



SMART SOLUTIONS TO DRIVE THE FUTURE

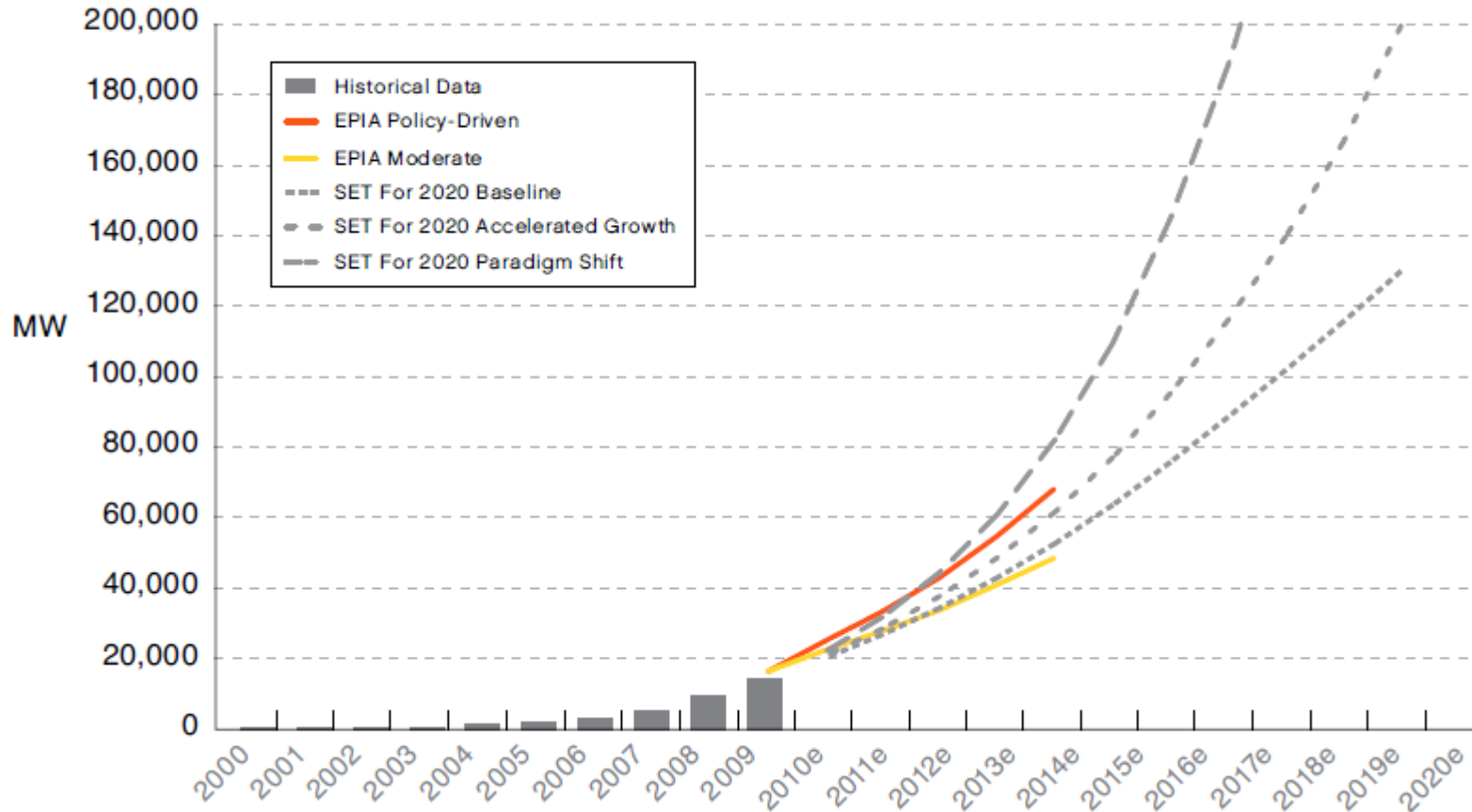
Status Report SINGULUS Solar - On the Road to Efficiency

Dr. Peter Wohlfart
Head of Research and Development

SINGULUS TECHNOLOGIES AG

SINGULUS 

- 2007
 - Decision to enter the PV market
 - Acquisition of STANGL
 - Start in the Solar equipment market
 - Decision to build own PECVD coater (SINGULAR)
- 2008
 - Definition of the **solar strategy**
 - Expansion with focus on c-Si and in selective areas of thin film (CIS)
 - Become a leading PV equipment supplier by 2018
 - Development of new machines and processes in the c-Si and thin film sectors
- 2009
 - Market introduction of SINGULAR and LINEA
 - Process and machine development continued
 - Integration of STANGL completed, sales organization restructured
- 2010
 - Major order for new thin film Solar production equipment
 - 13 % efficiency with ILGAR on large substrates proven
 - First FAT for c-Si Front End System
 - New orders for SINGULAR and wet chemical equipment



