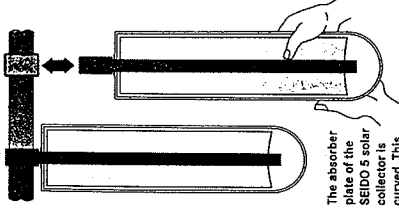
SEIDO



2 A new type of solar collector

The heart of the SEIDO solar collector is an aluminium nitride absorber plate. With its selective coating, the absorber transforms over 92 per cent of incoming solar radiation into heat.

A 'heat pipe' transfers the heat and feeds this into the heating circuit via a copper condenser. The collector pipes and the heating circuit are separated from one another by means of dry connection. This means that individual pipes can easily be replaced at any time whenever necessary – without interrupting the operation of the system. In order to prevent the heat loss which usually occurs in solar collectors due to the circulation of air, the absorber and heat pipe are mounted in a highly stable vacuum glass tube. This stops energy from being lost due to air circulation and protects the absorber plate and heat pipe in the long term against corrosion or other environmental influences.

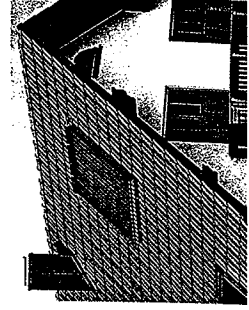
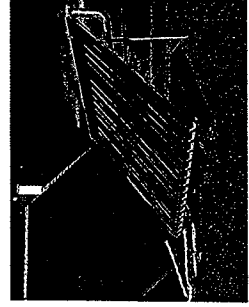


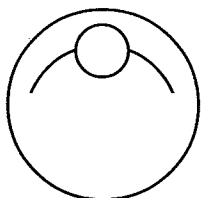
The absorber plate of the SEIDO 5 solar collector is curved. This means the absorber remains highly effective even when the sun is low in the early morning and late afternoon hours, thus guaranteeing a high yield in heat supply throughout the course of the day.

A concept 4

to meet your own personal requirements

SEIDO solar collectors can be installed without difficulty on any kind of roof. There is enough room for them even on the smallest available area. Around three square metres are sufficient to cover about 70 per cent of the hot water needs of a household of four persons. For the operation of larger systems too, such as industrial, hotel or sports facilities, SEIDO solar collectors are eminently suitable. With their enormous efficiency, they can provide enough energy to meet even high demands for hot water. Individual planning is of decisive importance for the dimensioning and layout of the solar energy system. That is why factors such as climatic data, energy consumption and roof orientation and inclination are analysed and evaluated in specially developed computer programmes. Thus SEIDO solar energy systems always fulfil specific requirements and guarantee optimal service, comfort and reliability.





Technical data

Model type	SEIDO 5-8	SEIDO 5-16
Construction Certificate	Vacuum tube collector with heat pipe DIN 4757	
Number of collector pipes	8	16
Absorber surface	1.8 m ²	3.6 m ²
Length x width x height (mm)	2110 x 960 x 125	2110 x 1920 x 125
Weight	50 kg	100 kg
Pressure drop per module at 100 l/h	5 mbar	10 mbar
Fluid content	0.48 l	0.96 l
Glass material	High-quality borosilicate glass	
Glass tube diameter	100 mm	100 mm
Wall thickness	2.5 mm	2.5 mm
High vacuum, long-term stability	< 10 ⁻⁵ mbar	< 10 ⁻⁵ mbar
Absorber material	Aluminium	
Coating	Aluminium Nitride	
Absorption coefficient	> 92 %	> 92 %
Emission coefficient	< 8 %	< 8 %
Angle of inclination	25 to 90 degrees	25 to 90 degrees
Test pressure	10 bar	10 bar
Permissible operating pressure	6 bar	6 bar
Max. temperature, } module	190° C	190° C
non-operating mode } pipe	247° C	247° C
Connection	Clamping ring	

Under normal circumstances: 1 m² collector surface per 100 l
water capacity or 0.7 m² per person

Consulting for planning of large-scale installation on request

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88090 Immenstaad
Telefon: 075 45 - 8 34 83
Fax: 075 45 - 8 29 25

Retailer address

ADVANTAGES OF SUNDA'S EVACUATED TUBE TECHNOLOGY

- 1) A high efficiency selective coating for the absorber and the high vacuum technology raise the efficiency of the SUNDA tubes far above the efficiency of other technologies. Thus much higher temperatures than with flat collectors can be achieved. At locations with high humidity and on partially cloudy days the output temperature is higher than with other technologies.
- 2) The SUNDA tubes can be installed as a closed loop using antifreeze fluid in areas with temperatures far below freezing. The vacuum works as an insulation.
- 3) In order to avoid energy loss by heat transmission, the absorber is mounted in an evacuated glass tube. The stable ultra high vacuum makes sure that the absorber even works at very low ambient temperatures. The vacuum prevents the absorber material from corrosion. This ensures a lifetime of at least 15 years without loss of efficiency.
- 4) SEIDO 1 and SEIDO 5 have a dry connection to the heat circuit. Water does not flow into the tube. Clogging is being avoided.
- 5) Compared to other technologies the SUNDA tubes reach the desired temperature earlier within a day. Under good conditions hot water can be provided twice a day.
- 6) SEIDO 2 can be integrated into facades horizontally or vertically. This gives new perspectives for a design-orientated architecture which incorporates the most modern technology with functionality and style.
- 7) SEIDO 3 with their integrated hot-water storage system requires no external space-consuming water storage tank. They are eminently suitable for small setting spaces and decentral or even mobile installations.
- 8) The tubes can bear high pressure. Large projects for high temperatures can be realized.
- 9) The collectors have a small wind resistance. They resist storms.
- 10) The collectors are easy to install and reliable.

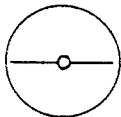
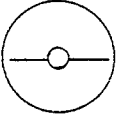
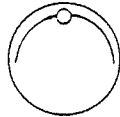
APPLICATIONS FOR SEIDO SOLAR COLLECTORS

SEIDO Solar Collectors can efficiently be used anywhere where hot water is needed and solar radiation is sufficient. The following list gives some ideas about the vast range of possible applications.

- Sanitary water
- Basic heating
- Pool heating
- Air-conditioning
- Refrigerating
- Icemaking
- Desalination
- Sterilization
- Sauna and steambath
- Pumping
- Keeping objects like tunnels or runways free of ice
- Car washes
- Garages
- Industrial Process Heat
- Sportsgrounds, stadiums and gymnasiums
- Mountain and Skiing Lodges

Beijing Sunda Solar Energy
Technology Co. Ltd.

Vacuum Tube Description

Item Specification	SEIDO 1	SEIDO 2	SEIDO 5
Type	Heat-pipe vacuum tube with flat absorber	Direct-flow vacuum tube	Heat-pipe vacuum tube with bent absorber
Configuration			
Characteristics	* resistance to freezing * small thermal capacity * thermal diode effect * continuing system operation if one broken	* high efficiency * less manufacturing * can be placed in horizontal	* resistance to freezing * small thermal capacity * thermal diode effect * continuing system operation if one broken * more solar irradiation over a day
Absorber area	0.175 m ²	0.175 m ²	0.229 m ²
Weight	4.6 kg	4.6 kg	4.7 kg
Size	Φ 100 mm × 2000 mm		
Absorber material	Copper - Aluminium		
Selective coating	Absorptivity: $\alpha \geq 0.92$ Emission coefficient: $\varepsilon \leq 0.08$		
Glass tube material	High-quality borosilicate glass		
Wall thickness	2.5 mm		
Vacuum	$< 10^{-3}$ Pa		
Min ambient temp.	- 25 °C		
Operating temp.	70 ~ 120 °C		
Stagnation temp.	250 °C		
Resistance to hail	Φ 35 mm		

REFERENCES

Client	Application	Type of Installation	System Cap. [Liters per day]	Install. Area [m ²]	Output Temp. [°C]
China					
Times Trading Company, Beijing	Domestic Water	Inclined Installation	12000	200	50-60
Da Lian Petrochemical, Beijing	Domestic Water	Inclined Installation	9240	154	50-60
Zhou Tian Technology Co., Beijing	Domestic Water	Inclined Installation	5400	90	50-60
Qing He Oil Production Factory, Shan Dong	Domestic Water	Inclined Installation	3600	60	50-60
The Kindergarten of the State Council, Beijing	Domestic Water	Inclined Installation	4080	68	50-60
Phase 1, Xinjiang Dushanzi Petroleum Refinery Plant, Beijing	Domestic Water	Inclined Installation	6840	114	50-60
Phase 2, Xinjiang Dushanzi Petroleum Refinery Plant, Beijing	Domestic Water	Inclined Installation	6000	100	50-60
Beijing Business Management Institute, Beijing	Domestic Water	Inclined Installation	10440	174	50-60
Beijing Apartment for Foreign Students, Beijing	Domestic Water	Inclined Installation	12000	200	50-60
Beidaihe Sanatorium of the Ministry of Railways, Beidaihe	Domestic Water	Inclined Installation	4320	72	50-60
Songshan District Postoffice, Chifeng City	Domestic Water	Inclined Installation	3600	60	50-60
State Earthquake Agency	Domestic Water	Inclined Installation	7840	118	50-60
Hospital of Beijing Post and Telecommunication Technology, Beijing	Domestic Water	Inclined Installation	14400	120	50-60
Chifeng Taxation Bureau, Inner Mongolia	Domestic Water	Inclined Installation	10000	150	50-60
Party Training Center, Zhenzou	Domestic Water	Inclined Installation	3600	60	50-60
Multi-level PCB Ltd., Dalian	Domestic Water	Inclined Installation	2400	40	50-60
Science and Technology Comission, Hebei Province	Domestic Water	Inclined Installation	2400	40	50-60
Microwave Communication Station, Tianshan Mountain, Xinjiang	Room Heating	Inclined Installation	-	20	15-18
Tanzhou, Zhongshan City, Guangdong	Fishpool Heating	Inclined Installation	-	50	28
Chinese Armece	Mobile Showertruck	Inclined Installation	1500	17.5	50-60

Client	Application	Type of Installation	System Cap. [Liters per day]	Install. Area [m ²]	Output Temp. [°C]
Germany					
Clinic Eisenmoorbar, Bad Schmiedeberg	Domestic Water	Inclined Installation	15000	150	50-60
Apartments, Schwaebisch-Gmuend	Domestic Water	Flat on the Roof	10000	100	50-60
Apartments, Bitterfeld	Domestic Water	Inclined Installation	10000	100	50-60
Apartments, Friedrichshafen	Domestic Water	Integrated in the Building's Fascade	10000	100	50-60
Mercedes-Benz, Bielefeld	Domestic Water	Integrated in the Building's Fascade	2000	20	50-60
Mercedes-Benz, Leipzig	Domestic Water	Integrated in the Building's Fascade	2000	20	50-60
Mercedes-Benz, Goettingen	Domestic Water	Flat on the Roof	2000	20	50-60
Mercedes-Benz, Munich	Domestic Water	Flat on the Roof	2000	20	50-60
Police Academie, Muenster	Domestic Water	Flat on the Roof	4000	40	50-60
Munich University, Munich, 9 KW LiBr. 2 stage	Air Conditioning	Flat on the Roof	2000	20	75-95
Golf Club Frankfurt, Frankfurt	Domestic Water	Inclined Installation	4000	40	50-60
Meissner & Wurst factory, Stuttgart	Air conditioning	Inclined Installation	-	400	80-95
Others					
Belroy Hotel, Benidorm, Spain	Air Cond./Heating/Domestic Water	Flat on the Roof	-	82	96 (AC)
Arab Pharmaceutical Industries, Amman, Jordania	Process Heat	Inclined Installation	4000	100	80-110
Bungalow, Austria	Domestic Water and Heating Support	Integrated in the Building's Fascade	1000	16	50-60
Lombok Island, Indonesia	Process Heat for Water Pump	Inclined Installation	-	25	>100
Medical Institute, Australia	Solar Sterilizer	Inclined Installation	-	-	>100
KIER, Korea	Solar Seasonal Storage System	Flat on the roof	-	56	-

Notes:

- 1) This list is just a partial list of references. Many systems are built by our customers and therefore not known to us.
- 2) One squaremeter of installation area has 4 tubes.

Tsinghua Solar Co.

向太阳索取 节约能源 改善环境 造福子孙



北京清华大学太阳能电子厂

TSINGHUA SOLAR CO.

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昆明清华阳光能 源开发有限公司	云南省昆明市(650228) 官渡区福海乡周家	0086-871-4611221	0086-871-4611221



晒乐牌

QB-SLU系列

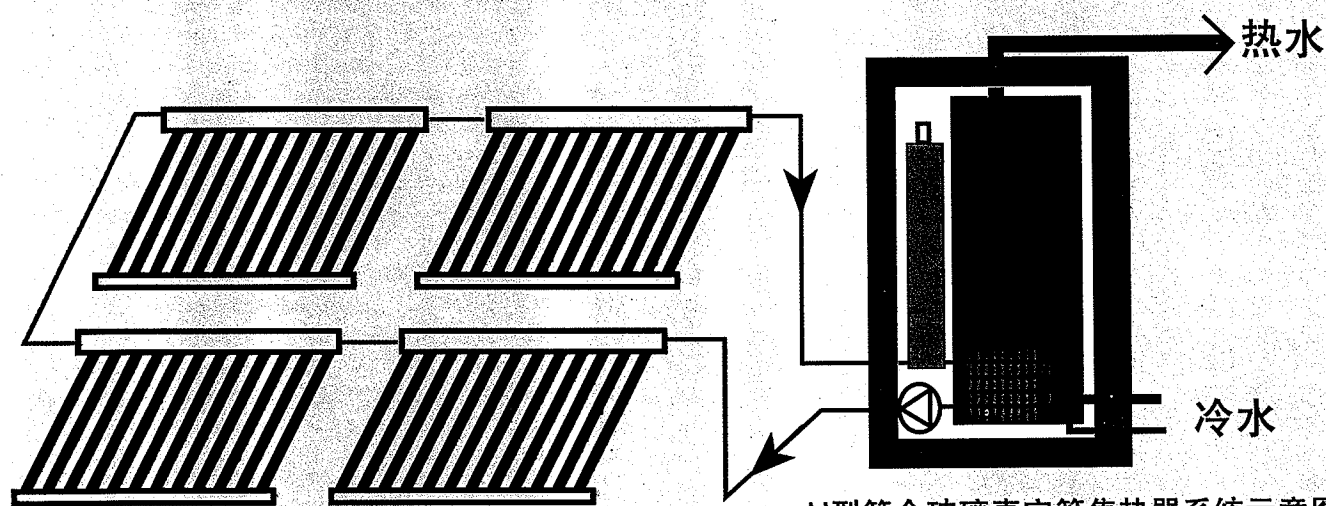
全玻璃真空管U管式
太阳集热器



北京清华大学太阳能电子厂

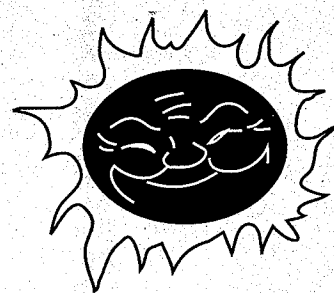
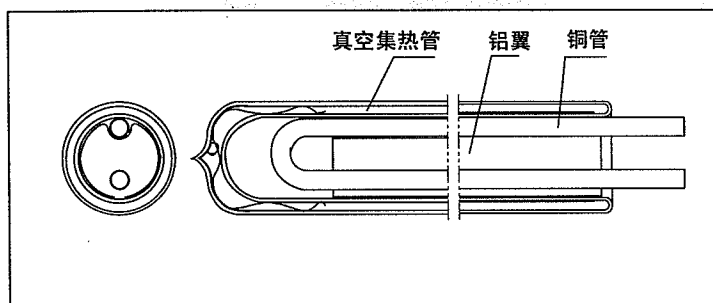
原理

SLU型真空管太阳集热器中的全玻璃真空集热管接收太阳辐射能转变为热能，通过紧靠内管内表面的铝翼传递到U形管内的传热工质，经换热器使储水箱中的水温升高。



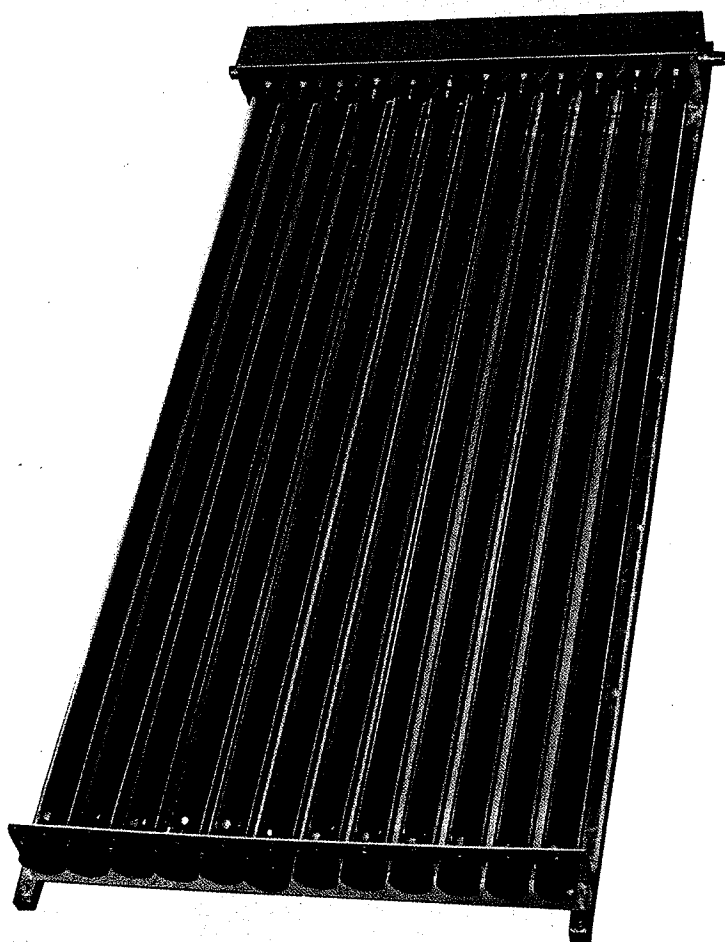
U型管全玻璃真空管集热器系统示意图

结构



特点

1. 采用清华大学专利产品——全玻璃真空太阳集热管集热效率高
2. 工质可采用防冻液，特别适于高寒地区四季使用
3. 系统承压能力高达 $12\text{kg}/\text{cm}^2$
4. 玻璃真空集热管破裂，不影响集热系统运行
5. 可以组成各种大小采光面积的集热系统；集热管放置随意，东西向或南北向；装置间可并联可串联
6. 南北向放置，全日跟踪；东西向放置，四季跟踪
7. 安装简单，维修方便



规格

	QB-SLU-1200/12	QB-SLU-1500/12
长度	1370mm	1670mm
宽度	760mm	760mm
厚度	140mm	140mm
集热面积	0.87m ²	1.09m ²
毛面积	0.94m ²	1.17m ²
重量	25kg	35kg
集热管型号	QB-SL-1200	QB-SL-1500
集热管数量	12	12
U型铜管	Φ8mmx0.75mm	Φ8mmx0.75mm
试验压力	12 bar	12bar
反射器	漫反射平板	漫反射平板
日集热效率	>50%	>50%

效率

集热器瞬时集热效率

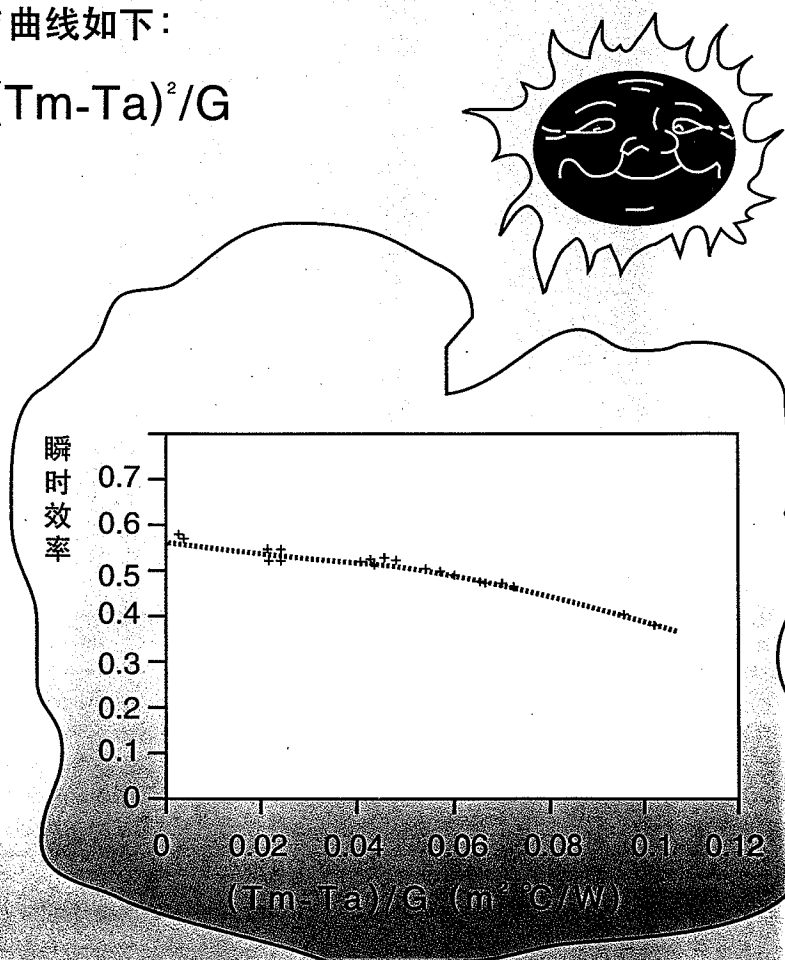
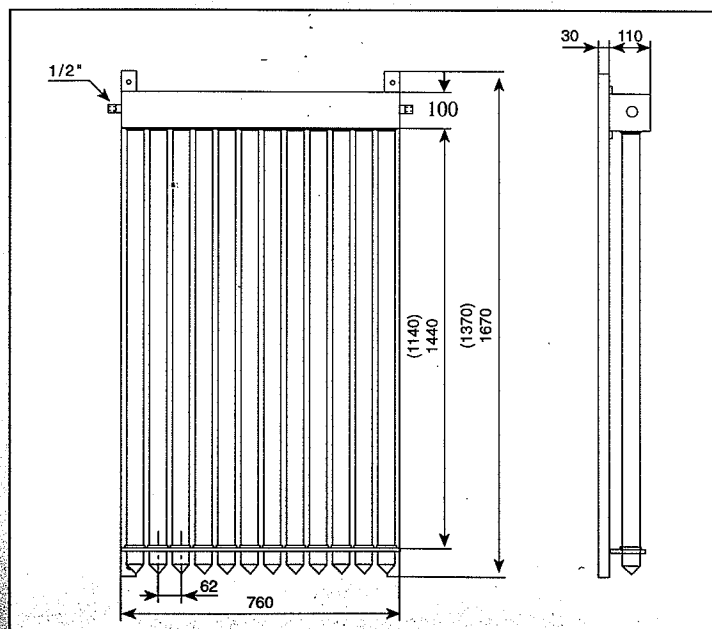
QB-SLU-1200/12型具有铝翼和U形管联集管的全玻璃真空管太阳集热器具有相当高的集热效率和低的热损系数，在国际权威机构瑞士Rapperswil太阳能检测中心检测了瞬时效率，集热器简图、表达式与曲线如下：

$$\eta=0.5608-0.92(T_m-T_a)/G-0.010(T_m-T_a)^2/G$$

其中：G-太阳辐照度

T_m-集热器平均水温

T_a-环境温度



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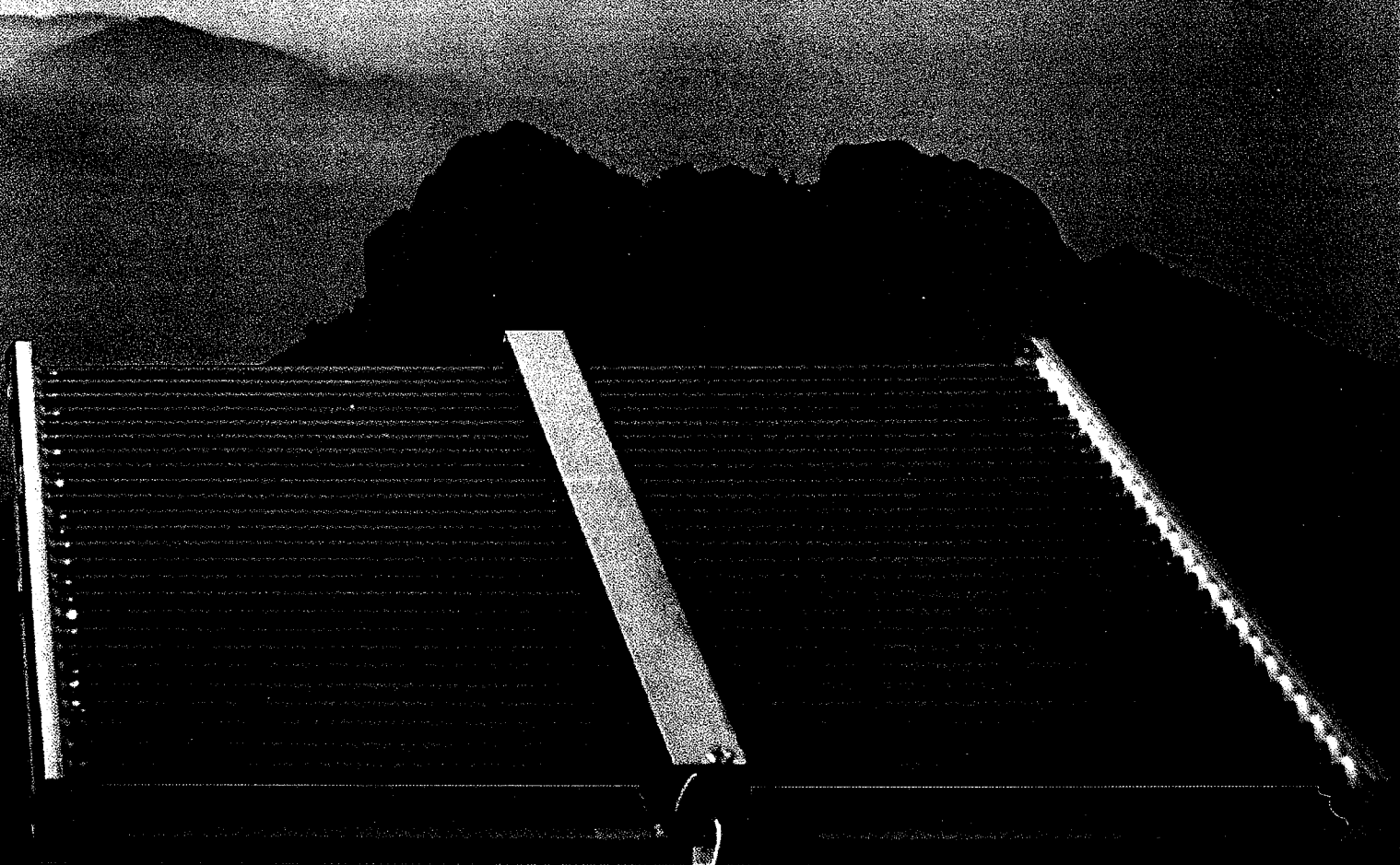
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晒乐牌
SHAILE

