



Solar Thermal Applied To Desalination

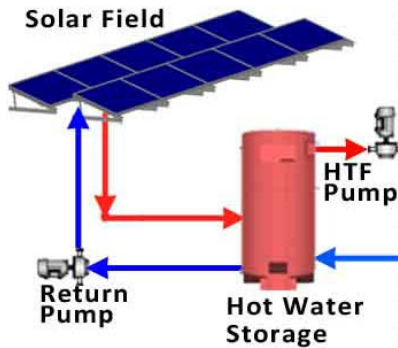
January 2017



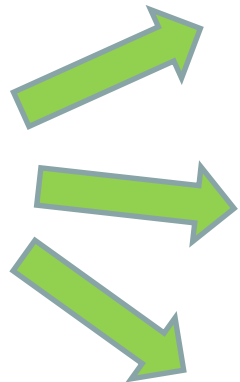
Solar Thermal Desalination for MSF, MED or MED/TVC

Retrofit existing thermal desalination capacity and integrate new, high GOR machinery

TVP delivers 80-180°C thermal energy, which covers the entire requirements range of all thermal desalination machinery

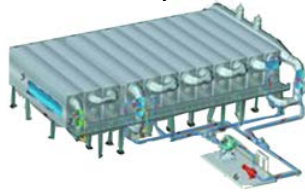


High efficiency ("GOR") machines (>10) require >120°C operating temperatures, which only TVP can provide



Multi Stage Flash (MSF)

Steam requirement: up to 110°C



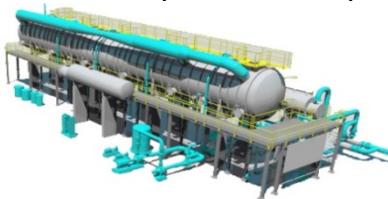
Multi Effect Distillation (MED)

Steam requirement: up to 80°C



MED Thermo Vacuum Compressor (MED/TVC)

Steam requirement: up to 180°C



Solar Thermal Desalination

Unique For:
High purity water
Off-grid & remote

Best For:
Coastal
Desert

Suitable for:
Potabilization

Solar Thermal Desalination: System Strengths & Uniqueness

Game-changing value proposition for the Middle East with TVP panels



**Minimise
Electricity
Use**

Lowest electricity consumption for highly energy-intensive water processing

Electricity is only an auxiliary energy source, running pumps for both thermal desalination machine and solar field (as low as 1 kWh_{el}/m³); steam is primary driver for thermal desalination (provided by solar).



**Remote
Off-Grid**

Only solar thermal desalination can serve remote off-grid sites

Solar thermal only directly drives desalination off-grid, with smooth output and extended coverage capabilities past daytime via hot water storage; continuous 24/7 operations with no damaging restarts.



**Hi-Purity
Water**

Only solar thermal desalination can serve high purity water for industrial use

Thermal desalination machinery steadily produces high purity water (with <4 ppm residual TDS) for industrial use in oil refineries, petrochemical, chemical and natural gas processing plants.



**Coastal
Site**

TVP is the best solar for coastal sites

TVP effectively capture diffuse light, making them ideal for coastal deployment, where sunlight is highly scattered. TVP panel all-metal anti-corrosive casing prevents typical high salinity coastal wear & tear.



**Dusty
Environ.**

TVP is the best solar for dusty environments

TVP panels are proven to uniquely need no water-based cleaning due to effectiveness in capturing diffuse light; energy outputs are consistent and predictable in any weather conditions, even deserts.