PV is the right strategic business field for SINGULUS

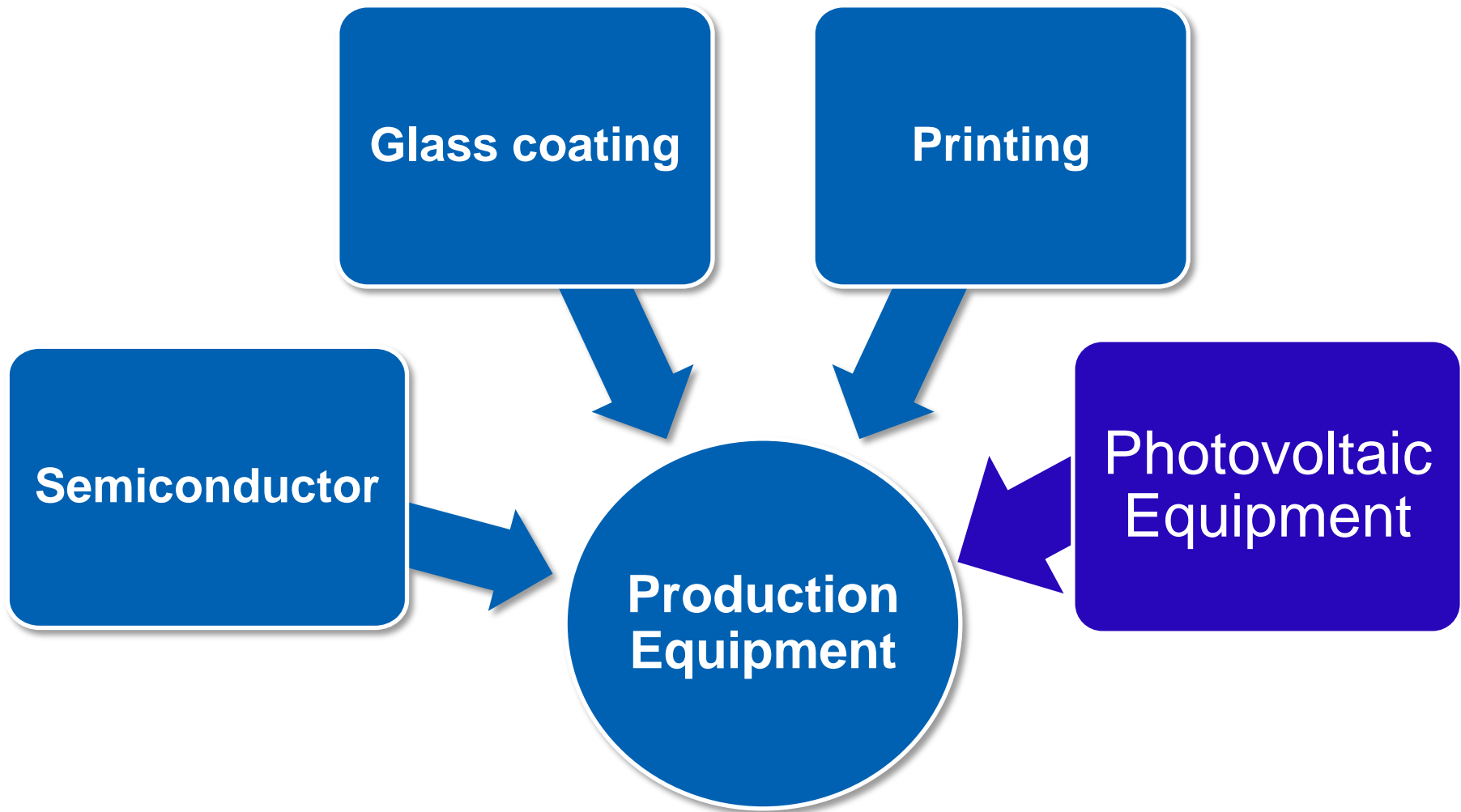
The PV industry has to achieve fast cost reductions.

Equipment suppliers are enablers for mass production of high-tech commodities

- **increase manufacturing yield by improved production technology**
 - high volume
 - low cost of ownership, efficient
 - fully automated, integrated, controlled
- **increase cell efficiency by improved process technology**
 - new materials and devices
 - scalable processes



The PV market requires innovative machine concepts



There is still not enough dedicated PV mass production equipment in the market

SINGULAR

dedicated PV equipment

higher
productivity

higher
cell efficiency

high uptime

high yield

low cost of
ownership

new
processes

more
sophisticate
d layers (e.g.
stacks)