QB-SLL SERIES

ALL-GLASS EVACUATED TUBULAR COLLECTORS WITH MANIFOLDS

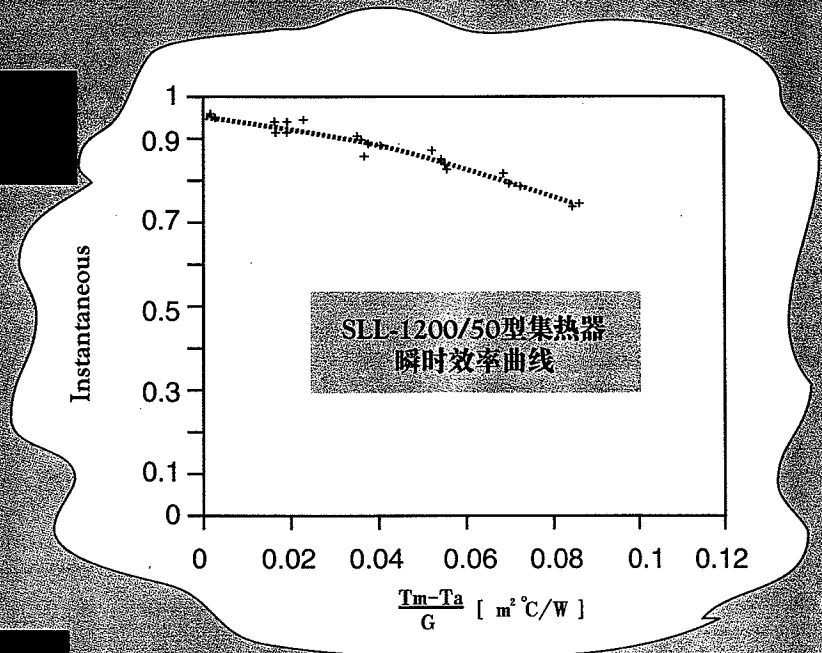


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A novel manifold has been patented No 94218448.3, 96215867.4, 96120414.1

All glass evacuated tubular collectors are installed from tilt angle of 0° in horizontal to 90° in vertical

The product of SLL - 1200 /50 all-glass evacuated tubular collector with water - in - glass manifold has the intercept of instantaneous of 0.9435 leading in the more than 200 testing collectors measured by Solar Energy Testing Centre in Rapperswil, Switzerland



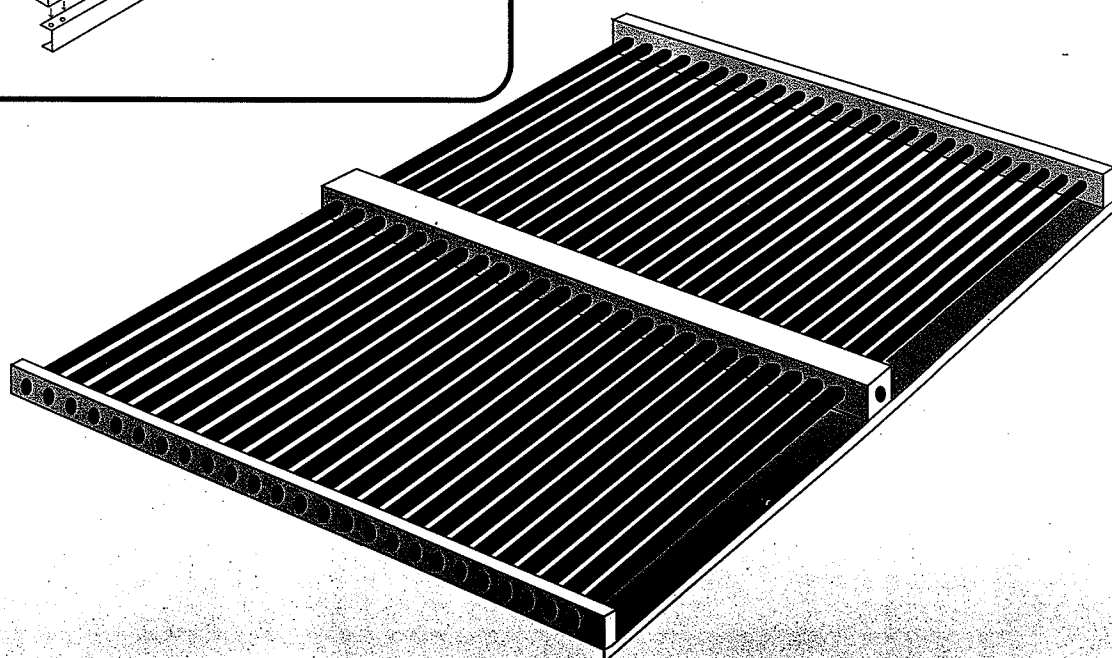
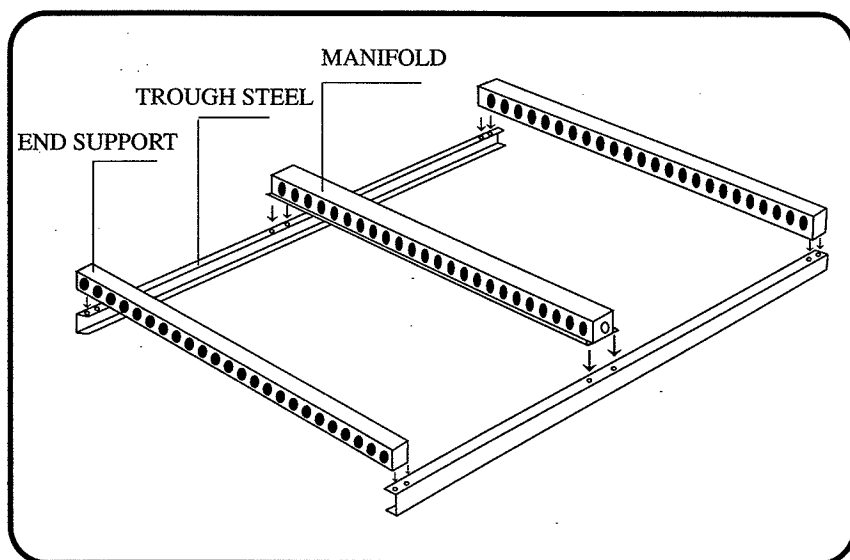
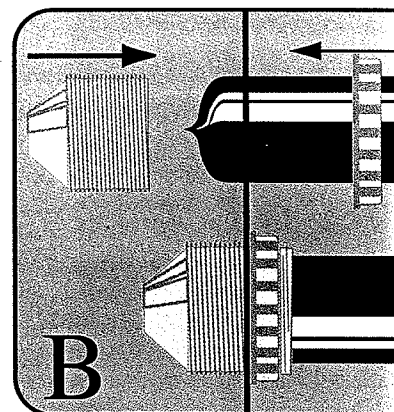
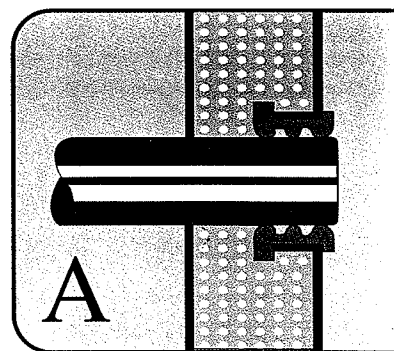
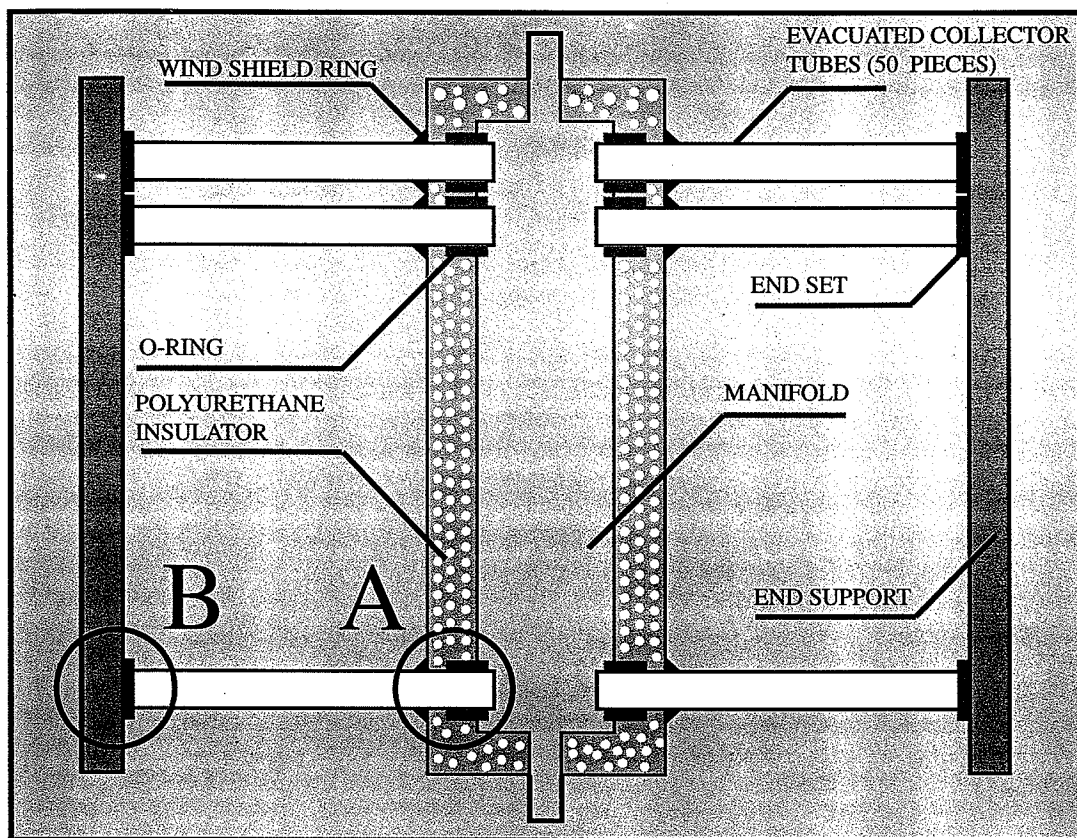
The projecting area of absorber of all-glass evacuated tubular collectors is almost constant due to West - East horizontal orientation of all - glass evacuated collector tubes installed with semi - tracking for four seasons, which can be utilized in equator area

An unique connector between collector tubes and the water -in - glass manifold withstanding 5 bar max. pressure. Multi - semi- O-ring sealing configuration patented No94218450.5, 96216122.5, which is made of silicon rubber, works in the temperature range of - 50 °C to 300 °C

All-glass evacuated tubular collectors with water -in glass manifolds withstanding water pressure of 3 - 5 bar because of manifolds, sealing components, end supports and frame are designed properly. Both thermosiphoning and pumping operation can be used

Various modules of SLL series of collectors can be made up from 2 m² till thousands m² aperture of water systems with multi- function operating as control panel used

Schematic of the installation of all-glass evacuated tubular collectors with water-in-glass manifolds



SPECIFICATION OF QB-SLL COLLECTORS WITH WATER-IN-GLASS MANIFOLDS

TYPE	SLL-1200/24	SLL-1200/50	SLL-1500/24	SLL-1500/50
Aperture (m ²)	2.2	4.5	2.8	5.7
Type of tube	SL-1200	SL-1200	SL-1500	SL-1500
Collector tube (piece)	24	50	24	50
Outer size of manifold (mm)	1000x140x136	2000x140x136	1000x140x136	2000x140x136
Material of manifold	stainless steel	stainless steel	stainless steel	stainless steel
Cover material of manifold	rolling aluminium or stainless steel	rolling aluminium or stainless steel	rolling aluminium or stainless steel	rolling aluminium or stainless steel
Insulation material	polyurethane	polyurethane	polyurethane	polyurethane
O-ring material	silicon rubber	silicon rubber	silicon rubber	silicon rubber
Withstanding pressure (bar)	3.0~5.0	2.5~3.0	3.0~5.0	2.5~3.0

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晒乐牌 QB-SLL 系列

全玻璃真空太阳集热管

ALL-GLASS EVACUATED SOLAR COLLECTOR TUBES



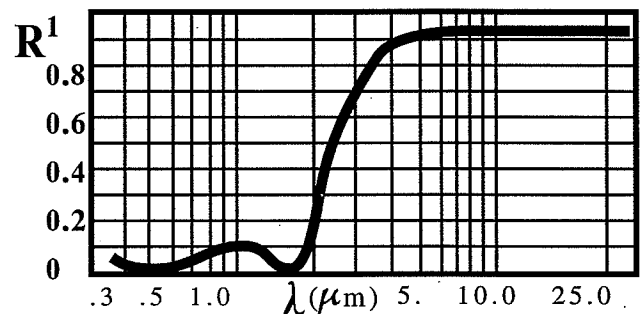
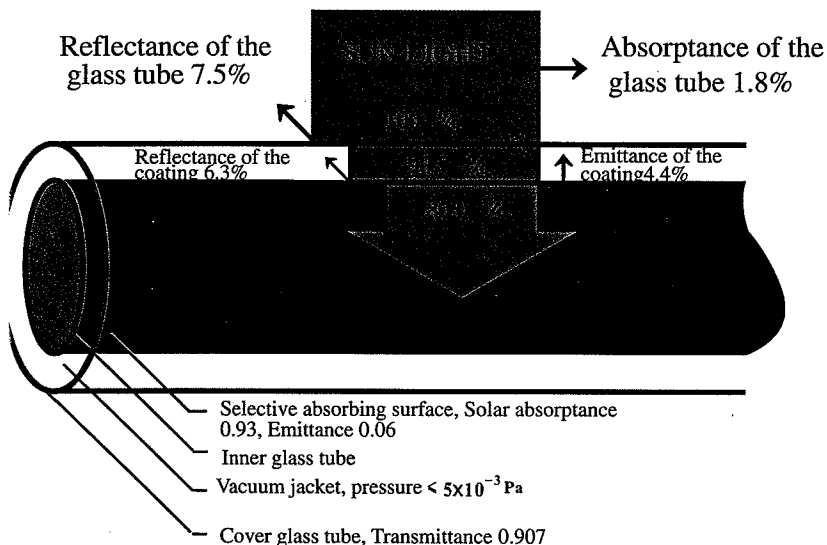
北京清华大学太阳能电子厂
TSINGHUA SOLAR CO.

SCHEMATIC OF SOLAR THERMAL CONVERSION OF ALL-GLASS EVACUATED COLLECTOR TUBE

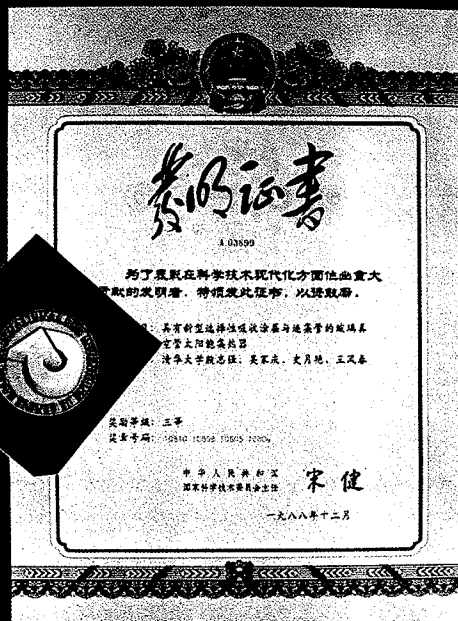
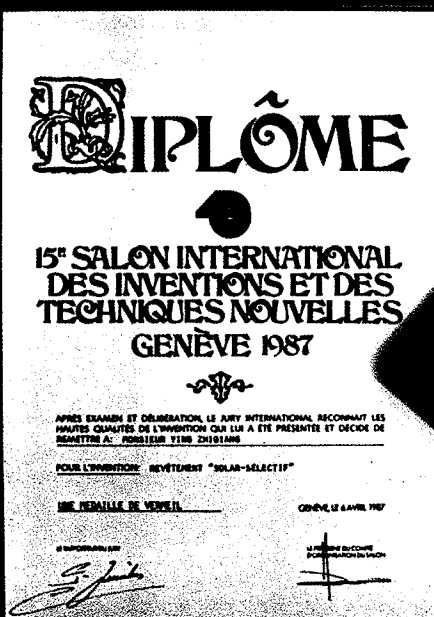
The limited availability of fossil fuel and their environmental impact, have led to a growing awareness of the importance of renewable energy sources. All-glass evacuated collector tubes and their collectors, high tech products, exhibit high efficiency of solar thermal conversion. The sputtered selective absorbing surface, a China invention patent (851001424), developed at Tsinghua University by professor Yin Zhiqiang is a graded aluminium-nitrogen on an aluminium base layer, which is now produced in Tsinghua Solar Corporation, Beijing, China. The technology won a gold medal of the Geneva International invention and new technology exhibition in 1987 and a state invention prize (3rd class) in 1988.

All-glass evacuated collector tube has the configuration of two concentric borosilicate glass tubes, the selective absorbing surface is coated on the outside of inner glass tube using magnetron sputtering, the jacket between cover and inner glass tubes is evacuated and permanently sealed off. The all-glass evacuated collector tubes have widely utilized due to their high efficiency, low heat losses, long life time and low costs.

SAVING ENERGY, SAFETY AND CLEAN ARE OUR GOAL

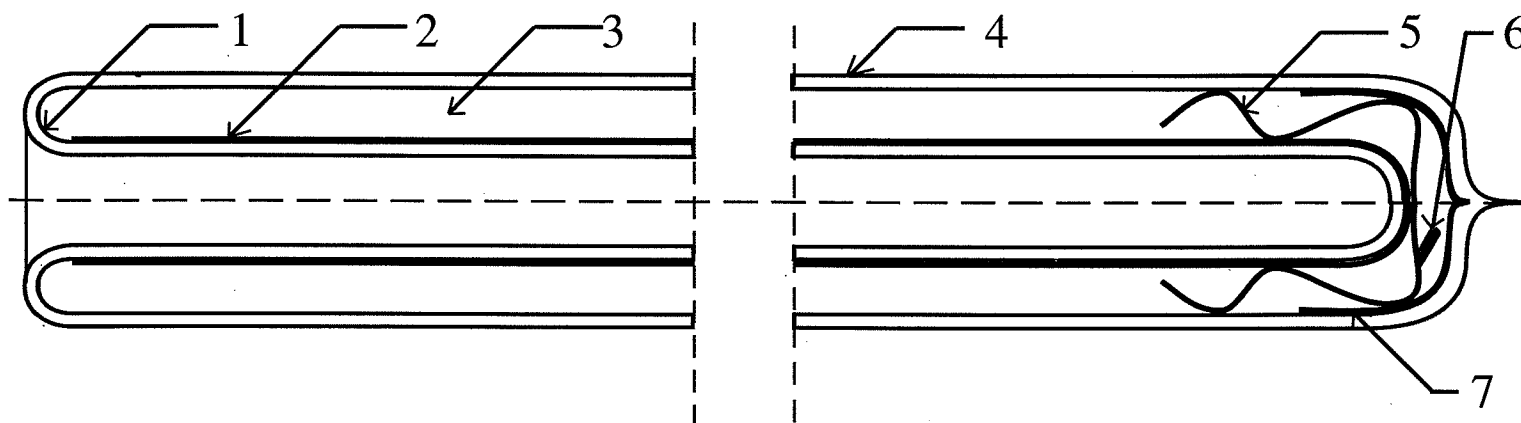


The dependence of near normal spectral reflectance on wavelength. China patent-Graded Al-N/Al solar selective absorbing coating.



SPECIFICATION OF ALL-GLASS EVACUATED COLLECTOR TUBES

Type	SL-1200 (QB-AI-N/AI-37/47-1200-1)	SL-1500 (QB-AI-N/AI-37/47-1500-1)
Configuration	Two concentric borosilicate glass tubes	Two concentric borosilicate glass tubes
Glass thermal expansion coefficient	$3.3 \times 10^{-6} / ^\circ\text{C}$	$3.3 \times 10^{-6} / ^\circ\text{C}$
Length	1200 mm	1500 mm
Cover tube diameter	47 mm	47 mm
Absorber tube diameter	37 mm	37 mm
Wall thickness	1.6 mm	1.6 mm
Transmittance of cover tube	0.91	0.91
Solar selective absorbing coating Technology	Graded Al-N/Al selective surface, Sputtering	Graded Al-N/Al selective surface, Sputtering
Solar absorptance (AM1.5)	0.93	0.93
Emissance (80°C)	0.06	0.06
Vacuum Gas Pressure	$\leq 5 \times 10^{-3} \text{ Pa}$	$\leq 5 \times 10^{-3} \text{ Pa}$
Stagnation temperature (typical)	200 °C	200 °C
Heat loss coefficient of collector tube	$\leq 0.85 \text{ W/(m}^2 \cdot ^\circ\text{C)}$	$\leq 0.85 \text{ W/(m}^2 \cdot ^\circ\text{C)}$
Impact resistance	Withstand 1 in (25mm) diameter hailstone without breaking	Withstand 1 in (25mm) diameter hailstone without breaking
Strength (pressure tested)	1 MPa	1 MPa
Empty weight	1.1kg	1.3kg



Schematic of all-glass evacuated collector tube

1, Inner glass tube 2, Selective absorbing coating 3, Vacuum space

4, Cover glass tube 5, Retainer 6, Getter 7, Fired getter film



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全玻璃真空管太阳

All-Glass Evacuated Tube Solar Water



清华大学太阳能电子厂



北京清华大学太阳能电子厂
TSINGHUA SOLAR CO.

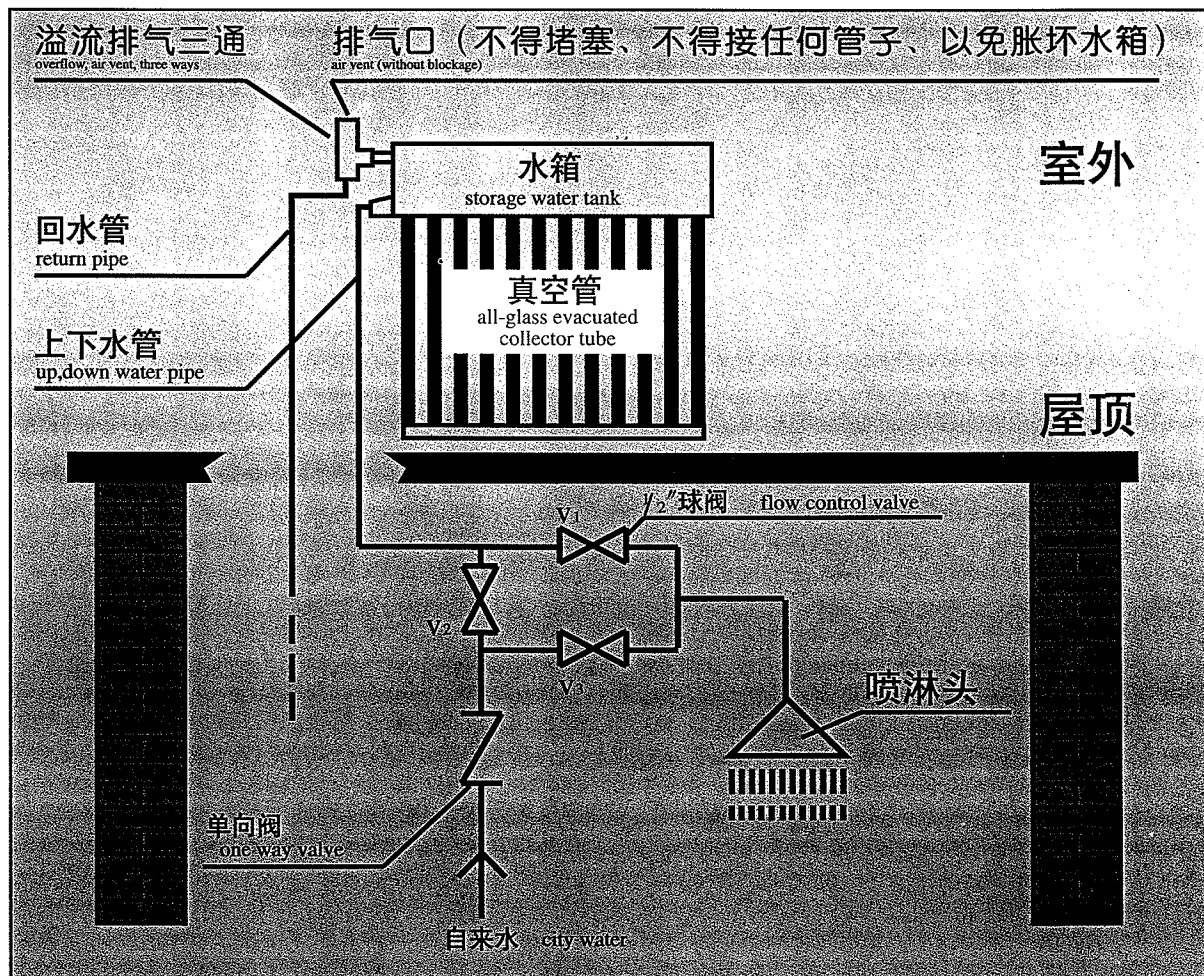
全玻璃真空管太阳热水器的特点

- 1、全玻璃真空太阳集热管使用清华大学发明并获国家专利的选择性吸收涂层，对太阳光具有极高的吸收率($>93\%$)和极低的热发射率($<6\%$)。(专利号: 851001424)
- 2、效率高，日集热效率达50%左右。
- 3、玻璃集热管与水箱采用我厂专利技术——翻边结构及具有三道"O"形环的硅胶密封圈，密封可靠。(专利号: 94218450.5, 96216122.5)
- 4、园形的集热管南北向放置，对一天内早、中、晚太阳以不同角度入射，集热管均有同样的直射集热面积，具有自然跟踪特性。
- 5、保温好，热损小，在高寒地区一年四季均能运行。
- 6、水箱采用SUS-304不锈钢板及氩弧焊工艺制造，牢固可靠，水质清洁。
- 7、耐冷热冲击好，抗冰雹。

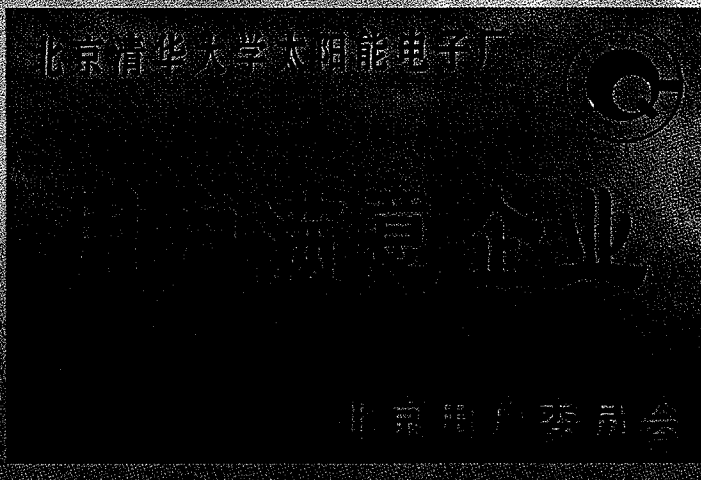
Features of All-Glass Evacuated Tube Solar Water Heaters

- 1.A novel selective absorbing surface utilized with higher solar absorptance, up to 0.93 and low emittance, lower than 0.06, which has been invented by Tsinghua University, and patented.
- 2.Higher efficiency, daily efficiency around 50%.
- 3.A special structure and silicon rubber O-ring patented for manifold and storage tank.
- 4.North-South orientation of collector tubes is semi-tracing, so has same projecting area at various daily time.
5. Working all year the round owing to good insulaton, low heat losses.
- 6.SUS-304 stainless steel plate as the materials for storage tank, and TIG processing have been used with solid, reliable and water clean:
- 7.Thermal shock and hails resistant.