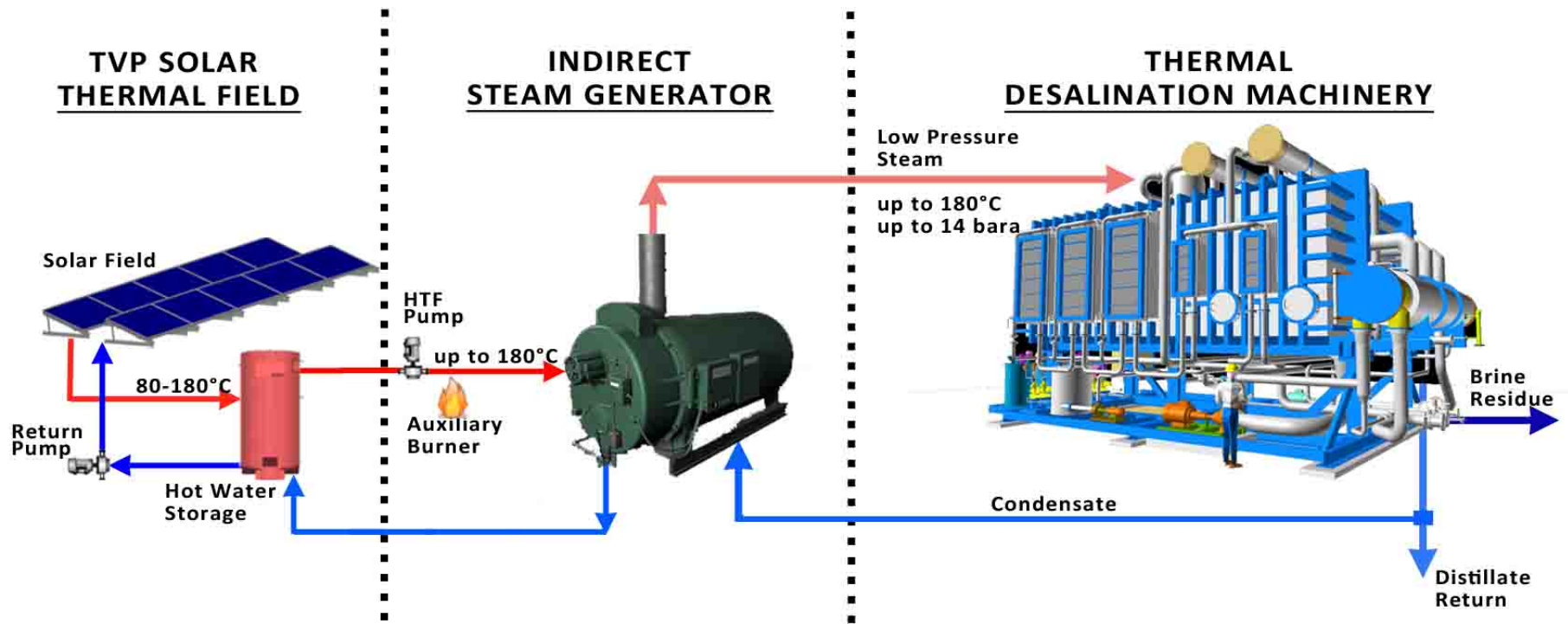
**Scalable
Flexible**

High scalability & flexibility

Solar thermal desal can scale to any client capacity requirement. Solar covers from 20% to 90% of the load. Thermal desal machinery can run <24 hrs without corrosion issues via internal water recirculation.

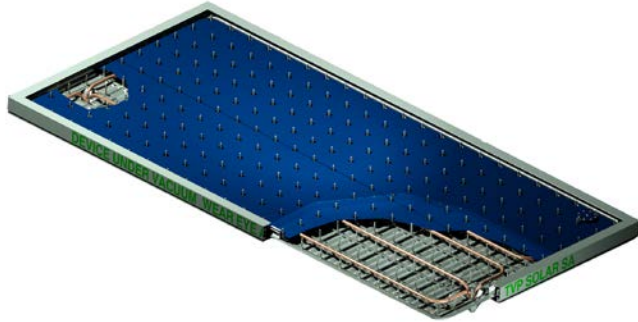
Solar Thermal Desalination: Basic Integration

TVP directly drives thermal desalination machinery via indirect steam generator



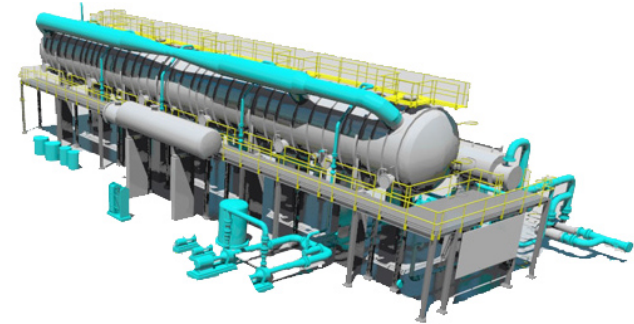
TVP + MED/TVC: New, High-GOR Thermal Desalination (I)

