Silicon-Thin-Film Photovoltaic makes solar power economically viable

Photovoltaic in Switzerland
30. 06.2011 SwissLaser Network Workshop

Dr. Andreas Baechli

Agenda

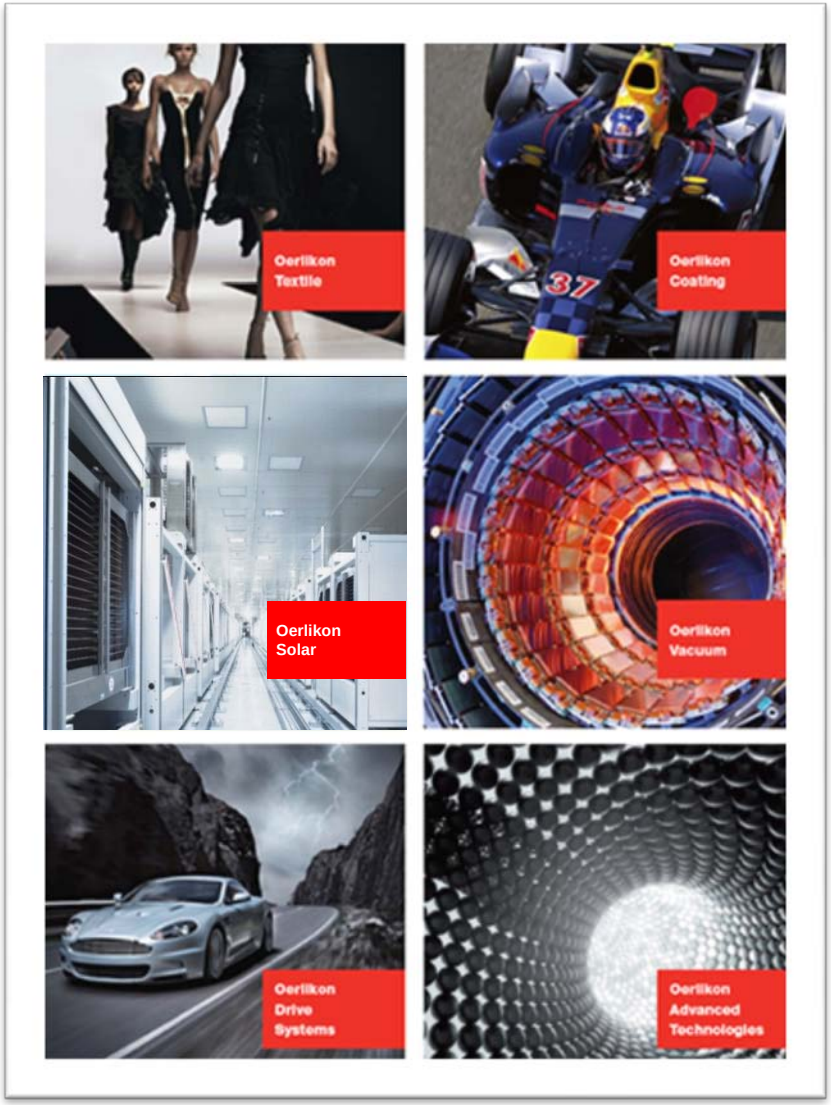
1. Oerlikon and Oerlikon Solar
2. Silicon Thin Film
3. Competitive Analysis

Enabling High Technology

The Oerlikon Group is one of the most innovative industrial groups in the world.

Oerlikon is active in various markets around the globe:
machine and plant engineering, solar technology, thin film coating, vacuum systems, textile machines, drive systems as well as semiconductors and nanotechnology.

With over 16,000 employees more than 150 sites in 36 countries, we develop solutions for leading industry applications and future-oriented markets.



Oerlikon is a provider of clean-technology solutions 100 years history of turning innovations into sales

Oerlikon Coating

- Leading coatings in the automotive sector:
  - 10x durability
  - 4% less energy consumption

Oerlikon Solar

- Leading provider of silicon based thin film solar technology

Oerlikon Vacuum

- Vacuum solutions for the solar and wind industry

Oerlikon Systems

- Advanced nanotechnology for solar cells, thermo-electric generators and batteries