热水器安装示意图



自然循环集热原理



玻璃真空管太阳热水器规格一览表

型号	SLJ-SY-1200/12	SLJ-SY-1200/16	SLJ-SY-1200/20	SLJ-SY-1500/12	SLJ-SY-1500/16
真空管型号	SL-1200	SL-1200	SL-1200	SL-1500	SL-1500
真空管支数	12	16	20	12	16
水箱容积(升)	70--75	90--100	110--120	85--90	110--120
水箱外皮材料	铝、不锈钢	铝、不锈钢	铝、不锈钢	铝、不锈钢	铝、不锈钢
支架	钢、不锈钢	钢、不锈钢	钢、不锈钢	钢、不锈钢	钢、不锈钢

(2) 水箱内桶为304不锈钢
(4) 密封圈为硅橡胶

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山东
全玻

All-Glass

管太阳

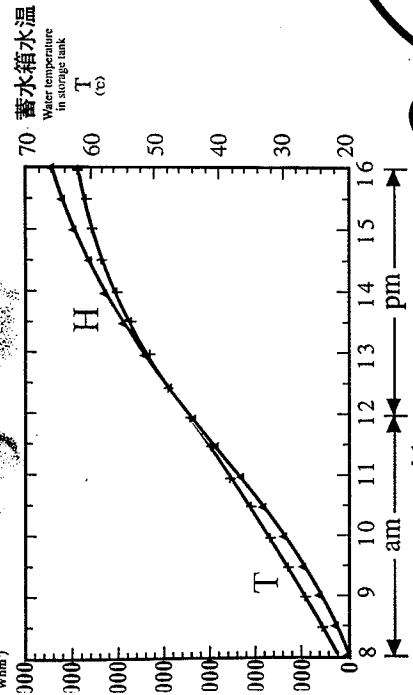
Evacuated Tube Solar Water



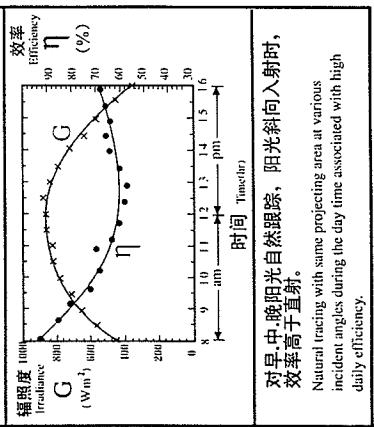
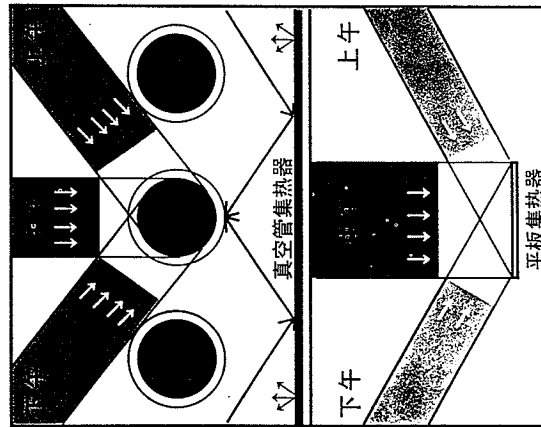
北京清华太阳能电
TIANGHUA SOLAR

辐射量
Irradiance
exposure
H
(W/m²)

蓄水箱升温曲线



采光面积1.42m²，结构简单，效率高，保温好，日平均热效率>50%
1.42m² aperture area, simple structure, good insulation, highly efficiency, daily average efficiency more than 50%



对早、中、晚阳光自然跟踪，阳光斜向入射时，效率高于直射。
Natural tracing with same projecting area at various incident angles during the day time associated with high daily efficiency.

The volume of the storage tank is 100 liter made of 1 mm thick stainless steel of SUS 304 and TIG processing.

V=100L 1mm不锈钢板 氩弧焊工艺精湛，牢固可靠。

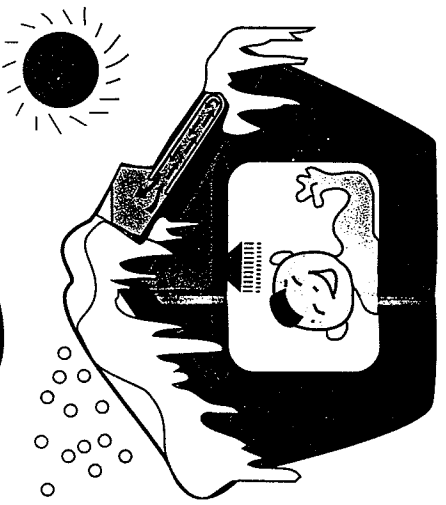
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IDEAL 'GREEN' ENERGY-ENERGY SAVING,
HIGH EFFICIENCY, NON-NOISE, NON-POLLUTION

热水器与地面夹角可以从0°至75°放置，水箱上下温差<1℃，特别适用于坡屋顶及赤道地区。
The tilt angle of the solar water heater is in the range of 0° to 75° to be installed from equator to large area in the world, and suitable for the slope roof of the house.

集热效率曲线

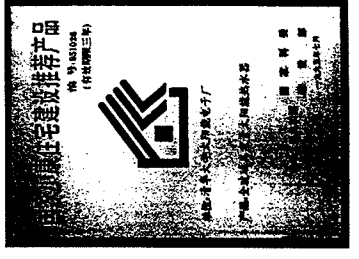
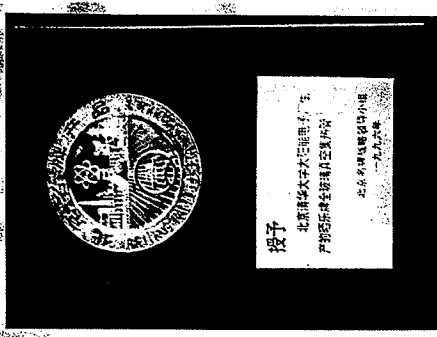
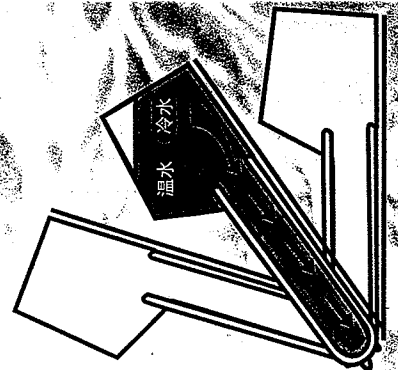
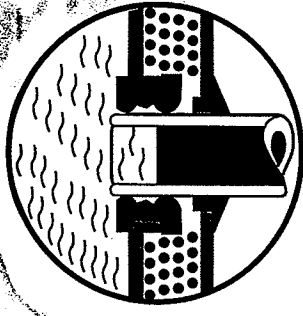
热损系数 $\leq 1 \text{ Wm}^{-2}\text{C}^{-1}$
可在高寒地区一年四季正常运行。
The heat loss coefficient of the water heater is less than $1.0 (\text{Wm}^{-2}\text{C}^{-1})$, the solar water heater is able to utilize all the year round in cold climate.



本厂专利

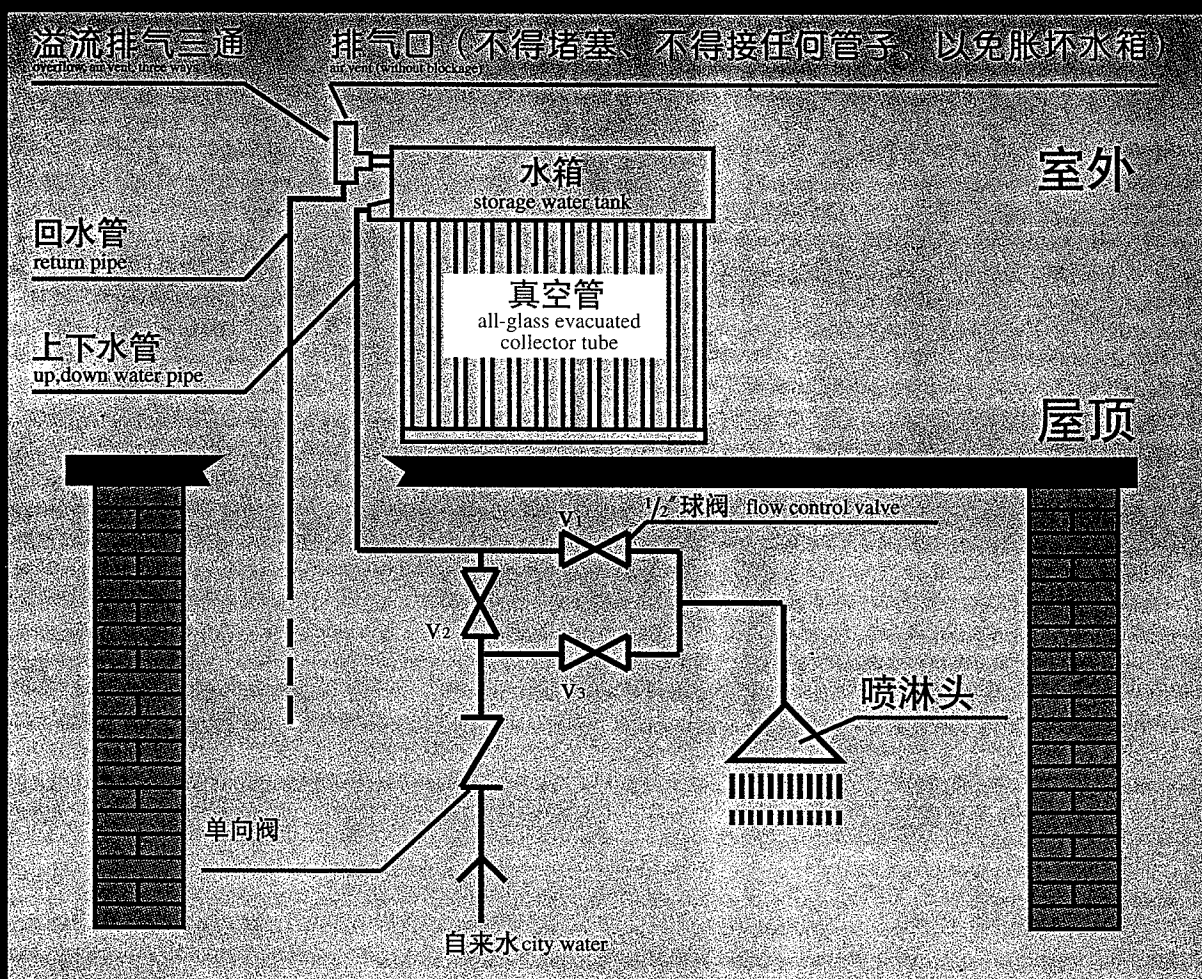
集热管与水箱连接处采用本厂专利密封结构，密封处可承压5kg/cm² (专利号: 94218450.5, 96216122.5)

Patented sealing structure between collector tubes and the storage tank, with standing 5 kg/cm² bar.



北京清华大学太阳能研究所
北京用户委员会

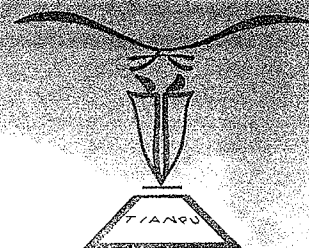
热水器安装示意图



通讯录 Address Book

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第一经营部	北京市朝阳区(100022) 西大望路21号	0086-10-67740769	0086-10-67740768
Running Dept.-1	21# XiDaWang Road ChaoYang District Beijing 100022 CHINA	0086-10-67740769	0086-10-67740768
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清华大学太阳能 电子厂山东分厂	山东德州市(253011) 解放南路139号	0086-534-2341717	0086-534-2321808
昆明清华阳光能 源开发有限公司	云南省昆明市(650228) 官渡区福海乡周家	0086-871-4611221	0086-871-4611227

Beijing Tian-Pu Solar Energy Industry Co.



北京天普太阳能工业有限公司



Beijing Tian-Pu Solar Energy Industry Co., Ltd.

是天普人的奉献

Beijing Tian-Pu Solar Energy Industry Co. Ltd.

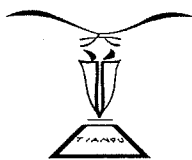
Beijing Tian-Pu Solar Energy Industry Co. Ltd. is specialised in producing solar glass vacuum tubes and solar heaters. It is the biggest of the similar in China. The company took the lead in getting ISO9000-the International Quality Authentication.

The company has a annual production capacity of 5 million glass vacuum tubes, 100,000 square meter copper and aluminium plank cores and 350,000 solar heaters. It's annual output has reached over RMB Yuan 500 million. With this capacity, 150,000 tons of standard coal can be saved; 200,000 tons of carbon dioxide and 4,000 tons of sulphur dioxide can be reduced.

The Tian-Pu solar heaters have the excellent quality and are renowned for its famous brand in China. The products have also been exported to Japan, Europe and America. In order to provide the best services to the customers, the company has set up 25 branches and 500 agents in China and the number is still increasing. In 1997, it became China's biggest solar company of the same type in terms of sales volume.

Beijing Tian-Pu Solar Energy Industrial Co. Ltd., with the aim of developing solar energy for the environmental purposes, firmly believes that the solar energy will become a very important resource in the energy industry in the future. With the rapid development of the photoelectric technologies, the company will continue the technological innovation and marketing development. Now, a high-tech comprehensive solar energy industrial base-Tian-Pu Sunshine Village-is under construction. It covers a area of 110 hectares. The project is supported by the State Planning Commission, the State Science and technological Commission, the State Economic and Trade Commission, the Ministry of Construction, the Ministry of Agriculture and the Beijing Municipality and its subsidiary counties.

The development of the solar energy will experience a long period. Tian-Pu would like to shoulder the heavy responsibilities together with other's joint efforts. For doing so, Tian-Pu is looking for various of co-operations with its partners in the same field both from home and abroad. For solar energy's bright future, Tian-Pu is determined to build a first class holding company in the solar energy industry.



北京天普太阳能工业有限公司（中日合资）

Beijing Tian-Pu Solar Energy Industry Co. Ltd. (Sino-Japanese Joint Venture)

电话: (010) 61239288 61239287 61239289

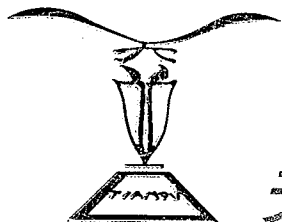
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地址: 中国北京大兴芦城工业区

Tel: (010) 61239288 61239287 61239289

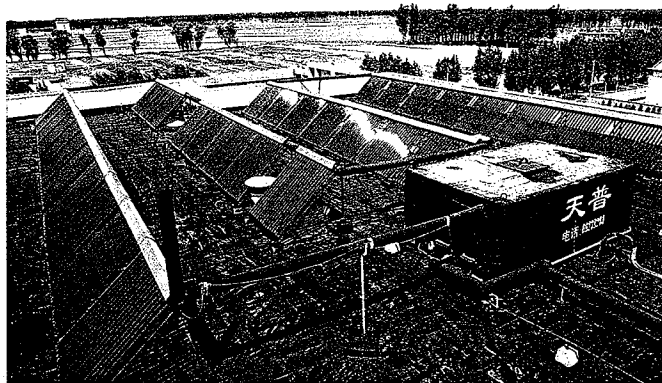
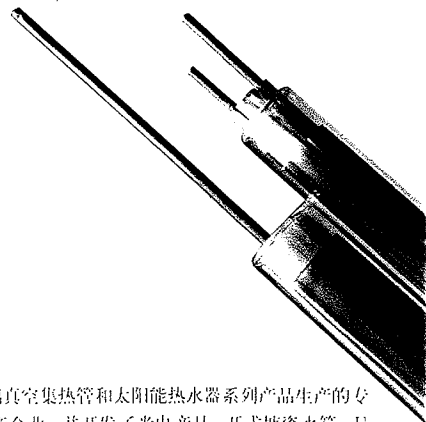
Postcode: 102600 Fax: 61239666

Add: Daxing Lucheng Industry Zone,
Beijing China.



天普傻瓜型

太阳能 U 型管热水工程系统



北京天普太阳能工业有限公司是从事全玻璃真空集热管和太阳能热水器系列产品生产的专业化公司，是国内最大的成套太阳能热水器生产企业，并开发了光电产品、开式搪瓷水箱、U型管热水系统、热管等产品，在同行中率先通过ISO9002国际质量认证。

公司现有年产500万支全玻璃太阳能真空集热管、热管和10万平方米铜铝板芯以及35万台太阳能热水器的生产能力，年产值可达5亿元。

天普太阳能系列产品品质优良，多次获奖，是中国一流知名品牌，行销全国并出口欧美、日本等发达国家。公司在全国设有500多家销售代理和25家销售公司，营销网络仍在不断完善，为用户提供良好的售后服务。96、97年热水器销量居全国同行业第一。

北京天普太阳能安装中心是天普公司直属的一家经营机构。其主要利用天普公司生产的集热元件在全国建立安装和售后服务一条龙体系。本中心可根据国内外不同客户的需求安装、设计太阳能热水系统。如达不到用户的要求，公司负责赔偿，质量信誉由中国经济技术投资担保公司负责担保，自然灾害由中国太平洋保险公司为用户承保。“用户满意”是天普公司永远的承诺。

98年天普公司引进西欧技术，研究开发了“傻瓜型太阳能U型真空管热水系统”，此系统经过实际应用，显示出原真空管太阳能热水系统和平板热水系统无法比拟的优越性，受到广大用户的好评。

傻瓜型太阳能U型真空管热水系统的应用及与建筑配套的几种形式：

中棉总公司三星宾馆上的150m²U型管太阳能热水系统



▼ 占地5万平方米的天普工业园



简介:

本公司引进西欧的U型管技术与本公司生产的全玻璃真空集热管元件相结合,开发生产了傻瓜型U型真空管热水系统,使太阳能热利用上了一个大台阶。本系统为快速直流系统,十几分钟可生产开水,水温根据需要可在100℃内调节,也可生产蒸气。

北京地区全年每 m^2 可产30吨以上45℃热水。每 m^2 每天可供2-4人洗澡,本系统可比原真空管热水系统提高热效率20%以上。能在白天阳光差的情况下生产出理想的热热水,而且最大的优势是性能可靠,系统全部电子自动控制,无人值守,做到开阀门用水,关阀门走人。

应用范围:

1)宾馆、机关等单位的集体淋浴和住宿小区的洗澡及生活用水的集中供应;2)小区的集中采暖,家庭和别墅的采暖与生活用热水;3)生活小区和机关的开水集中供应;4)游泳池加热;5)屠宰、印染等工厂的工业用热水;6)海水淡化;7)沼气池加热;8)为太阳能空调提供热源;9)温室土壤加热。

U型管与建筑美相结合的几种形式。(以北京为例)

● 集体浴室:

地下为储水罐,罐上建浴室,浴室上为U型太阳能热水系统,此系统为定温放水,用泵打热水使用。由于储热性能好,可解决全年全天候洗澡和采暖用。

● 小区集中供热:

地下为大型储热水罐,U型太阳能可安装在屋顶、阳台、楼栏杆、公园走廊、窗户遮阳棚及墙壁造型等建筑物上的太阳能系统生产出80℃热水集中在地下储热罐,供冬天采暖使用。如建一个为5000 m^2 楼房冬天采暖夏天制冷用的U型管热水系统,年需80℃热水8000吨,需建个6000吨地下储热罐,需U型管太阳能热水系统800 m^2 ,约需投资200万元左右。

用此储热方法可为温室进行土壤加热,在冬季生产出高档农产品。

● 家庭和别墅的采暖和生活用热水系统:

可在别墅的屋顶或阳台建立U型管热水系统,储水罐放在地下。如供一个200 m^2 的别墅采暖和生活用热水,需建一个200吨的地下储水罐,需U型管太阳能热水系统32 m^2 投资约10万元左右。

● 机关单位的开水系统:

机关单位喝开水用电费用太高,为此公司可为机关设计U型管集中供应开水系统,如一个单位150人喝开水,需建造开水系统16 m^2 投资约3万元左右。

用此技术可为工业提供100℃以内热水。

● 游泳池加热:

游泳池的顶盖为U型管太阳能热水系统,如建造一个12.5×25米的四季可用游泳池,水管积为456 m^2 需U型管太阳能250 m^2 ,约投资35万元左右;如建一个25×50游泳池,需U型管太阳能800 m^2 ,投资约120万元左右。

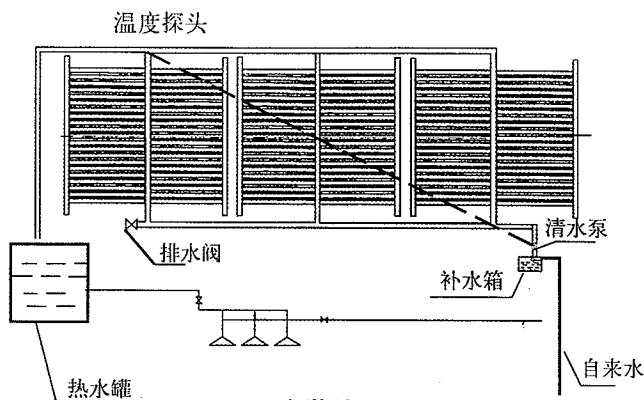
经济效益分析:

每 m^2 U型管太阳能全年累计可产45℃热水30吨,而用电加热到45℃,每吨水需电40度。每 m^2 每年节电1200度,按每度电0.60元计算,全年可节约电费1200×0.60=720元。每 m^2 U型管太阳能投资1800元,两年半可收回投资。而U型管太阳能可使用15年以上。每个标准游泳池每年可节约电费56万元。

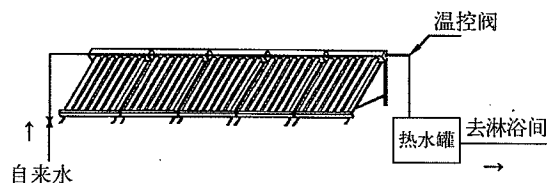
朋友们,在全世界都重视环境保护和节约能源的今天,请您选用U型管太阳能热水系统,让这一高科技产品为您、为社会创造出更大效益,做出最大的贡献。我们相信U型管太阳能热水系统的诞生,将逐步取代锅炉,造福社会。明天的天空会更蓝。

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北京市工商行政管理局



安装法一



安装法二



北京天普太阳能工业有限公司(中日合资)

Beijing Tian-Pu Solar Energy Industry Co., Ltd.

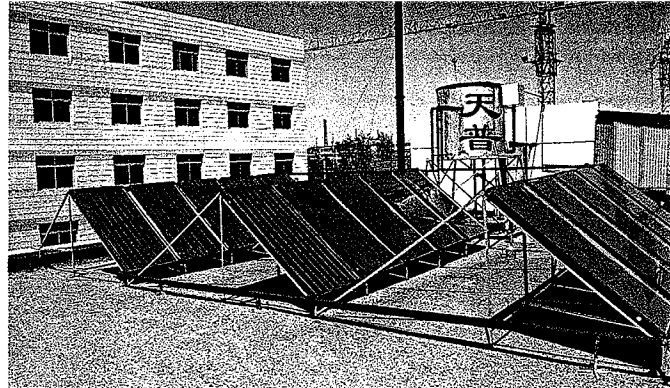
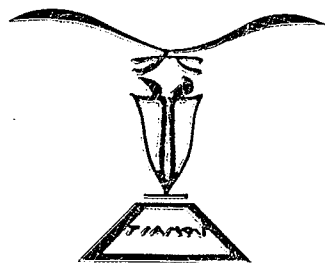
(Sino-Japanese Joint Venture)

电话 (Tel): (010) 61239288 61239287 61239289

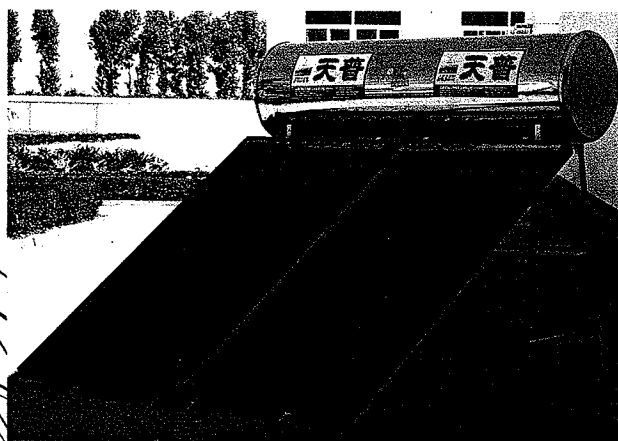
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地址: 中国北京大兴芦城工业区

Add: Daxing Lucheng Industry Zone, Beijing China.



天普牌 TVA 改型 铜铝复合平板太阳能热水器



北京天普太阳能工业有限公司(中日合资)

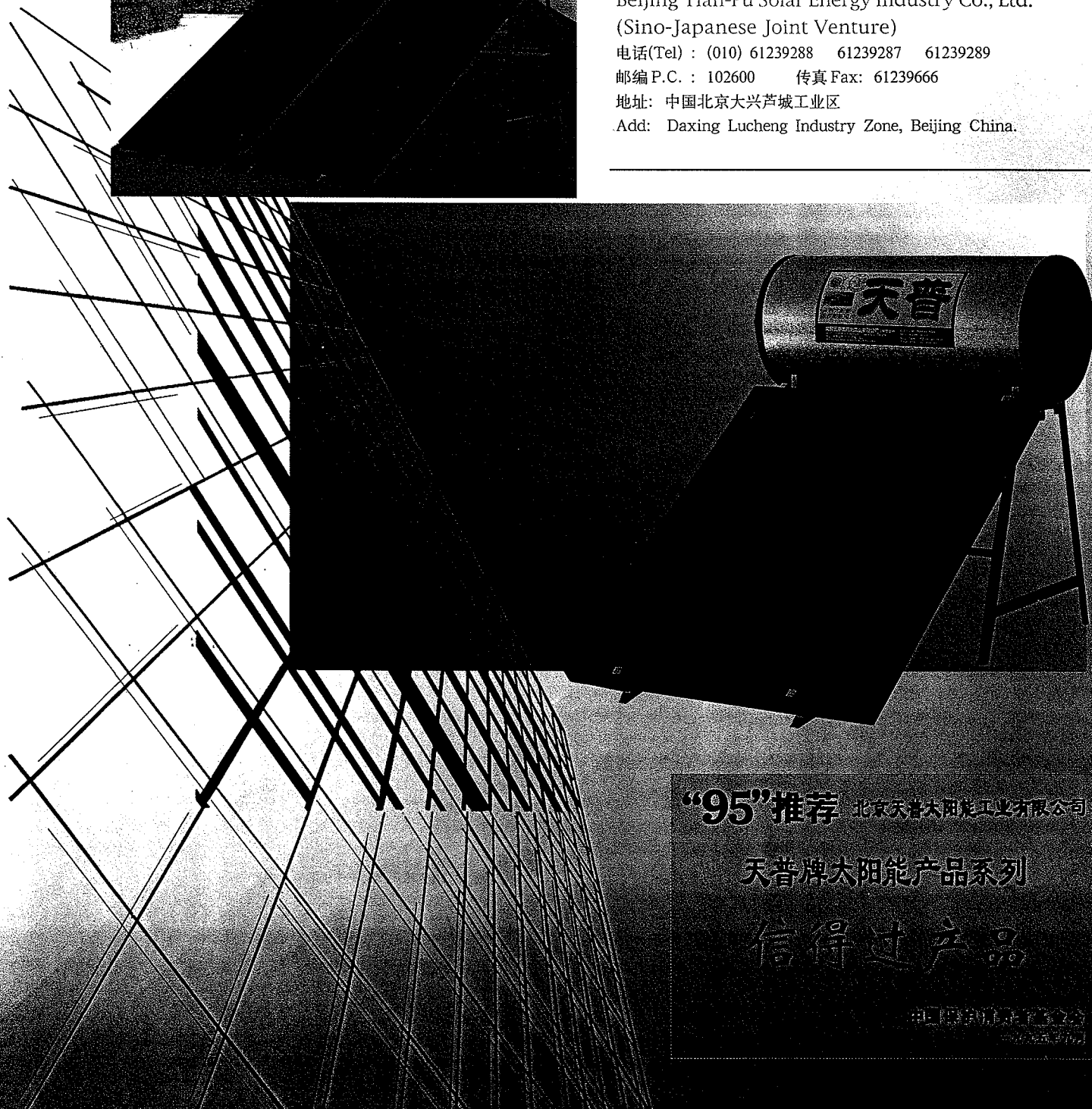
Beijing Tian-Pu Solar Energy Industry Co., Ltd.
(Sino-Japanese Joint Venture)

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“95”推荐 北京天普太阳能工业有限公司

天普牌太阳能产品系列

信得过产品

中国太阳能产业协会
1995.12.25 授予

天普牌 TVA 改型铜铝复合平板太阳能热水器

板芯为无缝紫铜管和优质铝带压延成型。效率因子 ≥ 0.96 ，日效率为 60%，具有热容小，耐腐蚀、易维修等优点，每 m^2 可日产 $45^\circ C - 65^\circ C$ 热水 100Kg，使用寿命 15 年。水箱采用 304 不锈钢内胆，水质清洁无毒。规格有 $4m^2$ 、 $2m^2$ 、 $1.5m^2$ 、 $1.2m^2$ 四种，最受普通消费者欢迎。

成套平板太阳能热水器组装方法：1. 取出支架和水箱用螺丝固定好；2. 内循环式，使集热板上口的两管对准水箱两孔插入，外循环式水箱端头下管与集热板下部侧管连结，水箱中部管与集热板上部侧管连结；3. 引进水管路至浴室（见图）。

注意事项：1. 室外结冰，热水器系统内的水要放净；2. 排气要畅通，以免压力过大，涨坏水箱；3. 如自来水压力过大，使用时，进水阀门应开小限压。

Tian-Pu Brand, TVA New Version Copper-Aluminium Plate Solar Energy Heating Water Device

The core of the plate is made of seamless copper tube and aluminium tape. The efficiency factor ≥ 0.96 , daily efficiency is 60%. It has the advantage of low heat capacity, corrosion resistance and easy service. The daily output of each sq. meter is $45^\circ C - 65^\circ C$ hot water 100 kg. The life of the device is 15 years. The lining of the tank is 304 stainless steel, which makes the water clean and safety. The types of the device are:

$4m^2$, $2m^2$, $1.5m^2$, $1.2m^2$. They are welcome by the common users.