Reduction of production cost
affects W_p/m^2

Increase of efficiency η
affects $\text{€}/m^2$

Both factors are needed to reduce PV energy generation cost

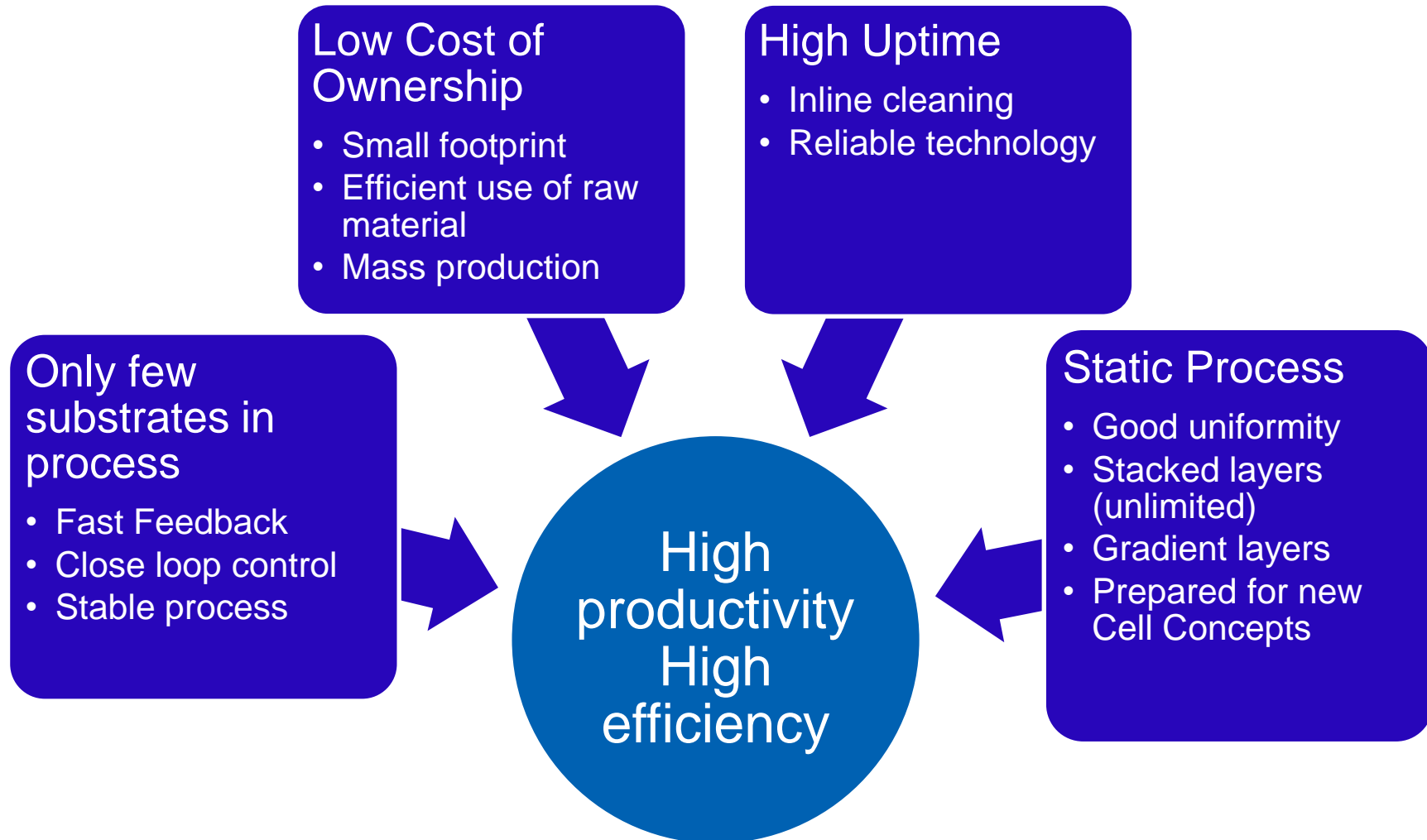
SINGULAR Multi Purpose Coating Machine

SINGULUS TECHNOLOGIES
November, 05 2010
- 7 -



Designed for both

- low cost of ownership for AR coating and passivation**
- new high efficiency cell applications**





Today

- Machine in production
- Standard processes developed
- High-efficiency processes in development
- Co-operations with several interested institutes and lead customers for new cell concepts in progress
- New orders acquired and further expected
- Sales activities in Asia enhanced

- Systems in production
- In front-end line integrated

- Integrated c-Si production systems and corresponding standard processes defined
- Marketing of systems has started

Tomorrow

- Application of high efficiency cell processes on existing equipment
- Introduction of new equipment for advanced cell concepts
- Integration of high efficiency processes into system business

