Abu Dhabi – Green Building Conference, Nov. 3, 2008

Sustainable Architecture using solar power systems:

>Market Perspectives
>Technologies
>Building Integration
>Case Study

Solar Glass Roof covering
New Yorks largest above-ground subway station

Roland Neuner
PV Building Solutions
SCHOTT SOLAR AG
D-63755 Alzenau

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SCHOTT Solar – Solutions for Photovoltaics (PV) and Concentrated Solar Power (CSP)

Photovoltaic – Solar Electric Power Systems (PV)

-> Direct conversion of solar energy into electricity

Concentrated Solar Electric Power Plants via solar heat conversion (CSP)

-> Indirect conversion of solar energy using solar heating turbine process to generate electricity

High quality components for solar applications

Solar power plants (CSP*)

- Solar receiver

Photovoltaics (PV**)

- Crystalline silicon module

- Thin film module

* CSP: Concentrated Solar Power
** PV: Photovoltaics

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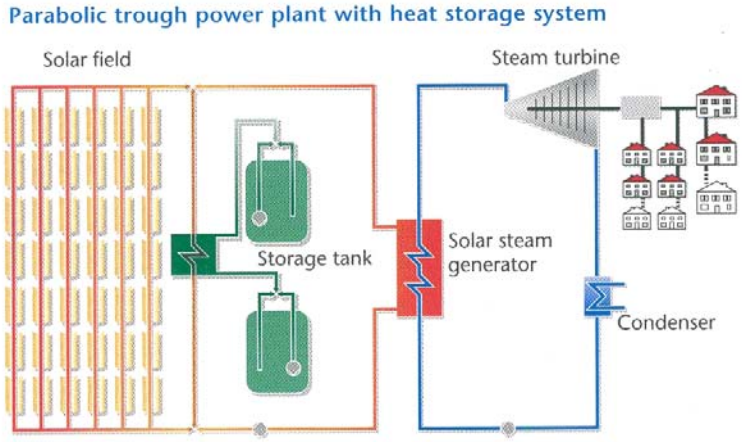
SCHOTT Solar: Products for solar power plants with parabolic trough technology

Concentrated Solar Power (CSP) for centralized power generation with solar thermal power plants:



The heart comes from SCHOTT:
SCHOTT PTR®70 receiver as the core component for parabolic trough power plants

Andasol 1 (Granada, Spain):

- Output 50 MW_{el}
- 510,000 m² area
- 20,000 receivers

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SCHOTT Solar – 50 years of experience in Photovoltaics

1958	▪ Development of solar cells for space applications (AEG)
1980	▪ Development work on thin film solar cells at MBB (a-Si)
1983	▪ First shipments of glass tubes for solar thermal power plants (SCHOTT Rohrglas GmbH)
2002	▪ Development of receivers (SCHOTT Rohrglas GmbH) ▪ JV RWE SCHOTT Solar founded
2004	▪ Module production set up in the Czech Republic
2005	▪ Takeover of 100% of RWE SCHOTT Solar
2006	▪ Receiver series production begins
2007	▪ JV Wacker SCHOTT Solar founded ▪ Thin film production started in Jena
2008	▪ R&D cooperation with Ersol Thin Film GmbH ▪ New sites set up in Spain and in the USA; existing sites expanded

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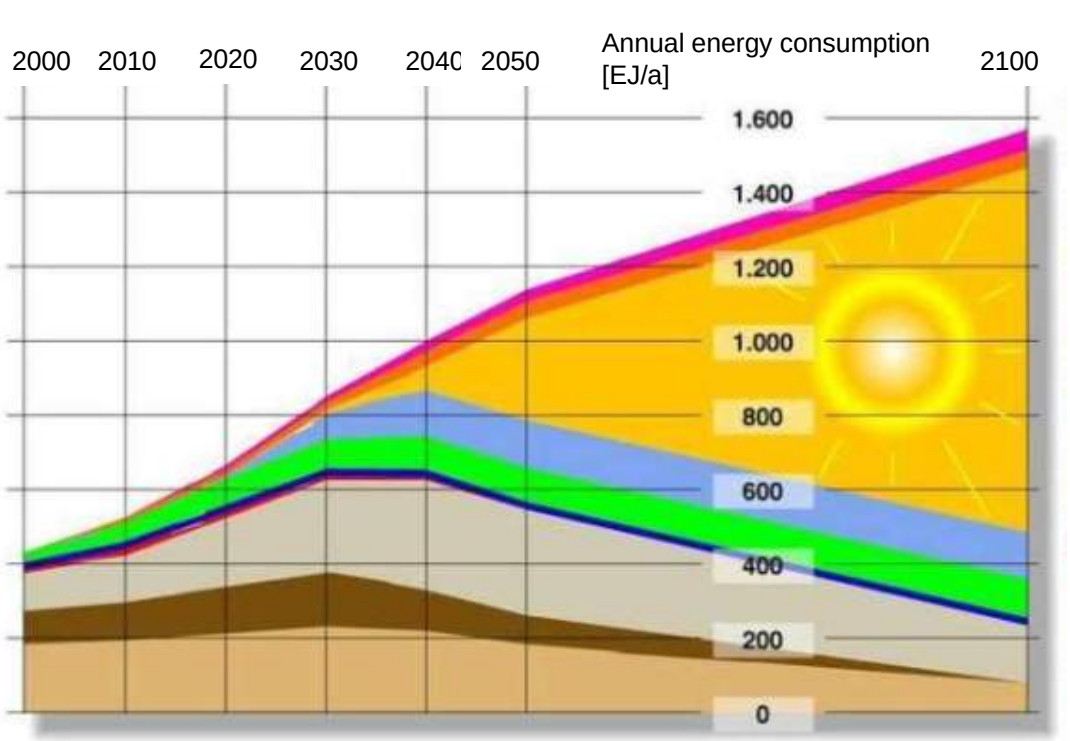
Solar power has the biggest potential in renewable energy

Changes in the worldwide energy mix through 2100, global primary consumption



Other renewables

Solarthermal (only thermal)

Solar electricity (PV and solarthermal power stations)

Wind

Biomass

Hydro

Nuclear

Gas

Coal

Oil

Prognosis of the German advisory council on global environmental change

Source: Solarwirtschaft.de, WBGU 2003

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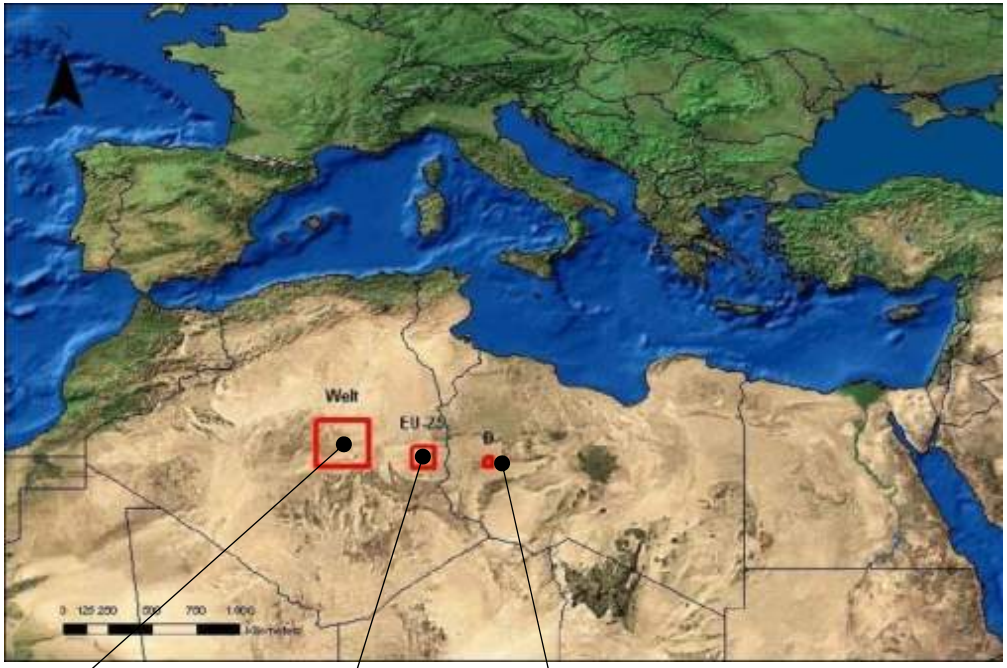
Current world electricity demand could be met using less than 4% of the area of the Sahara