Methods of mounting and assembling of the complete set of the solar energy heating water device:

A. Mount the support and the water tank with bolts.

B. For the type of inner circulation insert the two tubes of the upper part of heat collection plate into the holes of the water tank. For the type of outer circulation connect the lower tube of tank with the lower side tube of the heat collector and connect the middle tube of the tank with the upper side tube of the heat collector.

C. Lead the water output tube to the bath room. (see fig)

Warnings:

A. Drain the water of the system, if it is frozen outside the house.

B. The air pipe must be unblocked in case the tank ruined by the high pressure of the air.

C. If the pressure of the input water is too high, the opening of the valve should be small.

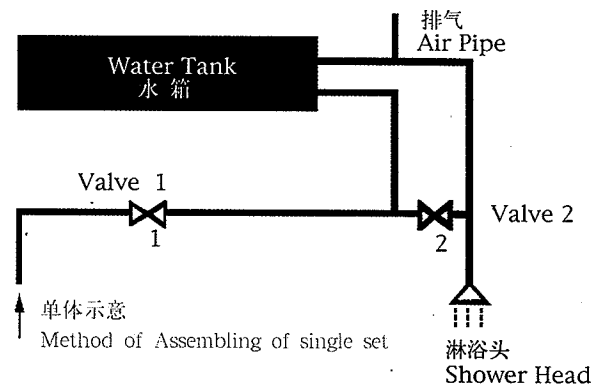
单体安装使用说明:

开阀 1 充水，淋浴头流水证明水箱已满关阀 1。淋浴时开阀 1 顶出热水，过热开阀 2 调节。冬天可开阀 2 顺水淋浴过热开阀 1 调节，用完再开阀 1 充水。

Instruction of Fig. 1:

Open valve 1 to fill the water until it comes out from the shower head, which means the water tank is full. When taking the shower, open valve 1 to make the hot water comes out. If the water is too hot open valve 2 to cool.

In winter when taking the shower, open valve 2 to let the hot water comes out from the tank directly. If the water is too hot open valve 1 to cool it. After shower open valve 1 to fill water.



A Corner of Tian-Pu Solar Energy Industry Zone





欢迎您选购天普产品

TP1500型

太阳能配套电热水淋浴器

使用该产品前，请仔细阅读说明书

北京天普阳太阳能配套电器有限公司

地址：北京大兴芦城工业区 邮编：102600 电话：(010)61239288 61239287 传真：(010)61239666

公司简介:

北京天普阳光太阳能配套电器有限公司是北京天普集团的全资子公司,北京天普集团是集太阳能热水器、太阳能光电产品、太阳能建筑配套产品的研发、开发、生产、销售于一体的太阳能利用专业集团。目前,天普集团已在京南置地110公顷兴建太阳能高科技观赏、休闲、示范的综合产业基地——天普阳光村。

天普集团愿和国内外同行携手合作,共创太阳能事业的辉煌。

产品简介:

为解决太阳能热水器在冬季、阴雨天洗浴温度不理想的缺憾,我公司最新推出天普TP1500型太阳能配套电热淋浴器,该产品具有防干烧装置、自动贮水、自动断电、音乐报警、水位显示等功能。箱体采用进口镀锌钢板或不锈钢板,坚固耐用,表面采用静电喷塑、美观新颖,其最大特点是将太阳能水箱中的温水(由于天气冷、光照不足、阴雨天、太阳能水箱中的水用于洗浴温度不够),注入本太阳能电热淋浴器水箱中,用较短的时间加热,就能达到理想温度。

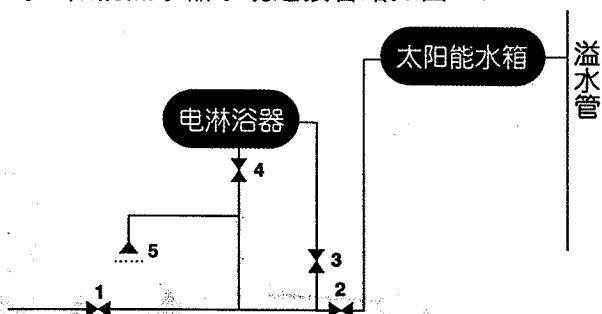
TP1500型太阳能配套电热淋浴器、安全可靠、是太阳能热水器的理想伴侣,使之成为真正的“全天候”。

本产品除上述功能外,还可直接连在自来水管路上独立使用,为淋浴,冬季家庭用水、宾馆、餐厅、理发美容店等提供日常用水,实为工薪阶层家庭贮水、洗浴的最佳选择。

安 装:

请用两个 $\phi 8$ 膨胀螺栓固定好箱体,并拧紧螺母,高度为超过或与人身体身高相等,喷头固定架应低于淋浴器阀门。

与太阳能热水器系统连接管路如图一:



操作使用说明:

1. 太阳能热水器上水, 开阀1、阀2(阀2常开), 待溢流管流水时, 说明太阳能水箱已满, 关阀1。使用时开阀5, 水温升高时, 开阀1调节。

2. 冬季、阴雨天, 太阳能热水器水温达不到洗浴温度时, 开阀3, 使太阳能水箱的水注满电淋浴器, 设定所需温度, 接通电源加热(此时绿灯亮), 达到温度时(绿灯灭, 自动断电)有音乐报警, 提示您拔掉电源插头, 关阀2, 阀3, 开阀4、阀5, 此时可安全使用, 另外, 可通过箱体一侧的透明水位管, 随时观察水位。

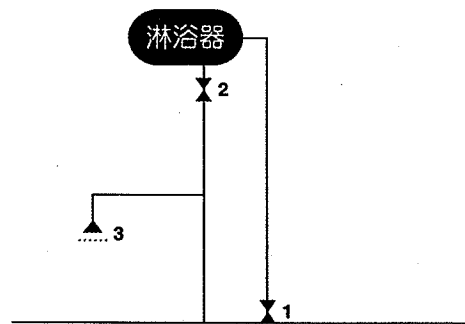
使用注意事项:

1. 洗浴时, 拔掉电源插头, 严禁带电淋浴。
2. 请按好地线或把电源插头插在有接地装置的三孔插座上。
3. 一定要先加水再通电, 避免电热原件, 无水干烧。
4. 产品如有质量问题, 请勿自行拆卸, 请与我公司或销售单位联系。
5. 产品自售出之日起, 保修期为一年。终身维修。

技术参数:

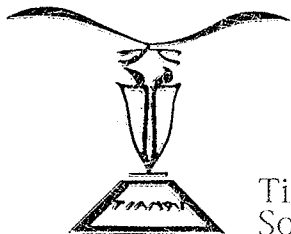
1. 使用电源交流: 220V, 频率50HZ
2. 加热功率: 1500W
3. 热效率: 90%(室温20°C时测)
4. 容积: 50L、60L

独立使用连接管路如图二:



操作使用说明:

1. 在浴室内的阀1处接上一个铜接头(外丝), 在进水口处接一个铜接头(内丝), 然后把进水管套在铜接头上, 用管卡紧固(所有紧丝处均应用生料带缠好)。
2. 打开阀1, 待水注满箱体后, 可以自动关闭, (适用于水压低和经常停水地区, 作为应急水源), 接通电源, 按顺时针方向转动旋钮, 设定所需温度(此时绿灯亮), 达到温度时(绿灯灭自动断电), 音乐蜂鸣器自动报警, 提示您切断电源(拔掉插头), 关阀1, 开阀2、阀3使用。



Tian-Pu Brand, TVB Vacuum Tube
Solar Energy Hot-water Device



天普牌 TVB
真空集热管太阳能热水器



北京天普太阳能工业有限公司(中日合资)

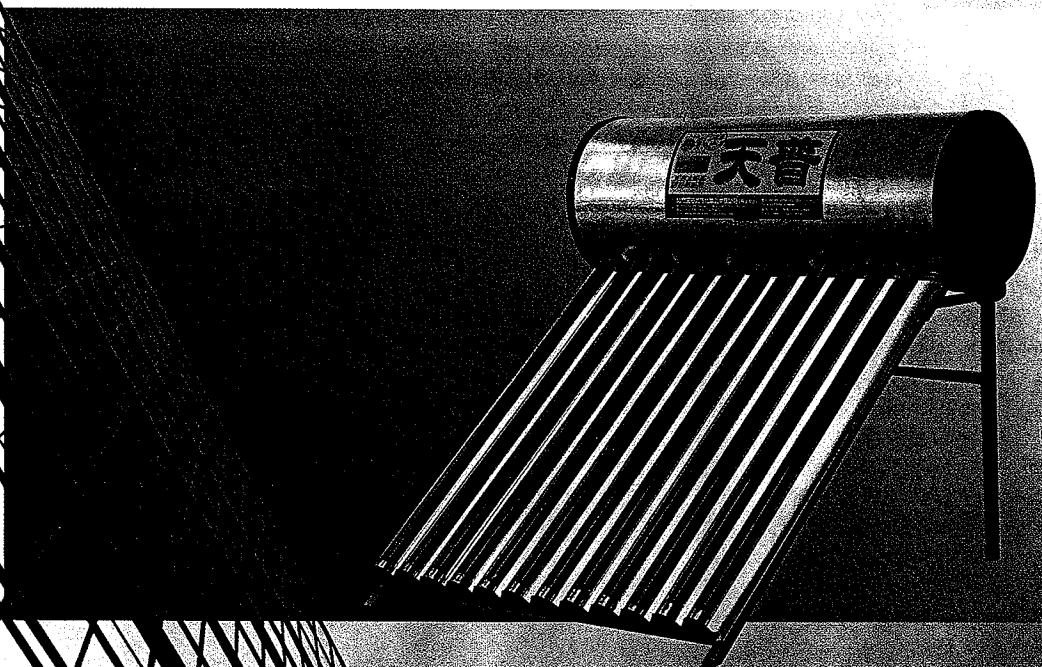
Beijing Tian-Pu Solar Energy Industry Co., Ltd.
(Sino-Japanese Joint Venture)

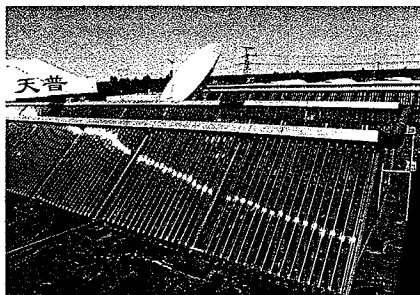
电话(Tel) : (010) 61239288 61239287 61239289

邮编 P.C. : 102600 传真 Fax: 61239666

地址: 中国北京大兴芦城工业区

Add: Daxing Lucheng Industry Zone, Beijing China.





尽情享受太阳能

中棉总公司 U 型管太阳能热水系统

北京天普太阳能工业有限公司是一家为国内外太阳能厂家生产关键性元件和大规模生产成套太阳能热水器的中日合资企业,具有年产500万支全玻璃真空集热管和50万台太阳能热水器的生产能力。在同行业中首家通过ISO9002国际质量标准认证。

天普牌TVB系列真空集热管太阳能热水器采用国际先进的高效光热转换材料和技术精制而成。有1.2m²、1.35m²、1.6m²、2m²、3m²五种规格,适用于家庭、机关、厂矿企业、别墅、游泳池等,可满足洗浴和生活用热水。易于在多种建筑结构上安装使用。

全天候使用 _____ 热效高、保温好、水箱有三天的储热性能。气温-18℃照常运行。

经济耐用 _____ 一次性投入,使用无需能源费用。寿命长达15年。能承受直径2.5cm冰雹袭击,故障率和维修费用大大低于其它类型热水器。

安全、无污染 _____ 省去触电、燃气泄漏之忧、对环境 and 身心无害。

包装运输 _____ 产品为整体包装,运输方便。

组装方法

- 1) 支架和水箱用螺丝固定好,反光板固定在支架上;
- 2) 支架需要安装牢固,以防大风;
- 3) 把玻璃真空管装满水转动插入水箱;引进出水管路至浴室后立即把水箱冲满水。

使用说明

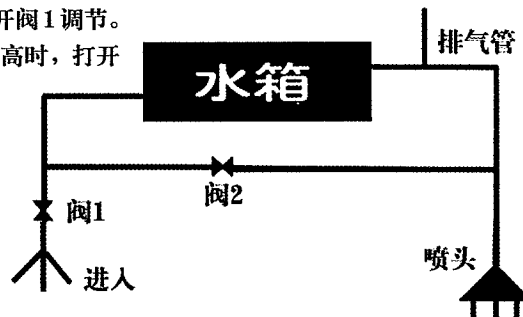
上水: 关闭2、开阀1,自来水进入水箱。等到喷头流水时表明水箱已满,关闭1。

取水: 1. 落水取水法: 关闭1、开阀2,水箱热水靠重力从喷头中流出,水温过高时,开阀1调节。

2. 顶水取水法: 关闭2、开阀1,冷水把水箱上部的热水顶出流至喷头。水温过高时,打开阀2调节。

注意事项

- 1) 如真空管被太阳晒后再充水应在早晨无阳光时,以免炸管。
- 2) 零下18度以下连阴天气注意放水(玻璃管内水不用放)以免冻坏水箱或管道。
- 3) 如自来水压力过大,使用时进水阀门要开小限压。以免排气孔出水。
- 4) 保持排气管畅通,以免涨坏水箱。

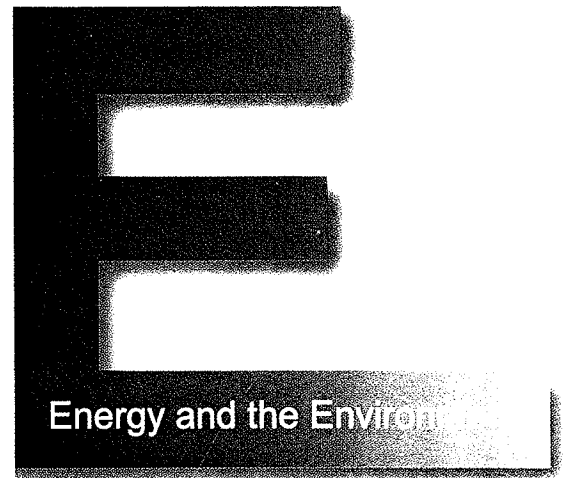


太阳能热水器与其它热水器比较

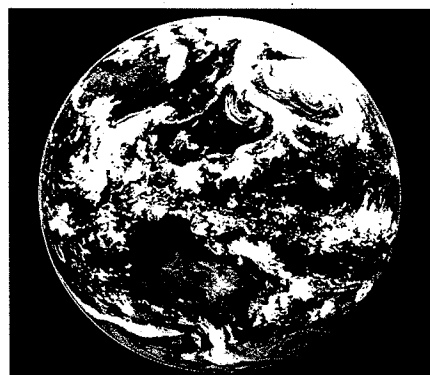
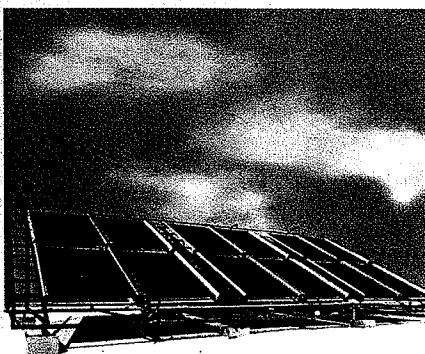
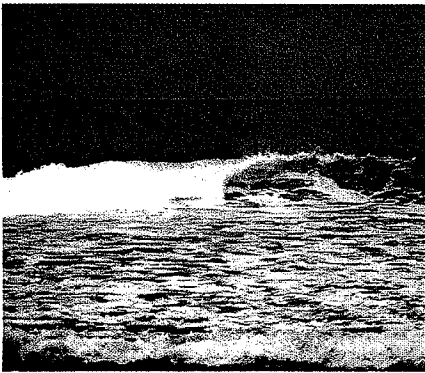
项目 名称	容水量 (kg)	投资金额 (元)	电费、燃 气费(元)	洗澡人数 (人)	使用寿命 (年)	年费用 250天计	使用期内 费用(元)	备注使用15 年费用(元)
真空管太阳 能热水器	100	1800	-	3人/天	15		-	1800
电热器	100	300	2.0/天	3人/天	3	500	1500	9000
燃气热水器	100	800	1.2/天	3人/天	5	300	2400	6900

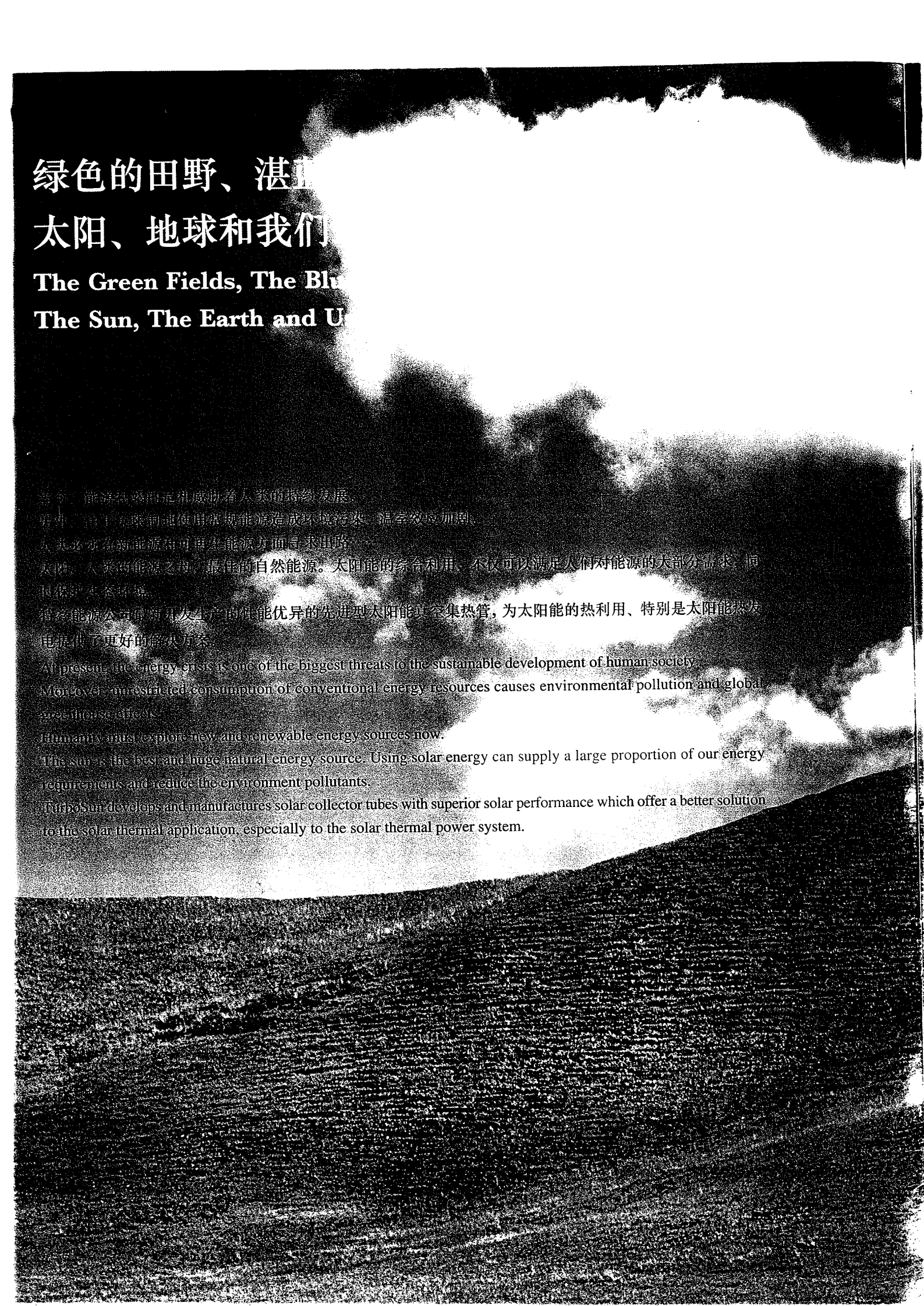


**Beijing TurboSun Technology
Development Co.**



太阳，人类的能源之母，最佳的自然能源。
The Sun is The Best and Huge Natural Energy Source.





绿色的田野、湛蓝的天空

太阳、地球和我们

The Green Fields, The Blue Sky

The Sun, The Earth and Us

当今，能源危机正严重威胁着人类的持续发展。

另外，由于无限制地使用常规能源造成环境污染、温室效应加剧。

人类必须向新能源和可再生能源方面寻求出路。

太阳，人类的能源之母，最佳的自然能源。太阳能的综合利用，不仅可以满足人们对能源的大部分需求，同时保护环境。

福森能源公司最新开发生产的性能优异的先进型太阳能真空集热管，为太阳能的热利用、特别是太阳能热发电提供了更好的解决方案。

At present, the energy crisis is one of the biggest threats to the sustainable development of human society.

Moreover, unrestricted consumption of conventional energy resources causes environmental pollution and global greenhouse effect.

Humanity must explore new and renewable energy sources now.

The sun is the best and huge natural energy source. Using solar energy can supply a large proportion of our energy requirements and reduce the environment pollutants.

FusenSun develops and manufactures solar collector tubes with superior solar performance which offer a better solution to the solar thermal application, especially to the solar thermal power system.



特鑫能源公司与北京大学和悉尼大学密切合作,成功开发出性能优异的不锈钢-氮化铝先进型太阳能真空集热管并开始规模生产。工作温度可达到500°C的先进型高温太阳能真空集热管正在开发当中。先进型太阳能真空集热管使用的先进型选择性吸收陶瓷涂层由悉尼大学发明并于1995年申请了国际发明专利。

特鑫公司拥有悉尼大学上述专利技术在中国的独家生产和销售许可权。目前公司生产三种不同系列先进型太阳能真空集热管,同时也为用户设计、制造和安装实用的太阳能热水器和太阳能热水工程。另外,太阳能过热蒸气装置和海水淡化装置等也正在开发当中。

TurboSun Energy

TurboSun, in conjunction with Peking University and the University of Sydney, has commercially developed evacuated solar collector tubes incorporating sputtered stainless steel-Aluminum nitride (SS-AlN) cermet solar selective coatings. Solar collector tubes incorporating tungsten-Aluminum nitride cermet solar selective coatings, which can be used at high operating temperatures up to 500 °C in vacuum, are currently being developed. Solar selective coatings of these new cermet materials were invented at the University of Sydney and patented in 1995. Currently TurboSun, under exclusive patent license to the University of Sydney, manufactures three different series of solar collector tubes with superior solar performance in China. TurboSun also designs, manufactures and installs utility-scale solar hot water systems.

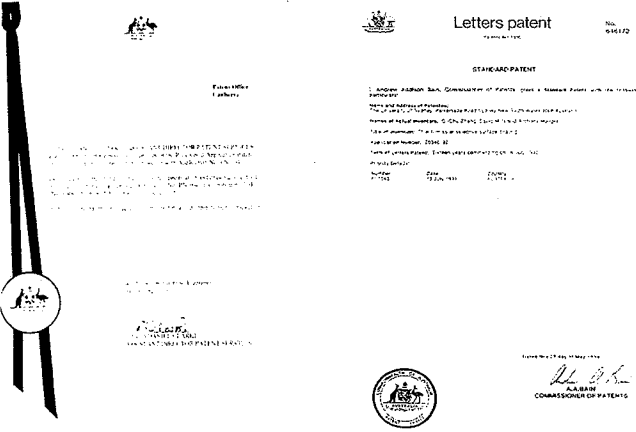
先进型太阳能选择性吸收涂层

—— 太阳能热利用领域的最新专利技术

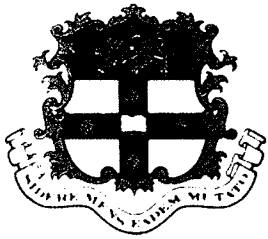
Advanced Solar Selective Coatings :

Double Cermet Film Structures

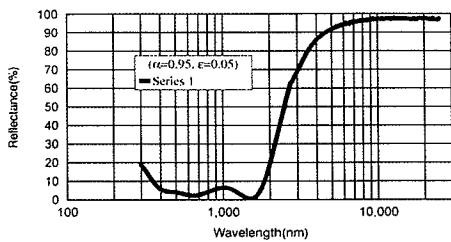
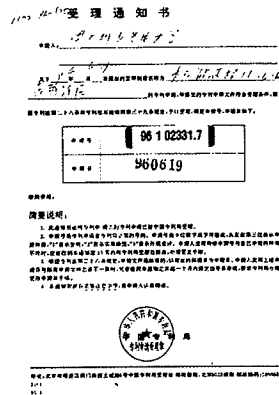
Metal-Aluminum Nitride Cermet



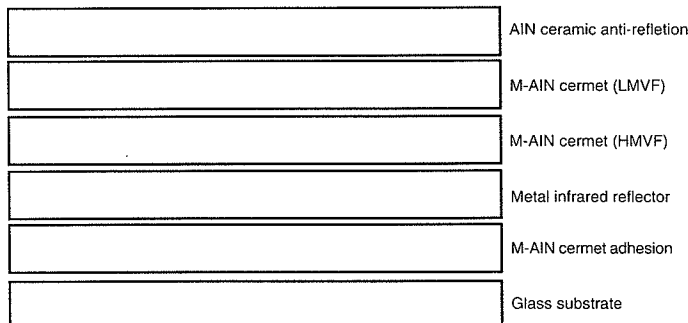
专利证书



The University of Sydney



Advanced Solar Selective Surface Reflection Chart
先进型太阳能选择性吸收涂层光谱反射曲线



金属-氮化铝陶瓷选择性吸收涂层的典型结构

The typical film structure of M-AlN cermet selective surfaces

太阳能选择性吸收涂层起何作用？

太阳能选择性吸收涂层尽可能高地吸收入射的太阳辐射能同时将自身的热发射损耗尽可能低地进行抑制。大多数太阳能选择性吸收涂层的吸收层采用金属-介质复合材料，即所谓的金属-陶瓷材料。太阳能选择性吸收涂层的性能主要取决于它们的吸收率 α 和热发射率 ϵ 以及热稳定性指标等。

How do the solar selective coatings work?

Solar selective coatings absorb most of incident solar radiation while simultaneously suppressing the thermal emittance loss from coating surfaces. Most solar selective coatings use ceramic and metal composites, known as cermets, as the absorber of solar radiation. They vary mainly in their solar performance, solar absorptance α and thermal emittance ϵ , and thermal stability.