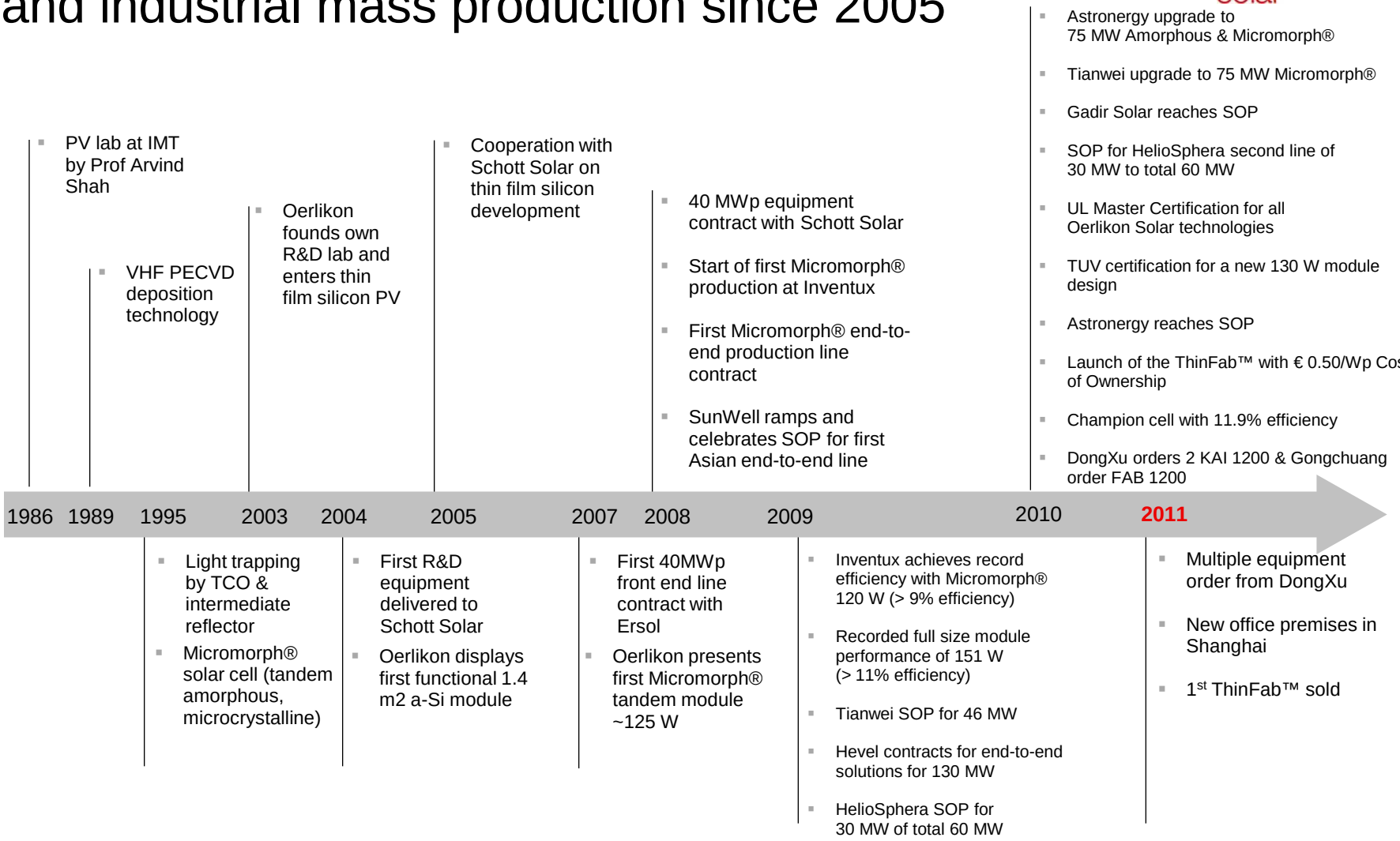
Oerlikon Fairfield

- Loose gears and gearboxes for wind turbines

Oerlikon Graziano

- Transmissions for hybrid and electrical cars

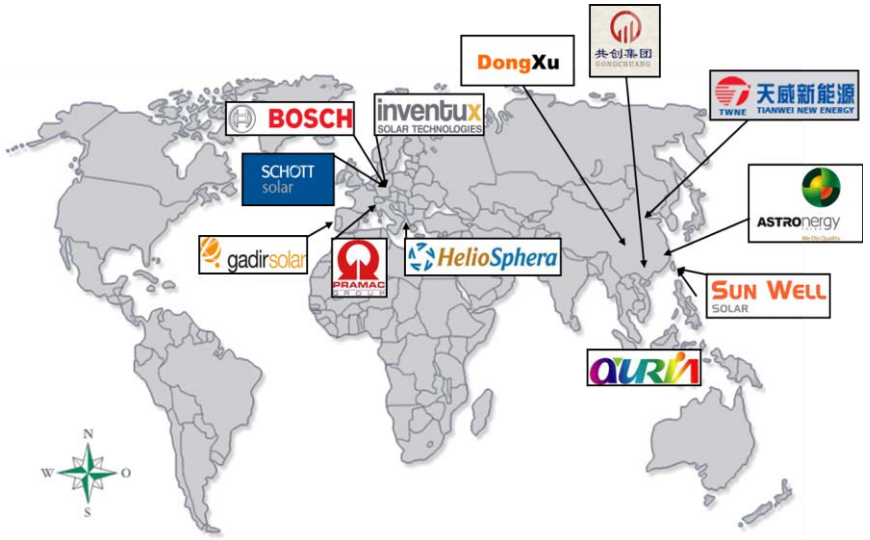
15 years of R&D experience and industrial mass production since 2005



Opportunity identification → Concept and product → Commercialization → Globalization

Oerlikon Solar at a Glance

- The leading supplier of production lines for thin film silicon modules
- More than 750 MW contracted to-date and more than 450 MW delivered to 11 customers meeting all performance targets
- Approximately 700 employees including 300 scientists and engineers as well as 200 global customer personnel
- R&D investments of MCHF 70 in 2010



Serving from 13 locations
in 9 countries

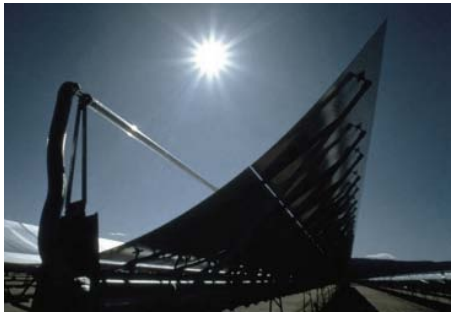
Oerlikon Solar's vision is to make solar power economically viable.

Solar Technologies Overview

Solar Power

Concentrated Solar Power

… concentrate sunlight to heat source fluid for a conventional power plant. CSP cannot be deployed at small scale and geographic range is limited.



Photovoltaic (PV)

… direct conversion of sunlight into electricity through photoelectric effect. PV supports broad functional applications from roof-tops to large farms at competitive energy value.

Wafer based

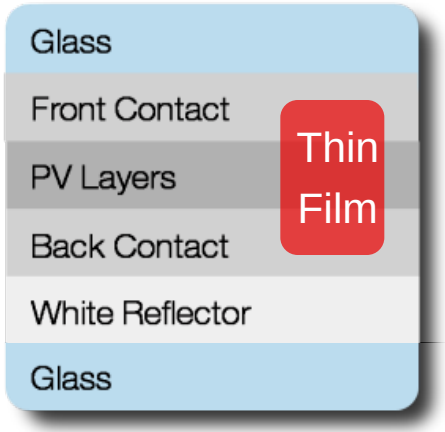
Thin Film Technologies

	c-Si	TF-Si	CdTe	CIGS
				
Market Share	**79%**	**9%**	**10%**	**2%**

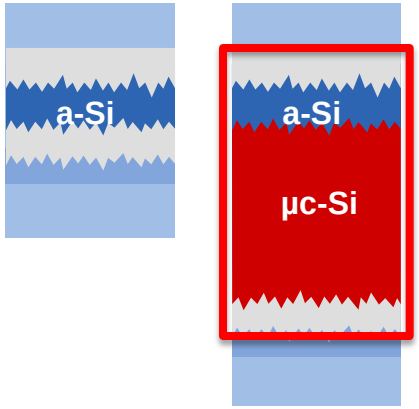
Oerlikon Solar .. a pioneer in Thin Film Silicon technology

Oerlikon Solar thin film silicon technology

Cell Structure



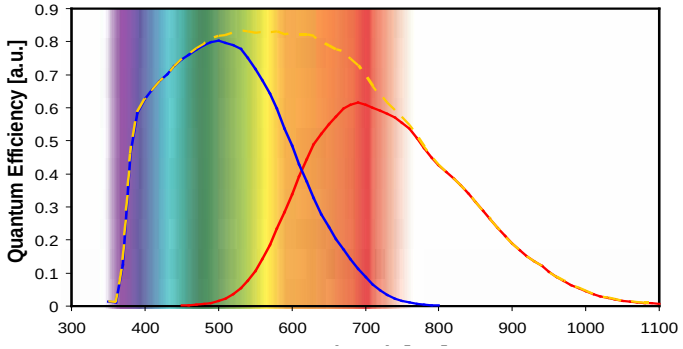
Cell Cross Sections



Amorph
Single Junction

Micromorph®
Tandem Junction

Spectral Cell Sensitivity



THINFAB™ with next generation equipment

Laser (LSS ThinFab™)

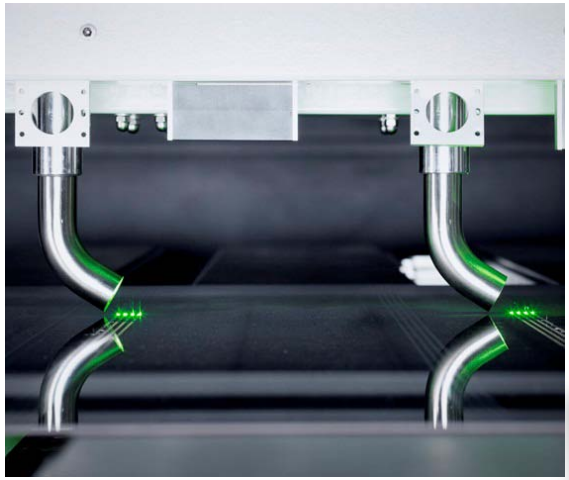
- World leading laser scribe dead zone of 180 µm for TF silicon mass production
- Doubled throughput since last generation
- Improved process stability – 96% uptime

PECVD (KAI MT)