The world (300x300 km)

Europe (EU-25)

Germany

- In regions with high sun exposure, the land area used for solar energy is significantly less than that used for other methods for producing energy.
- Ideal sites are often located in dry regions that cannot really be considered for other uses.
- The boxes outlined in red show the areas for solar collectors that would theoretically be sufficient to produce enough electrical energy in solar thermal power plants to meet the electricity demands of the world, Europe (EU-25) or Germany.

Source: German Aerospace Center [Deutsches Zentrum für Luft- und Raumfahrt (DLR)], 2005
MENA: Middle East North Africa

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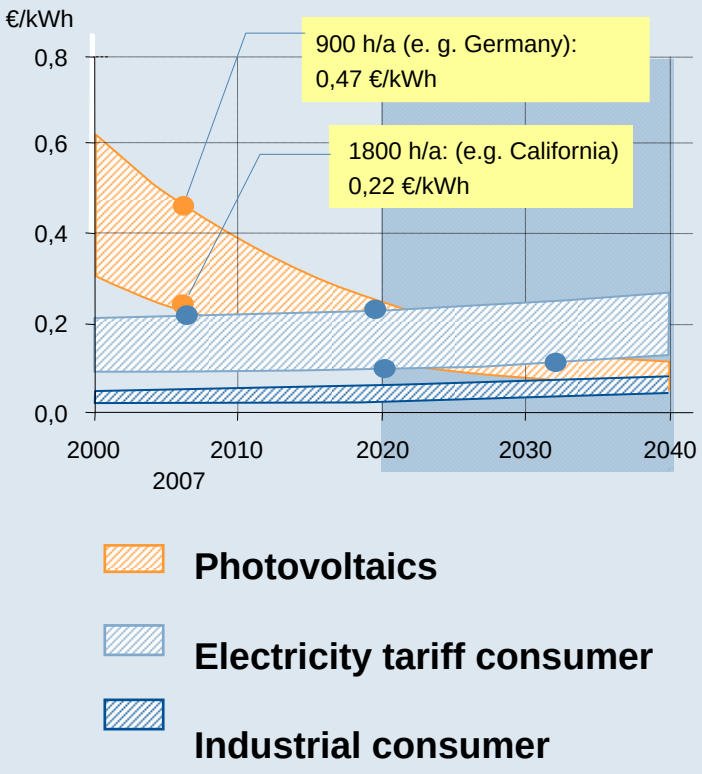
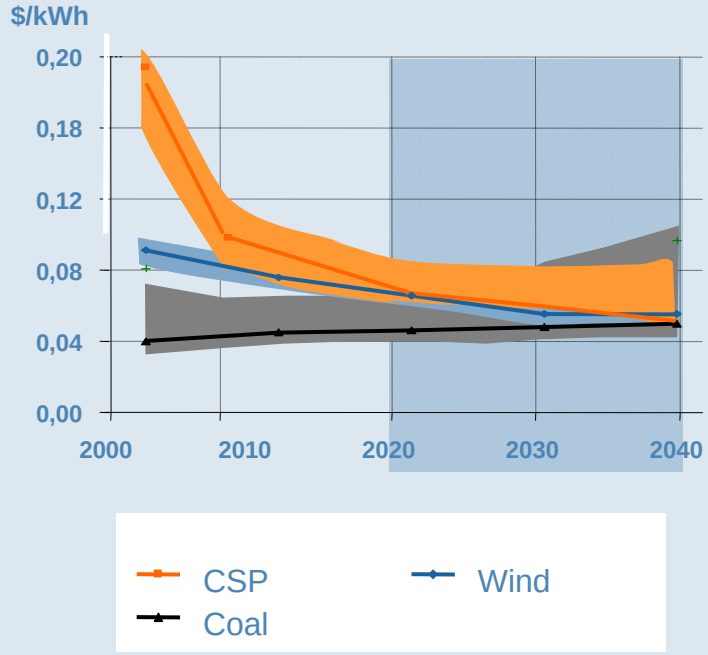
In some regions the electricity generating cost with PV are already on the level of utility prices

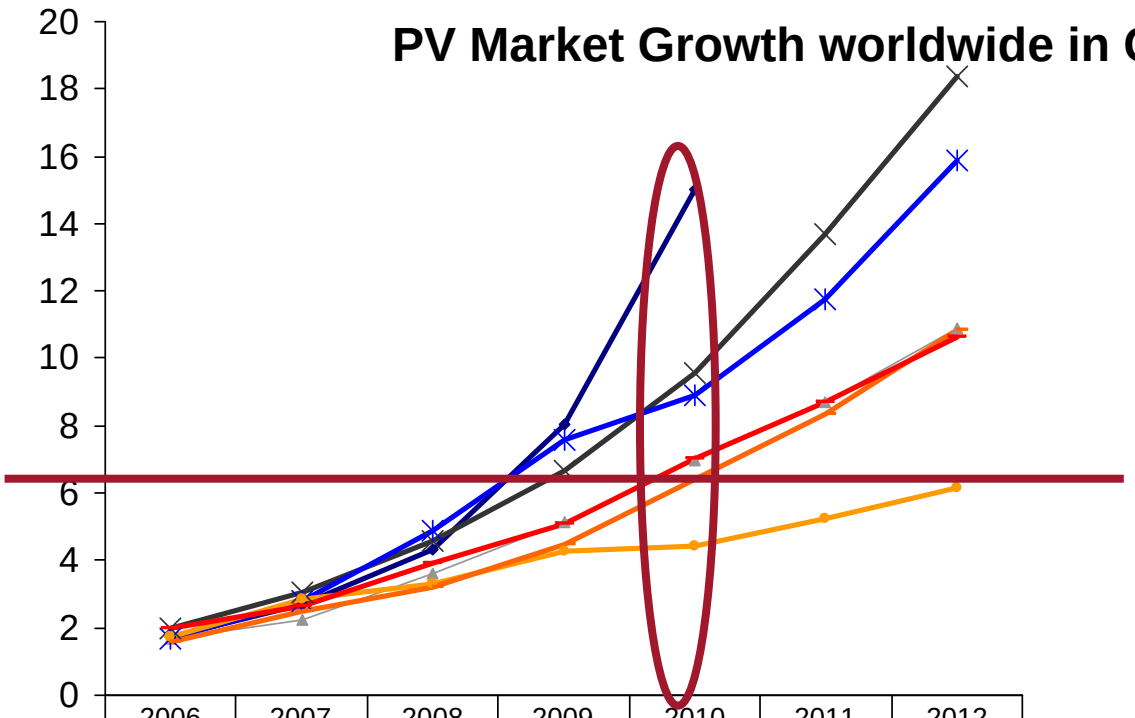
Comperison of standard electricity prices with PV generated power prices (world)