先进型太阳能选择性吸收涂层

先进型太阳能选择性吸收涂层使用了悉尼大学九十年代的两项发明专利：(1) 具有最高光热转换效率的双层陶瓷膜结构；(2) 采用奇特的溅射技术沉积金属-氮化铝陶瓷材料。

金属-氮化铝陶瓷选择性吸收涂层的典型结构如图所示：(1) 透明的减反射层；(2) 由上层为低金属体积和下层为高金属体积的双层同质金属-氮化铝陶瓷材料构成的吸收层；(3) 用以减少基底热发射的红外反射层；(4) 金属-氮化铝粘结层；(5) 玻璃基底。

Advanced solar selective coatings

Advanced solar selective coatings employ two patent technologies invented at the University of Sydney during 1990s: (1) double cermet film structure with the highest photothermal efficiency, and (2) metal-Aluminum nitride cermet (M-AlN) materials deposited by a novel sputtering technology. The typical film structure of M-AlN cermet selective surfaces, schematically shown in the figure, from surface to substrate consists of: (1) a transparent AlN or AlN_xO_y anti-reflection layer that enhances solar absorption; (2) an absorbing layer composed of two homogeneous M-AlN cermet layers: a low metal volume fraction (LMVF) cermet layer on a high metal volume fraction (HMFV) cermet layer; (3) a metal infrared reflector which reduces substrate emittance; (4) a M-AlN cermet adhesion layer; and (5) a glass substrate.



先进型全玻璃太阳能真空集热管

Advanced Evacuated All-glass Solar Collector Tubes

太阳能真空集热管的构造和原理

全玻璃太阳能真空集热管与传统的杜瓦瓶类似。内管的一头为密闭的半球形面，内管的外表面上溅射有上述的先进型太阳能选择性吸收涂层，内管的密闭端用片状弹簧固定在外管内端，内管的开放端同外管的开放端环形熔封起来，外管与内管之间抽成真空用以减少对流和传导的热损。太阳辐射能透过外管被选择性吸收涂层吸收并转化为热能并从内管内部导出。全玻璃太阳能真空集热管采用透光率高、热膨胀系数低、强度高的高硼硅玻璃。

How is the solar collector tube constructed?

The construction of evacuated all-glass solar collector tubes is similar to a conventional Dewar flask. The outside of the inner tube, closed at one end, is sputtered with advanced solar selective coatings described above. The coated inner tube is sealed at the other, open end, to an outer tube. The space between the outer tube and inner tube is evacuated and maintained at a high vacuum with firing getters to virtually eliminate heat loss by conduction and convection. These glass tubes are made of borosilicate glass with high strength.

How does the solar collector tube work?

Solar radiation passes through the highly transparent outer glass tube and reaches the solar selective coating on the outside of the inner tube. The solar selective coating absorbs the solar radiation and converts it to thermal energy which is transported from inside the inner tube to an application.

TurboSun 先进型太阳能真空集热管系列产品

特鑫能源公司目前生产三个系列的先进型太阳能集热管。即使在冬季寒冷和太阳能辐照不太强的地区也能四季工作。先进型太阳能集热管的使用寿命长达20年。

TurboSun products of advanced solar collector tubes

TurboSun currently manufactures three different series of advanced solar collector tubes. The solar collector tubes work in all four seasons even in areas that experience very cold winters. TurboSun's collector tubes perform not only at noon or on clear sunny days, but also when the sun is low or the weather is cloudy. Wind or low temperatures have less effect on its performance. The lifetime of these solar collector tubes is 20 years.

1. AA 系列—低温 (最高到 150 °C) 太阳能真空集热管

AA series -- low temperature (up to 150 °C) solar collector tubes
膜结构 Film structure : AlN/Al-N (LMVF)/Al-N(HMVF)/Al/Al-N/Glass tube
太阳能吸收率 Solar absorptance α : 94 - 96%
吸收率沿管长的不均匀度 α variation along tube length: < 3%
热发射率 Thermal emittance ϵ : < 6% (100 °C)

2. SA 系列—中高温 (最高到 330 °C) 太阳能真空集热管

SA series -- medium temperature (up to 330 °C) solar collector tubes
膜结构 Film structure : AlN/SS-AlN (LMVF)/SS-AlN (HMVF)/Al/SS-AlN/Glass
太阳能吸收率 Solar absorptance α : 94 - 96%
吸收率沿管长的不均匀度 α variation along tube length : < 1%
热发射率 Thermal emittance ϵ : < 6% (100 °C), < 10% (300 °C)

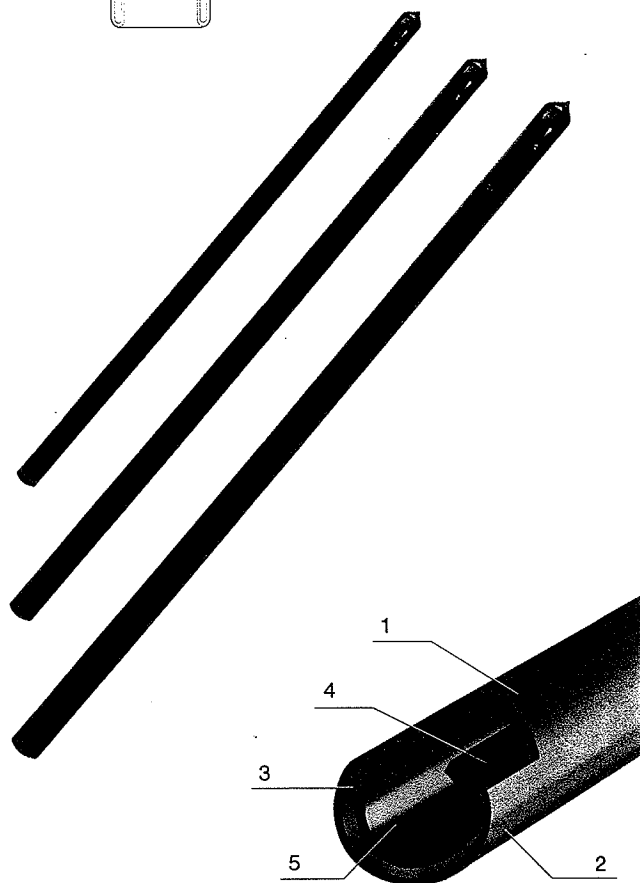
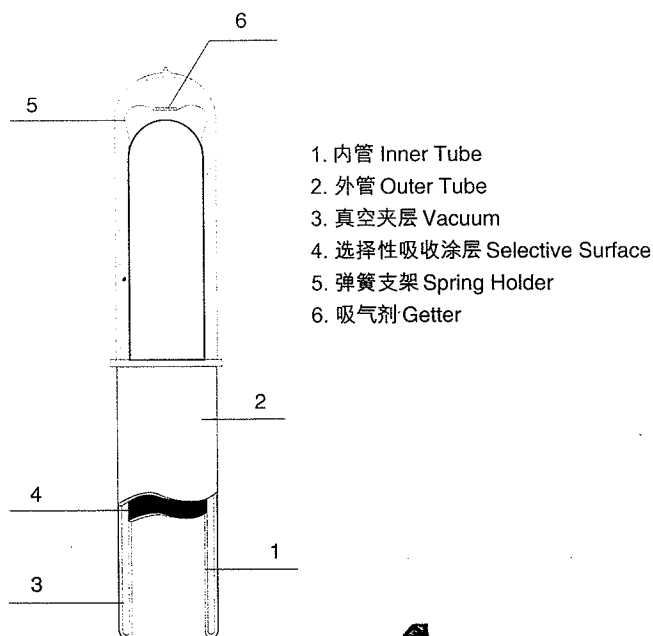
3. SC 系列—中高温 (最高到 380 °C) 太阳能真空集热管

SC series -- medium temperature (up to 380 °C) solar collector tubes
膜结构 Film structure: AlN/SS-AlN (LMVF)/SS-AlN (HMVF)/Cu/SS-AlN/Glass
太阳能吸收率 Solar absorptance α : 94 - 96%
吸收率沿管长的不均匀度 α variation along tube length : < 1%
热发射率 Thermal emittance ϵ : < 5% (100 °C), < 8% (300 °C), < 10% (350 °C)

4. WC 系列—高温 (最高到 500 °C) 太阳能真空集热管正在开发当中。

WC series -- high temperature (up to 500 °C) solar collector tubes are being developed.

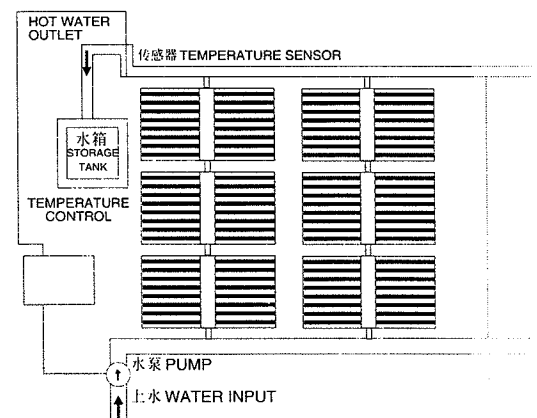
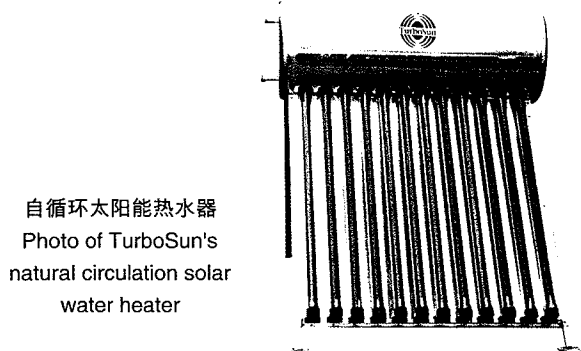
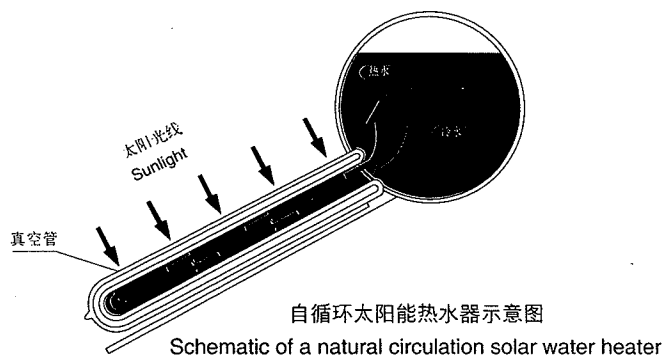
膜结构 Film structure: AlN/W-AlN (LMVF)/W-AlN (HMVF)/Cu/W-AlN/Glass



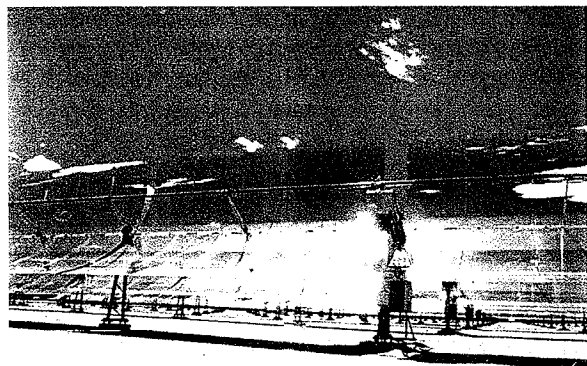
太阳能真空集热管的应用

Solar Collector Tubes

Thermal Application



太阳能真空管热水系统示意图
Schematic of Evacuated Tubular Collector System



Luz 公司在美国南加里福尼亚太阳能热发电厂一角

View of Luz solar electricity generation system (SEGS) constructed in Southern California

作为最好的集热元件，先进型太阳能真空集热管可应用于任何需要热力的场合。

The advanced evacuated collector tubes can be used as the best components in all solar thermal processes and applications.

- 家用太阳能热水器和工程
Domestic hot water system
- 太阳能蒸汽系统
Solar water steam system
- 建筑供暖
Building Heating
- 太阳能吸附式制冷
Solar absorption cooling
- 海水淡化
Desalination
- 工业供热
Industrial process heat
- 太阳能热发电
Solar thermal power system

太阳能热发电

Luz 公司的 SEGS 类型太阳能发电系统，自 1984 年在美国南加里福尼亚被用于建设目前世界上唯一达到商业化规模的太阳能热发电厂。集热器的抛物面槽的反射面将阳光聚在置于槽的焦线上的太阳能集热管上，管子里流动的高温热流可以送至热交换器中产生蒸汽，或者可以在太阳能集热管中直接生成蒸汽用来发电。Luz 公司的总发电能力达 254MW 的 9 个太阳能发电厂已向该地区电网输送电力，占世界太阳能发电总量的 90%。然而，太阳能发电费用特别是启动投资费用，仍比常规发电费用高好多。拿 Luz 公司的情况来讲，建设实际电量达 80MW 太阳能热电厂的投资费用约每千瓦 3000 美元，是 80MW 油发电厂的 2 倍。其中，太阳能集热管和太阳能抛物面发射面是额外投资费用的两个主要部分。

TurboSun 公司的 SC 系列太阳能集热管，温度升至 380℃ 仍保持稳定，可以用于太阳能热发电站当中。SS-AIN 陶瓷太阳能集热管的成本比目前已在规模生产的用于太阳能热水器系统的 AIN 型陶瓷太阳能集热管稍高，但要比 Luz 公司已工业化生产用于太阳能热电厂的同类产品低得多。使用生产 SS-AIN 太阳能集热管的同一生产线，经过少许调整，即可生产 W-AIN 陶瓷型高温（达 500℃）太阳能集热管。

可以预料，使用 TurboSun 公司的性能优越的先进的太阳能集热管将会提高太阳能发电厂效率，也使人们一直期待的设计具有优越性能又很经济的太阳能集热系统成为可能。



太阳能热发电

—— 最具发展前途的应用技术

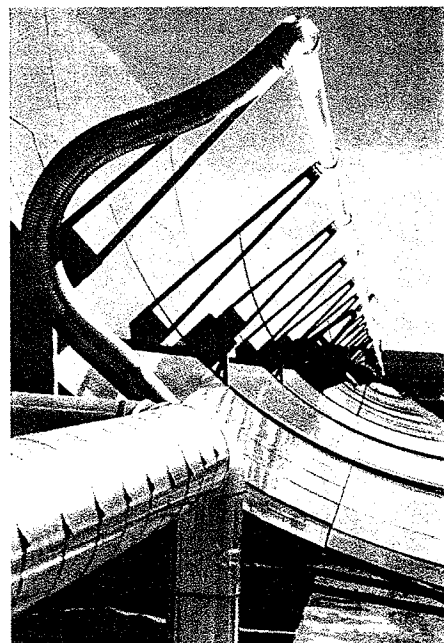
Solar Thermal Power

Solar Thermal Power

Solar thermal generation power plants of the Luz solar electricity generation system (SEGS) type, have been constructed in Southern California since 1984. The SEGS projects are the world's only commercial-scale solar thermal power plants. The reflective surface of a parabolic trough concentrates sunlight onto a solar collector tube located along the trough's focal line. Heated fluid flowing in the tube can be transported to a heat exchanger to raise steam for use in a turbine/generator. Alternatively, steam can be directly generated in the solar collector tube. Nine plants with a total net electricity capacity of 354 MW are under operation to feed electricity into the grid of the regional utility. They account for over 90% of the world's solar power production. Solar thermal electricity costs and, in particular, the investment costs, are still much higher than conventional electricity costs. From Luz experience, the investment costs for the actual Luz 80 MW solar thermal power plants, about US\$3000/kW, are two times higher than an 80 MW oil power plant. The solar collector tubes and solar parabolic reflectors are the two MAIN parts contributing the extra investment costs.

TurboSun SC series solar collector tubes are stable at elevated temperature up to 380 °C in vacuum and will supply the demonstration station of solar thermal electricity generation. The costs of the SS-AIN cermet solar collector tubes is slightly higher (~10%) than those for Al-N cermet solar collector tubes currently being mass-produced for solar hot water systems but much lower (5 - 10 times) than those produced commercially by the Luz Company for solar thermal power plants. By using the same production line as for SS-AIN cermet solar collector tubes, after minor modifications, it would be possible to produce W-AIN cermet high-temperature (up to 500 °C) solar collector tubes.

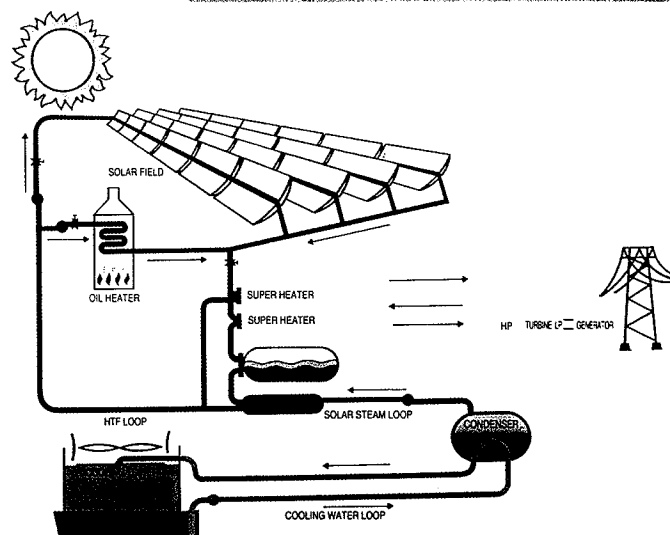
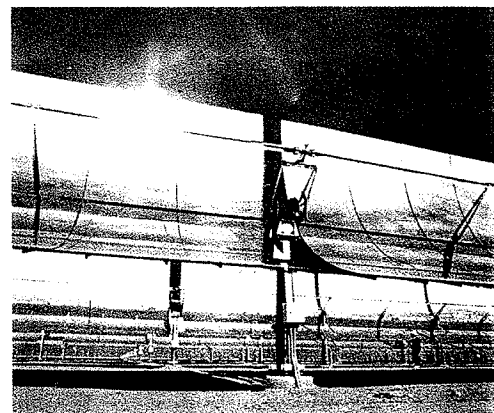
It is expected that solar electricity efficiency will be increased using TurboSun advanced solar collector tubes due to their superior solar performance. It will also open up the possibility for the design of solar collector system for solar thermal electricity generation with superior performance and economy to that previously contemplated.



抛物面槽聚太阳能
真空集热器

Parabolic Trough
Concentrated solar
collector

Luz 公司在美国南加利福尼亚太阳能热发电厂一角
View of Luz solar electricity generation system (SEGS) constructed in
Southern California



太阳能热发电系统流程图

The Luz Solar Thermal Power Plant Flow Chart



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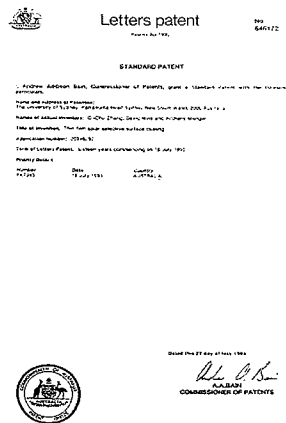
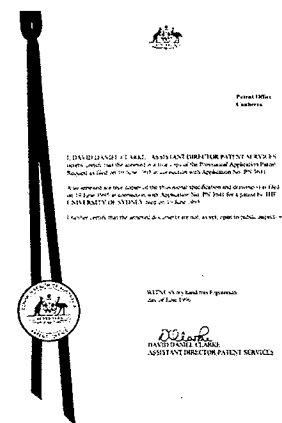
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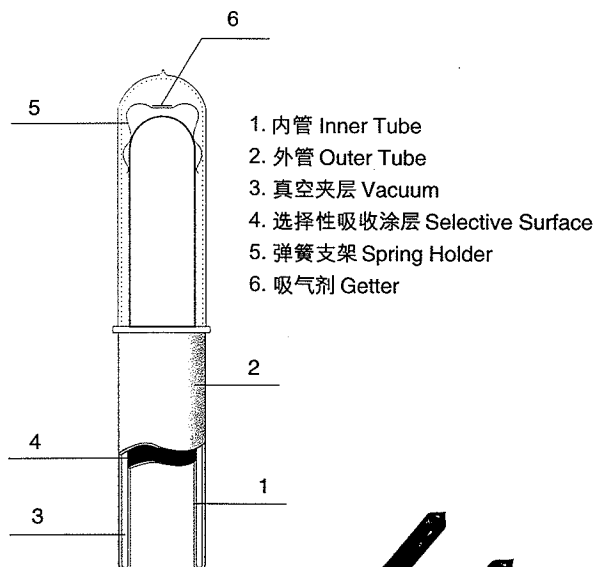
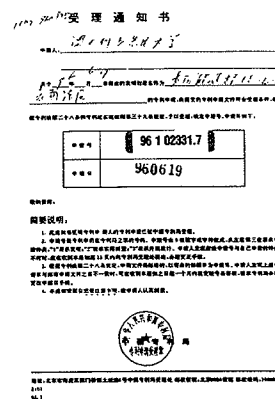


先进型全玻璃太阳能真空集热管

Advanced Evacuated All-glass Solar Collector Tubes



The University of Sydney



1. 内管 Inner Tube
2. 外管 Outer Tube
3. 真空夹层 Vacuum
4. 选择性吸收涂层 Selective Surface
5. 弹簧支架 Spring Holder
6. 吸气剂 Getter

简介

特鑫能源公司与北京大学和悉尼大学密切合作，成功开发出性能优异的不锈钢-氮化铝先进型太阳能真空集热管并开始规模生产。先进型太阳能真空集热管使用的先进型选择性吸收陶瓷涂层由悉尼大学发明并于1995年申请了国际专利。目前特鑫公司生产三种不同系列先进型太阳能真空集热管。

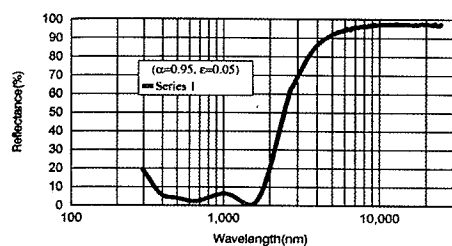
Brief Introduction

TurboSun, in conjunction with Peking University and the University of Sydney, has commercially developed evacuated solar collector tubes incorporating sputtered stainless steel-Aluminum nitride (SS-AlN) cermet solar selective coatings. Solar selective coatings of these new cermet materials were invented at the University of Sydney and patented in 1995. Currently TurboSun manufactures three different series of solar collector tubes with superior solar performance.

先进型太阳能选择性吸收涂层

先进型太阳能选择性吸收涂层使用了悉尼大学九十年代的两项发明专利：(1) 具有最高光热转换效率的双层陶瓷膜结构；(2) 采用奇特的溅射技术沉积金属-氮化铝陶瓷材料。

金属-氮化铝陶瓷选择性吸收涂层的典型结构如图所示：(1) 透明的减反射层；(2) 由上层为低金属体积和下层为高金属体积的双层同质金属-氮化铝陶瓷材料构成的吸收层；(3) 用以减少基底热发射的红外反射层；(4) 金属-氮化铝粘结层；(5) 玻璃基底。



Advanced Solar Selective Surface Reflection Chart
先进型太阳能选择性吸收涂层光谱反射曲线

	AlN ceramic anti-reflection
	M-AlN cermet (LMVF)
	M-AlN cermet (HMVF)
	Metal infrared reflector
	M-AlN cermet adhesion
	Glass substrate

金属-氮化铝陶瓷选择性吸收涂层的典型结构
The typical film structure of M-AlN cermet selective surfaces

Advanced solar selective coatings

Advanced solar selective coatings employ two patent technologies invented at the University of Sydney during 1990s :
(1) double cermet film structure with the highest photothermal efficiency, and (2) metal-Aluminum nitride cermet (M-AlN) materials deposited by a novel sputtering technology.

The typical film structure of M-AlN cermet selective surfaces, schematically shown in the figure, from surface to substrate consists of : (1) a transparent AlN or AlN_xO_y anti-reflection layer that enhances solar absorption ; (2) an absorbing layer composed of two homogeneous M-AlN cermet layers : a low metal volume fraction (LMVF) cermet layer on a high metal volume fraction (HMVF) cermet layer ; (3) a metal infrared reflector layer which reduces substrate emittance ; (4) a M-AlN cermet adhesion layer ; and (5) a glass substrate.

先进型太阳能真空集热管性能及规格

Specifications of Advanced Solar Collector Tubes

项目 Items	系列 Series	AA 系列 - 低温太阳能集热管 AA series-low temperature solar collector tubes	SA 系列 - 中高温太阳能集热管 SA series-medium temperature solar collector tubes	SC 系列 - 中高温太阳能集热管 SC series-medium temperature solar collector tubes	WC 系列 - 高温太阳能集热管 WC series-high temperature solar collector tubes
结构 Structure		全玻璃双层同轴结构 All-glass concentric tube geometry			
玻璃材料 Glass Material		高硼硅玻璃 Borosilicate glass			
外管直径及厚度 Outer Tube Diameter & Thickness		$\phi=47 \pm 0.7\text{mm}$ $\delta=1.5\text{mm}$			
内管直径及厚度 Inner Tube Diameter & Thickness		$\phi=37 \pm 0.7\text{mm}$ $\delta=1.5\text{mm}$			
* 管长度 Tube Length		1200mm, 1500mm	1200mm	1200mm	1200mm
吸收涂层 性能 Absorptive Coating Properties	结构 Construction	AlN/Al-N (LMVF) / Al-N (HMVF) / Al/Al-N/Glass tube	AlN/SS-AlN (LMVF) / SS-AlN (HMVF) / Al/SS-AlN/Glass tube	AlN/SS-AlN (LMVF) / SS-AlN (HMVF) / Cu/SS-AlN/Glass tube	AlN/W-AlN (LMVF) / W-AlN (HMVF) / Cu/W-AlN/Glass tube
	沉积方法 Method of Deposition	直流反应溅射 DC reactive sputtering			
	吸收率 α Absorptance	94-96%			
	吸收率沿管 长不平均度 α Variation Along Tube Length	<3%	<1%	<1%	—
	发射率 ϵ Emittance	< 6% (100℃)	<6% (100℃) , <10% (300℃) .	<5% (100℃) , <8% (300℃) , <10% (350℃) .	—
真空度 Vacuum		$P < 5 \times 10^{-2}\text{Pa}$			
推荐使用温度 Recommend Working Temperature		$\leq 150^\circ\text{C}$	$\leq 330^\circ\text{C}$	$\leq 380^\circ\text{C}$	$\leq 500^\circ\text{C}$
寿命 Lifetime		20 年 20 years			

* 所有系列的真空管长度都可以根据用户要求生产 (最长 2 米)。

The tube lengths of all the series can be produced depend on the user's requirement (max.2.0 meters) .



特鑫能源

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Xin-Ao Solar Energy Development LTD.

中澳合资

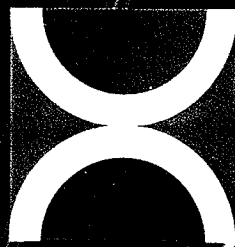
新奥太阳能发展有限公司

全玻璃真空太阳集热管

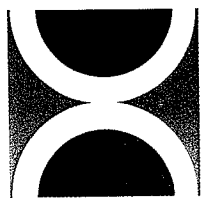
ALL GLASS EVACUATED SOLAR
COLLECTOR TUBES

SINO-JOINT

XINAO SOLAR ENERGY
DEVELOPMENT CO., LTD.