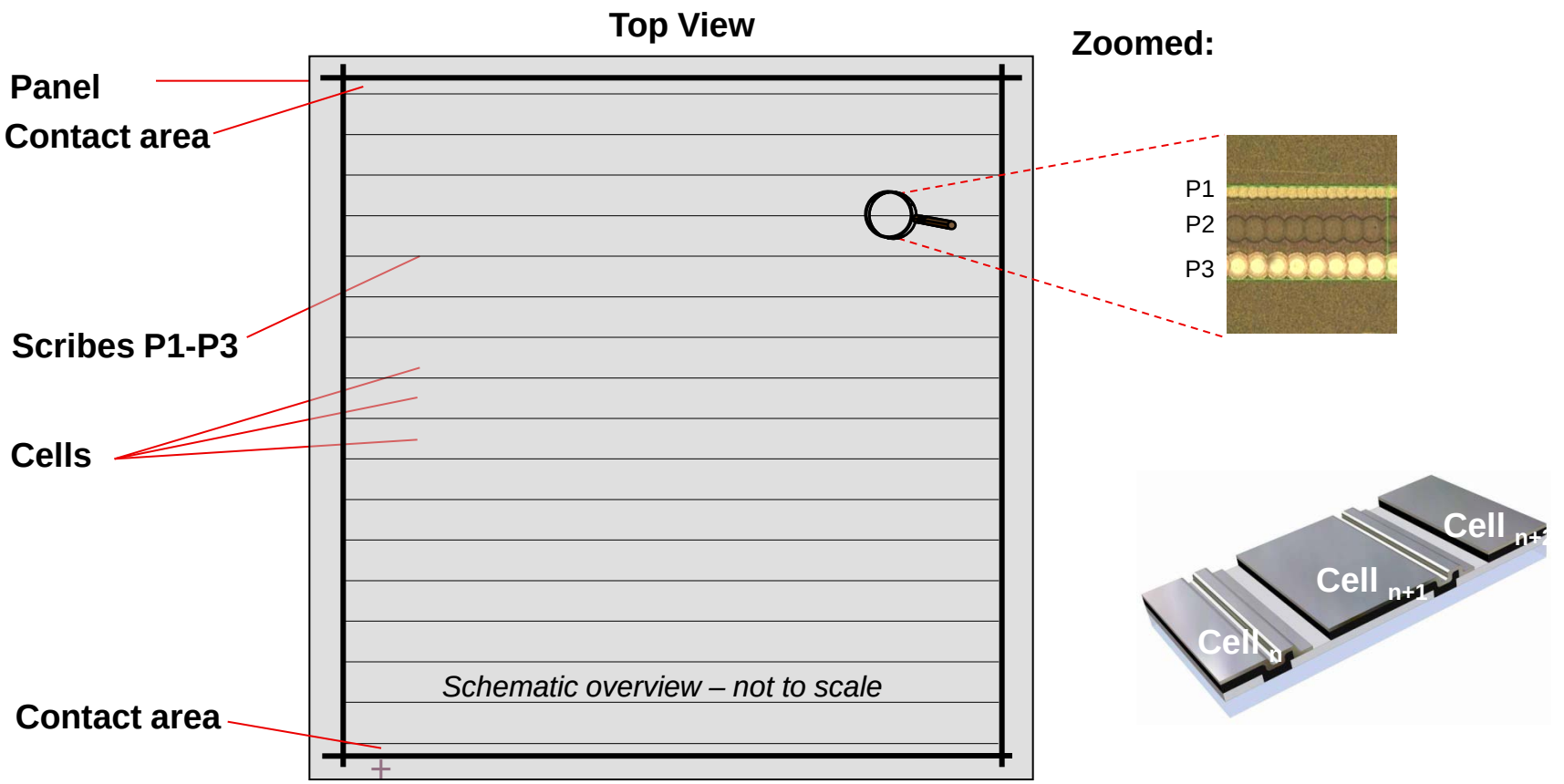
- Micromorph® absorber deposition system capable of depositing a-Si and µc-Si layers with 40 MHz technology
- Equipped with 30 reactors enabling 43 m2 of glass processing in single prod.
- 50% less footprint & 50% faster cleaning

LPCVD (TCO ThinFab™)

- 60% higher throughput and 40% lower costs
- Best-in-class transmittance and light trapping enables a high efficiency thin absorber layer
- In-house front contact TCO enables cost-efficient local bare glass sourcing

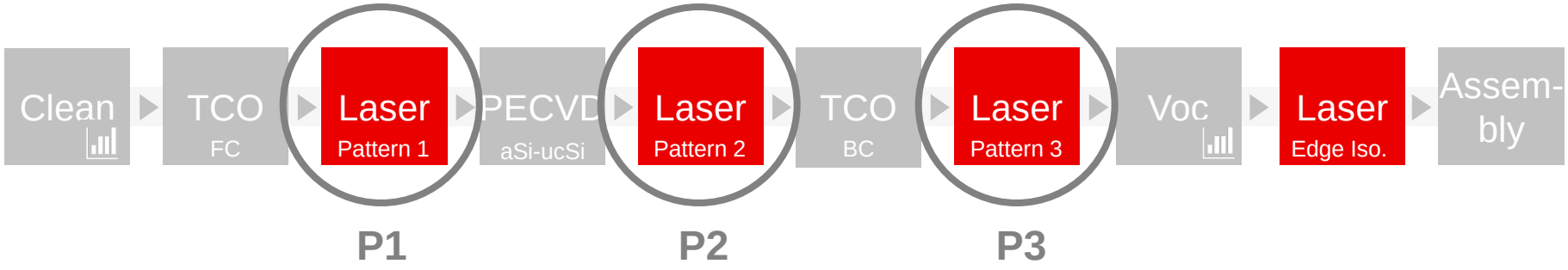


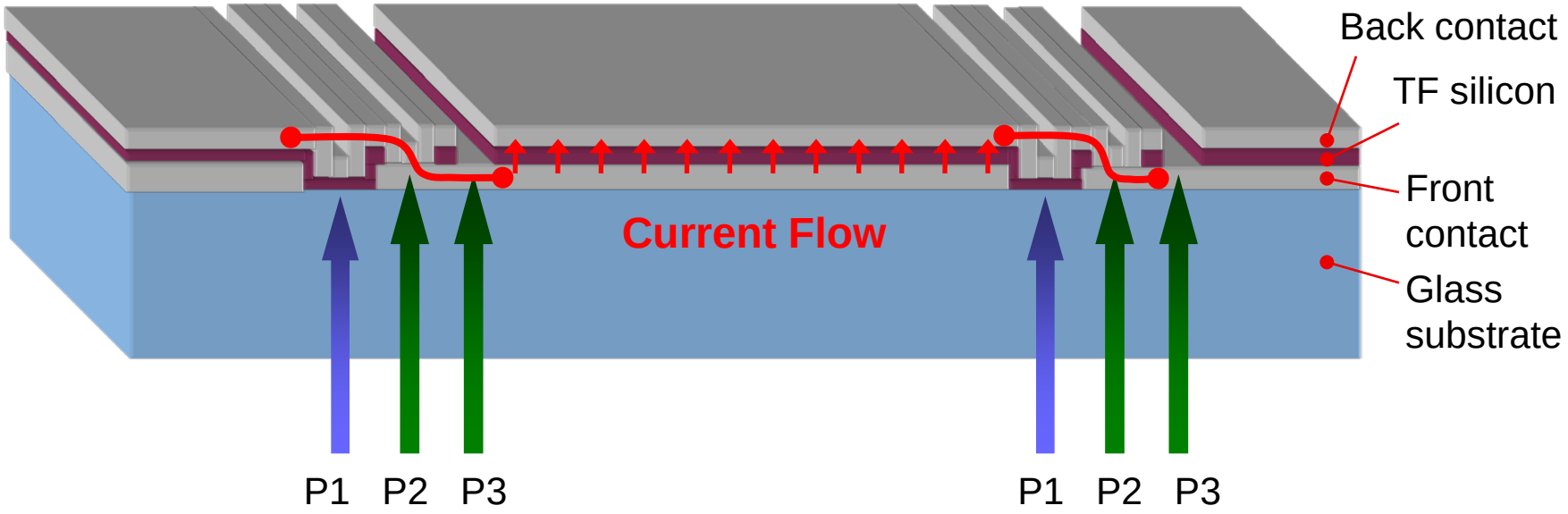
The layout for a panel defines the cells and thus reduces the ohmic losses and defines the voltage