Comperison of different energy sources with CSP price develepment (Welt)



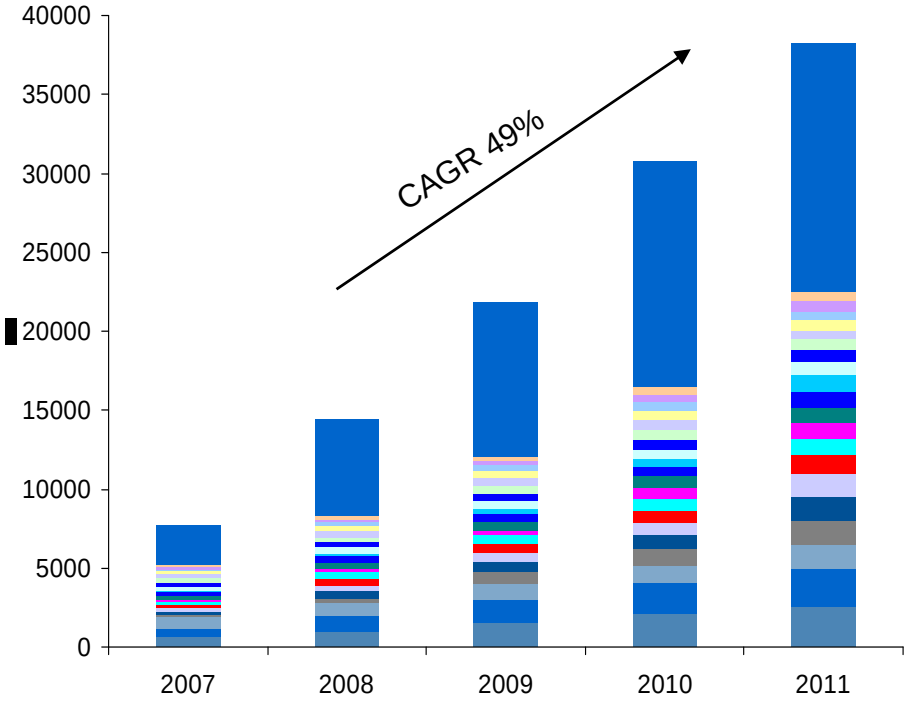
World Market Demand for Photovoltaics at 6,5 GWp in 2010



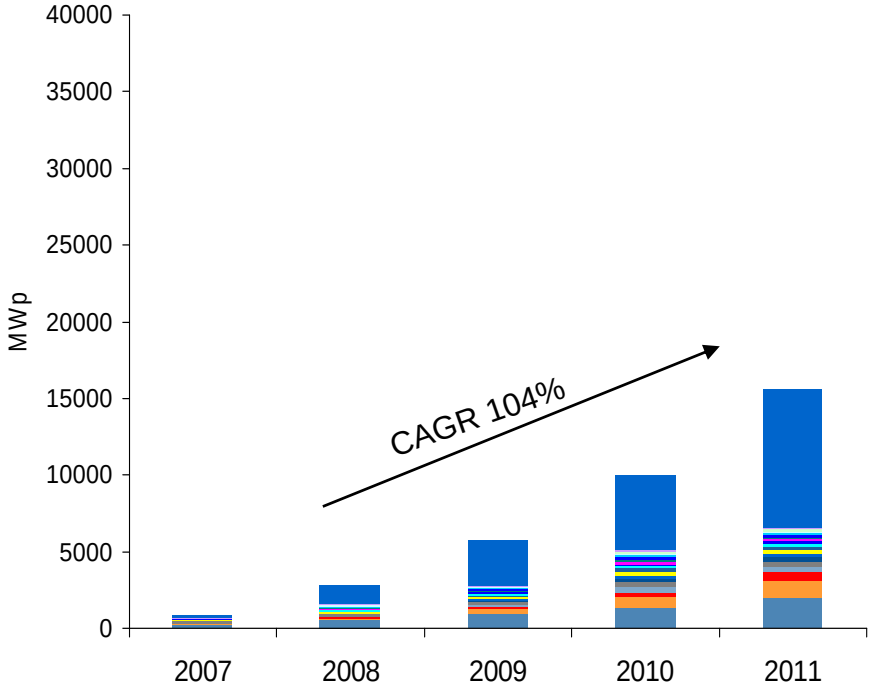
	2006	2007	2008	2009	2010	2011	2012
LBBW (Feb 2008)	1,75	2,699	4,305	8,047	15		
Navigant acc. (Feb 2008)	1,985	3,061	4,591	6,674	9,548	13,699	18,379
EPIA (prog)	1,7	2,25	3,625	5,16	6,95	8,7	10,91
Solarbuzz (Production led)	1,7	2,8	4,9	7,6	8,9	11,737	15,88
Solarbuzz (Balanced)	1,744	2,826	3,314	4,262	4,438	5,246	6,179
SCHOTT	1,553	2,5	3,2	4,5	6,42	8,345	10,849
Goldman Sachs	1,985	2,621	3,942	5,1	7,017	8,692	10,617

Manufacturing capacities of PV Industries grow substantially worldwide

Ramp-up of capacities crystalline technologies



Ramp-up of thin film capacities



Solar Photovoltaic (PV) Power Systems:

Main features:

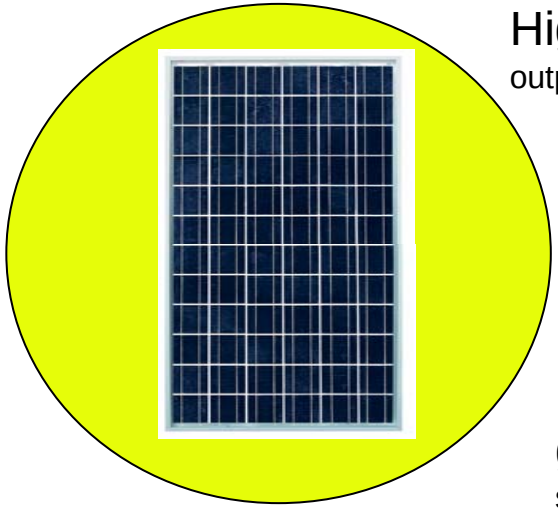
Universal Use
everywhere, every day,
focus on building related installations

Long product life
> 25 years

Availability short-term
Safety for investors

Clean Energy
Short amortization period 1 – 3 Jahre
no emissions, no scrap, recycling

Perfect matching
* reliable on-grid operation
* future mobility source combined with batteries



High system efficiency, stable power output for > 25 years

Modular System Design
1 kW bis 10 MW
10 m² bis 100 Tm²

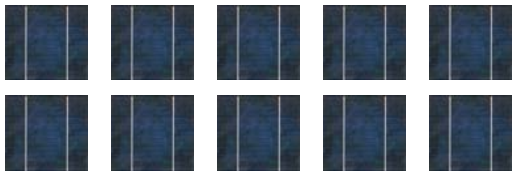
Decentral Power mainly grid connected, reliable, simple system design, low maintanance

Direct energy conversion
Sun energy -> on-grid power / off-grid power

Two main PV-Technologies in worldwide operation

c-Si crystalline-Silicon Solar Cells and Modules:

* product design on the basis of crystalline aesthetics, colour and modularity
* main application of c-Si in BIPV is the ventilated cold facade
* small format solar cells (156 mm x 156 mm) are combined in order to create large area, customized modules



a-Si amorphous-Silicon

***** Thin film technology directly applied to glass as the supporting material. Typical dimensions 0,6 m² to 1,4 m² for raw modules. Finished BIPV modules **up to 6 m² per unit**

ASITHRU® is the semitransparent option with transparency of 10 or 20%. Laminates and Double glazing available. The solution for solar glass roofings and daylight facades.