Combining best-of-breed solar thermal panels and thermal desalination machines for new deploiments



TVP panels:

- SolarKeyMark certified highest sun-to-thermal efficiency up to 180°C (without concentrating mirrors)
- Produce massive thermal energy throughout daylight hrs
- Ideally suited for high ambient temperature environments
- Ideally suited for dusty, humid, hazy, coastal environments due to diffuse light capturing and for remote locations
- High durability & no performance degradation over time
- Minimal maintenance: no water-based panel cleaning
- Smallest installation footprint and no ground preparation
- Operate without supervision

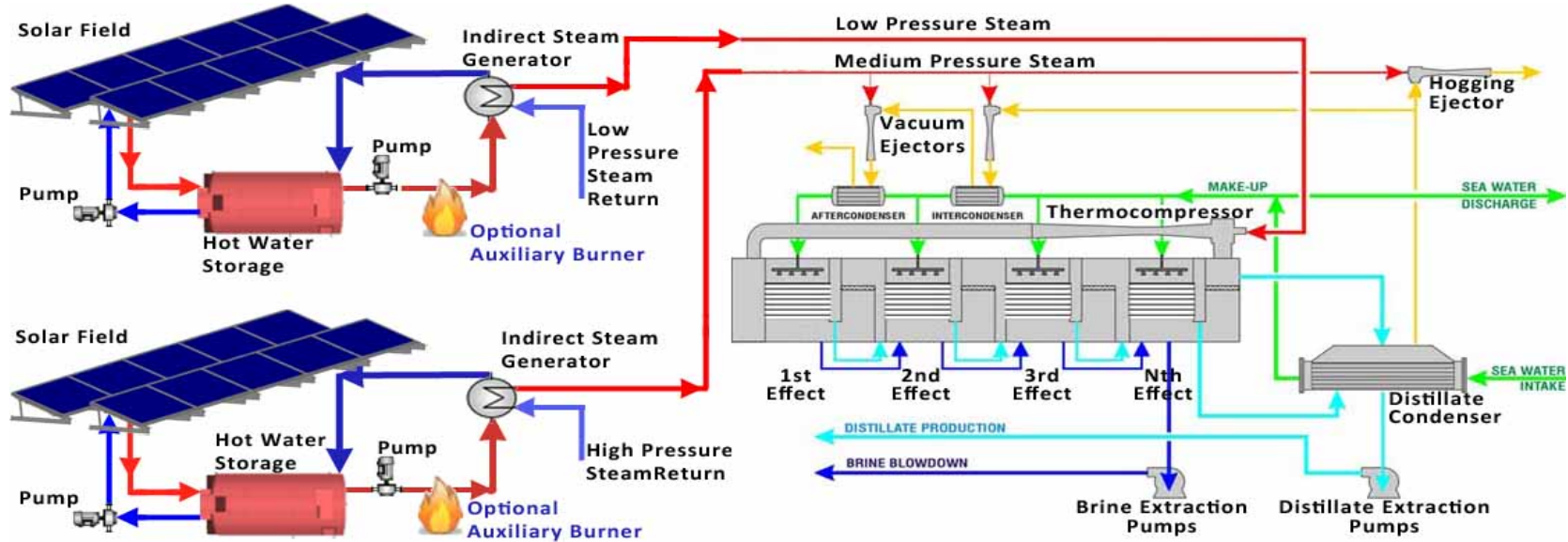


MED/TVC desalination machinery:

- Lowest electrical consumption (<1.5kWh_e/m³)
- Lowest thermal consumption (up to GOR 16)
- Steadily produces high purity distillate
- Tolerates any type of sea water, does not require complex pre-treatment
- Highly scalable, rangeable and flexible
- High reliability and operational availability
- Lowest maintenance
- Minimal footprint and related civil works
- Operates with minimal supervision

TVP + MED/TVC: New, High-GOR Thermal Desalination (II)

TVP is a reliable thermal energy supply for MED/TVC steam requirements up to 14 bar