Low electrical loss connections between cells

Generation of high parallel & low serial resistances





THINFAB™

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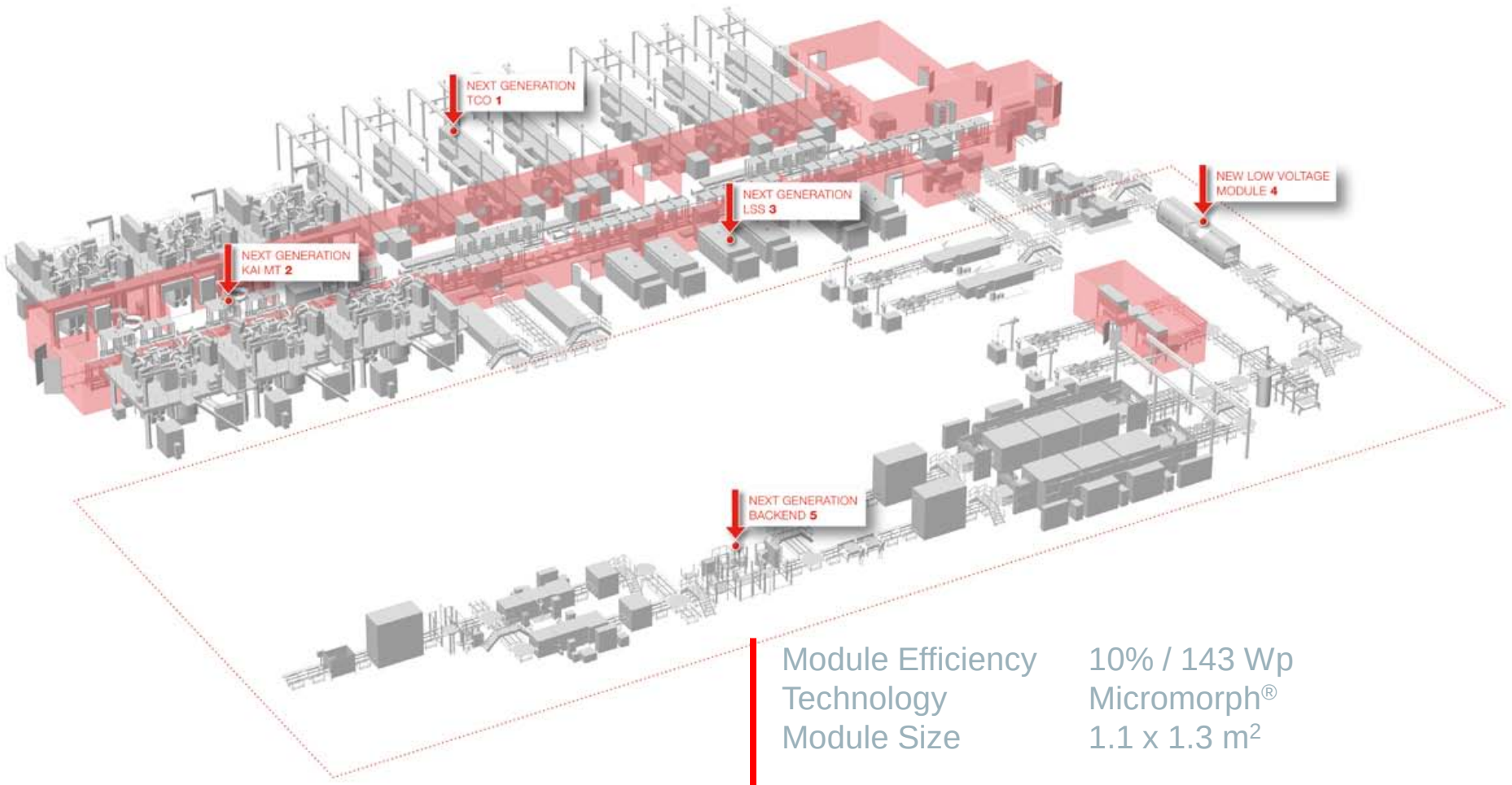

Module Efficiency	10% / 143 Wp
Technology	Micromorph®
Module Size	1.1 x 1.3 m^2
Annual Output	120 MW /~850‘000 Modules
Yield	97%

Thin Film Silicon PV Applications

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Ground-mounted PV Systems (GMS)

- Utility scale PV power plants
- Grid-connected
- Ground based installation
- Typical system size > 1000 kWp

Commercial Rooftop PV Systems (CRT)

- Large rooftop PV power plants
- Grid-connected
- Sloped industrial roofing
- Industrial flat roof
- Typical system size 10 to1000 kWp

Residential Rooftop PV Systems (RRT)

- PV systems on residential homes
- Grid-connected
- Retrofit rooftop
- BIPV rooftop/ façade
- Typical system size 1 to 10 kWp

Off-grid PV Systems

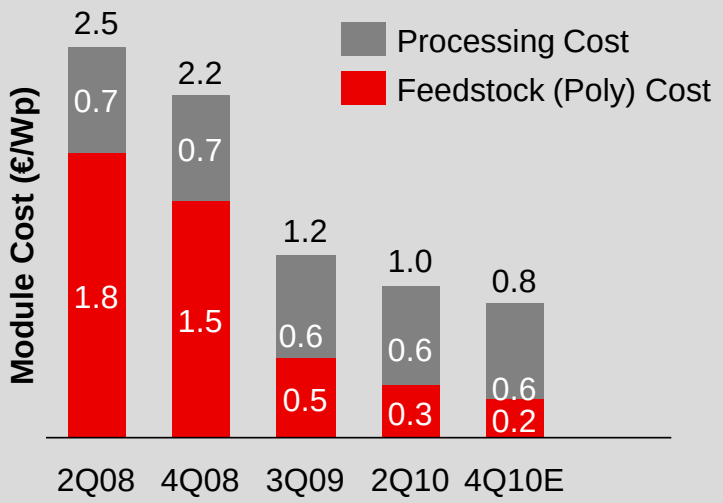
- Pumping systems
- Rural electrification
- Standalone systems
- Mini-grids
- Remote site power supply
- Mobile power

BIPV

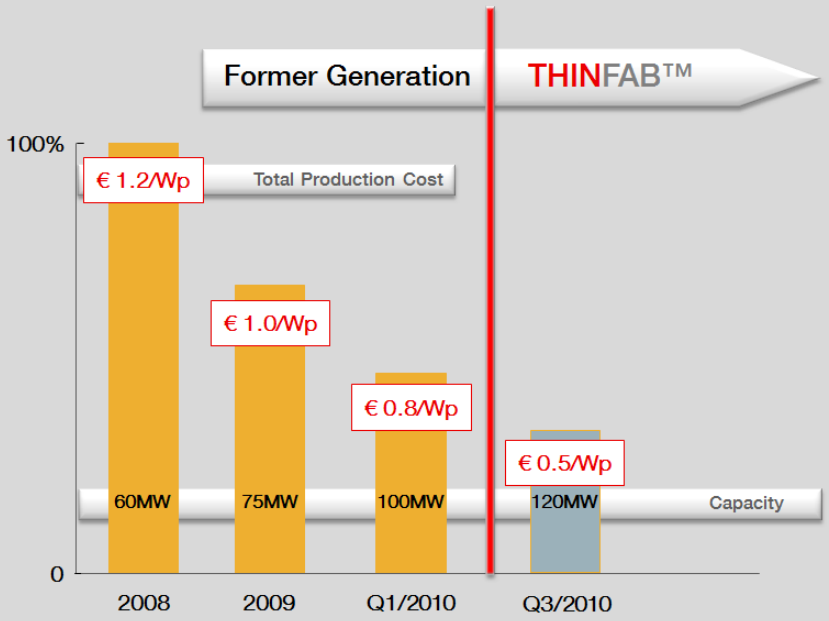
- Roof Integration
- External facades
- Semi-transparent facades
- Skylights
- Shading systems
- Noise barriers

Development of costs for PV solutions

c-Si Cost Structure



Thin Film Si Cost Structure



THINFAB™

Economically Viable Solar Power with
Thin Film Silicon – NOW!