ASIOPAK® non-transparent option for curtain-type cold facades and overhead shading systems.

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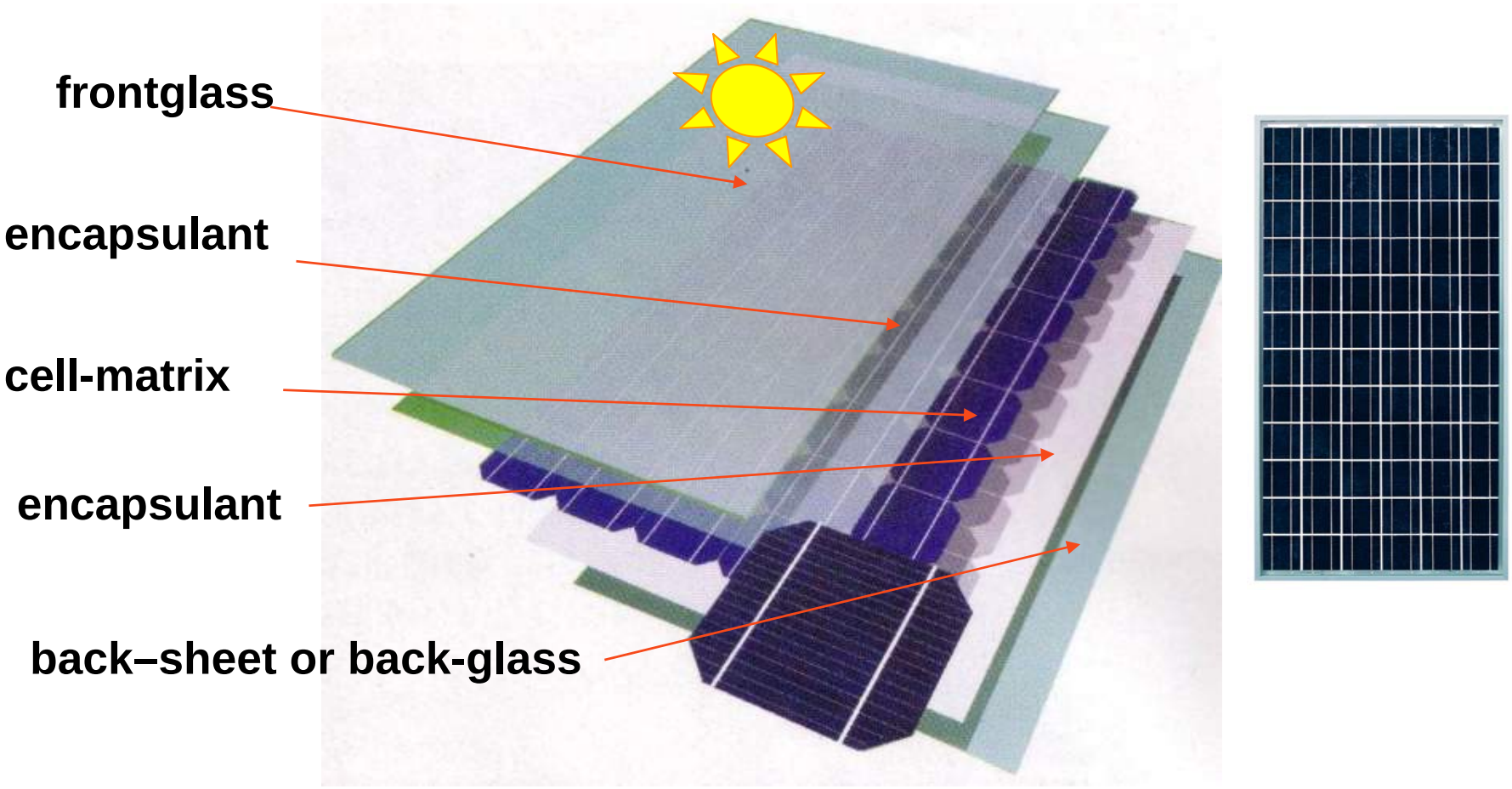
Crystalline Si-module design



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Modules based on thin film solar cells

Three different types of semiconductors dominate the market:

CIS + CIGS aSi CdTe

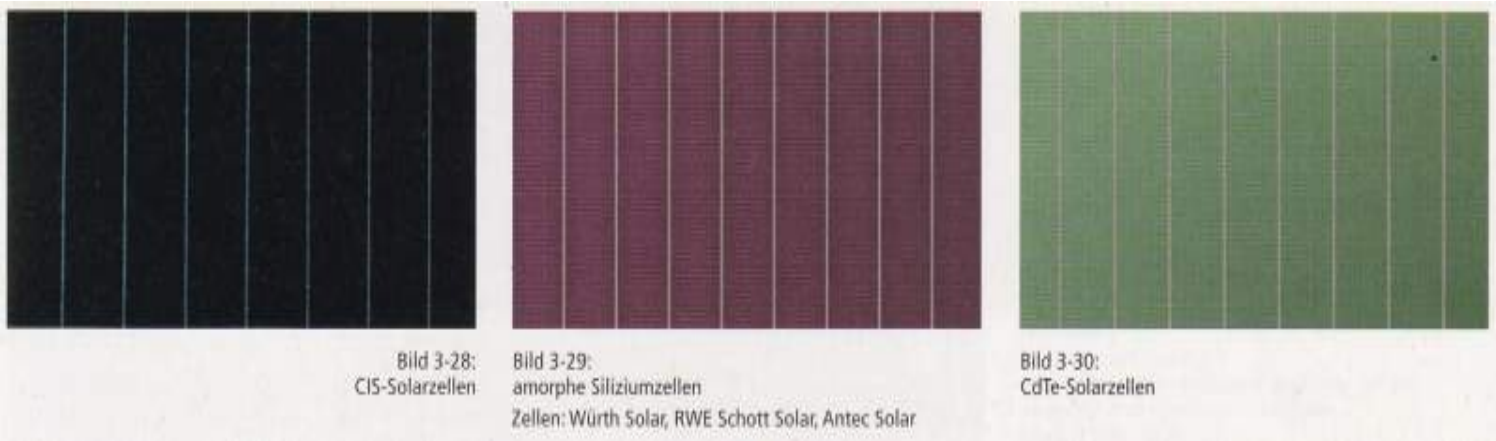
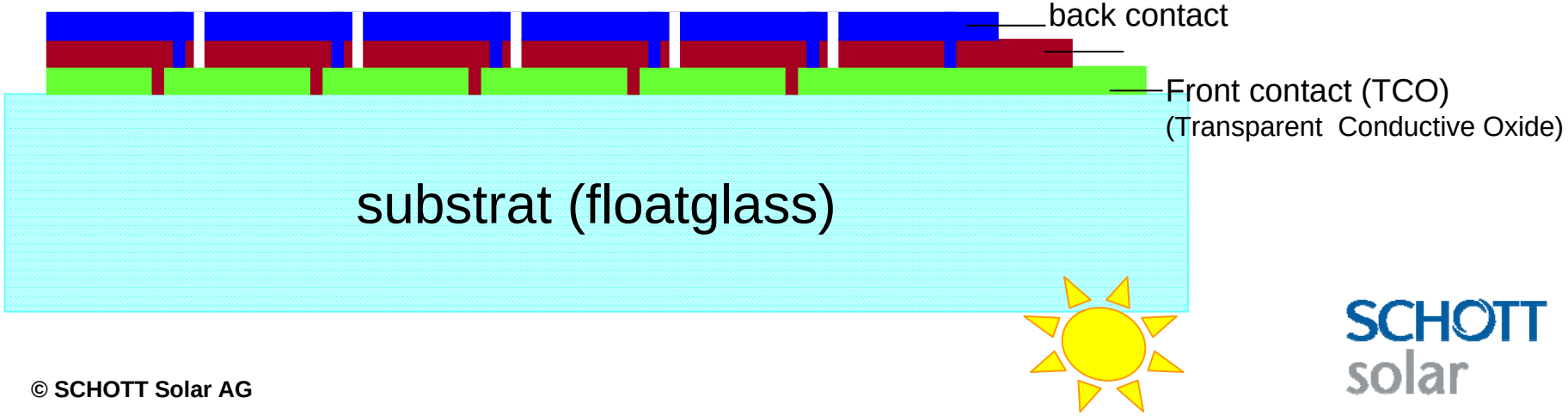