XINAO SOLAR ENERGY



新奥集团

XINAO GROUP

河北新奥集团股份有限公司是集城市基础能源、房地产、太阳能开发利用、高新技术中试、市政建设工程、旅游餐饮为一体的综合性现代化大型企业集团。

集团拥有3亿元人民币资产，下设具有独立法人资格的廊坊市天然气有限公司、廊坊新城房地产开发有限公司、廊坊新奥太阳能发展有限公司、澳大利亚高新技术有限公司、廊坊开发区市政建设工程有限公司、山明水秀大饭店(无锡太湖畔)等十一家现代化企业。

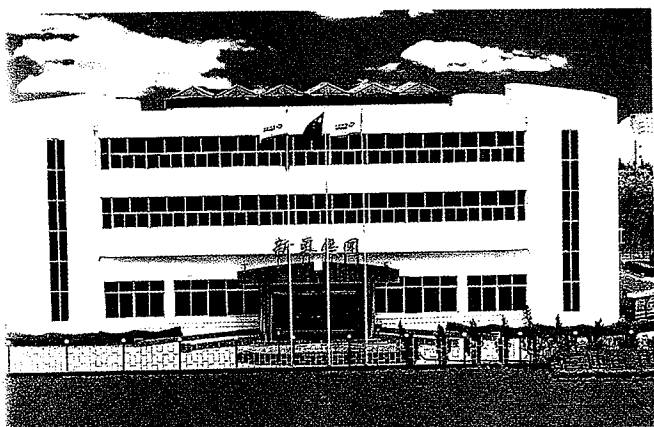
集团公司独家承担着廊坊市区、开发区管输天然气供应工程的建设和经营以及开发占地18万多平方米的“金三角”商贸居住区；并在太阳能开发利用领域取得可喜进展，一座集科研、生产、销售为一体的“新奥太阳城”将成为集团公司产业结构的主体。

以工业为主、物业为辅、商业为补是新奥集团的经营方针；以

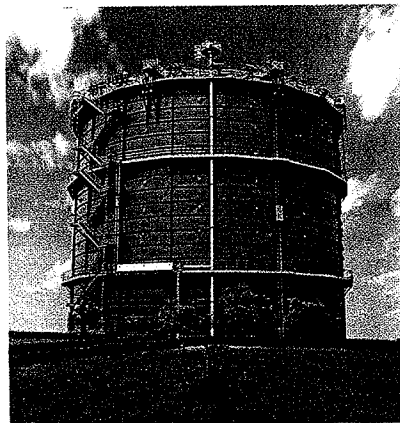
理解为桥梁、以发挥为主体、以人为中心是新奥集团永恒的企业理念；营造自由、明朗、积极进取的气氛，创造自身价值，实现共同目标是新奥人的追求。

新奥集团总部位于河北省廊坊市经济技术开发区华祥路，公司办公大楼等物业占地24540.76平方米，规划长远，气势博大。特别是作为集团公司龙头企业的廊坊市天然气有限公司，在极短的时间里，铺设了覆盖整个廊坊开发区、市区的天然气环形管网100多公里，首批1万多户居民、30多家工业福利用户用上了管输天然气，从而在河北省各市中首家实现城市民用燃料采用管道天然气。

拼搏自信，团结进取，服务社会，造福人民是全体新奥人的心声！



新奥集团总部
The Headquarter of Xin-Ao Group



三万立方米贮气罐
The Natural gas container that can
contained 30 thousand cubic metre



山明水秀饭店
Green hills and clear waters Hotel.
Wu Xi city

Xin-Ao Group CO.,LTD.HEBei province. is a comprehensive and modernizing large enterprise group which engages in urban basic energy,real estate,solar energy exploitation and utilization, medium test of high level and new technique,municipal engineering and tourist restaurant.

The Group has assets of 300 millions yuan(Ren Min Bi).in which has set up eleven modernization enterprises such as LangFang Natural Gas Limited company,LangFang XinCheng real estate exploiting limited Company,LangFang Xin-Ao Solar energy developing Limited company,Xin-Ao High level-New Technique limited Company in Australia,municipal Engineering company in LangFang Economic Technology Development Zone and Green Hills and Clear Waters Restaurant(by the bank of Taihu lake,WuXi)which have independent legal person qualifications.

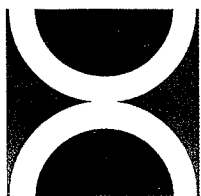
The Group itself undertakes the building and management of pipeline Natural gas Supply engineering,exploits gold triangle commerce and trade residential area with 180,000m2,and has made pleasing headway in the area of solar energy development and utilization. Xin-Ao solar city which is engaged in Scientific research,production and sale will become a mainbody of the Group industrial structure.

The managing principles for Xin-Ao Group regards industry as

main,estate as assistance and commerce as Supplement,The permanent enterprise sense of the Groups regards understanding as bridge,playing as mainbody and person as center.The seeking of Xin-Ao people is to create a free,clear and positive and initiative atmosphere,self value and realize common objectives.

The headquarter of Xin-Ao Group locates at Huaxiang road of LangFang Economic technology Development Zone in HeBei Province.Its work building occupy land of 24540.76m2.which program is for a longterm and momentum is tremendoas.LangFang Natural gas Limited Company which is the most important enterprise in the Group especially layed ring natural gas pipeline over 100 kilometers,throughout LangFang Economic technology Development zone and whole urban district in very short time.The resident of over 10000 families and more than 30 industrial welfare factories for the first batch have used pipeline Natural gas. Therefore,it's the first city to use pipeline Natural gas as fuel for urban resident among all cities and prefectures in Hebei province.

Making a desperate effort and self-confidence,unity and progress,service for Society and bringing benefit to people are the aspirations of all people from Xin-Ao.



新奥太阳能

XINAO SOLAR ENERGY



新奥太阳能发展有限公司

经济的发展给社会带来了物质的繁荣，同时也给人类赖以生存的自然环境和自然资源造成了极其严重的威胁与危机。

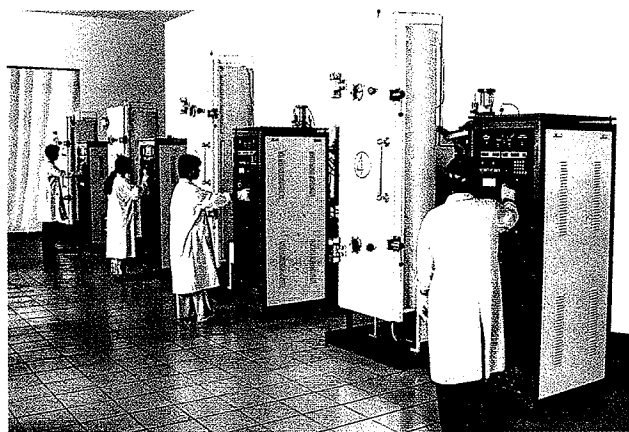
对自然的保护，同样为新奥集团视作己任。在对廊坊市实行天然气气化的同时，又着手开展了对太阳能资源热利用的研究开发工作。并于95年底成立了中澳合资新奥太阳能发展有限公司，她座落在被誉为京津“黄金走廊”的廊坊经济技术开发区内。公司下设太阳能研究所、全玻璃真空太阳集热管生产车间、太阳能专用设备制造车间、

热忱服务 Warmhearted service

Brief Introduction of the Solar Energy CO., LTD.

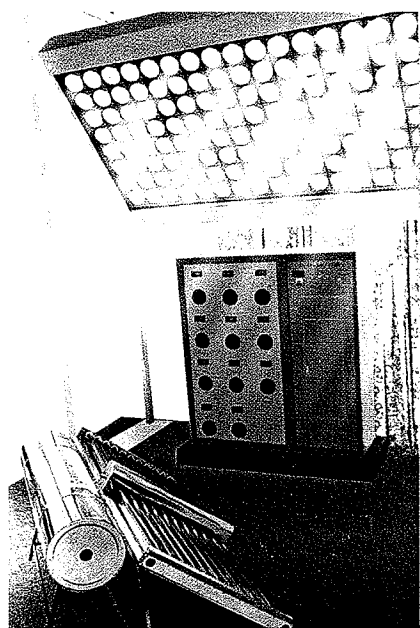
The economic development has brought material prosperity to our Society,mean while it has also produced very Serious threat and crisis to the natural environment and resources of human existence.

Xin-Ao Group regard natural protection as its own task.While putting into effort the natural gas liquifying for the urban district of LangFang,we started to study and develop the thermal utilization of solar energy resources.Sino-Australian Joint Venture Xin-Ao Solar Energy Development limited Company was set up by the end of 1995.This company locates in LangFang Economic technology Development Zone So called Gold Corridor between Beijing and Tianjin. It contains Solar Energy Research Institute,Full glass Vacuum Solar Energy heatcollecting tube Production



中国进口的第一台大型太阳模拟器
Solar Simulator

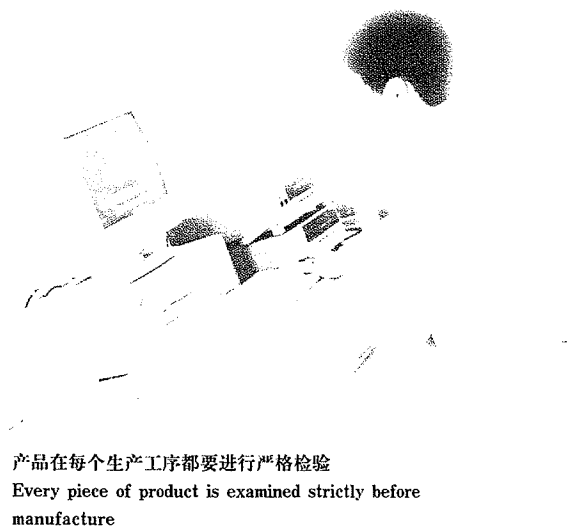
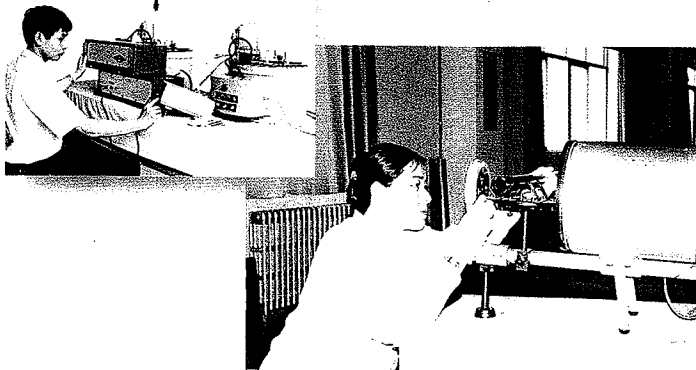
严密监控 Monitor strictly



workshop,Special Equipment Manufacture Workshop,Test House etc.There are branches in the northwest China and Australia, which mainly develop and produce full glass solar energy heat-collecting tube.

The product use hard,high boron silicon glass approved by international as raw material.The manufacturing technology,equipment,testing measure and product property have reached to the advanced level in our Country.It's specification is as follows:sunlight absorbance: ≥ 0.92 in frared radiarion ratio: $\leq 0.07(80^{\circ}\text{C})$ sunshiny: $\geq 240^{\circ}\text{C}$.The initial production capacity is 1.0 million pieces.

Under the guide of initiative thought of high starting point,science and technique quality,speed and benefit,developing and utilizing area for solar energy has got new development.



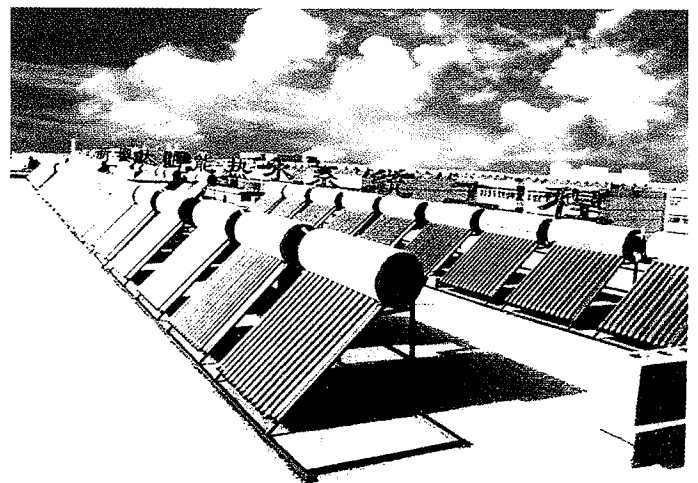
产品在每个生产工序都要进行严格检验
Every piece of product is examined strictly before
manufacture

检测室等。并在我国西北和澳大利亚等地建立了分支机构。主要研制和生产全玻璃真空太阳集热管。

该产品采用国际认证的特硬高硼硅玻璃为原料，在制造工艺、设备和检测手段及产品性能等方面，均达到国内先进水平。

其技术指标为：太阳吸收比： ≥ 0.92 ，红外发射率： $\leq 0.07(80^\circ\text{C})$ ，空晒温度： $\geq 240^\circ\text{C}$ ，年生产能力为100万支。

在高起点，高科技，高质量，高速度，高效益的兴业思想指导下，在太阳能的开发和利用领域内有了新的发展。

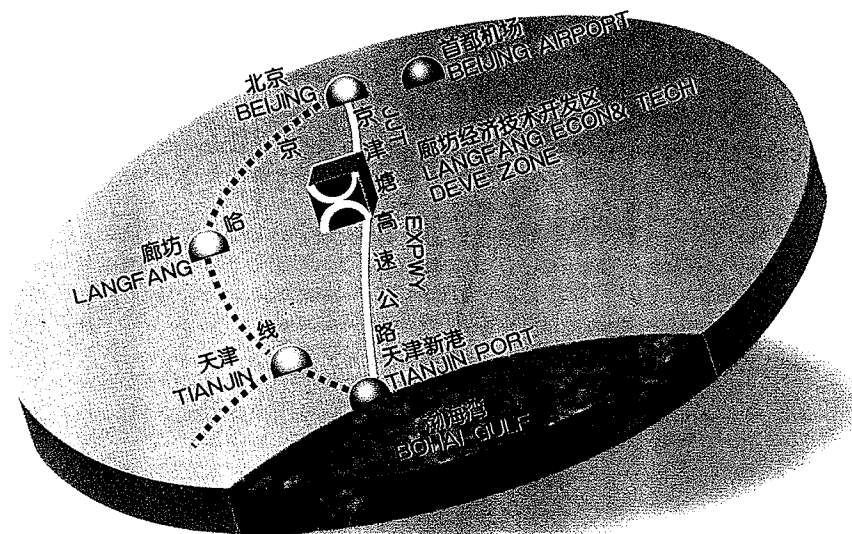


太阳能热水系统工程
Solar hot-water system



以高热值的天然气对产品进行退火，确保了
玻璃管体的纯净和质量
The products are annealed with high heat
value to ensure glass tube to be pure





廊坊新奥太阳能发展有限公司
 传真: (0316)6080999 6079998
 澳大利亚新奥高技术有限公司
 新奥集团北京销售公司

地址: 河北廊坊开发区华祥路
<http://www.xinao.com> 邮编: 065001
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 地址: 朝阳区华严北里甲1号健翔山庄C4座

电话: (0316)6079999 6079990
 电话: 00612-9682-7128
 电话: (010)62054232

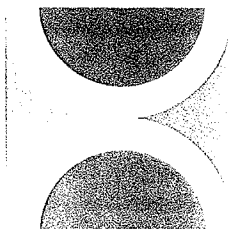
LangFang Xin-Ao solar Energy Development Co.,Ltd. Add:Huaxiang road of LangFang Economic Technology Development Zone in Hebei Province,P.R China

Tel:(0316) 6079999 6079990 Fax:(0316)6080999 6079998 Post code:065001 <http://www.xinao.com>

XIN AO High Level-new technique Limited Company. Add:18A. ELSINORE St. MERRY LANDS SYDNEY N.S.W 2160 AUSTRALIA. Tel:00612-9682-7128

Peking Saling Company of Xin Ao Group . Add:C4/F Jianxiang mountainvilla First No.1 Huayan North street. ChaoYang district BeiJing China. Tel:(010) 62054232

对于太阳能资源开发和利用的前景,如同太阳的光芒一样,光辉灿烂。新奥太阳能发展有限公司,在生产和推广高品质的全玻璃太阳集热管的同时,正在太阳能应用的新领域努力探索。新奥太阳能研究所已致力于豪华热水器、太阳能热水瓶、海水淡化、太阳池、太阳能空调等方面的研究开发工作,并取得了可喜的成果,大型太阳模拟器的建造将为太阳能的开发和研究提供必要的手段。新奥太阳城的落成,将吸引更多、更优秀的科技人才,开发适应不同地区、不同条件和不同需求的新型太阳能产品,为科学利用资源,保护环境和造福于人类做出新的贡献。

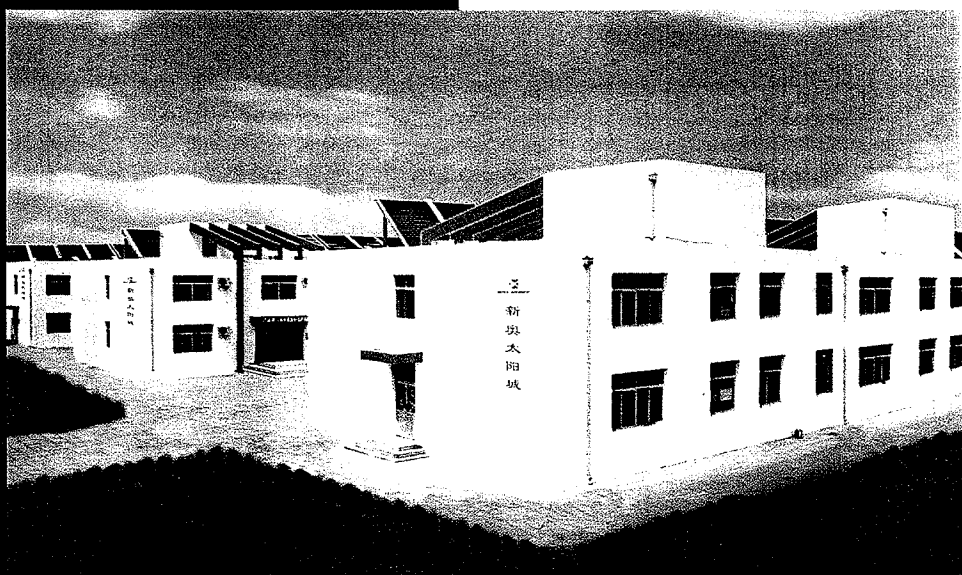


XINAO SOLAR ENERGY

把太阳的温暖留下

REMAIN SUNSHINE WARMTH

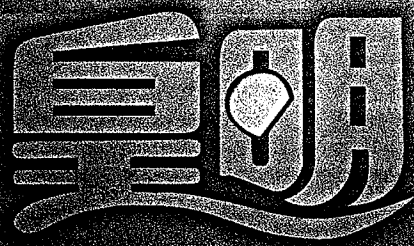
The future of exploiting the solar energy just as bright as the sunshine. Besides producing and popularizing the quality all glass evacuated solar collector tubes, Xin-ao Solar Energy Limited is trying to make some new exploitation on solar energy. Xin-ao Solar Energy Research Institute are now working on the Luxurious hot-water apparatus, Solar thermos flask, desalination of sea water, solar pool, solar air conditioner, etc., and pleasing results have been achieved. The construction of the giant solar simulator will provide the necessary means for the exploitation and study of the solar energy. The completion of Xin-ao solar City will attract more excellent experts to work on new solar products according to different regions, different situation and different demands. New contributions will be made to make Scientific use of the resources, to protect environment and to benefit the human being.



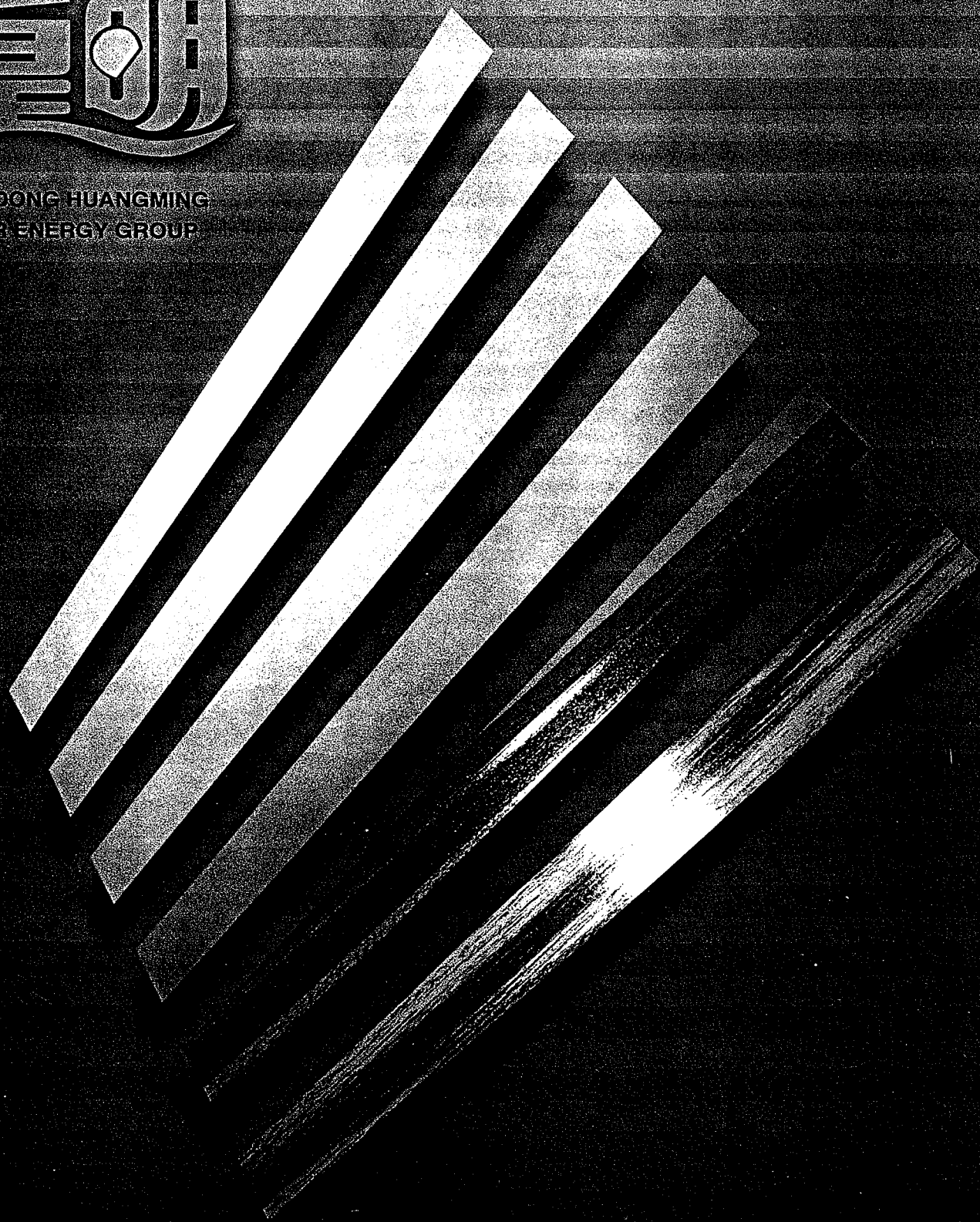
新奥太阳城 XIN-AO Solar City

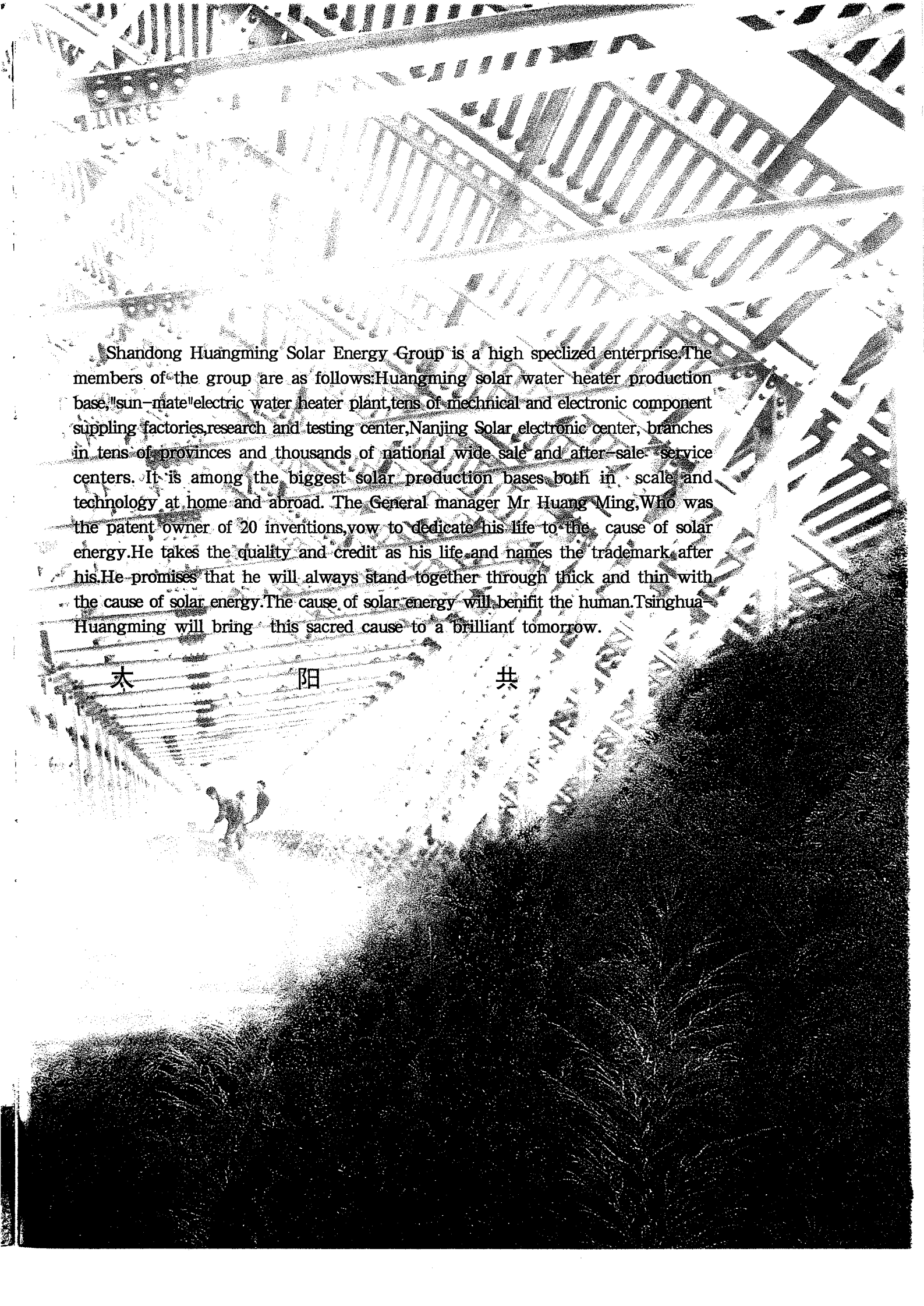
Shandong Huangming solar energy group

山东皇明太阳能集团



SHANDONG HUANGMING
SOLAR ENERGY GROUP





Shandong Huangming Solar Energy Group is a high specialized enterprise. The members of the group are as follows: Huangming solar water heater production base, "sun-mate" electric water heater plant, tens of mechanical and electronic component supplying factories, research and testing center, Nanjing Solar electronic center, branches in tens of provinces and thousands of national wide sale and after-sale service centers. It is among the biggest solar production bases both in scale and technology at home and abroad. The General manager Mr Huang Ming, Who was the patent owner of 20 inventions, vow to dedicate his life to the cause of solar energy. He takes the quality and credit as his life and names the trademark after his. He promises that he will always stand together through thick and thin with the cause of solar energy. The cause of solar energy will benefit the human. Tsinghua-Huangming will bring this sacred cause to a brilliant tomorrow.