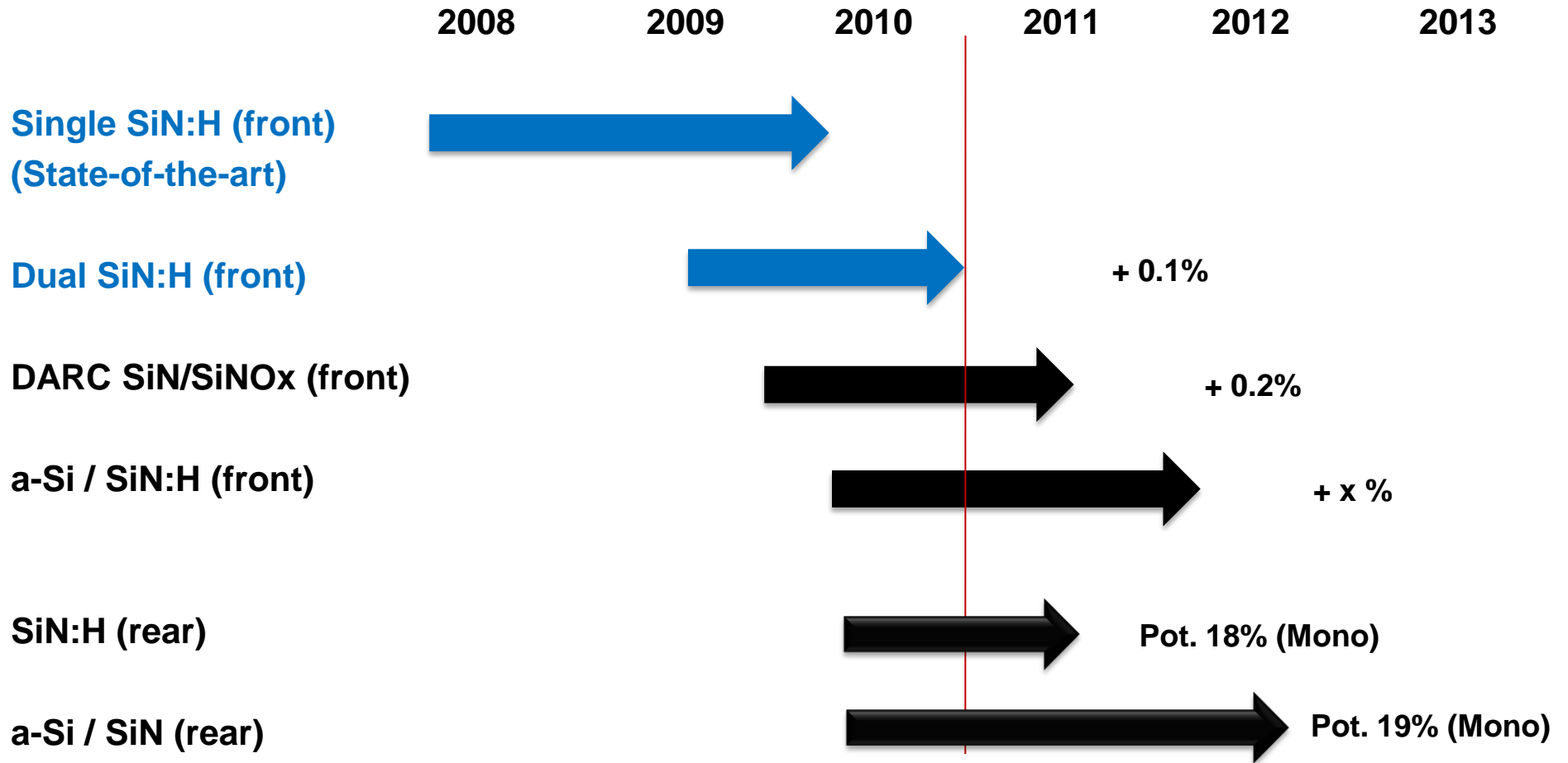
2 x LINEA / 1 SINGULAR / 5 x Handling Systems Integrated c-Si Front-End System in Operation

SINGULUS TECHNOLOGIES
November, 05 2010
- 10 -



Wet and Vacuum Processes - The Decisive Steps for High Efficiency Cell Production

Standard	ASPIRe	EWT	RISE EWT	IBC	i PERC	LFC PERC
Texture	Structuring: Holes (Laser)	Structuring: Holes (Laser)	Pass rear + masking for Emitterdiffusion: SiO ₂ (Wet Oxidation)	Texture: Aniso	Texture: Iso (Wet/Plasma)	Pass rear: SiO ₂ (Thermal Oxidation)
POCI	Texture: Iso	Etching: LDE along with SDR	Etching: Oxide front	POCI	POCI front	Etching: Oxide front
PSG	POCI	Texture	Texture: Aniso	Structuring: Emitter removal + rear surface	PSG	Texture: Aniso
ARC + Pass: SiN _x front	Structuring: Rear emitter removal + rear surface	Selective Emitter: Diffusion barrier with open channels {1}	Structuring: ablation rear & hole drilling (Laser)	PSG	ARC + Pass: SiN _x front	POCI
Metall1: Ag front (Screen Print)	PSG	POCI	Etching: LDE	ARC + Pass: SiN _x front	Pass: SiO _x rear	PSG
Metall2: Al + Ag rear (Screen Print)	ARC+ Pass: SiN _x front	PSG	POCI	Pass: SiO _x rear	Mirror: SiN _x rear	ARC + Pass: Oxidation SiO ₂ front
Firing: Furnace Co	Pass: SiN _x rear	ARC + Pass: SiN _x front	PSG	Mirror: SiN _x rear	Structuring: Opening pass/mirror rear (Laser)	Structuring: Opening front grid (Laser)
Isolation: Laser	Metall1: Ag front + rear + holes (Screen Print)	Pass: SiN _x rear	ARC + Pass: double SiN _x front	Firing: Pass Furnace?	Metall1: Al rear (Evaporation)	Metall1: Ti/Pd/Ag front (Evaporation)
	Metall2: Al rear (Screen Print)	Metall1: Al p-contact = open channels {1} (Screen Print)	Oxidation (Tunneloxid for emitter-contact): SiO ₂ (Thermal)	Metall1: Al (Lithographic + Evaporation)	Metall2: Ag front (Screen Print)	Metall2: Al rear (Evaporation)
	Firing: Furnace Co	Metall2: Al n-contact + connecting holes (Screen Print)	Metall: Al rear (Evaporation)	Metall1: Mask lift off	Firing: Furnace Co	Firing: rear locally (Laser)
		Firing: Furnace Co	SiO ₂ : Etchbarrier rear (Evaporation)	Firing: Al Furnace?		Metall3: Ag front (Plating)
			Etching/Isolation: Al flanks	Metall2: Ti/Pd/Ag (Lithographic + Evaporation)		
			Firing: Base (Laser)	Metall2: Mask lift off		
				Forming gas anneal		