Bild 3-28: CIS-Solarzellen

Bild 3-29: amorphe Siliziumzellen

Zellen: Würth Solar, RWE Schott Solar, Antec Solar

Bild 3-30: CdTe-Solarzellen



Fully automated process: A-Si thin film solar modules

TCO - Laser scribing

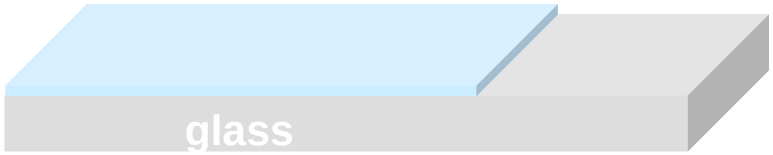
PECVD

Laser scribing

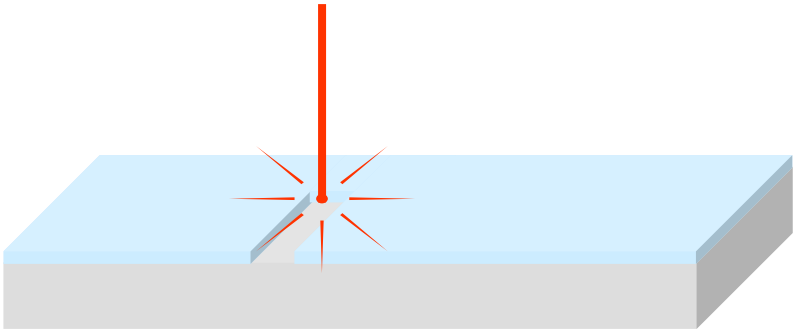
Metal back-contact

Laser structuring of a-Si-cells

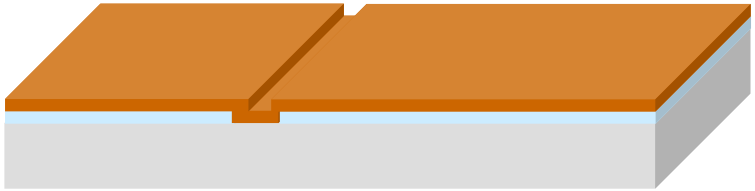
1. TCO-coating (glass supplier)



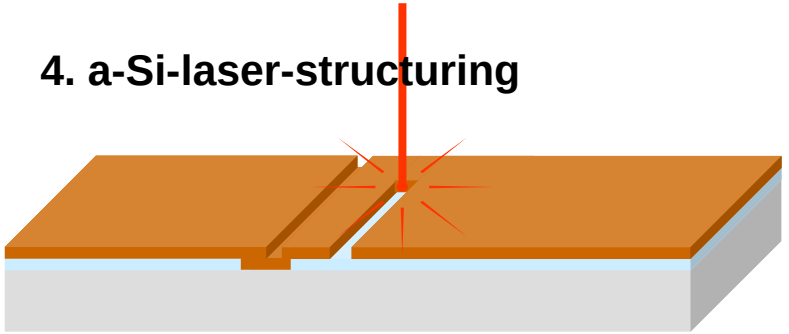
2. TCO-laser-structuring



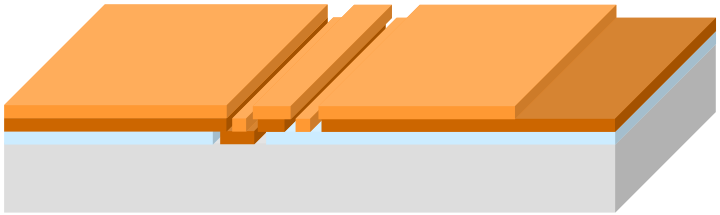
3. a-Si cell (PECVD)



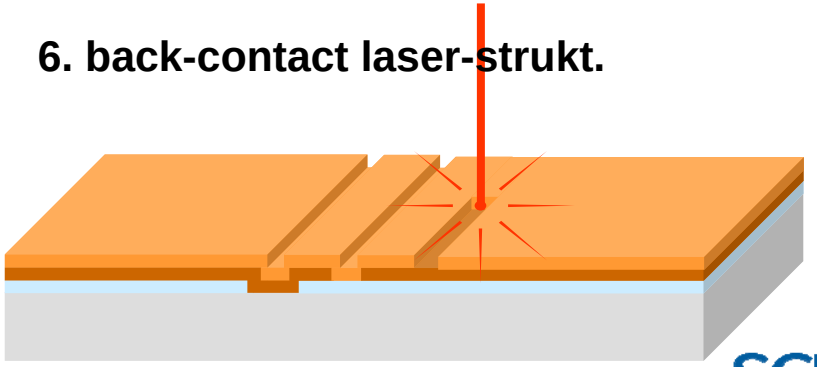
4. a-Si-laser-structuring



5. back-contact



6. back-contact laser-strukt.