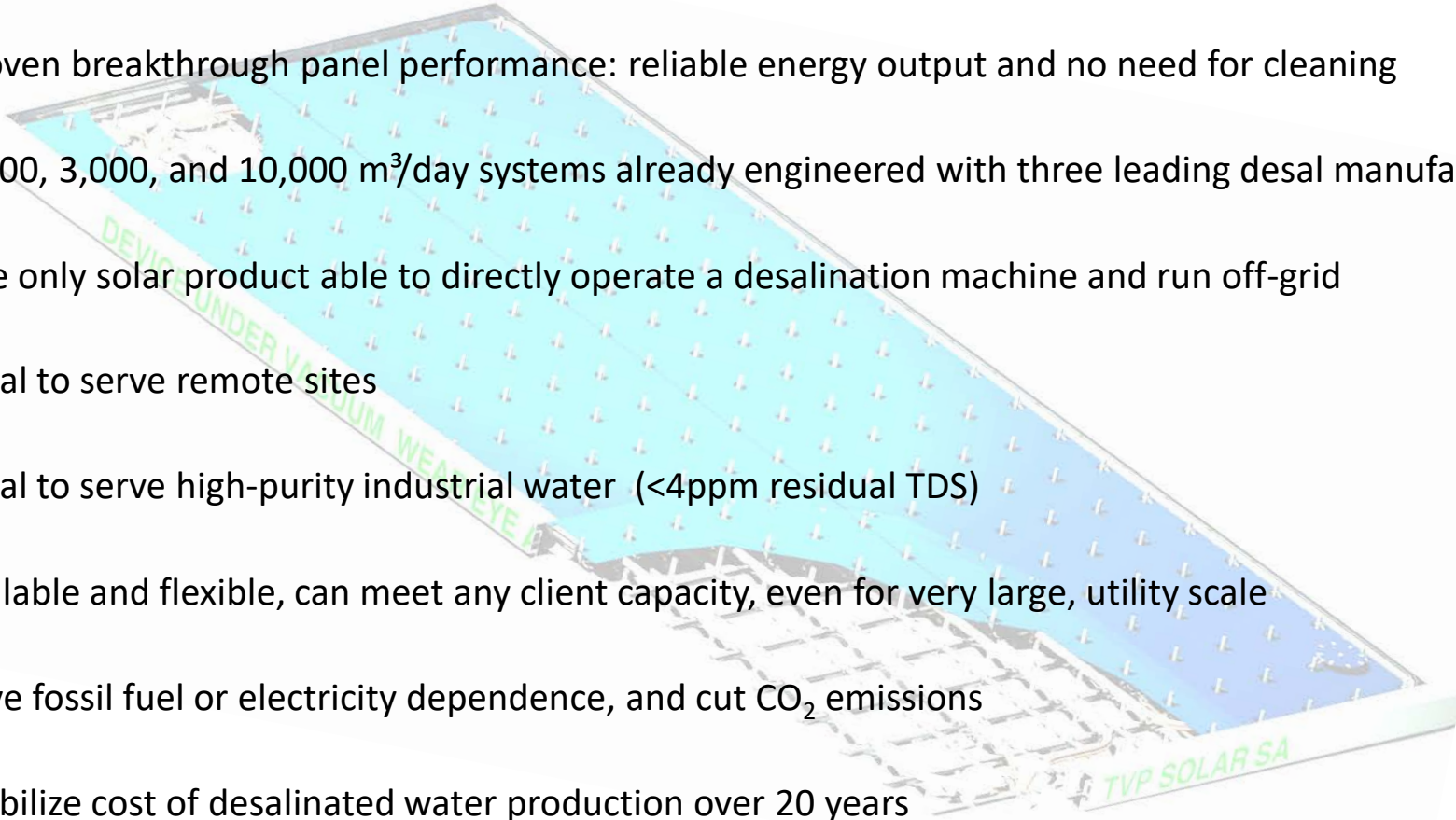
TVP thermal panels provide MED/TVC desalination machine with Low Pressure (LP) steam for the thermo-compressor and Medium Pressure (MP) steam for the vacuum system (when required).