**All processes in SINGULAR realized
no additional process step**

- Continued cooperation with industrial partners and institutes for high efficiency processes
- Further development of passivating and anti-reflective coatings with SINGULAR on front and back of cells
- Development of complementary vacuum deposition processes and machines
- Development of advanced wet chemical processes
- Combination of these processes to enable cost efficient mass production of new cell types e.g. PERC, also others
- Further integration of these machines and processes into complete production systems

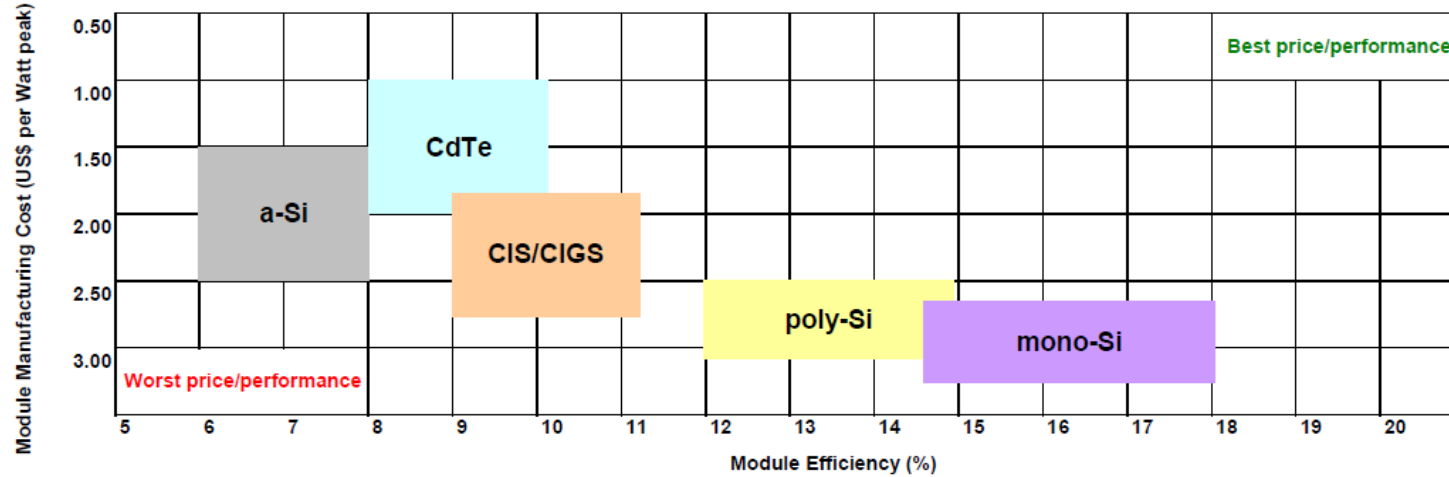


- Increase of SINGULAR and LINEA market penetration
- Further transfer of and integrated „Optical Disc“ inline concept to PV production
- Get more orders for front end systems and orders for complete production systems
- Set up of manufacturing site in China for wet processing systems
- Continue and expand process and equipment development programs with institutional and industrial partners for high-efficient cells
- Integration of new processes into PV production technology to further decrease cost per Watt

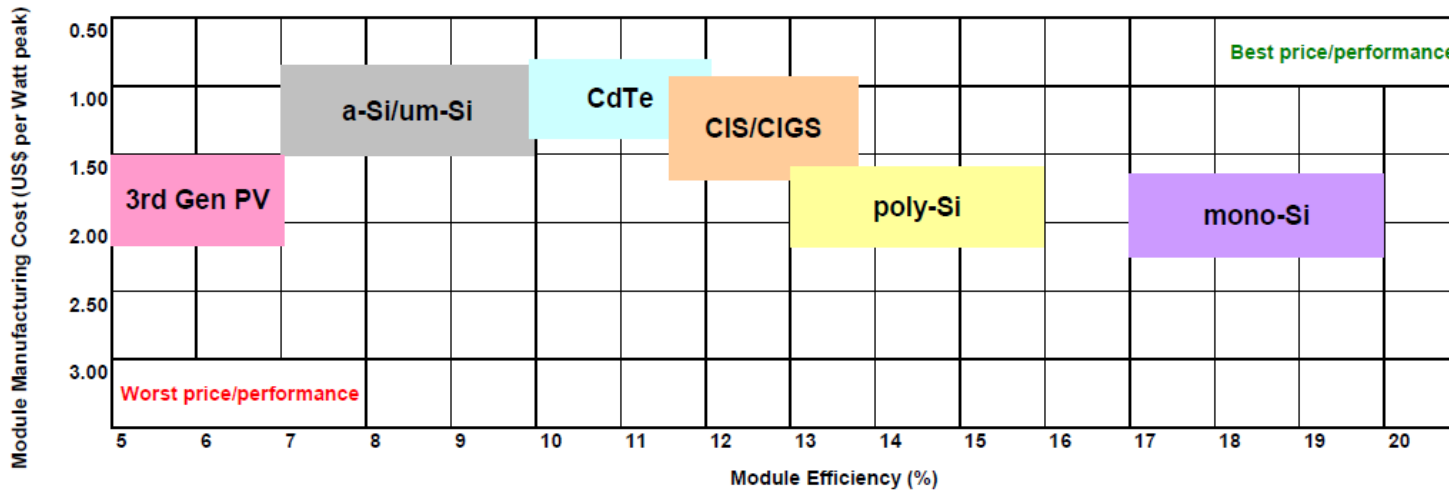


SINGULUS Thin Film - Focus on CIGS

PV Products in 2008

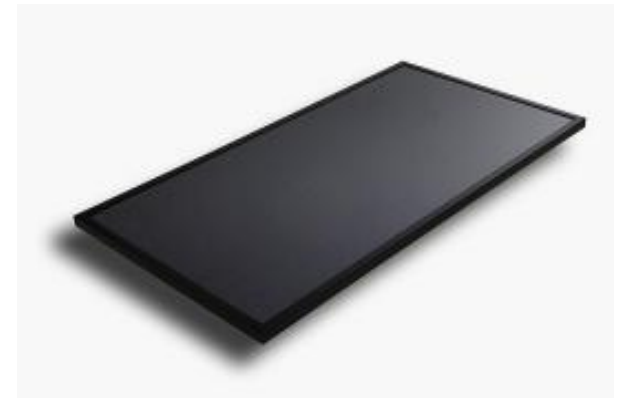


PV Products in 2013

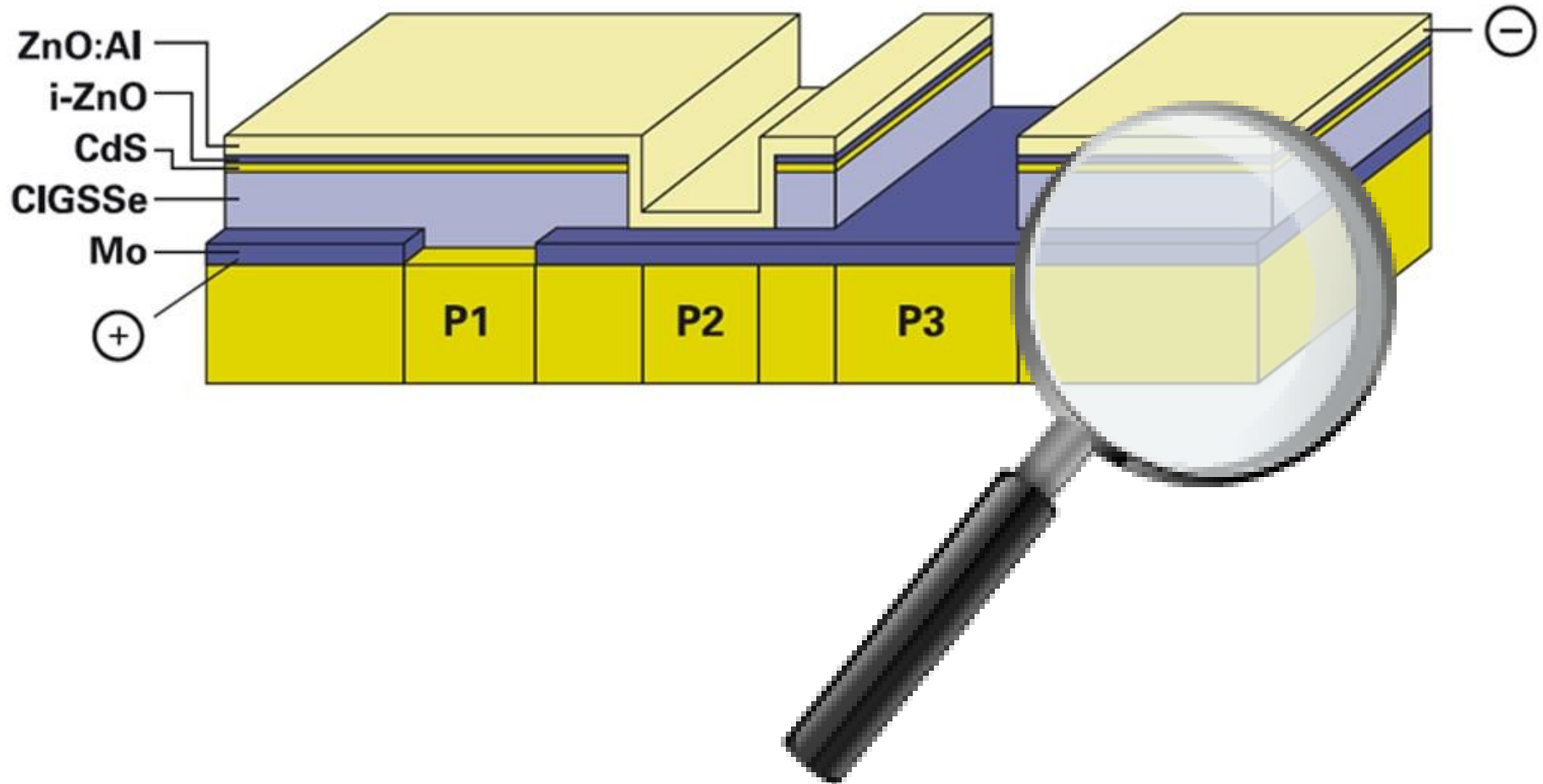


Source: Envision – Solar energy solutions report 2008

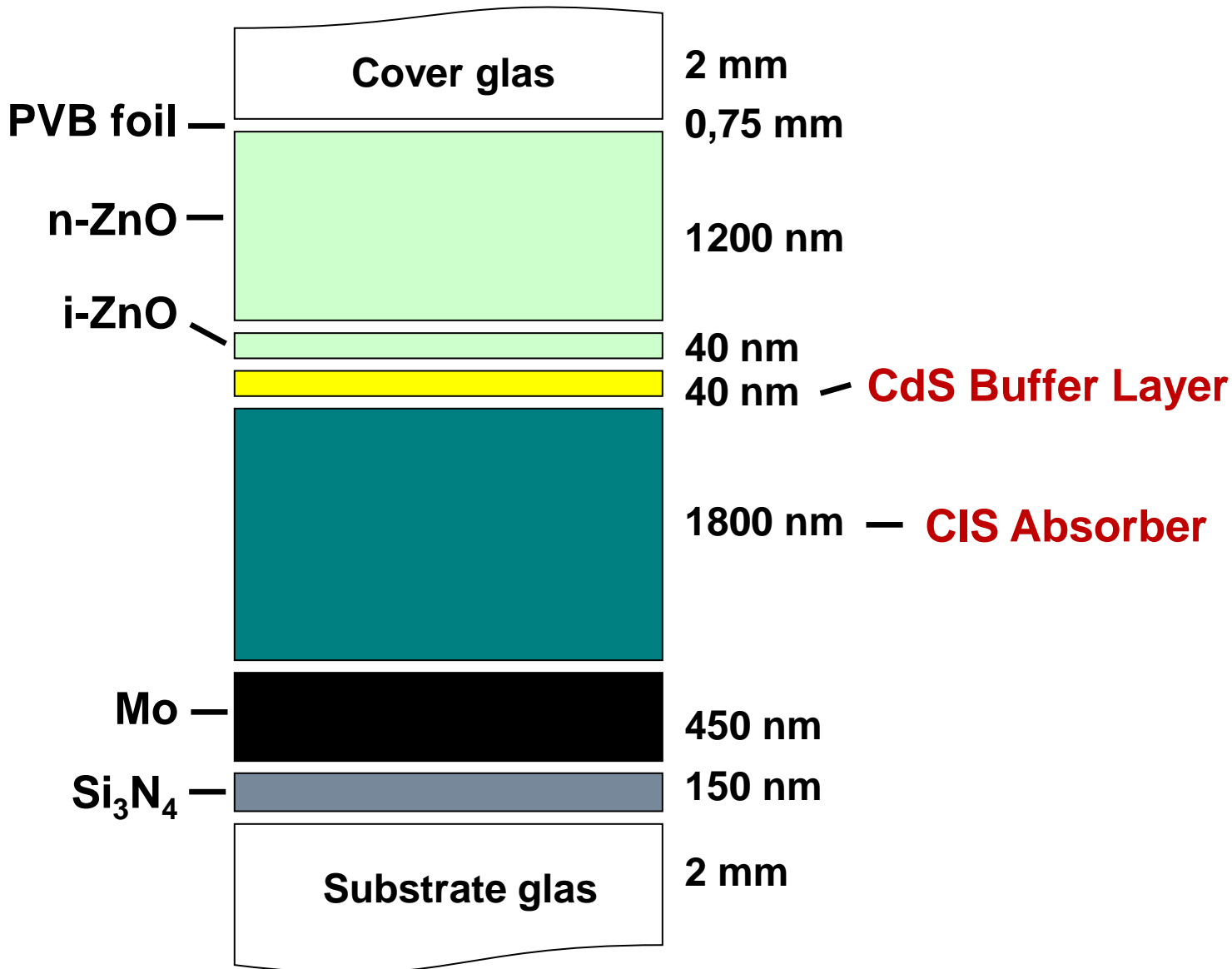
- High efficiencies (more than 20% in the lab, more than 13% in production)
- High technological threshold, but well established and reliable technology
- Low manufacturing costs
- Limited number of competitors
- High potential for innovation and development
- Aesthetic module design,
branding with proprietary module technology possible



Cross Section of a CIGS Module



Typical Layout of a CIGS Module



SINGULUS products:

TENUIS / IMPEDIO and
ILGAR

Diffusion Furnance
(for certain applications)

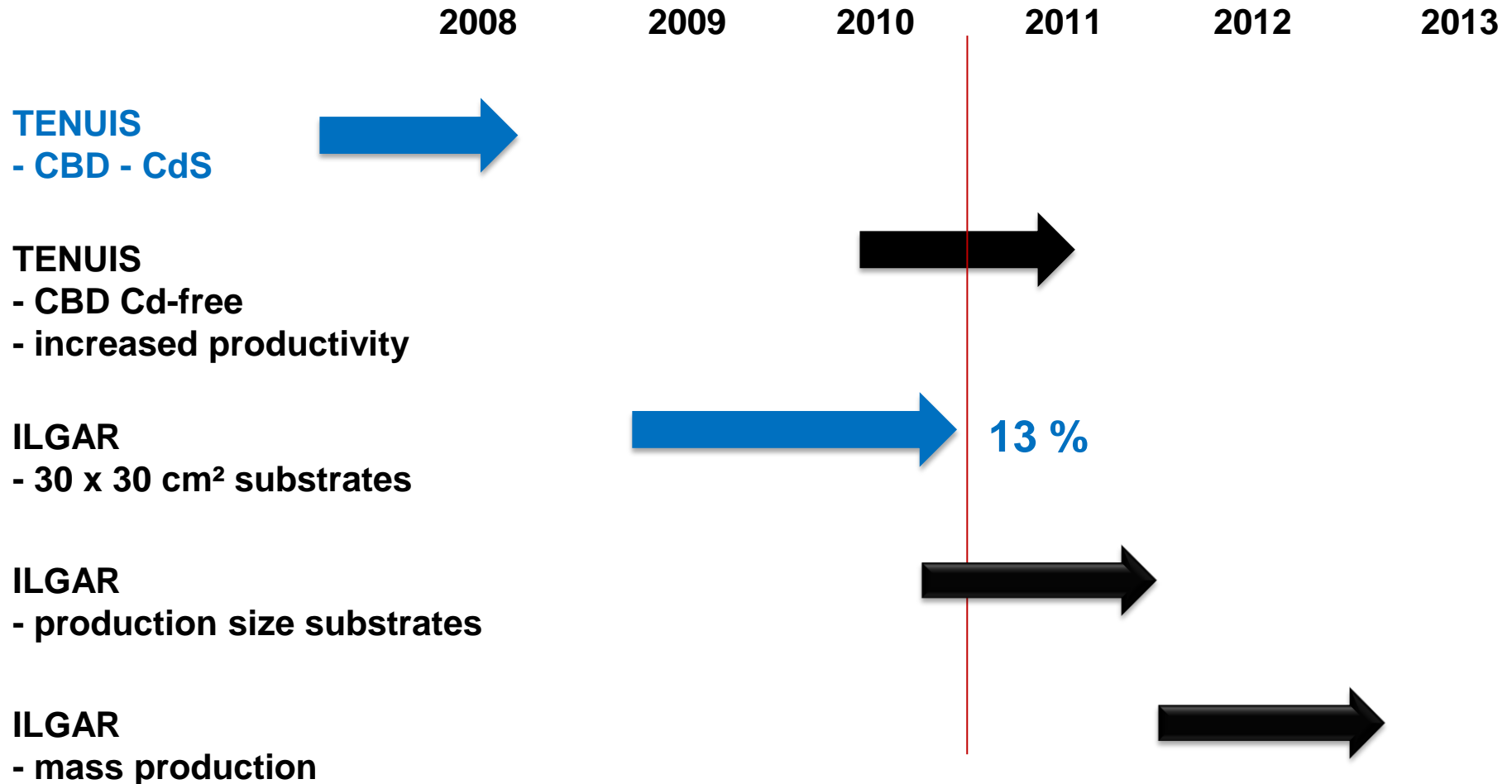
plus: VITRUM
for cleaning, etching etc.

TENUIS Production Line for CIGS Buffer Layer Deposition

SINGULUS TECHNOLOGIES
November, 05 2010
- 19 -

- State-of-the-art production tool
 - Chemical Bath Deposition (CBD)
 - high efficiency
 - high market penetration





2nd Generation inline diffusion furnace with optimized cycle time and improved media consumption values



- Continued cooperation with industrial partners and institutes for high efficiency and for high throughput/low COO processes
- Further development of processes and hardware for CBD (TENUIS / IMPEDIO)
- Further development of ILGAR as a low-cost, Cd-free and non-vacuum industrial application
- Extension of diffusion furnace knowledge (= decisive for efficiency)
- Combination of these processes to enhance module efficiency and to reduce production cost
- Integration of different single machines and processes



- Keep focus on CIGS technology
- Hold or increase market share in buffer layer equipment for CIGS (with TENUIS and ILGAR)
- Make further use of know-how in inline diffusion furnaces
- Become standard supplier also in other thin film process steps
- Introduction of alternative Cd-free buffer layer with low-cost ILGAR process
- Gain additional process know-how in CIGS production to improve equipment and help to increase module efficiencies



Conclusion

- SINGULUS' strategy of 2008 (c-Si and selected thin film processes) is still valid and followed
- We are well positioned with key technologies in the attractive, sharply growing solar market (decisive “wet & vacuum” in c-Si and core process steps in CIGS)
- SINGULUS designs and delivers dedicated PV equipment that reduces production cost and increases cell efficiencies
- SINGULAR and LINEA in production

- Continued development of new processes and equipment in cooperation with institutes and industrial partners
- Active participation in new cell design
- Integration of different processes to reduce complexity and cost

SINGULUS TECHNOLOGIES AG

Hanauer Landstrasse 103

D-63796 Kahl/Main

Dr.-Ing. Stefan Rinck, President and CEO

Tel +49-6188-440-101

Stefan.Rinck@singulus.de

Markus Ehret, CFO

Tel +49-6188-440-204

Markus.Ehret@singulus.de

Dr.-Ing. Anton Pawlakowitsch, COO

Tel +49-6188-440-205

Anton.pawlakowitsch@singulus.de

Maren Schuster, Head of Investor Relations

Tel +49-6188-440-612

Maren.Schuster@singulus.de

Bernhard Krause, Communications Worldwide

Tel +49-6181-9828020

Bernhard.Krause@go-metacom.de

Forward-Looking Statements

This presentation contains forward-looking statements based on current expectations, assumptions and forecasts of the executive board and on currently available information. Various known and unknown risks, unpredictable developments, changes in the economic and political environment and other presently not yet identifiable effects could result in the fact that the actual future results, financial situation or the outlook for the company differ from the estimates given here. We are not obligated to update the forward-looking statements made in this presentation unless there is a legal obligation.