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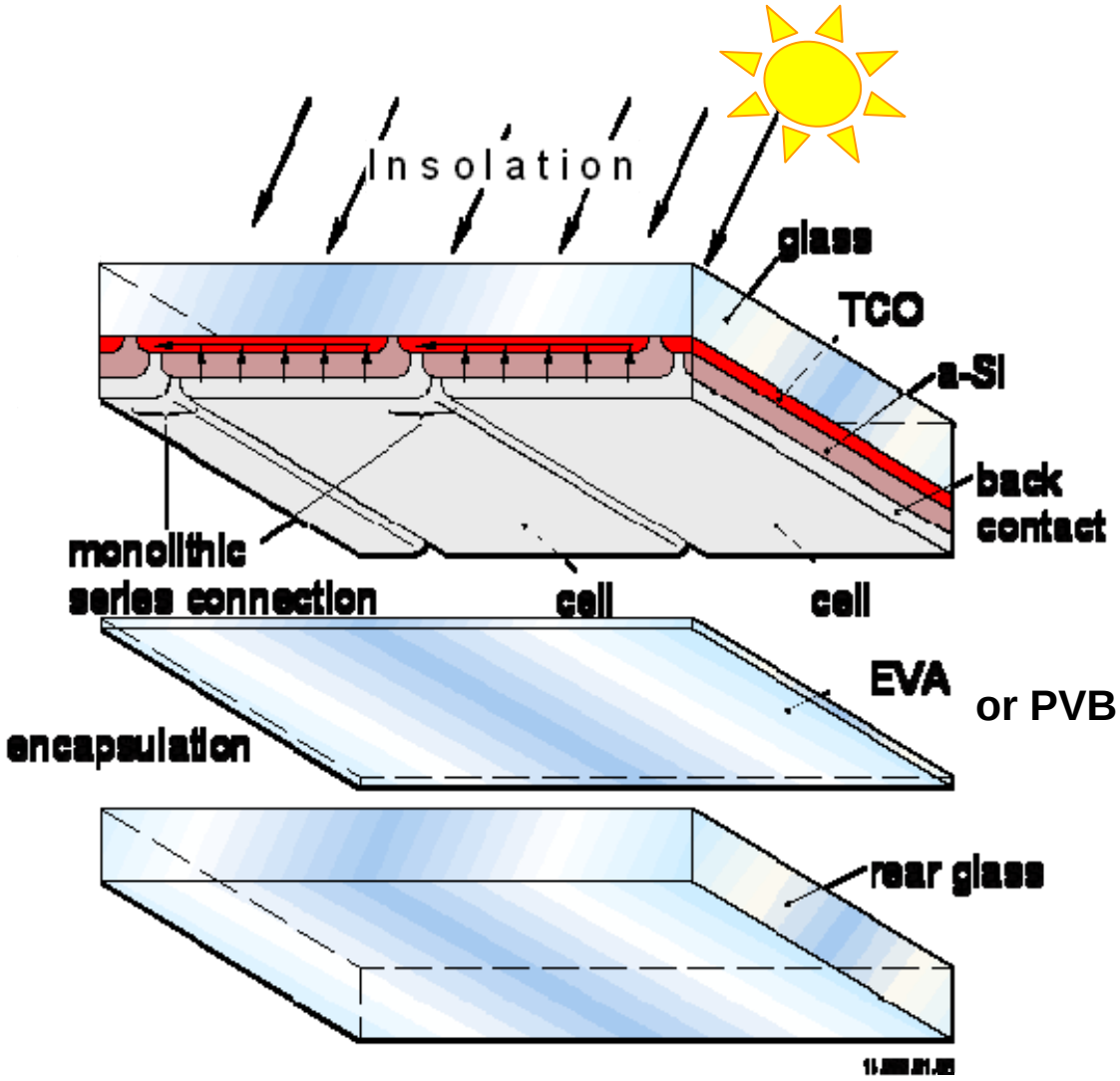
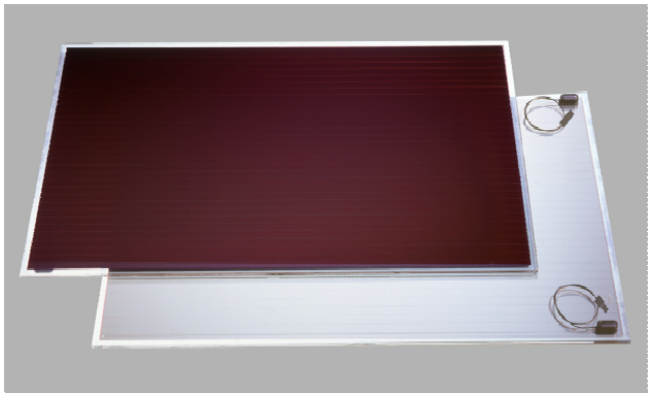
Encapsulation (superstrate) for thin-film Si modules





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SCHOTT offers attractive architectural solutions: Innovative façades and indoor equipment

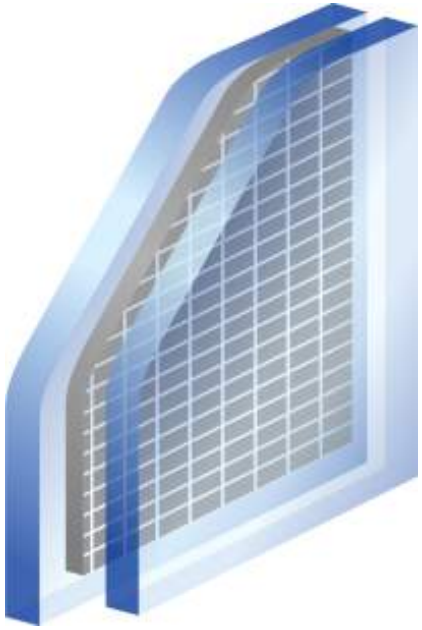
IMERA®,
AMIRAN®,
NARIMA®,
OPALIKA®,
ASITHRU®,
LIGHTPOINTS,
ASIOPAK®,
ASI®GLASS
…

Highly transparent glass, fire resistant glass, coloured and deco glass, solar glass, highly reflective glass, LightPoints, Bricks made of glass …

SCHOTT solar

Building Integrated Photovoltaic (BIPV) with "State of the Art" ASITHRU® laminates and double glazings

Customer-specific solar modules with semi-transparent effect as a multifunctional building element for innovative building design.
ASITHRU® - SCHOTT Solar is patent-holder for worldwide use.



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Advantages of Building Integrated Photovoltaics (BIPV) based on ASI Thin Film Technology

Semitransparent ASI Thin Film Technology offers:

- **sun protection and daylight transmission**
- **basic constructive features of glass products like weather protection (rain, hail, storm), statics, low maintenance, long-life cycle, ease of handling**
- **innovative design, large area homogeneous look**
- **building internal climate control**
- **generation of clean solar power**
- **cost savings for initial investments and long-term building operation:**
  - *** smaller air conditioning systems**
  - *** replacement of additional mechanical shading systems**
  - *** less artificial light**
  - *** delivers peak power in summer well matching power needs**

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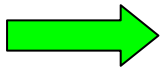
Thin Film Modules from SCHOTT Solar are designed to meet the Requirements of Building Integration

- **Low material costs: Less than 1/1000 mm thick (1 gram/sqm) amorphous silicon alloy can absorb sunlight. Crystalline technologies use 0,3 mm cell units**

- **Excellent low light performance of ASI Technology to beneficially use cloudy and low light weather conditions to generate electrical power**

- **Superior high temperature performance of ASI Technology**
  - 6% at 55 degrees versus -14% of crystalline modules
  for best practise when incorporated in laminates or isolated double glass units missing (cold) air ventilation



More delivered energy (up to 20%) per rated Watt

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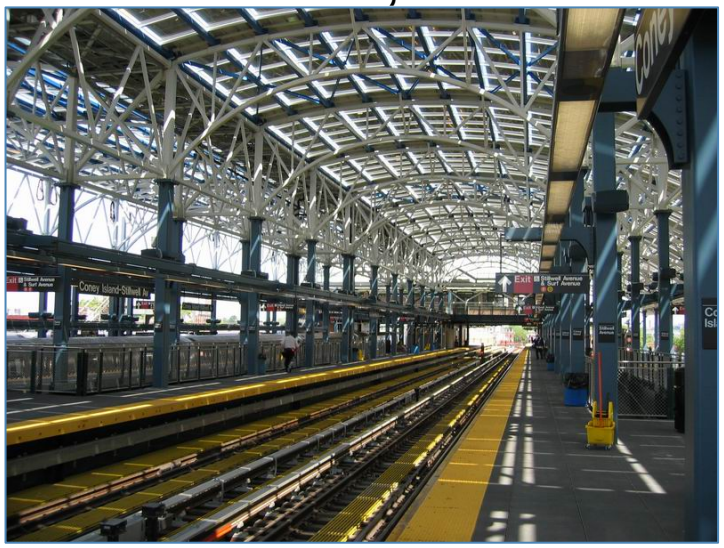
SCHOTT Solar`s worldwide BIPV references