Solar thermal contribution to overall desalination energy requirement varies depending on solar field size with related thermal storage capacity and/or use of an auxiliary burner:

- Extending solar coverage above MED/TVC peak thermal load (e.g. for non-daylight operations) requires stored thermal energy generated by an oversized solar field (TVP panels can provide up to 100% of thermal energy for process steam)
- An auxiliary (natural gas, LPG, diesel, biogas, biomass, etc.) burner is an option to complement solar energy, providing additional lift between solar field thermal generation and temperature need by MED/TVC when solar resource is insufficient (e.g. nighttime)

TVP + MED/TVC: Value Proposition

Unique high-GOR value proposition via solar thermal desalination

- 
- ✓ Proven breakthrough panel performance: reliable energy output and no need for cleaning
 - ✓ 1,000, 3,000, and 10,000 m³/day systems already engineered with three leading desal manufacturers
 - ✓ The only solar product able to directly operate a desalination machine and run off-grid
 - ✓ Ideal to serve remote sites
 - ✓ Ideal to serve high-purity industrial water (<4ppm residual TDS)
 - ✓ Scalable and flexible, can meet any client capacity, even for very large, utility scale
 - ✓ Save fossil fuel or electricity dependence, and cut CO₂ emissions
 - ✓ Stabilize cost of desalinated water production over 20 years



VACUUM

Send us a project and application machine specs

TVP will supply a detailed feasibility study including:

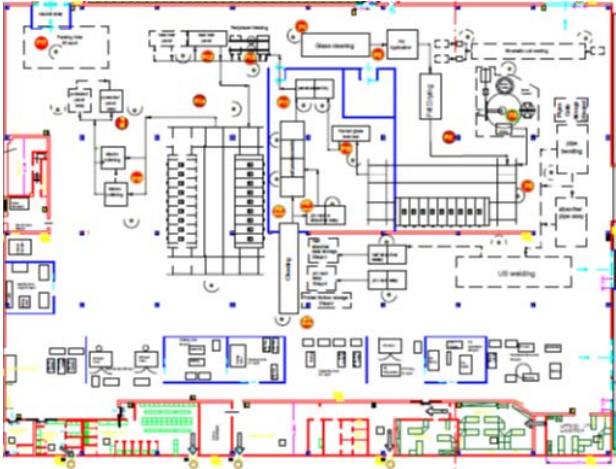
- **Preliminary solar field design**
- **Simulated energetics**
- **Budget quotation**
- **Economic analysis**

email: info@tvpsolar.com

TVP Solar SA: A Swiss Company



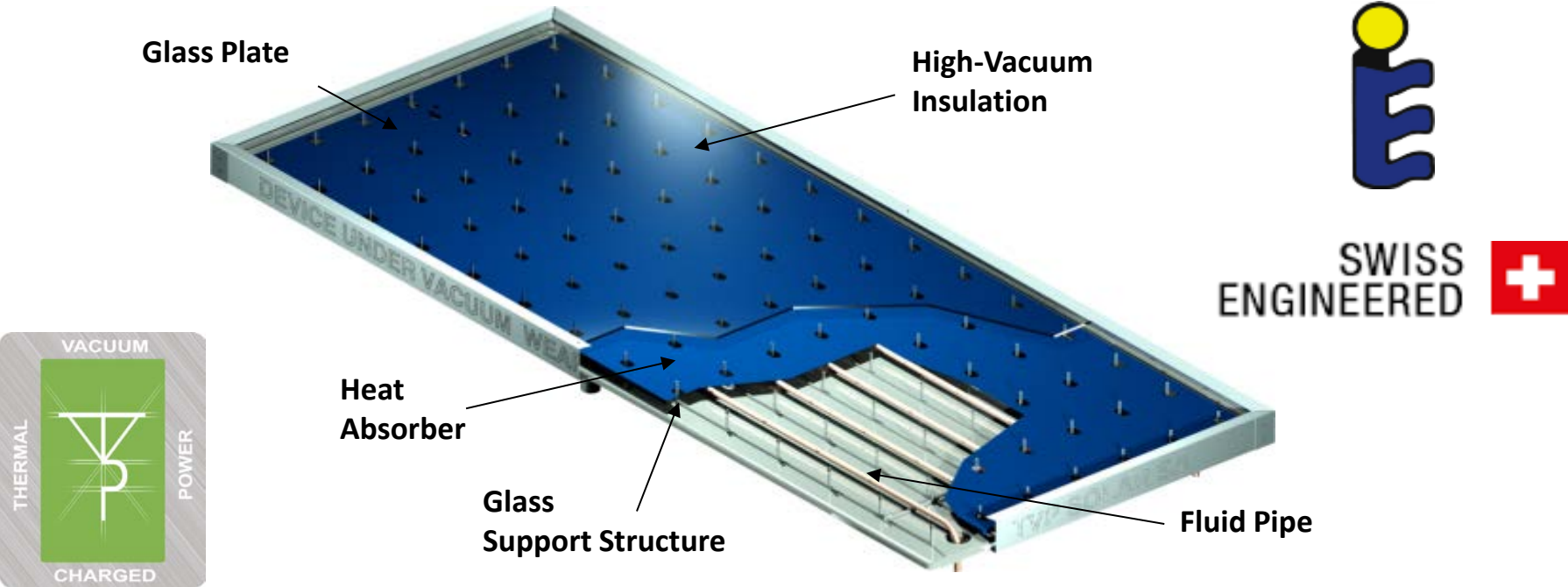
Develops, manufactures and markets innovative high-vacuum flat solar thermal panels



TVP Technology: Thermal Vacuum Power Charged™

Breakthrough solar thermal technology built on 10 proprietary patents

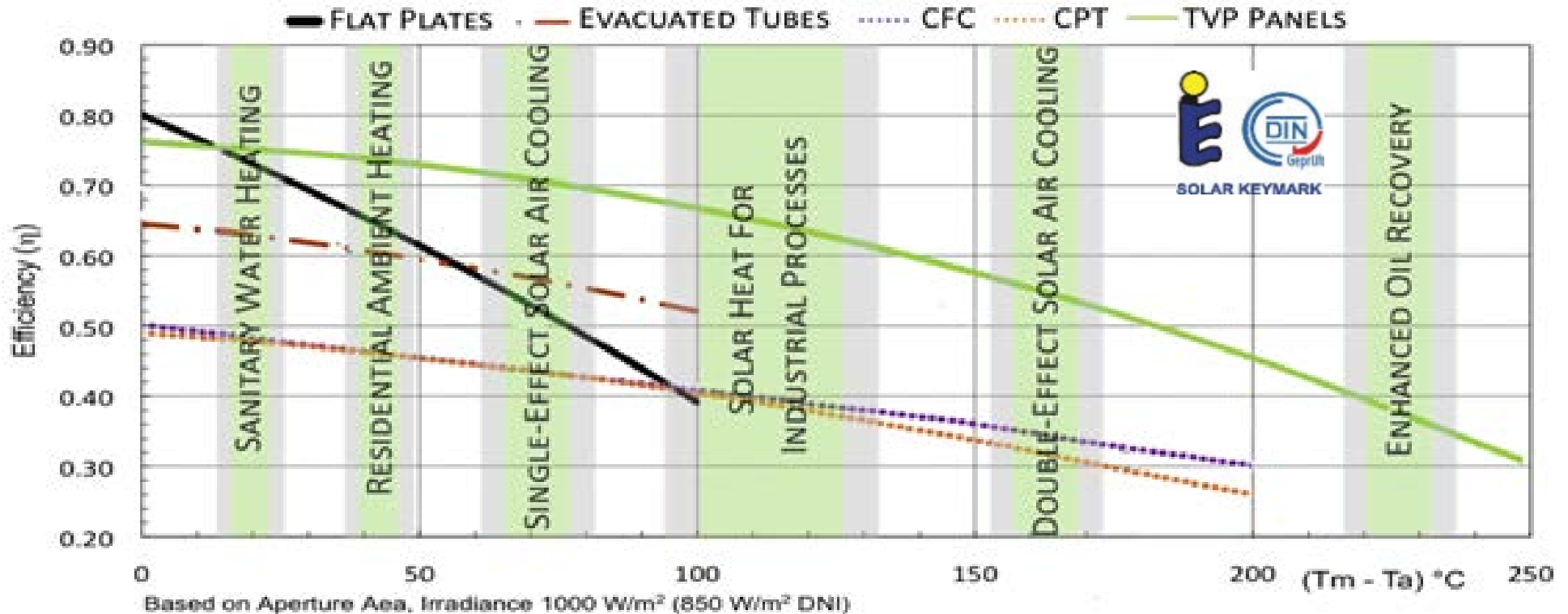
TVP uniquely combines high-vacuum insulation and planar layout in solar thermal offering high performance up to 200°C!



Suppression of convection losses via high-vacuum insulation allows to operate with high efficiency at high temperatures without concentrating mirrors

TVP Panels: Certified Best Thermal Performance

Highest performance at any operating temperature, in any light condition, for every thermal app

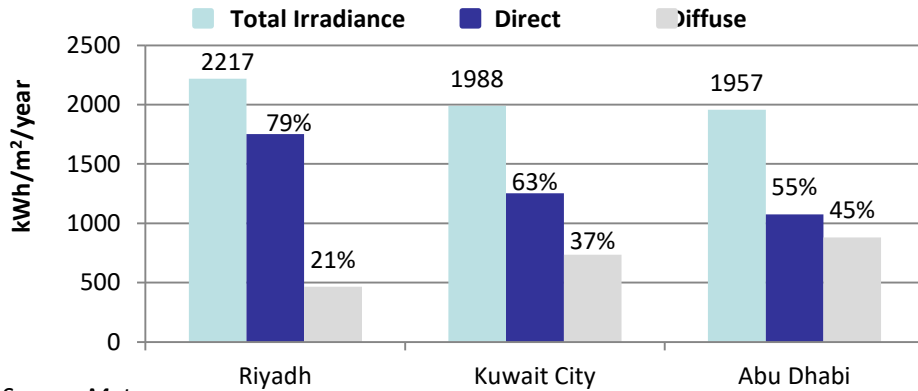


TVP beats flat plates, evacuated tubes and concentrators in efficiency and energy production, in any environment, due to best insulation and highest direct & diffuse light capturing

TVP Unique Features: Diffuse Light Capture & No Cleaning

The only solar product that consistently operates without cleaning in harsh/dusty environments

TVP captures both direct and diffuse light

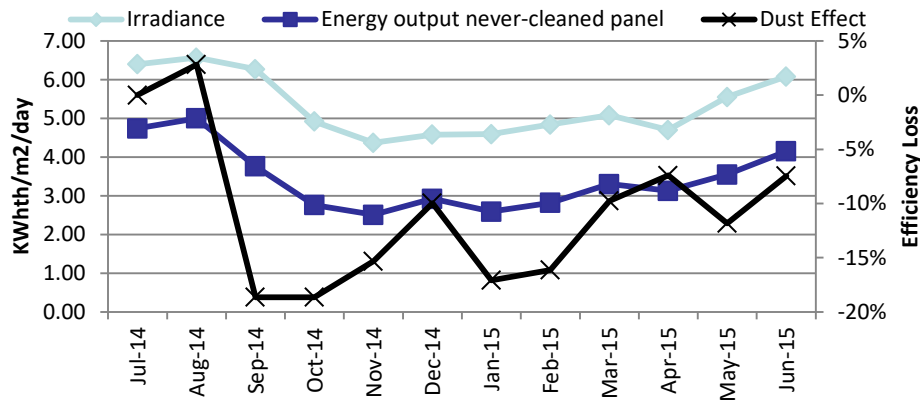


Source: Meteonorm

Dust accumulation increases sunlight scattering (diffuse)



Dust accumulation only affects TVP efficiency up to 20%



Source: TVP, IEA SHC

No cleaning is required by TVP panels



TVP Panels: High Performance Even Without Cleaning (I)

Demonstrated performance in-field without cleaning over continuous years



TVP Panels: High Performance Even Without Cleaning (II)

Dust accumulation was measured to have minimal effect on TVP performance



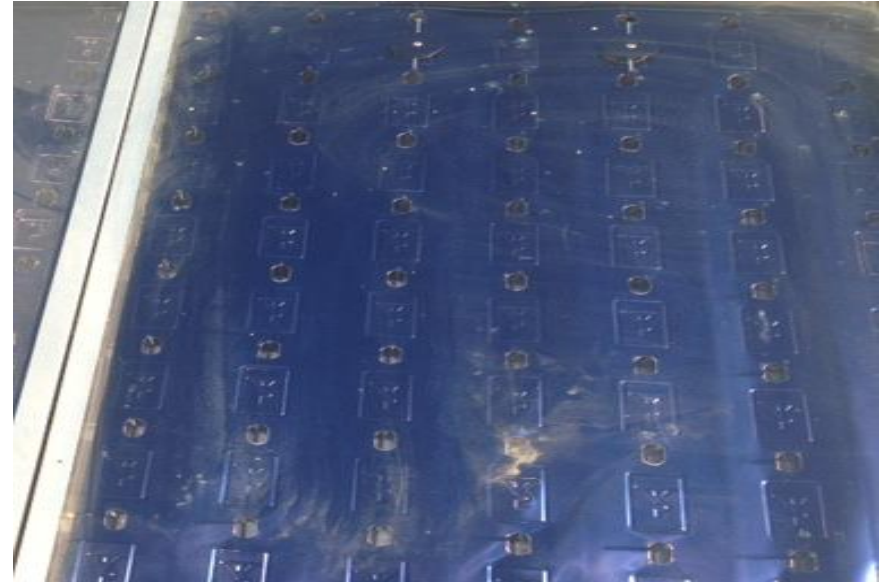
May 12th 2015

before cleaning

2,44kWh_{th} with 5.95 kWh_{th} (40% efficiency @175°C)

Peak panel operating temperature 164°C

Peak ambient temperature 43,6°C



May 13th 2015

after dry-brush cleaning

2,73kWh_{th} with 5.71 kWh_{th} (47% efficiency @175°C)

Peak panel operating temperature 176°C

Peak ambient temperature 47,5°C

Dust-covered panel performance only affected by 14%!!!

TVP Performance: Consistent and Predictable Energetics

Thermal energy savings proven in-field in GCC for applications up to 180°C

GCC Cities	GHI kWh/m ² /year	MT-Power	Tout (°C)								
			60	95	110	120	130	140	150	165	180
Riyadh	2217	kWh/m ² /year	1727	1528	1427	1355	1279	1200	1118	1034	861
		kWh/m ² /day av.	4.7	4.2	3.9	3.7	3.5	3.3	3.1	2.8	2.4
Jeddah	2117	kWh/m ² /year	1702	1502	1401	1330	1255	1179	1099	977	852
		kWh/m ² /day av.	4.7	4.1	3.8	3.6	3.4	3.2	3.0	2.7	2.3
Dubai, Kuwait City	2003	kWh/m ² /year	1557	1363	1266	1297	1125	1050	974	857	738
		kWh/m ² /day av.	4.3	3.7	3.5	3.6	3.1	2.9	2.7	2.3	2.0
Abu Dhabi, Muscat, Manama, Dammam	1957	kWh/m ² /year	1528	1333	1234	1163	1090	1013	935	814	691
		kWh/m ² /day av.	4.2	3.7	3.4	3.2	3.0	2.8	2.6	2.2	1.9
Doha	1839	kWh/m ² /year	1391	1200	1104	1034	966	895	822	712	602
		kWh/m ² /day av.	3.8	3.3	3.0	2.8	2.6	2.5	2.3	2.0	1.7

Notes

- Energy production & thermal efficiency are dependent on irradiance and operating temperature
- Several field tests allowed TVP to refine software tools, providing realistic predictions under any climate condition
- Capturing both direct & diffuse light leads to consistent and predictable performance

TVP Solar Thermal Collector: Key Advantages

Game changing technology perfectly suited for Gulf region:

- ✓ Thermal Vacuum Power Charged™ panels are designed to operate at high temperature
 - MT-Power panels deliver (up to 200°C) without concentrators or mirrors
- ✓ Ideally suited for high ambient temperature environments
 - The higher the ambient T°, the higher the panel efficiency
- ✓ Captures diffuse light making panels ideal for dusty & hazy environments
 - Uses up to 40% more light in Gulf region than other technologies!
- ✓ Totally off-grid thermal supply (removes power demand from the electrical grid)
 - Peak performance highly correlated with peak demand
- ✓ Minimal or no cleaning and maintenance
 - Thanks to diffuse light capturing, cleaning is not necessary and can be done at customer option
 - Runs automatically and independently, has a web-based remote control system
- ✓ Efficiently utilizes available space
 - Requires minimal footprint
 - Easy architectural integration: can be deployed on any walkable rooftop (50kg bearable load)