太

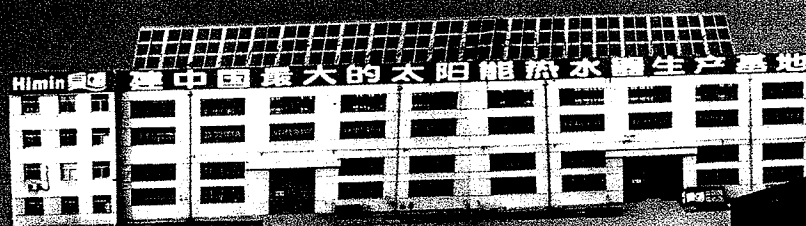
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共

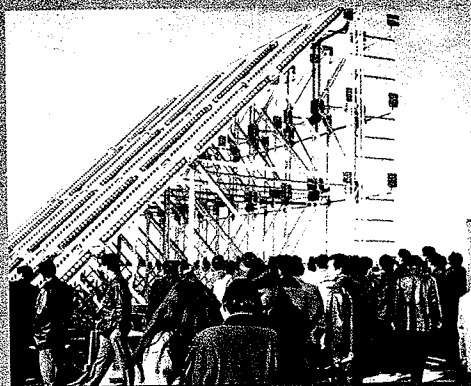
产业篇 I

厂区占地40亩，厂房面积10000平方米，一期工程年设计生产能力20万台，产值1亿元，是继意大利、以色列之后又一世界著名的太阳能热水器生产基地。具有全自动化、标准化、严格规范化、现代化生产线。

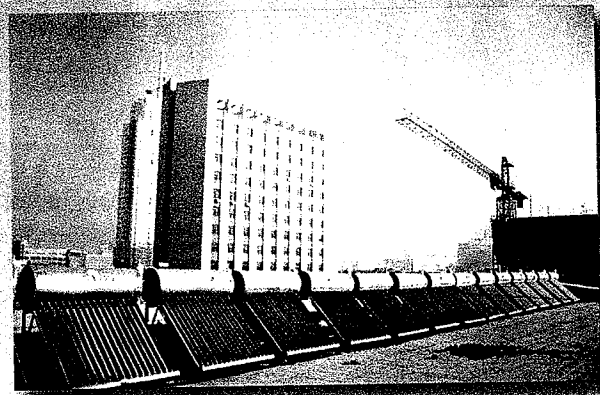
The factory area is 40 mu, with a total area of 10,000 square meters buildings. The production capacity is 200,000 units per year, with a value of 1 billion RMB. It is another largest world level solar water heater production base. After Australia and Israel, it has become the production line with completely automation, standardization, strict and modernization.



厂区外景
Exterior View of the Company



大型集热工程
Large-scale Solar Water Heating System

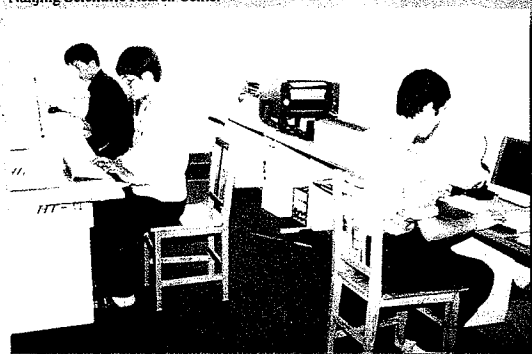


大型家用热水工程
Large-scale Water Heater for Domestic Use

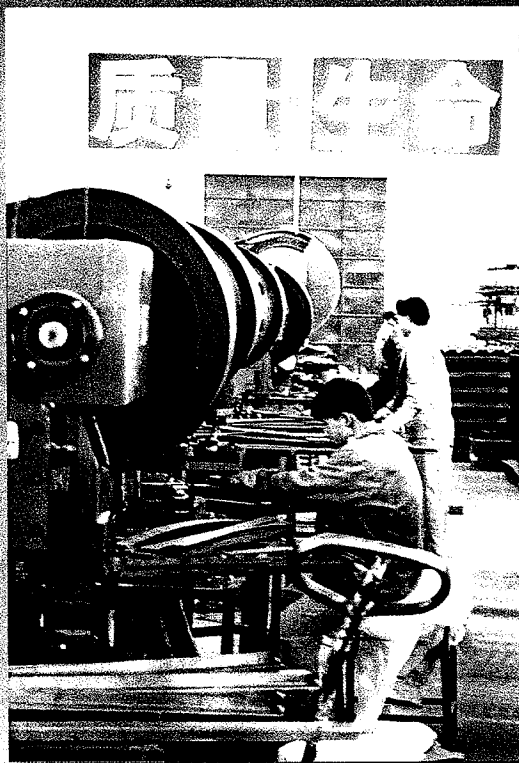




南京科研中心
Nanjing Scientific Research Center



用户档案微机管理
Customers' Files Computer Center



生产车间
Workshop



产业篇 II

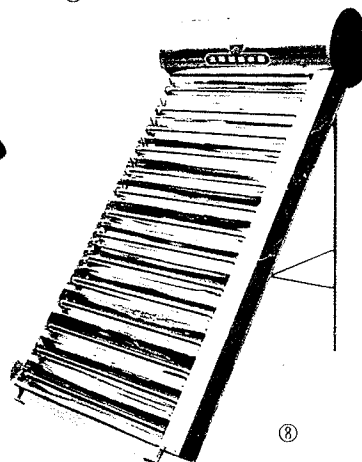
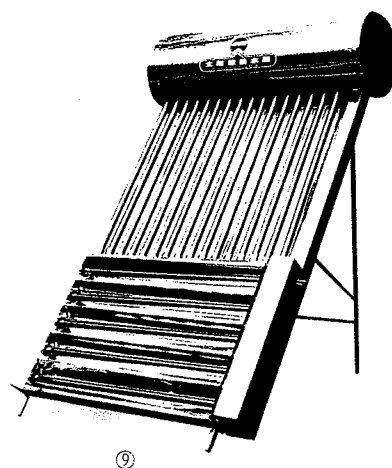
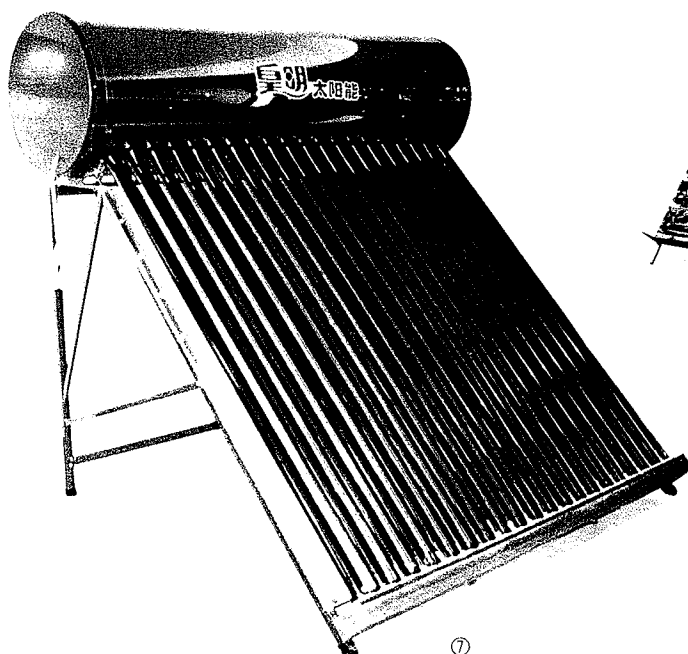
皇明太阳能热水器全部采用清华大学全玻璃真空集热管,从普通家用型到豪华别墅型,太阳能开水器(8),开水热水两用器(9)等40多个品种规格。严格执行与清华大学出口产品同步的生产、质检、监测、售后服务标准。

Huang ming solar water heaters are made of glass vacuum tube of Tsing Hua University. From ordinary to luxurious type, solar boiler water heater, and solar boiling and heat water heater, etc, its series has more than 40 sizes and types. The product, quality inspection, monitoring and the service are in according with TsingHua standard.

产品特点

清华大学原装玻璃真空集热管。零下18℃可得50℃热水。高硼硅特硬玻璃抗2.5cm冰雪正面打击。高真空度 $< 5 \times 10^{-3} \text{pa}$, AL-N-AL真空溅射选择性吸收镀膜。选材标准: 国产过关的选最好的。国产稍差的选进口的。进口不锈钢(SUS304)高铬高镍氩弧焊接水箱内胆。水质纯净, 永不锈蚀。加厚进口聚氨酯发泡保温层。冬季隔夜水仍热。全免焊喷塑组合支架(国家专利)。

HuangMing products are made of Tsinghua glass vacuum tubes with selective observe AL-N-AL layer, hard vacuum below $5 \times 10^{-3} \text{Pa}$ which can offer 50℃ water at 18℃ below zero. The tubes' material is high boron silicon glass which can bear the hit of 2.5cm hailstone, imported stainless steel arc welding water tank, stainless for ever in water its lifetime being more than 30 years, enthichked polyurethane insulation layer keeps the water hot until the next day, and weldless trestle with plastic casing (patent of the nation). HuangMing's material principle is chosing the best domestic material if it meets the standard and using the imported if the domestic is below the standard.



清华－皇明精品

1. 大型工程定温：温差复合控制全自动控制系统，过热保护、漏电保护、无水保护、防冻循环保护功能、自动补水、定温上水、自动温差循环功能、辅助电加热等。

2. 皇明98新品“太阳伴侣”电热水器，既可单用，又可配太阳能、全天候热水，微电脑控制、安全、方便、节能。

3. 50支管别墅型太阳能热水器。跨世纪产品，24小时热水。

4. 家用太阳能智能化水位水温自动控制显

Huangming Exacting Series

1. Automatic electronic controller for large scale system has the function of automatic temperature control, overheat proof, anti-electric leakage and freeze proof, etc. and it can fill the water automatically in a designed temperature. The system consists of temperature control function change-over device and assistant electric heating device.

2. "Sun-mate" electric water heater, the new product of Huang ming in 1998, which is microcomputer controlled, safety and convenience. It not only can be used singly but also can be used with the solar water heater. Then they can both save energy and offer hot water all weatherly.

3. Palcony type solar water heater.

示仪，具有水位水温检测显示，自动温控上水，温度显示，辅助电加热等功能。

5. 1.5M加长真空管热水器系列，优点是占地面积小，与同类普通产品相比较，性能提高25%。

6. 阳台承压式太阳能热水器。美观，不须管线保温，不占楼面，适于在城市高层建筑，尖顶楼房。

7. 辅助电加热太阳能热水器，带漏电保护功能，365日全天候热水。

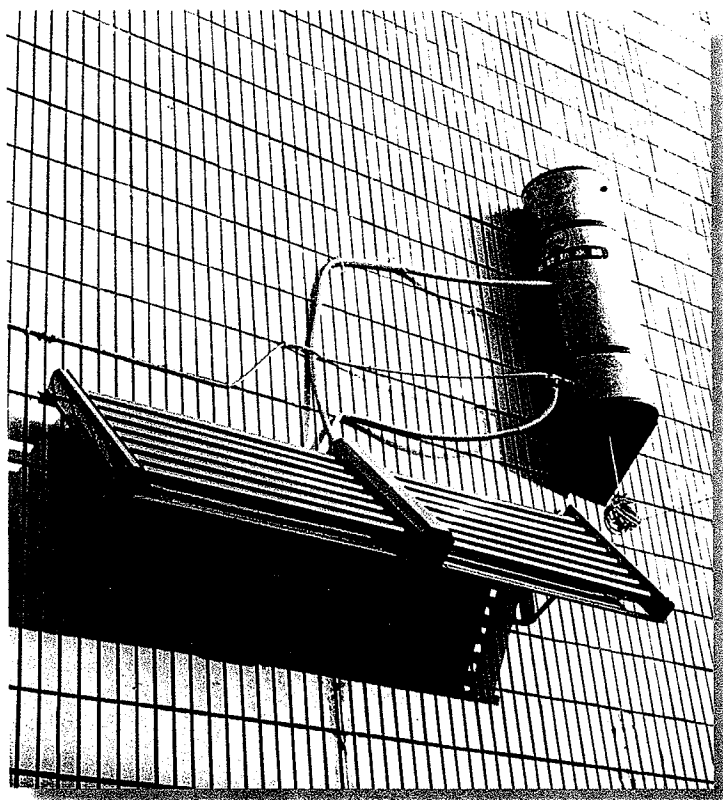
beautiful shaped and small occupation, fits for high buildings.

4. Ordinary solar water heater controller, functions as follows, display the water level and water temperature, fill the water automatically, and heat the water with assistant electric heating device.

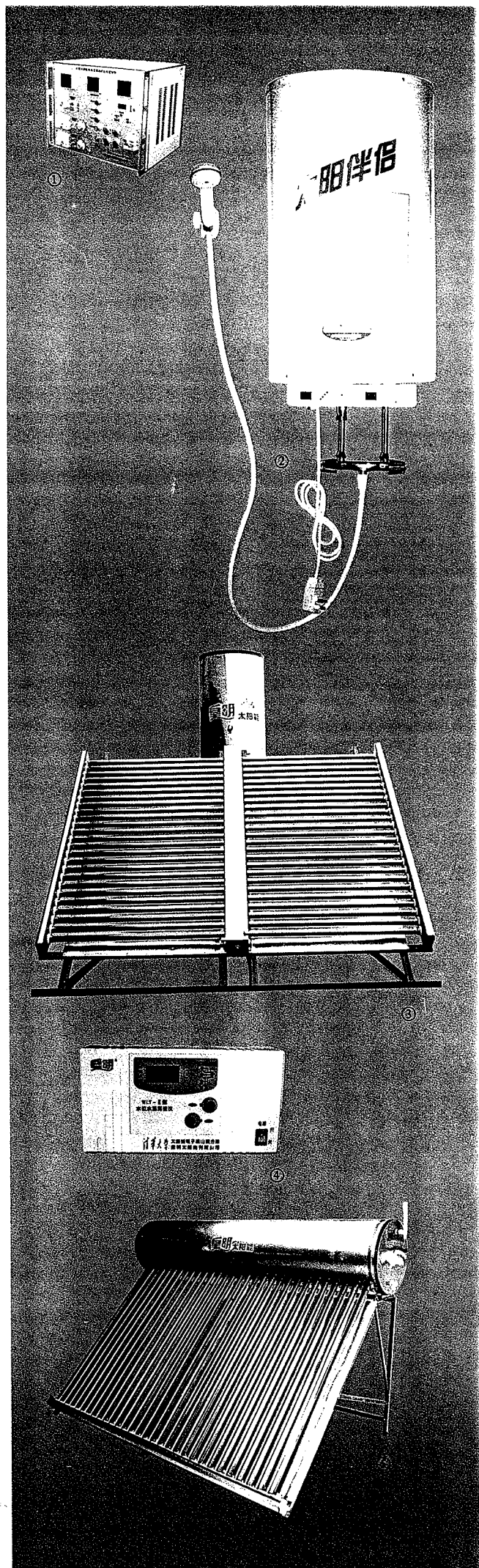
5. 1.5meter enlenghed vacuum tube, small occupation, has the capacity 25% hinner than the ordinary one.

6. Luxurious solar water heater with 50 vacuum tubes, the wonderful products offer hot water all weatherly.

7. Solar water heater with assistant electric heating device can offer hot water all days with the function of electricity leakage prevention.



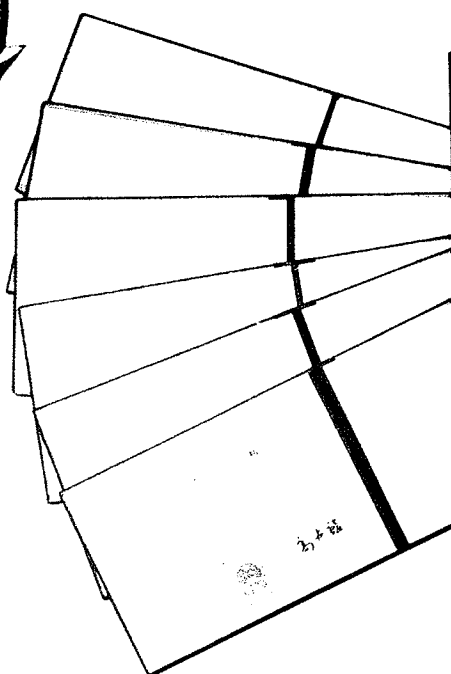
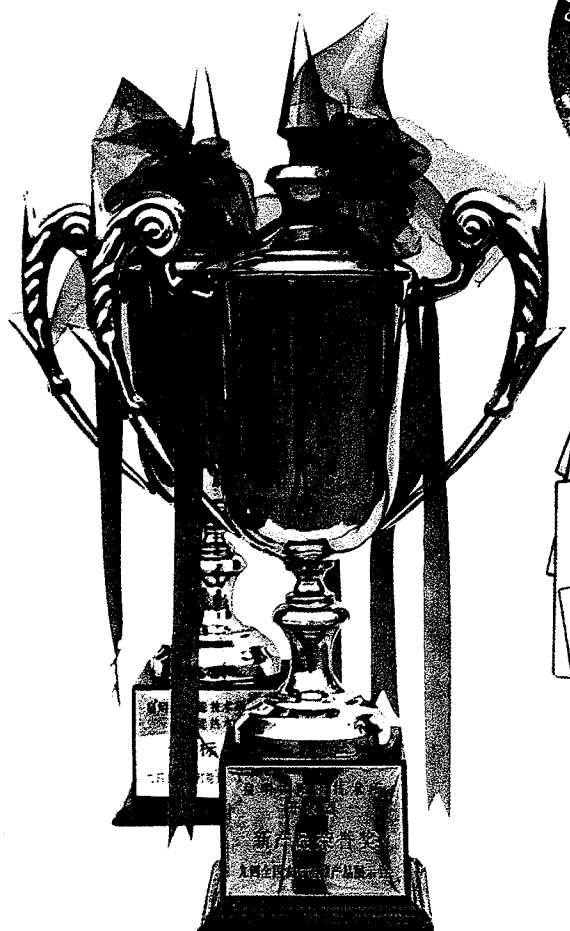
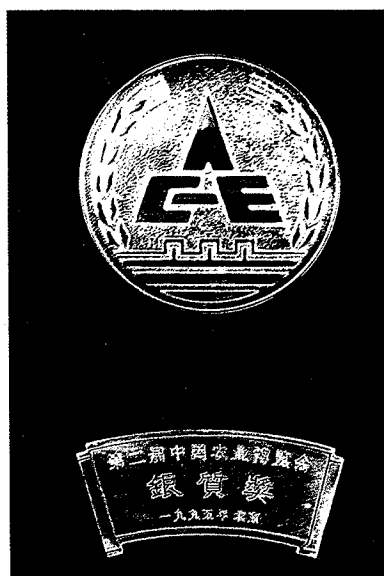
⑥



产业篇III

清华-皇明太阳能热水器1995年获全国十年发明成果金奖;同年获行业博览会银奖,样品永久保留在全国第二届农业博览会精品厅。国内首创的万能转换式开水、热水两用器获国家发明金奖(专利号IL9422310-07)。太阳能开水器是国家检测过关的第一台。获1994年行业评比唯一新产品奖,获96年建设部科技成果重点推广项目,97年全国产品质量消费者跟踪调查组推荐的消费者信得过产品,全国建设节能推荐使用的新技术产品。

Tsinghua-Huangming solar water heater won the gold prize on the ten year new productive invention exhibition. At the same year, it won the silver prize on the profession fair and the sample was kept in the essence hall of the second agricultural fair for ever. The solar water heater and the boiler with automatic changable function won the state invention gold prize(patent No IL942231007).Solar water boiler is the first one which passed through the state inspection, and it is the only one which won the new product prize on the competition of the profession in 1994.It's the mayor item that the construction ministry recommended and the reliable product that approved by the national-wide consumers investigation commission in 1997.



太阳能科普宣传万里行

几十辆宣传车载着太阳能产品、宣传牌、飘挂着“向太阳索取，为人类造福”的旗帜，浩浩荡荡，行程万余里，经山东、河北、河南、湖北等十几个省市，以广播录音、散发清华-皇明科普报，现场演示、讲解等形式进行宣传，此项活动已作为常规活动连续开展。

National-wide Science Propagnada Tens of propagnada cars,set out with solar energy water heaters and many flags on which slogan is: "EXACT FROM THE SUN BRING BENEFIT TO THE HULMNBEING." The journey started from Dezhou,via Shandong,Henan,Anhui,Jiangsu, Zhe jiang,Hunan,Hubei,etc.about tens of provinces and cities,They conduct propaganda through broadcas-ing,newspapers,making on-the-spot experiments and explanation and so on.It is expected to be continued as a regular activity.



绿色慈善捐赠

Dontion to the philanthropies



太阳能科普讲座

Lectures of solar energy experts

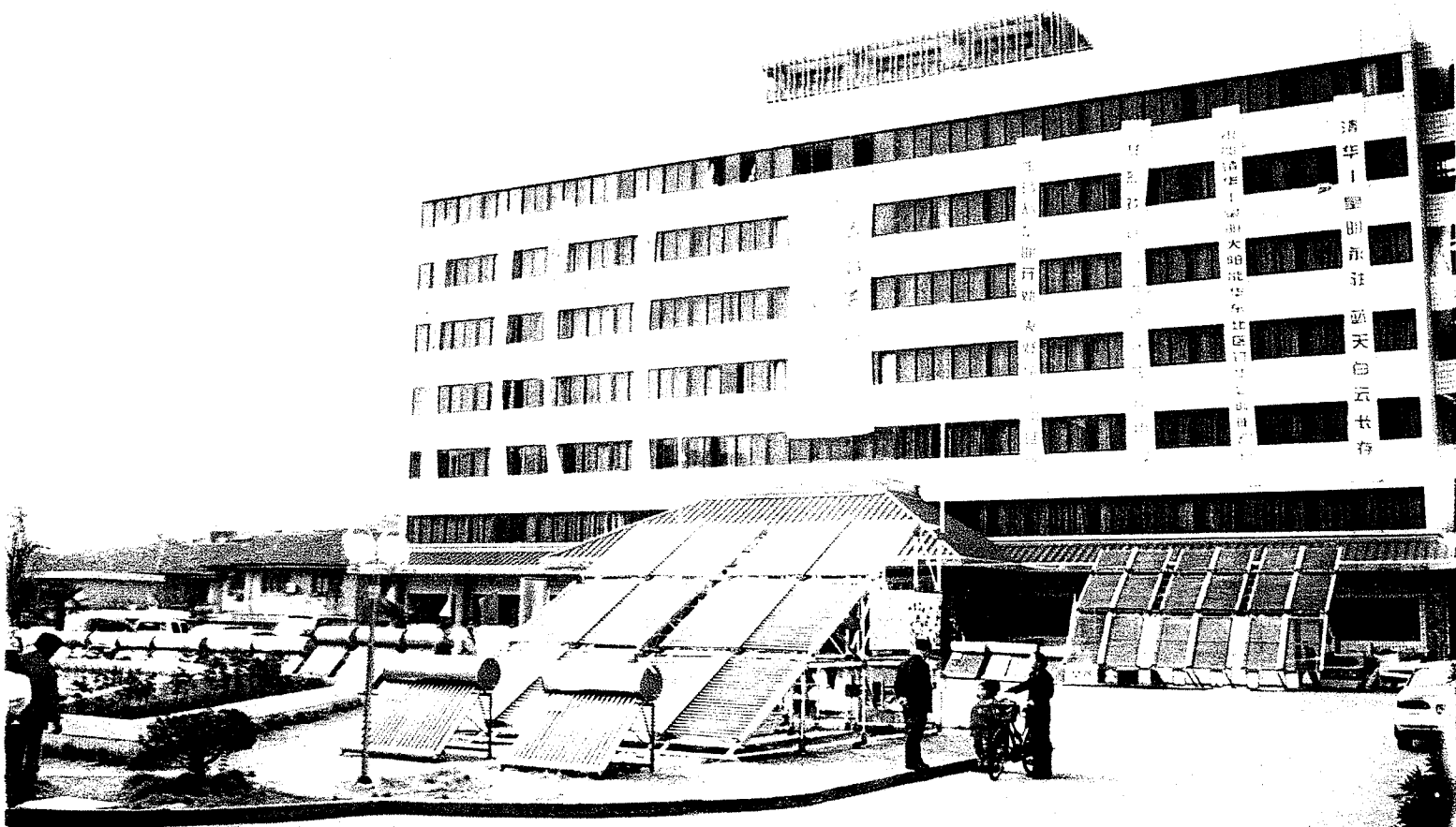
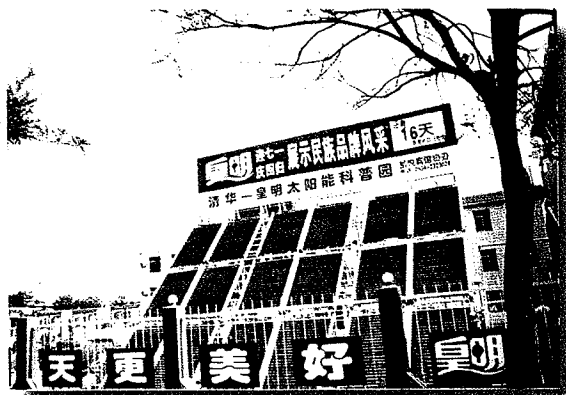


公益篇II

全国独创太阳能科普园

1996年12月1日,清华-皇明向社会推出了全国独创的太阳能科普园,开创了以游园形式进行科普宣传之先河。97年3月2日、7日,济南科普园、南京科普园也相继落成。科普园设有太阳能产品展示、太阳能科普知识宣传栏、太阳能活动浴房,向人展示了新奇广阔的太阳能世界,洋溢着强烈的绿色文化氛围。

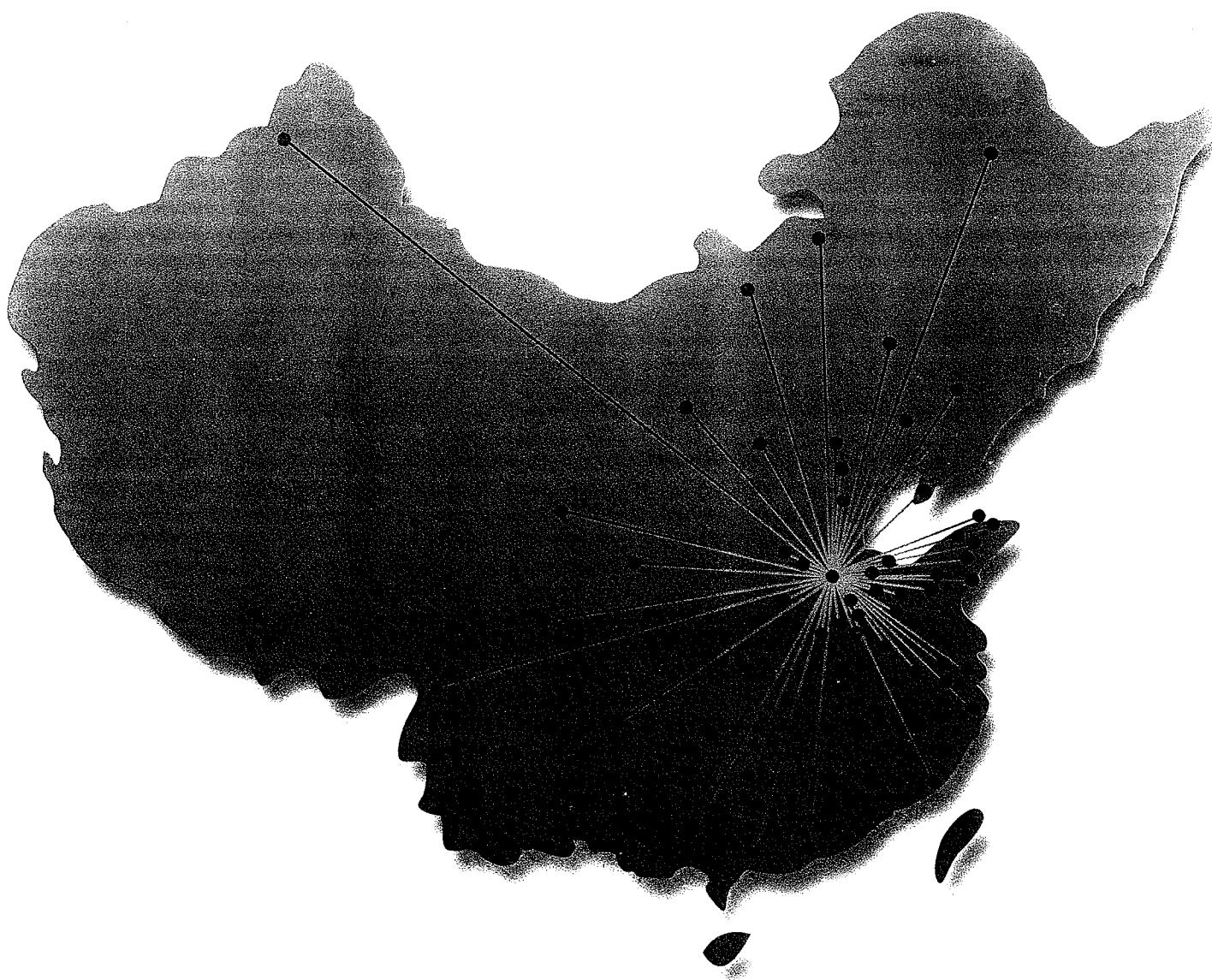
Solar Exhibition Garden—Originality in China. On December 1st, 1996, Huang Ming had originally brought the solar exhibition garden to the public. Since then, it started a new way of conducting propaganda of using solar energy and environment protection. On March 2nd and 7th, 1997, the solar Exhibition Garden was built in Jinan and Nanjing successively, it consists of many solar science popularization boards, various solar products shows, and solar energy prefabricated bathroom, etc, which show the people a vast novel solar energy world brimming over with strong green cultural atmosphere.



星火篇

星星之火,可以燎原。清华--皇明销售网络覆盖全国,三个分公司及 200 多个经销商尽最大努力做好售后服务工作,并计划打入国际市场,以真正达到燎原之势。

A single spark can start a prairie fire. Huang ming Solar Energy Group. The products of TsingHua-HuangMing can be found all over the country. It has three subsidiaries and several hundred agents. HuangMing is always doing its oumost to do the service for customers nationwide. The company has mapped out a magnificent project of entering the international market. Then the "prairie fire" could come into being.



HuaYang Solar Water Heater Co.

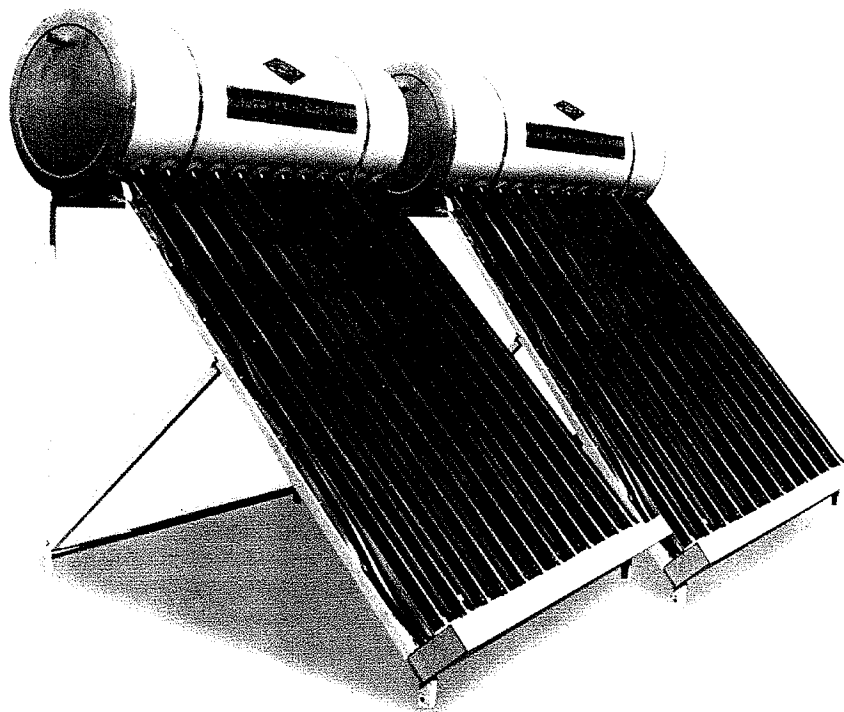


扬州市华扬太阳能热水器有限公司

YANGZHOU HUAYANG SOLAR ENERGY WATER HEATER CO., LTD

华扬牌太阳能热水器

HUAYANG SOLAR ENERGY WATER HEATER



华扬牌太阳能热水器安全、节能、无污染、四季适用。家用型有高可靠、长寿命机械式自动上水及数字水位显示，阳台壁挂式及大型团体热水器，全自动，操作简便。本产品是各类团体及家庭最经济的热热水供应中心。

Huayang Solar Energy Water Heater is featured by its safety, safe-energy and no-pollution. It is suitable for the four seasons. The type of family-used water heater has the function of water storage automatically with mechanical style and digital display of water level. Other types are balcony wall-hanged and large mass-used. All types are high-reliable, long-time life and easily operated. Our company's product is the best choice of the favourable water heater for all sorts of families and enterprises.

全玻璃真空集热管

ALL-GLASS EVACUATED SOLAR COLLECTOR TUBE

全玻璃太阳真空集热管采用耐冷热冲击，抗冰雹的双层高硼硅玻璃，夹层高真空，内层玻璃外壁采用磁控溅射真空镀膜工艺，镀有国际先进水平的选择性吸收涂层，对阳光具有极高的吸收率和极低的热发射率，使用寿命可达15年以上。单管试验：晴天-18℃二小时左右，真空管内水可达沸点。Ø47/1000mm、1200mm、1500mm及可按用户需要定制的各种规格产品。是中小太阳能热水器厂家理想的核心配套元件。

All-glass evacuated solar collector tube uses double layer Borosilicate glass which can resist the impact of heat, cold and hailstone. The out-wall of inner tube uses the technology of magnetic-control splashing vacuum chromed layer to form the selective absorption coating layer which has a high rate of absorption and low rate of heat radiation. The using life time of this vacuum tube is over 15 years. The result of single tube test shows that water in this vacuum tube can reach boiling-point in 2 hours under a fair weather (-18℃). Diameter of this vacuum tube is Ø47mm and the length has three: 1000mm, 1200mm and 1500mm. It's acceptable to produce various specification tubes according to the user's demand. All-glass evacuated solar collector tube is the ideal main parts for the solar energy water heater factories.



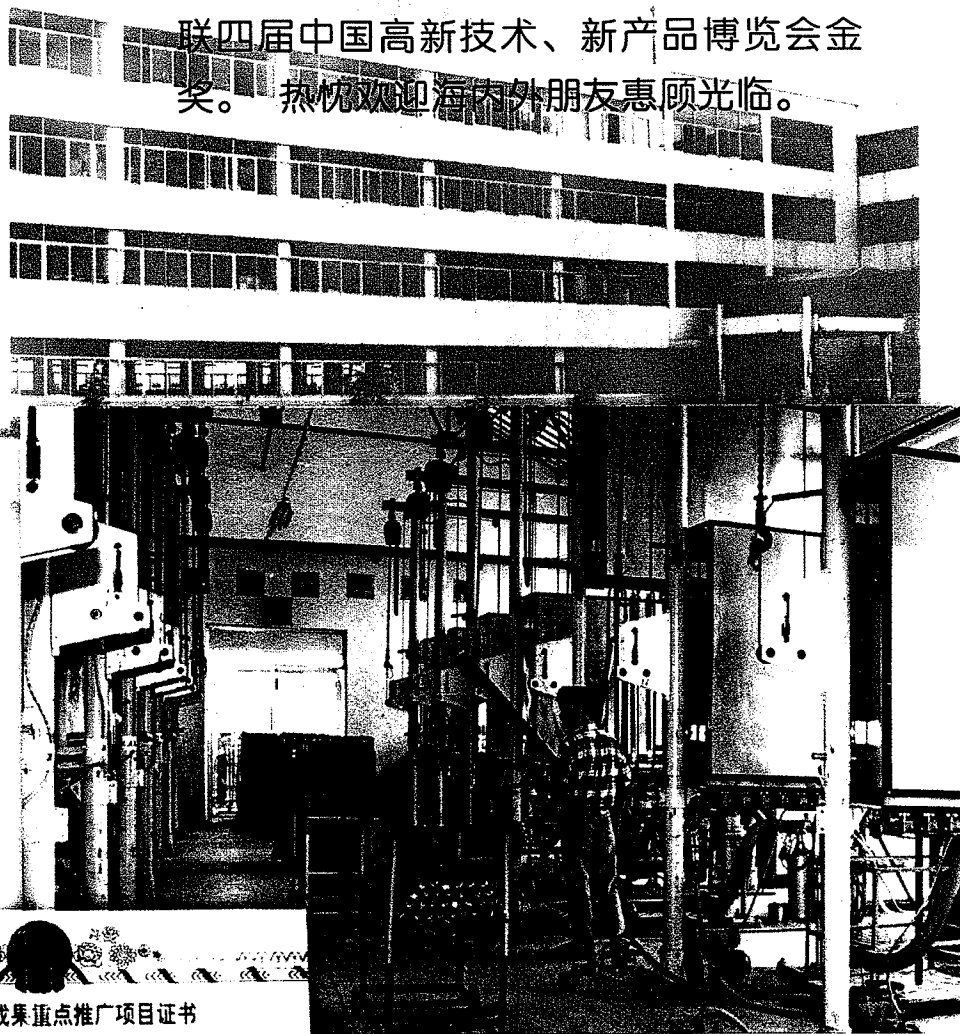
地址：中国·江苏 扬州市经济开发区振兴路2号 电话TEL:0514-7871008 7875362 传真FAX:0514-7873263



扬州市华扬太阳能热水器有限公司
YANGZHOU HUAYANG SOLAR ENERGY WATER HEATER CO., LTD

Huayang Solar Energy Water Heater Co., Ltd. is the largest company specialized in producing all-glass vacuum tube and solar energy water heater in large scale. Its products have advanced technology, stable quality, good function and high reputation and were awarded the gold medal on the 4th China High-New-technology, New Products Exhibition. Warmly welcome friends from all over the world to have a business talk with us in Yangzhou.

华扬太阳能热水器有限公司是中国太阳能行业全套大规模专业化生产全玻璃真空管及太阳能热水器的龙头企业。产品工艺先进,质量稳定,性能优良,信誉卓著,蝉联四届中国高新技术、新产品博览会金奖。热忱欢迎海内外朋友惠顾光临。



建设部科技成果重点推广项目证书
建筑节能新技术新产品

项目名称: 扬州华扬太阳能热水器有限公司
证书编号: 建科[1995]第100号
证书日期: 1995年10月10日

该科技成果,列为一九九五年建设部科技成果重点推广项目,全国建筑节能推广应用的新产品。

Certificate of
Products recom-
mended by the
Ministry of National
Constution.

**国家级新产品
证书**

扬州市华扬太阳能热水器厂

你单位 真空管太阳能热水器
一九九五年度国家级新产品



被评为

**国家级新产品
证书**

扬州市华扬太阳能热水器厂

你单位 全玻璃真空管太阳能热水器
一九九五年度国家级新产品



被评为

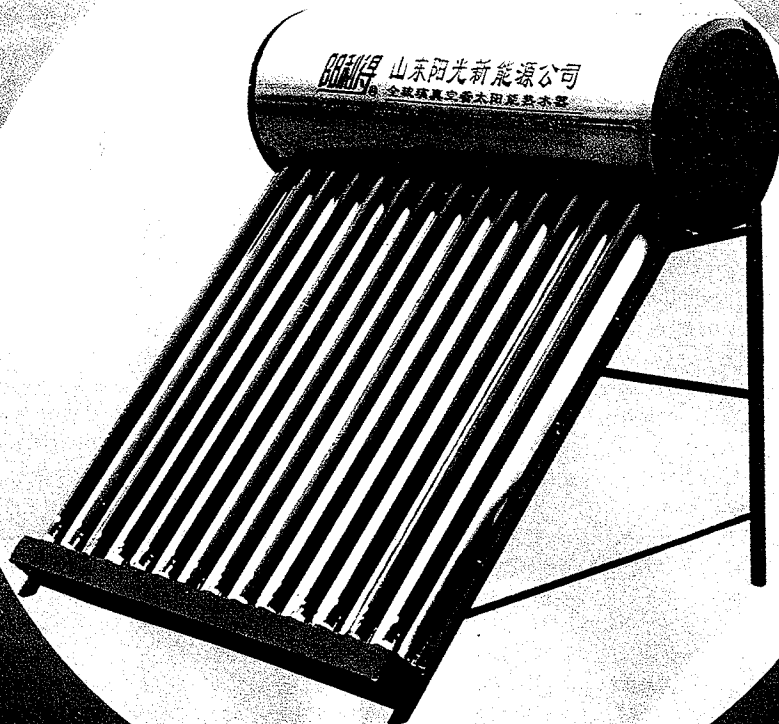
Certificate of new products on National Level

Add: Yangzhou Economic Development Zone, Jiangsu, China

Shandong Sunshine New Energy Co.

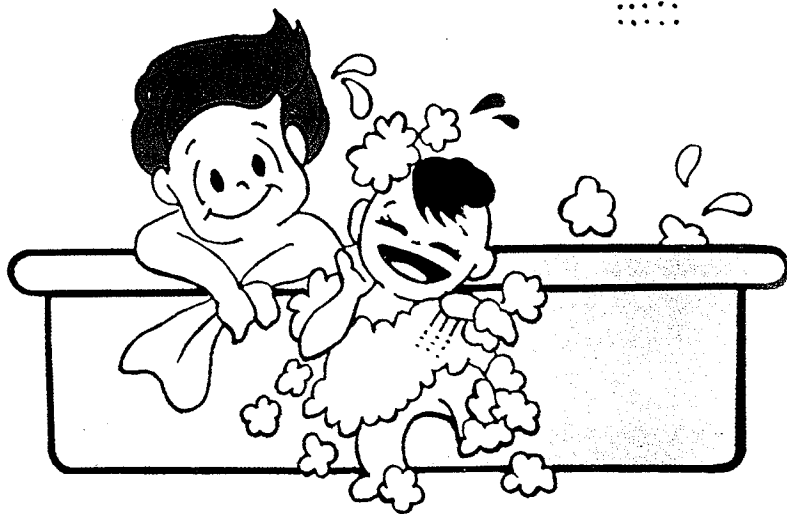
阳利得®

陽光——永遠潔淨的能源



山東陽光新能源公司

SHANDONG SUNSHINE NEW ENERGY CO



簡 介

山東陽光新能源公司是國內首家引進清華大學專利技術生產全玻璃真空太陽集熱管的高新技術企業，公司擁有固定資產貳仟余萬元，十幾條居國內領先水平的現代化生產流水綫。形成年生產真空集熱管 200 萬支及太陽能熱水器壹萬臺的能力，是目前國內生產真空集熱管的重點企業。

公司生產的全玻璃真空集熱管及太陽能熱水器，註冊商標為“陽利得”牌。產品在原材料選擇、工藝技術、生產設備、檢測手段及產品性能等方面均達到領先水平。連續獲得“山東省最受消費者信賴的產品”“山東省科技星火獎”“山東省星火示範企業”等稱號，成為目前國內市場上的名牌產品。並已出口到馬來西亞、泰國、新加坡等國家。

先進的技術設計，可靠的質量保證，完善的售後服務，良好的企業信譽是山東陽光新能源公司對廣大用戶的承諾。

山東陽光新能源公司地處舉世聞名的泰山腳下，公司全體員工熱忱歡迎國內外朋友光臨泰安惠顧本公司。

ABSTRACT

Shandong sunshine New Energy Co. is a high-and-new-tech enterprise producing all glass evacuated solar collector tubes which is the patent of Tsinghua university and firstly adopted by our Co. The Company, with the fixed assets of 20000000 yuan, has more than ten advanced modern assembly lines which are able to produce 2 millions of tubes and 10,000 units of solar water heating systems. At present, our company is a key enterprise producing evacuated solar collector tubes.

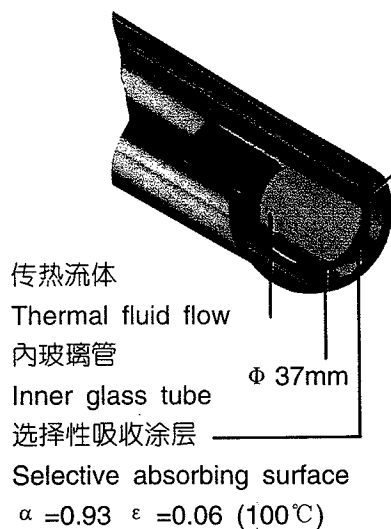
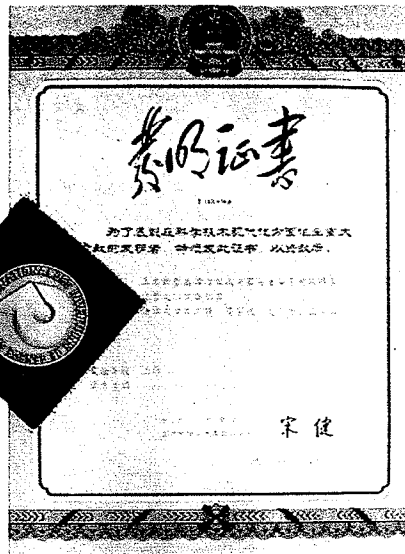
Our "yangdeLi" brand tubes and solar water heating systems feature with advanced equipment, experienced technical force, efficient management and mechanized production. Our products have won prizes of "products most trusted by consumers in shandong province", "Medal of scientific and technological spark of shandong province". Our products are sold to Malaysia, Thailand and Singapore as well as widely sold in China.

Shandong Sunshine New Energy Co. makes all users the following promises on their products: advanced technical design, reliable quality guarantee, perfect after-sale service and good enterprise prestige.

Shandong Sunshine New Energy Co. is at the foot of Mountain Tai Which is famous in the world due to its beautiful scenery and pleasant weather. Warmly welcome all friends from home and abroad to our company for investigation and suggestion.



內筒材質 inner tube material	鍍鋅板 zinc plating plate	不銹鋼板 stainless steel plate
規 格 specifications (可根據用戶 需要,訂做各 種規格、材質 的熱水器)	10 支 10 tubes	12 支 12 tubes
	15 支 15 tubes	14 支 14 tubes
	18 支 18 tubes	40 支 40 tubes



真空: 压强
Vacuum: Pressure
 $P < 6 \times 10^{-3} \text{Pa}$
外罩管
Cover tube
 $\Phi 47\text{mm} \quad T=0.91$

玻璃真空太陽熱水系統應用範圍

APPLYING LIMITS OF SOLAR WATER HEATING SYSTEMS COMPOSED OF ALL GLASS EVACUATE SOLAR COLLECTOR TUBES

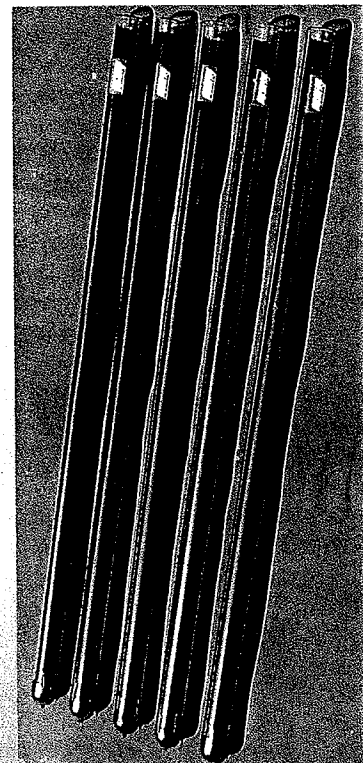
不僅用于家庭生活用熱水, 燒開水, 而且可用于工業用熱水, 干燥, 去濕, 空調制冷, 海水淡化等領域。

It can be used not only to produce hot water and boiling water, but also for industrial heat generation, drying, air conditioning, refrigeration and sea water desalination, etc.

玻璃真空太陽集熱管性能規格

(Specifications):

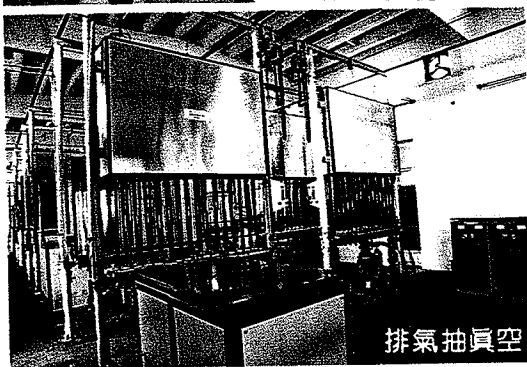
結構 Structure		全玻璃雙層同軸結構 All-glass concentric dual tube geometry
玻璃材料 Glass Material		硼矽玻璃 Borosilicate glass
外管直徑及厚度 Outer Tube Diameter and Thickness		$\Phi = 47 \pm 1\text{mm}$
內管直徑及厚度 Inner Tube Diameter and Thickness		$\Phi = 37 \pm 1\text{mm}$
管長度 Tube Length		$1200 \pm 10\text{mm}$ ($1500 \pm 10\text{mm}$)
吸收塗層性能 Absorptive Coating Properties	結構 Construction	漸變 A1-N/A1 選擇性吸收塗層 Graded A1-N/A1 solar selective absorbing coating
	沉積方法 Method of Deposition	直流反應濺射 Dc reactive sputtering
	吸收率 Absorptance	$> 93\%$
	發射率 Emittance	$< 6\% (100^\circ\text{C})$
真空度 vacuum		$P < 5 \times 10^{-3} \text{Pa}$
空曬溫度 Stagnation Temperature		250°C
壽命 Lifetime		15 年 (year)



玻璃材料: 硼矽玻璃
Borosilicate
空氣悶曬溫度: 250°C 以上
Stagnation temperature: $> 250^\circ\text{C}$

山東陽光新能源公司

使用安全可靠能受直徑 2.5 厘米水雷襲擊
Tubes have proved extremely reliable in practical applications and can withstand the attack of ball of 1 inch in diameter



廠址：山東省泰安市靈山大街東首

Add: the East of Lingshan St. , Taian. Shandong

總經理：石金泉

Chief Manager: shi Jin Quan

電話(Tel): (0538)6114682 6112930

電掛(Cab): 7829

傳真(Fax): (0538)6112930

郵編(Postcode): 271000

泰安市祥雲廣告設計公司承印 電話: (0538)8331362

攝影：王希春 設計：常新春、張 玲



山東陽光新能源公司

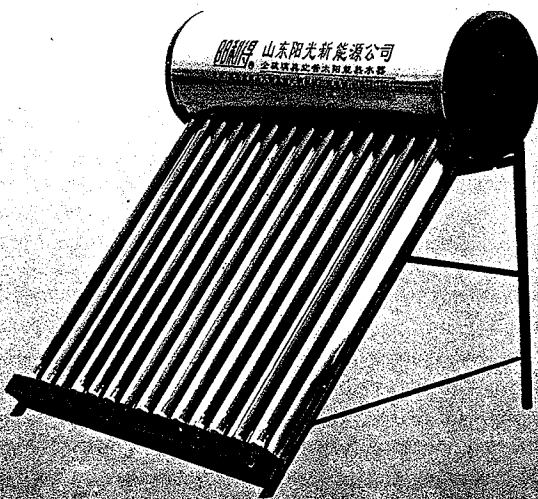
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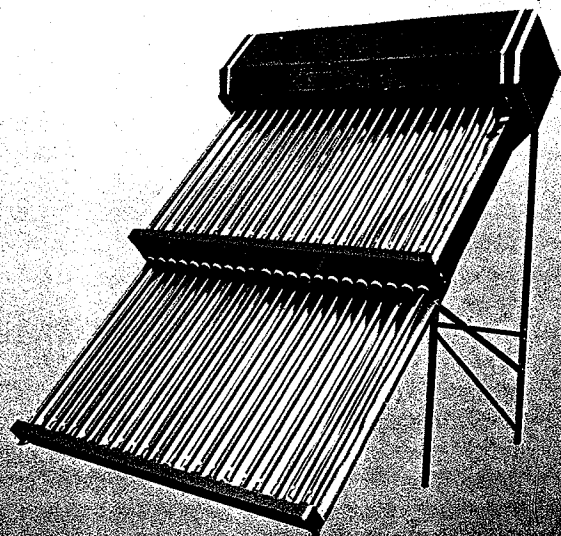
10 支管热水器



12 支(15 支、18 支)管热水器



14 支管热水器



44 支(40 支)管热水器

中國人民保險公司泰安分公司
獨家保險

一、自然灾害保险

因下列的自然灾害事故所造成正在使用的太阳能热水器的损失，保险公司负责赔偿暴雨、冰雹、泥石流、地震、雷暴。

二、产品质量保险

不系属太阳能热水器自购买之日起，出现下列情况之一者，均可持保单，向保险公司或烟台分公司联系维修，如属质量问题，照价赔偿。

①热水器装置出现漏水、漏电现象。

②玻璃真空管在不破裂的情况下，出现真空管失效（即管前失真空）情况现象。



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硅膠內桶密封圈：無毒、無味、耐高溫、抗老化、壽命長。

保溫好：水箱保溫採用冰箱保溫材料進口聚氨酯，一次性發泡，保溫層達4cm厚。

水箱外殼：採用IF21防銹鋁合金板，封頭、護盒烤漆，即耐用又美觀。

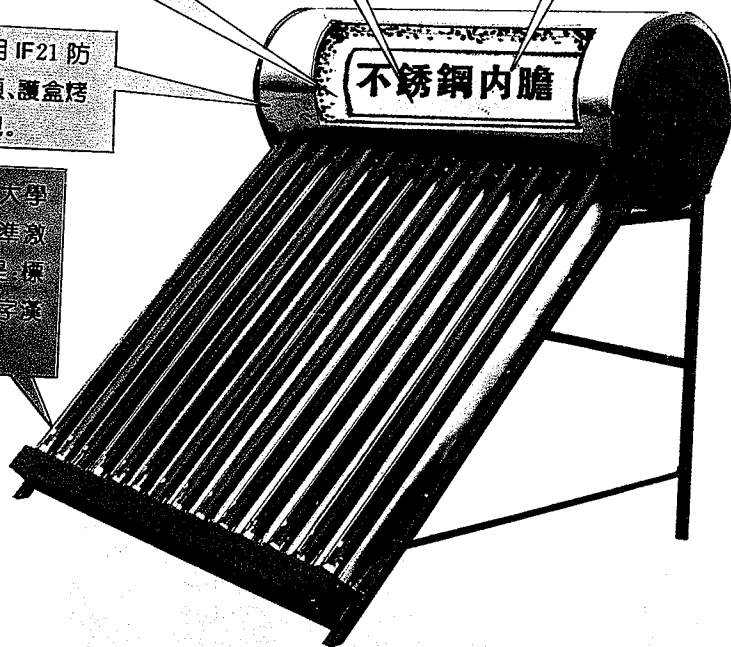
真空集熱管：清華大學專利技術制作，請認準激光防偽標記，其特徵是：標記中間有“陽利得”三字及商標商標 YLD。

壽命長

水箱內膽：高頻縫焊制作，水質純淨永不生銹，完全可做飲用水

陽利得®

“陽利得”熱水器
隨心所浴



一、與燃氣熱水器和電熱水器相比，太陽能熱水器具有如下優點：

1. 安全——絕對沒有“漏電、漏氣”，造成人身傷害的危險。
2. 節能——不消耗任何常規能源。
3. 無污染——不產生任何固、液、氣體污物，對環境無任何影響。
4. 高效益——每平方米采光面積，每年節電300度，省氣50公斤。
5. 四季運行——該產品春、夏、秋每平方米集熱面積，每天可產生45℃以上的熱水100—150kg，冬季晴天生產45℃以上熱水80—100kg，它解決了板式和其它太陽能熱水器季節性閑置停用的缺陷。
6. 使用範圍——除用于洗澡外，還可用于洗菜、洗衣服等其它家庭用熱水。

二、安裝和使用過程中應注意的事項：

1. 熱水器主體朝陽，前上方無遮擋物，注意固定牢固。
2. 水箱上部排氣口不得堵塞，以免因進氣或排氣不暢而脹壞或抽瀉水箱。
3. 為了冬季安全運行，室外管路必須保溫良好，以防冬季將管路凍壞或每日適量通水，防止管路結冰。
4. 嚴防缺水、斷水、空曬。斷水、空曬後不要在集熱管周圍溫度很高時突然注入冷水，以免管子炸裂，要在早晚水溫下降後再注入冷水。
5. 塵埃影響陽光透射率，要經常清掃管子表面。



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