Missawa Kinki, JPN

New York, USA

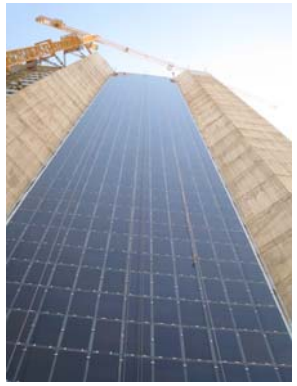


Barcelona, ESP

Eggenfelden, DEU

Gevel Zwolle, NLD

Tower, SDN



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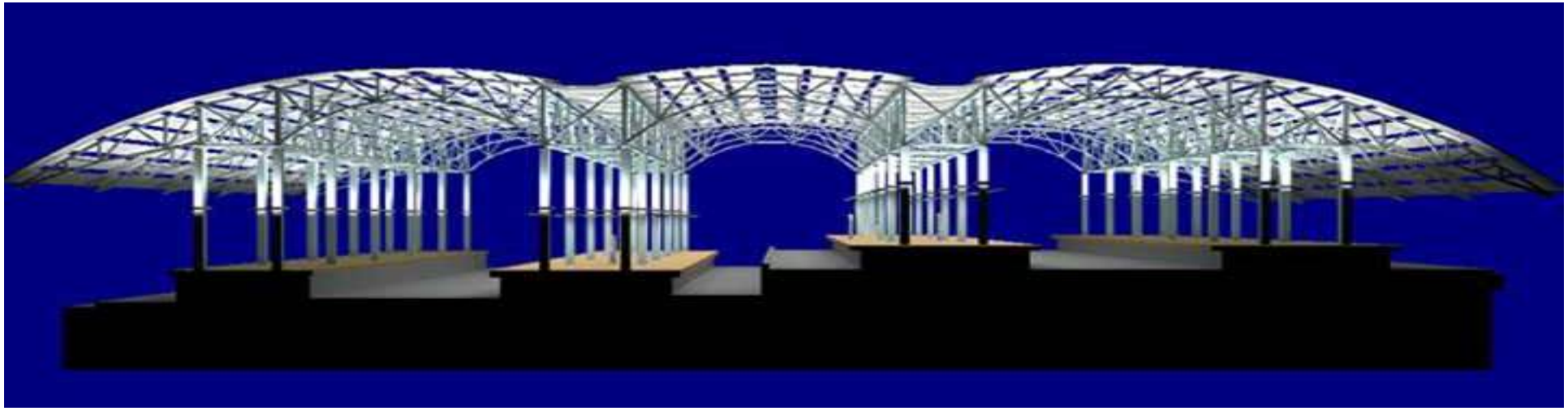
Coney Island-Stillwell Av

The idea: Innovative Renovation of the 86 year-old (above-ground) station of New Yorks Subway Station Stillwell Avenue Terminal, Coney Island, N.Y.



Technical Requirements:

*** Use Glass Elements as Overhead Glazing to**
- allow daylight transmission reducing energy costs for artificial light.
- provide long-lasting, weather-proof protection of the roof.
- offer rapid installation reducing traffic delays or platform blockings.
*** Incorporate Solar Technology generating clean, renewable power.**
*** Use Thin Film Solar Technology (ASI) offering homogeneous look.**

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The main prerequisites of the Stillwell Station Project:

*** The roof structure had to pass the country hurricane test**

*** The system had to be maintained from the top – you did not have to stop train traffic to maintain it**

*** UL approval for ASI Glass Solar Panels required**

The ASI Glass Solar Panels have added benefits other than just generating electricity. They become roofing material and also provide shade. Solar roof panels can replace conventional glazing systems and shading arrangements.

The Responsible Project Members

Building Owner:
Metropolitan Transportation Authority MTA, New York

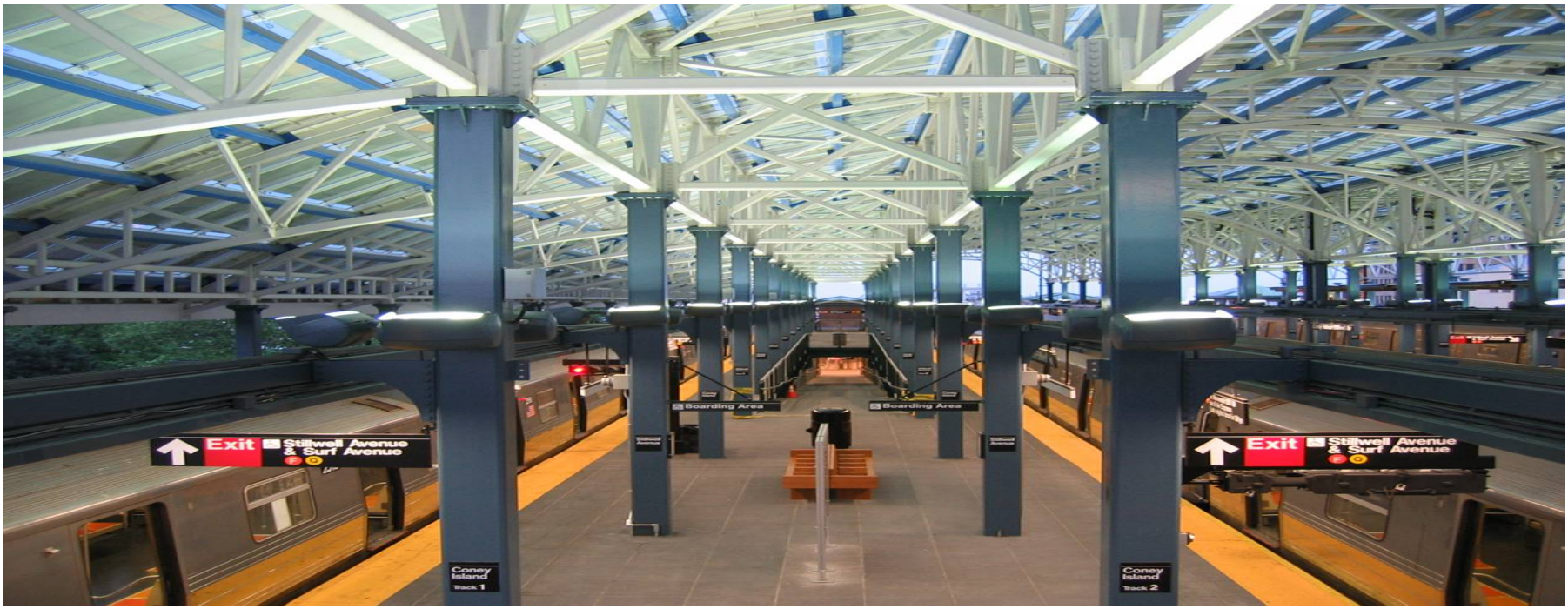
Architect:
Gregory Kiss
Tony Daniels
Kiss&Cathcart