PV Cost Structure Breakdown

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- Materials
- Gases
- Investment
- Labor
- Utilities

- Inverters
- Mounting
- Cabling
- Transformer
- Labor

- Engineering
- Procurement
- Construction

- Maintenance
- Land Lease
- Insurance
- Monitoring
- Cleaning

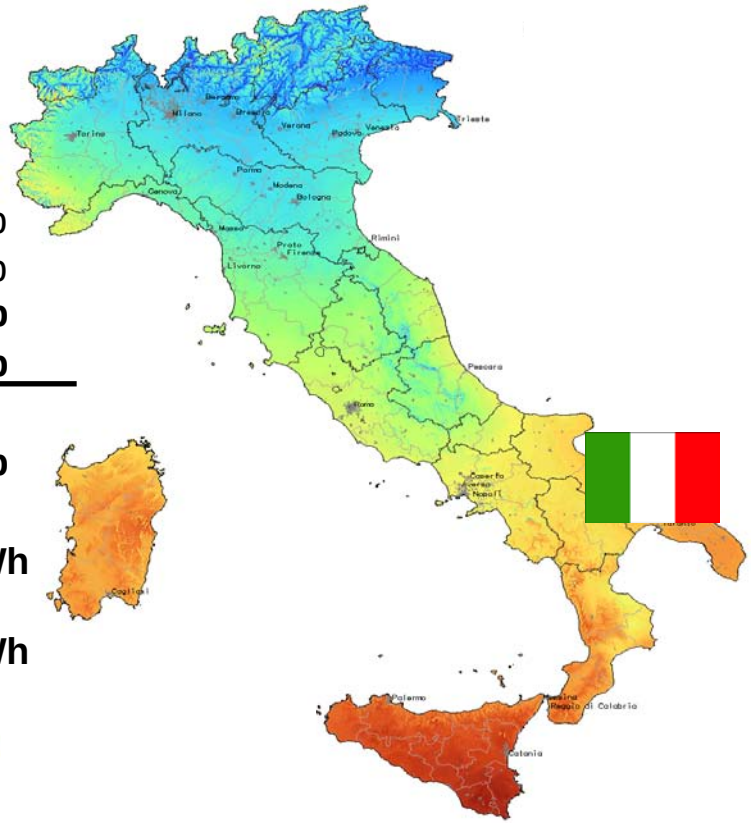
- Capital Structure
- Projects IRRs

Electricity costs further driven by

- Energy Yield
- System Degradation
- Capital Structure
- Inflation Rate
- Tax Rate and Credits
- (Accelerated) Depreciation

Cost of Electricity with Oerlikon Solar Technology
10 MW Solar Farm in Bari, Italy

Module Production Cost	0.50	€/Wp
Module Margin (35%)	0.27	€/Wp
Module Price	**0.77**	**€/Wp**
BOS Price	**0.91**	**€/Wp**
Total system cost	**1.68**	**€/Wp**
Electricity Cost	**0.07**	**€/kWh**
Electricity Price*	**0.12**	**€/kWh**



Assumptions: 10 MW solar farm in Bari, Italy, Average Energy Yield: 1690 kWh/kWp/year, Modu[illegible] → Based on OS EU estimates in 2012, 14% EPC Margin included, Annual Land Lease Costs ~ 2000 EUR/ha, Corporate Tax 30%, Inflation Rate 2.5%, O&M costs/yr: 0.8% of System Cost, Project life 25 yrs.

* Including WACC 8.5%

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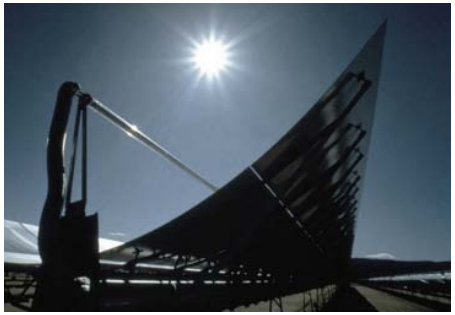

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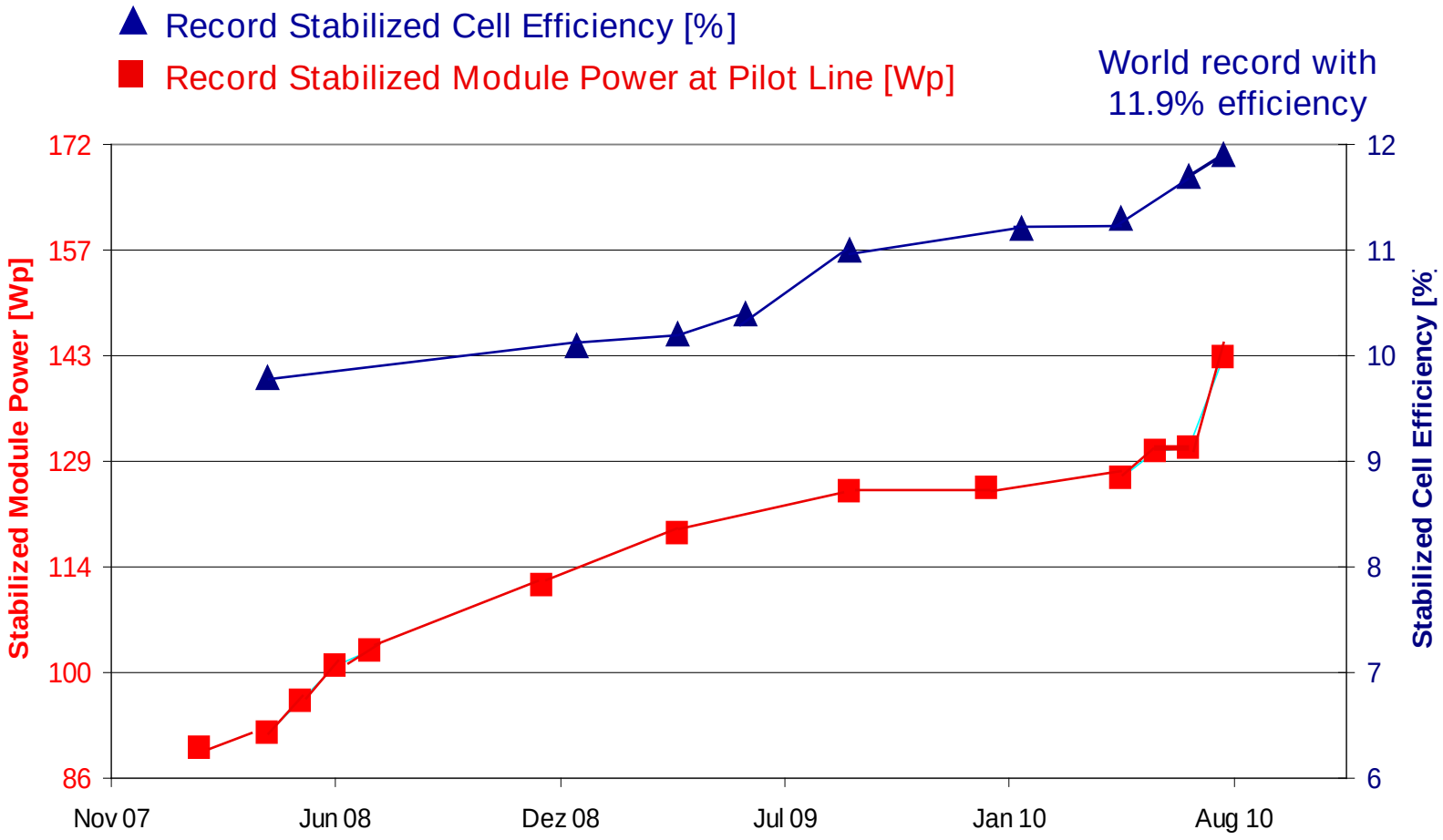
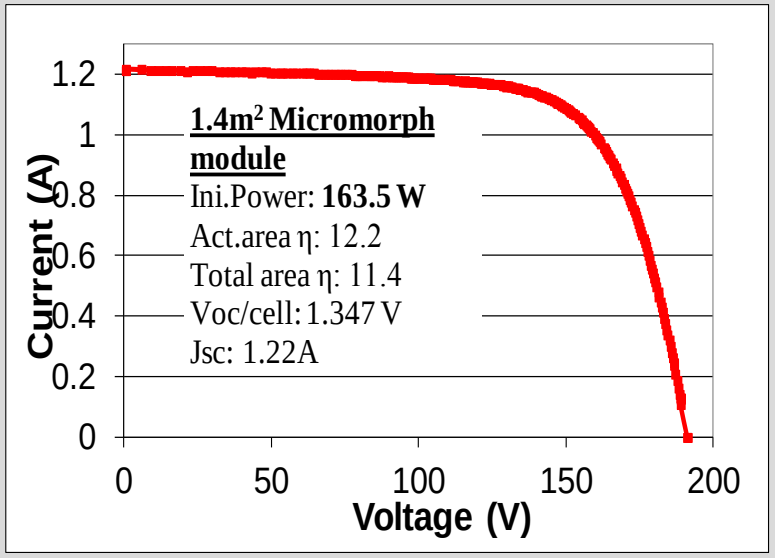
From champion cell to record modules

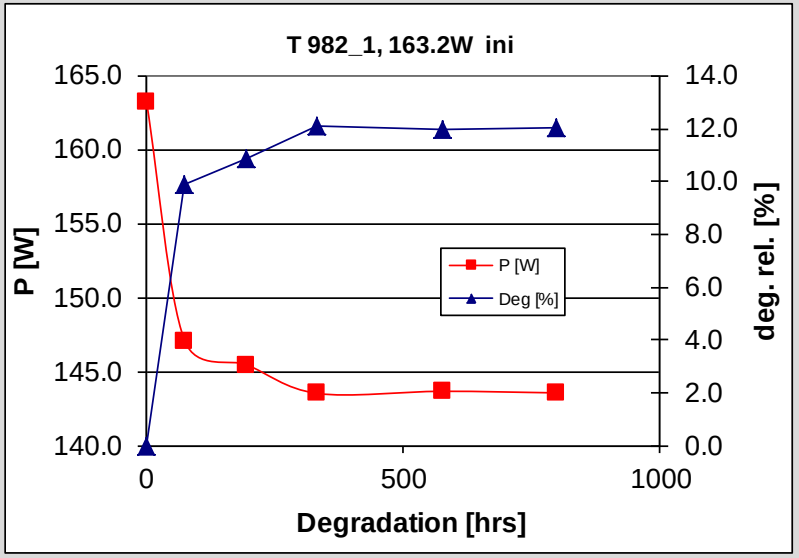


Record* Micromorph® Tandem Module Degradation Results



I-V Curve

Highly stable top cell, improved bottom cell and excellent light trapping lead to 11.4% total area initial efficiency

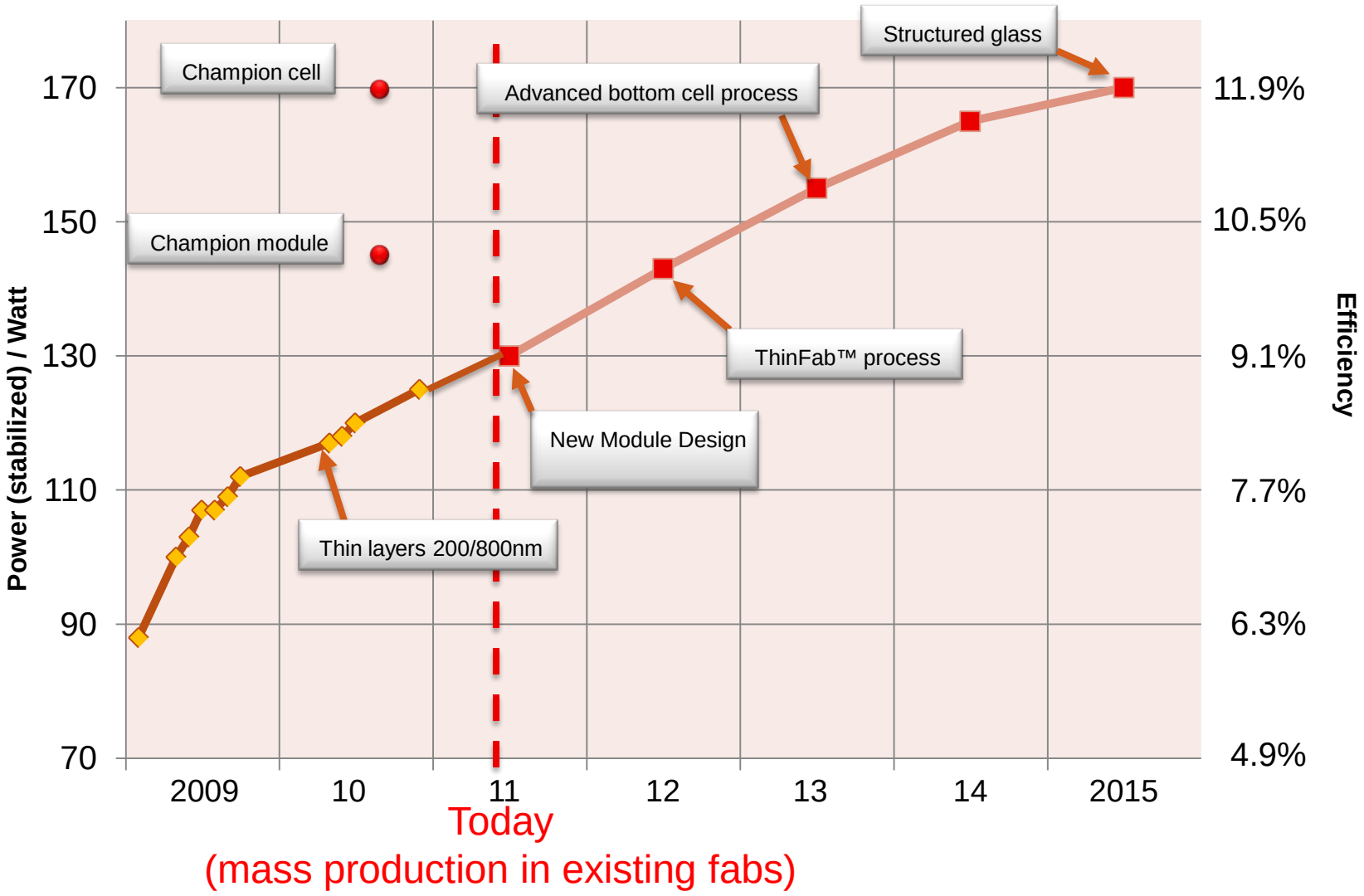


Initial Degradation Curve

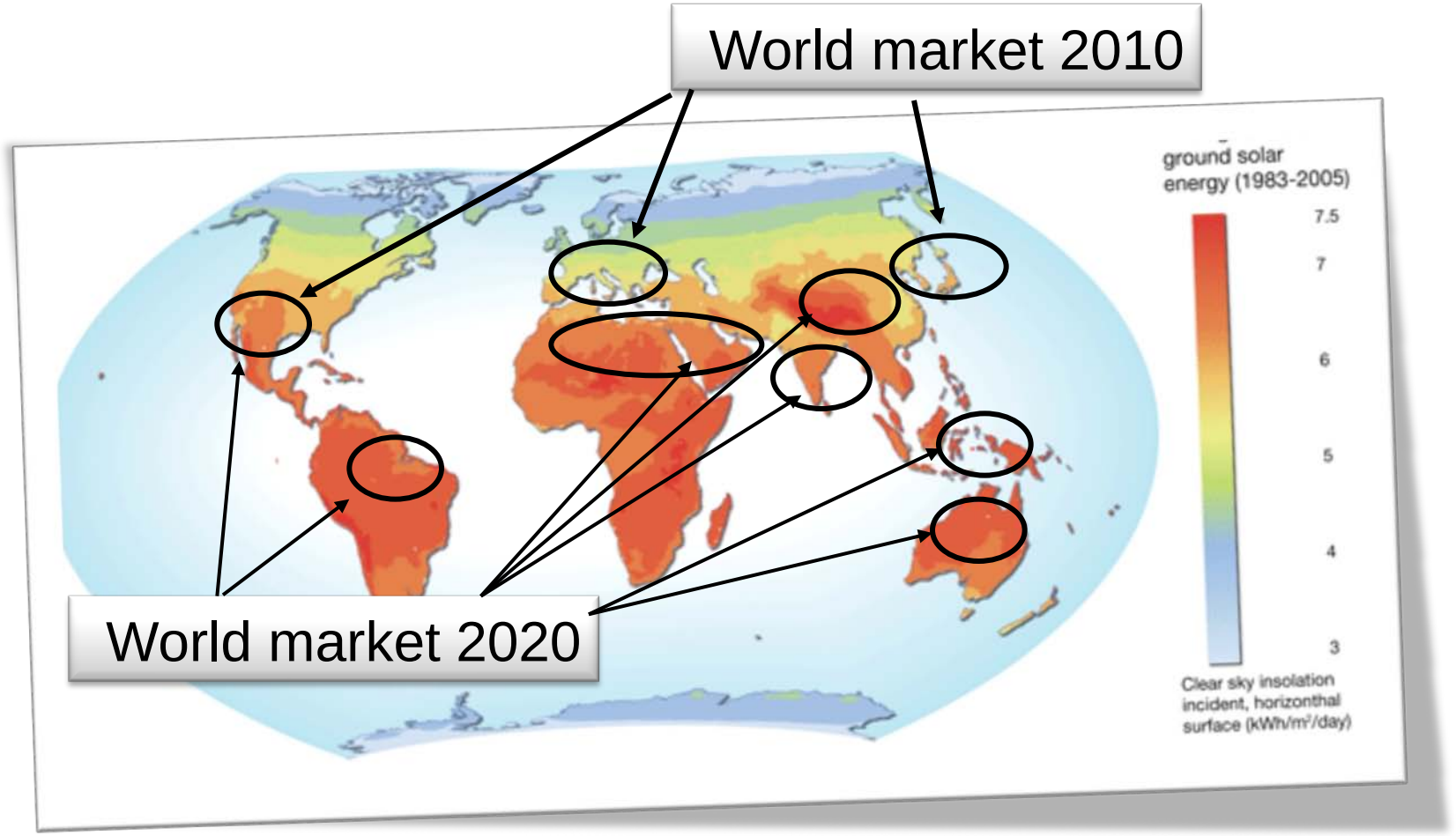
Degradation corresponds to > 10% stable total area efficiency

*Results achieved consecutively on the Oerlikon Solar 1MW pilot line.

Key innovations already identified

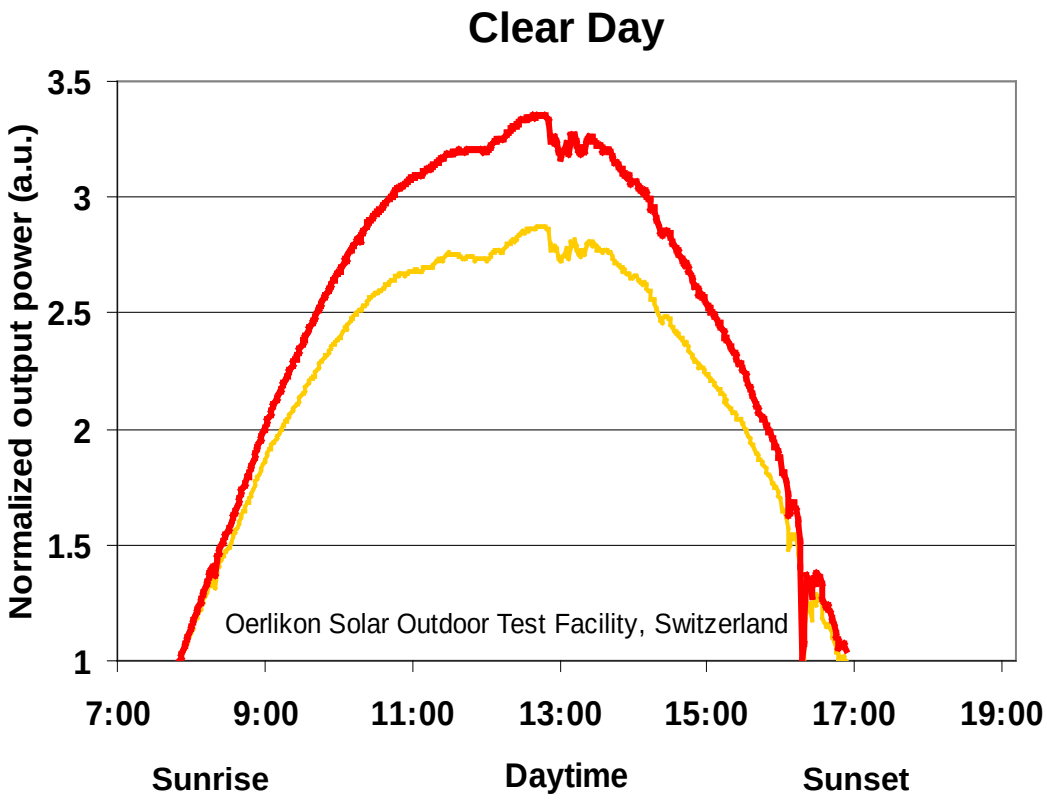


Thin Film® is well-positioned for future markets



Reduced subsidy levels, markets shifting to sun-belt regions
Favorable high-temperature performance for TF Si

Relative Energy Gain: Up to 13% compared to c-Si Oerlikon Solar Micromorph® technology



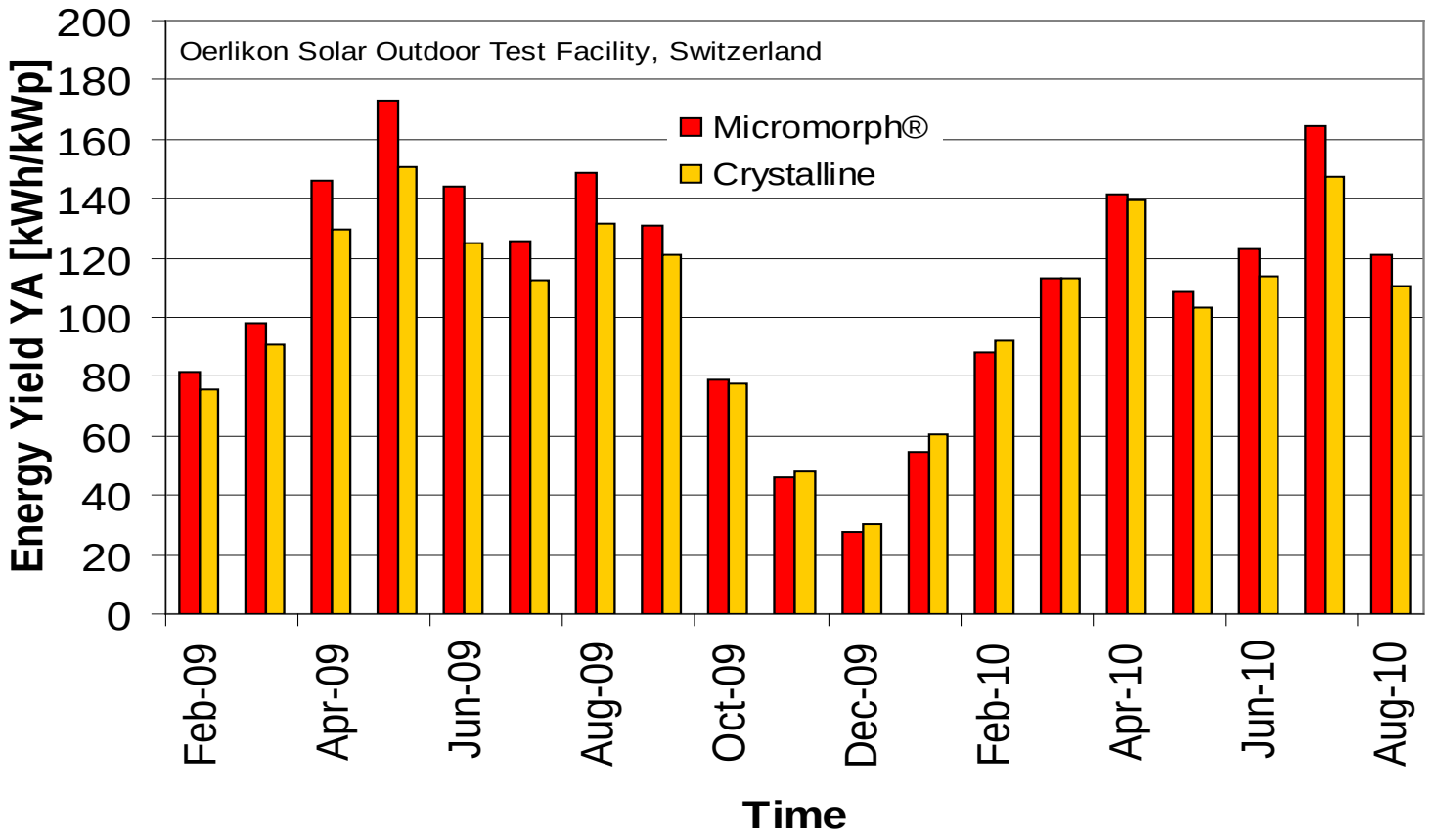
Due to Thin Film Silicon Micromorph® lower temperature coefficient higher energy yield is achieved at higher temperatures compared to crystalline.

Crystalline

Micromorph (R)

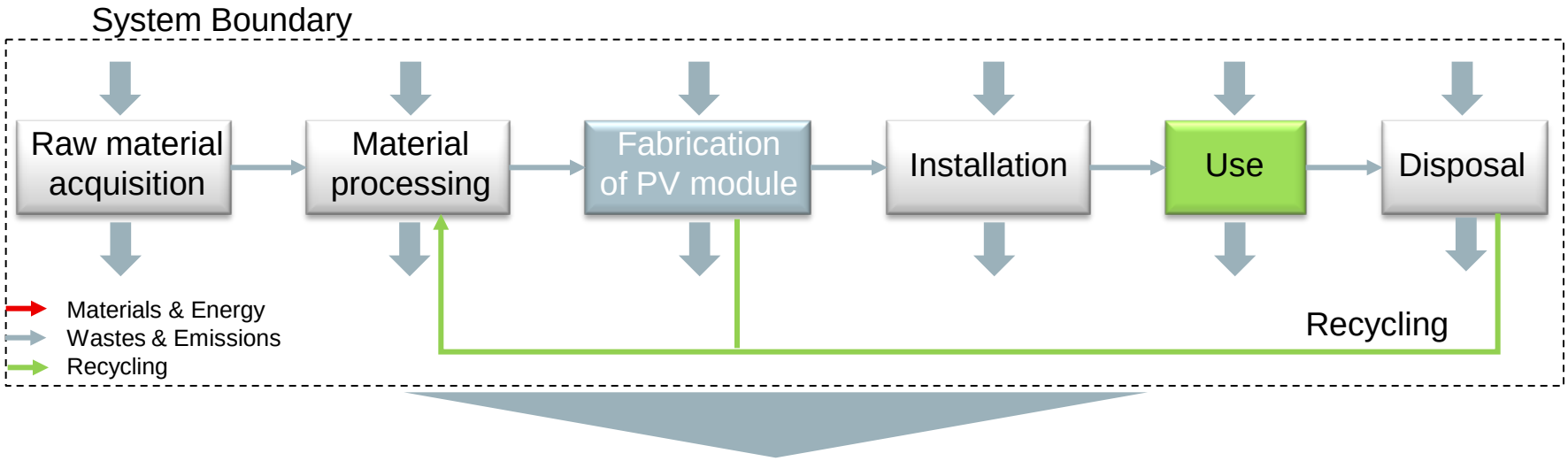
Stabilized modules were used. All data at module level (DC side) to allow comparison of module technologies and exclude inverter influences. Normalized to sunrise.

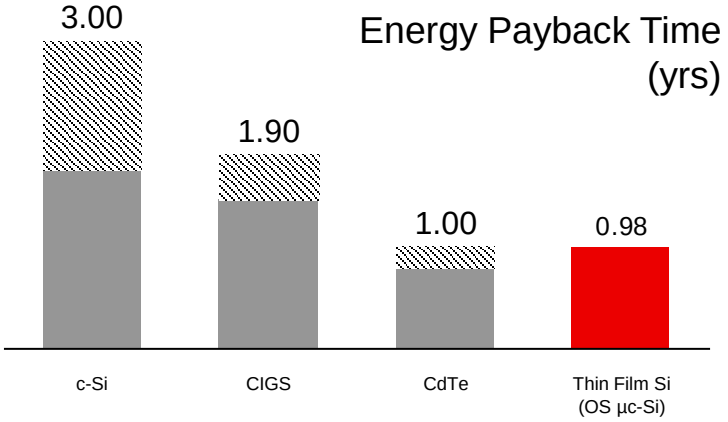
More than 9% higher energy yield compared to c-Si Oerlikon Solar Micromorph® technology

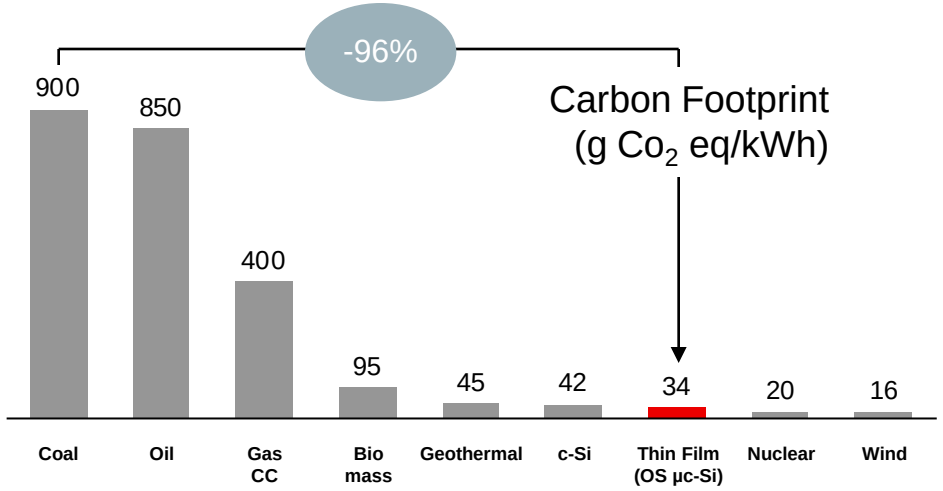


c-Si modules from European manufacturer, best modules in the batch used. All data at module level (DC side) to allow comparison of module technologies and exclude inverter influences

Life cycle assessment of Oerlikon Solar Micromorph® module







Source: Axpo, Oerlikon, Fthenakis V., BNP Paribas

Overview Technology Competitive Analysis

	Thin Film Si (OS ThinFab)	Thin Film CdTe (captive with First Solar)	Thin Film CIGS	Best Cost c-Si (China> GW Scale)
Efficiency	◔	◑	◑	◕
Capex	◕	Captive FSLR	◔	◑
Module Cost	◕	●	○	◑
Energy Yield (Performanc, Suitability to hot climates)	●	◕	◑	◔
Electricity Cost	◕	◕	◔	◑
Energy Payback	◕	◕	◑	○
Toxic Composition	●	◔	◕	●
Raw material Scarcity	●	◔	◕	●

Attractiveness

- ○ Very Low
- ◔ Low
- ◑ Medium
- ◕ High
- ● Very High

Installation by Oerlikon Solar customers
4 million panels produced as of today

2.7 MWp, Saarbrucken, Germany

Modules produced by Oerlikon Solar customer Heliosphera

Three reasons to invest into THINFAB™

oerlikon solar

Disclaimer

This presentation is based on information currently available to management. The forward-looking statements contained herein could be substantially impacted by risks and influences that are not foreseeable at present, so that actual results may vary materially from those anticipated, expected or projected.

Thank you
for your attention.