Supplier of ASI Glass Solar Panels:
SCHOTT Solar

Many Others

Project Planning Phase started year 2000
Delivery ASI Solar Glass: Mid 2003
Installation of ASI Glass Solar Roof: 2004/5

The solution: Solar Glass Roof using ASI Technology



Additional advantages of the ASI Glass Concept:

*** Perfect matching between daylight insolation and shading**

*** Saving costs avoiding mechanical shading systems in front of the glass.**

*** Reducing energy costs using the reflecting light effect of ASI Glass rear contact artificially spotlighted at night.**

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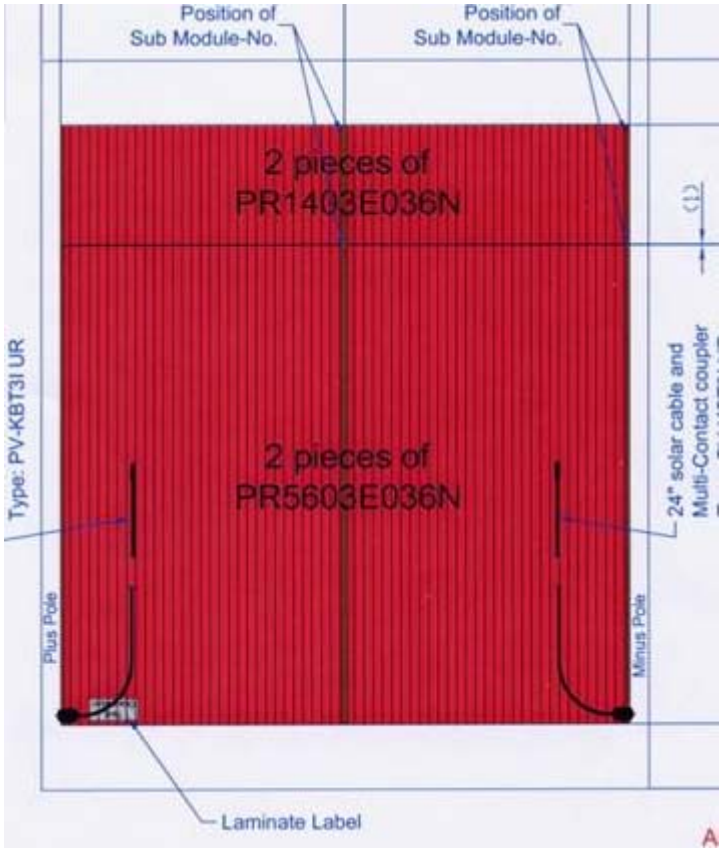
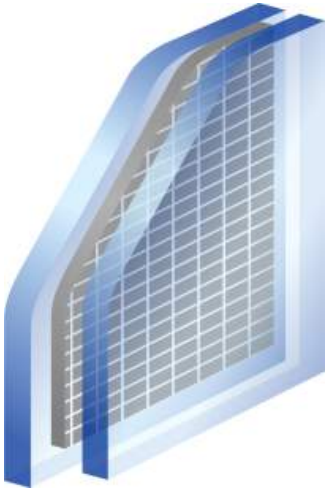
In the beginning: Design of a very special customized ASI Glass Solar Panel



Four ASI Glass sub-modules in one unit with 1232 mm x 1486 mm and an active PV zone of 1153 mm x 1221 mm.

Glass-Glass laminates based on PVB process for safety and long-term stability.

Oversized glass laminate for semitransparency (20 %) by clear glass edge.



Meanwhile: The triple-vaulted steel structure was built, covering four platforms and eight tracks

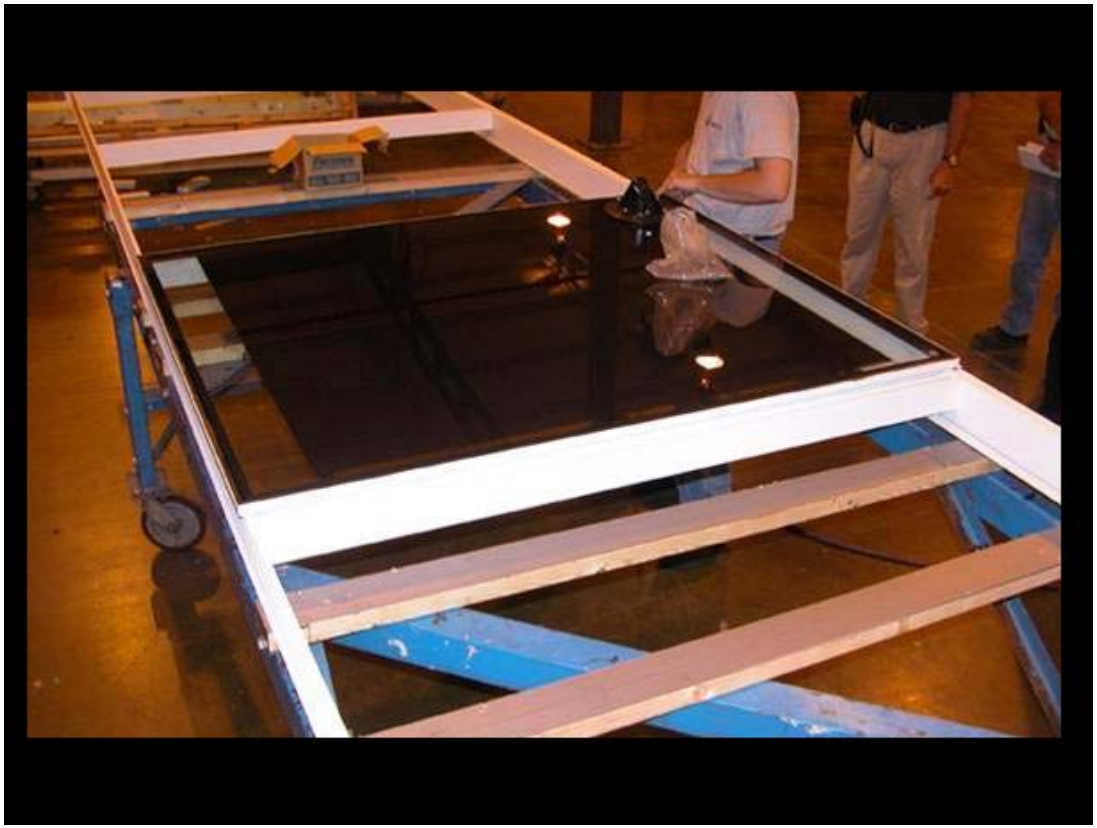
More than 2900 ASI Glass Solar Panels were produced

Initial installed Power of ASI Glass Solar Panel at ~78 Wp

Voltage range per Solar Panel at ~105 Vmpp

Cell material: Amorphous Silicon

Five large-area ASI Glass Solar Panels were built together in a 10 m² roof construction element in order to reduce installation time on-site.



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Well-balanced: The system design

*** 1,83 m² per ASI Glass Panel**
*** 10 m² per solar roof element**
*** High crane installation**
*** UL approval of solar panels**
*** Total Solar Roof System offering >210 kWp installed initial power output**
*** Central DC-AC inverters for grid connection**

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Exit
Stillwell Avenue
& Surf Avenue
Coney Island-Stillwell Av
Exit
Stillwell Avenue
& Surf Avenue
Stillwell
Avenue

Stillwell Station today: A translucid, architectural „monument“ made of Glass, Steel and ASI Solar Technology

SCHOTT Solar is committed to quality products, high energy yield and long lifetime: