



Line Concepts for Thinfilm Solar Lines

TOPICS



COMPANY	The Grenzebach Group
COST	Cost per Wp of a CIGS module
MODULE SIZE	What is the best module size
ECONOMY OF SCALE	What is the best size of a CIGS production line
LOCATION	Influence of production location
LINE CONCEPTS	Various line concepts
CONCLUSION	Results

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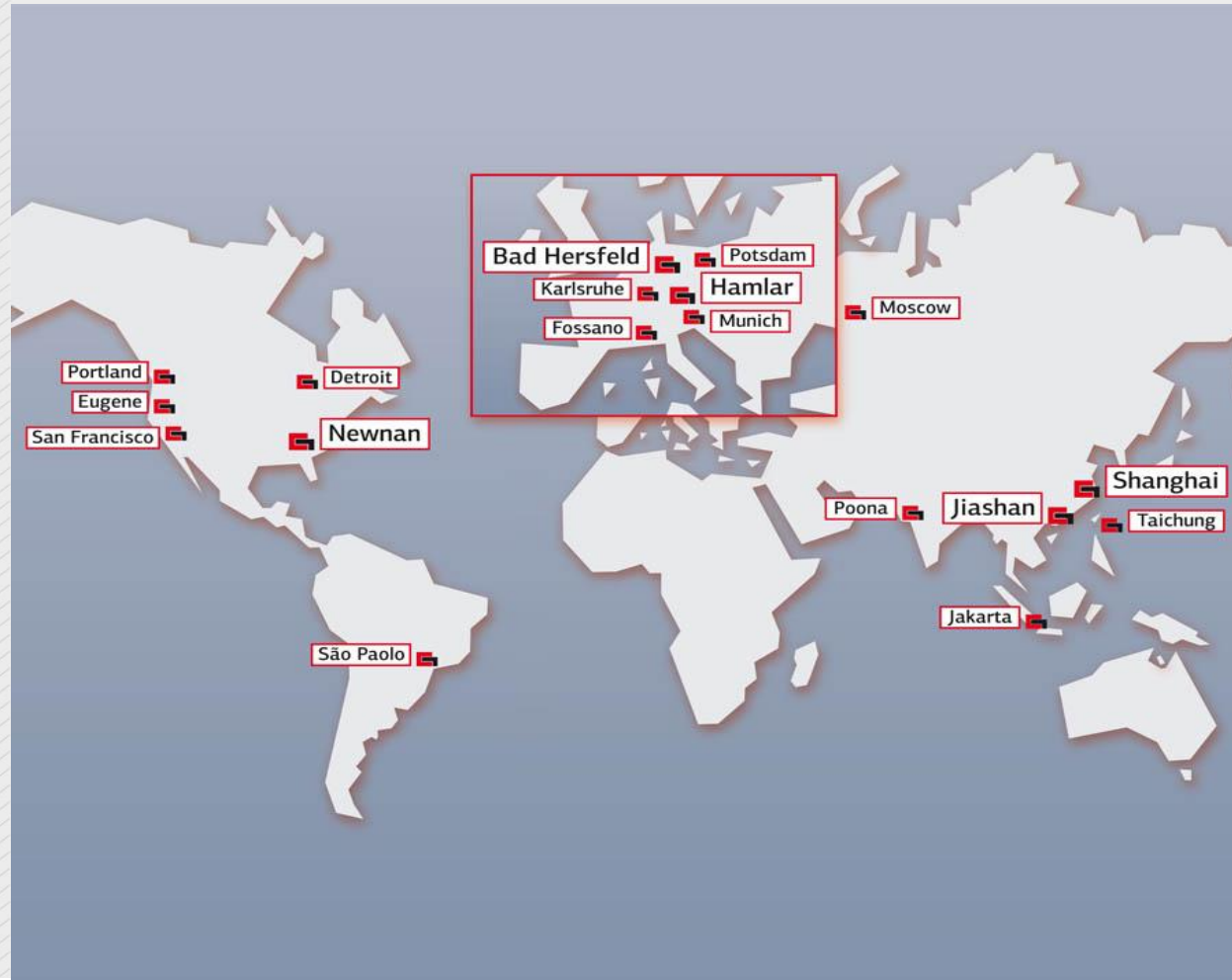
COMPANY | INTRODUCTION

From Hamlar into the World

Grenzebach is one of the worldwide leading material flow and process technology suppliers.

With a workforce of 1500 and 5 manufacturing locations as well as 13 branch offices we are close to our worldwide markets.

All over the world over 900 Grenzebach designed lines warrant a 24-hour-7-days-a-week continuous production



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Competence in Glass

Grenzebach is your number one innovative partner in the production of float glass.

Our services: Engineering, design, manufacturing, automation solutions, commissioning and After Sales Services.

Flat Glass

Thin-Film Photovoltaics

CSP and CPV

Display



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Building Material Equipment

Already since the end of the 1960s Grenzebach builds processing equipment for a wide variety of building boards.

We supply dryers, saws, conveyors, cooling chambers, stackers as well as palletizers and packing stations in function of the materials to be handled.

Gypsum plaster boards

Ceiling tiles

Insulating materials

Veneers



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COMPANY | GENERAL INDUSTRY

Material flow

Transferring technology, conquering new business lines and markets with tailor-made solutions.

Airport Baggage Handling

Intralogistics

Inspection systems



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Service

Service from Grenzebach means service around the clock and all over the globe.

Grenzebach is available to customers on a 24-hour-7-day-a-week basis.



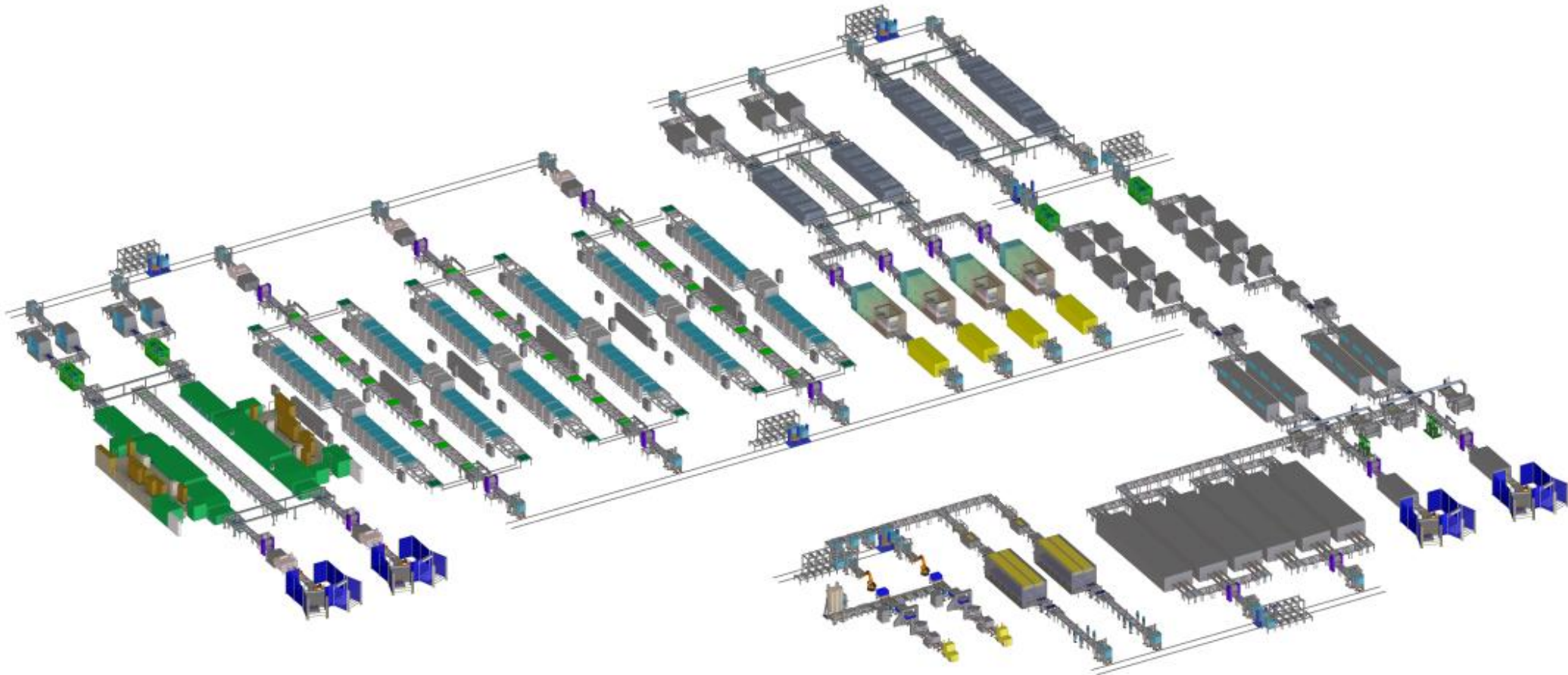
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COST | EXAMPLE 180 MW CIGS LINE



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COST | ASSUMPTIONS OF TCO

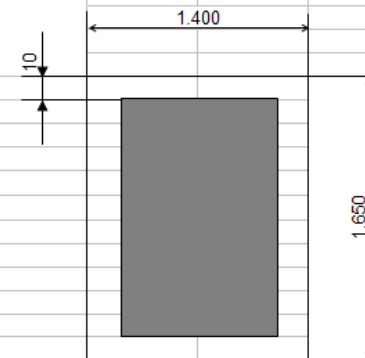
Assumptions for Total Cost of Ownership

Total Cost of Ownership calculation as per VDMA standard 34160.

Module size of 1.400 mm x 1.650 mm for a 180 MW output at 85% uptime and a module efficiency of 12%.

The line is supposed to run in southern Germany. Depreciation period is 7 years.

Total Cost of Ownership					
regarding VDMA norm 34160					
Project Number	0			Date:	01.09.2011
Project Version	0				
Factory / Production Assumptions					
	Country of Operation	Germany Munich			
D1	Duration	7	[a]		
	Constructin or Reconstruction	Construction			
	Size/level of Factory	26.250	m ²		
	Number of Levels	1			
	Estimated Weight of Line	1.478	[t]		
	Freight	CIF Destination			
	Operation hours per day	24	[h]		
	Operation days per year	365	d		
D2	Operation hours per year	8.760	[h / a]		
	Cycle Time [sec]	40,2	[s / pcs]		
	Watt per year	180.000.000	[W / a]		
	Availability of Prod.Line	85,000%			
D3	Yield	100,000%			
D4	Produced units per hour	89,6	[pcs / h]		
D5	Produced units per year	666.844	[pcs]		
Module Assumptions					
	CIGS Coating Option	Co-Evaporator			
	Length of Module	1.650	mm		
	Width of Module	1.400	mm		
	Thickness of module (without frame)	5	mm		
	Thickness of Laser Edge Deletion	10	mm		
	Watt / Module (Ref)	1.000	W/m ²		
	Efficiency	0,12			
	Watt / Module (Actual)	269,9	W		
Module Layers					
	i-ZnO	50	nm		
	Al:ZnO	1000	nm		
	CdS	50	nm		
	CIGS	1,9	µm		
	Molybden	400	nm		



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COST | SUMMARY OF TCO

Assumptions for Total Cost of Ownership

Costing Setup : Cost to install the line incl. Infrastructure

Operating Costs Duration : Operational costs for the duration of the production period

Elimination : Costs or remaining asset after lifetime

Estimated costs per Watt Peak are 0,7783 Euros

Total Cost of Ownership						
regarding VDMA norm 34160						
Project Number	0					
Project Version	0					Date 01.09.2011
Summary Total Cost of Ownership						
			Vendor	Customer	Actual Value	Details
E		Costing Setup	184.965.245 €	0 €	184.965.245 €	184.965.245 €
	E1	Purchasing	169.215.245 €		169.215.245 €	
	E2	Infrastructure	15.750.000 €		15.750.000 €	
	E3	Miscellaneous	0 €		0 €	
B		Operating Costs Duration	791.530.008 €	0 €	791.530.008 €	791.530.008 €
	B1	Operating Costs / Year	113.075.715 €	0 €	113.075.715 €	
	IH1	Maintenance and Inspections	632.592 €		632.592 €	
	IH2	Scheduled Repairs	443.087 €		443.087 €	
	IH3	Unscheduled Repairs	206.187 €		206.187 €	
	RK1	Occupancy Costs	278.588 €		278.588 €	
	MK1	Material Costs	68.810.847 €		68.810.847 €	
	EK1	Costs for Electric Power	20.553.396 €		20.553.396 €	
	EK2	Costs for Compressed Air	963.434 €		963.434 €	
	HB1	Operating Supplies	72.270 €		72.270 €	
	EN1	Disposal Costs	1.051 €		1.051 €	
	PK1	Personnel Costs	21.107.921 €		21.107.921 €	
	WK1	Tooling Costs	6.342 €		6.342 €	
	RU1	Set-up Costs	0 €		0 €	
	LK1	Storage Costs	0 €		0 €	
	SO1	Miscellaneous	0 €		0 €	
V		Elimination	4.171.636 €	0 €	4.171.636 €	4.171.636 €
	V1	Dismantling	5.493.630 €		5.493.630 €	
	V2	Declining Balance	-1.321.994 €		-1.321.994 €	
	V3	Miscellaneous	0 €		0 €	
		Total Cost of Ownership				
		Total Cost of Ownership / Watt				0,7783 € / Watt

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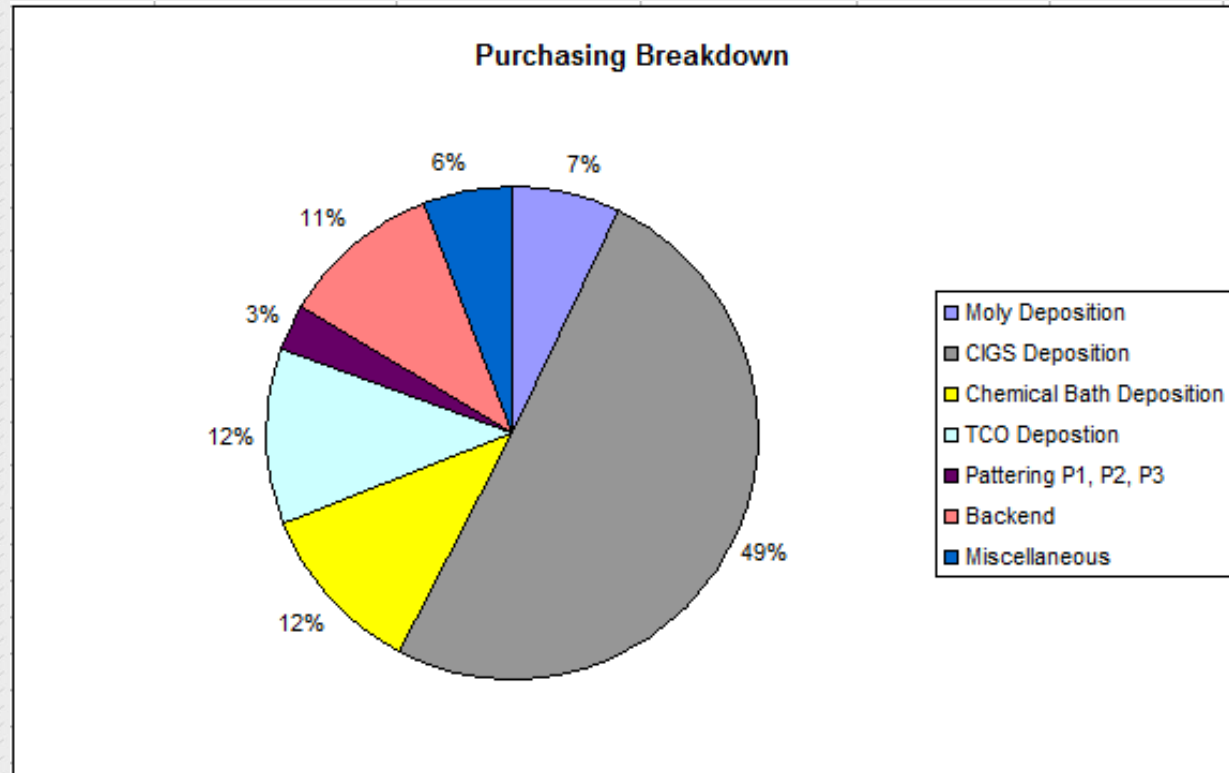
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Split of equipment costs

The deposition equipment accounts for appr. 80% of the equipment costs. The CIGS deposition tools dictate the majority of the CAPEX.

The infrastructure (building, etc.) is not included in the chart



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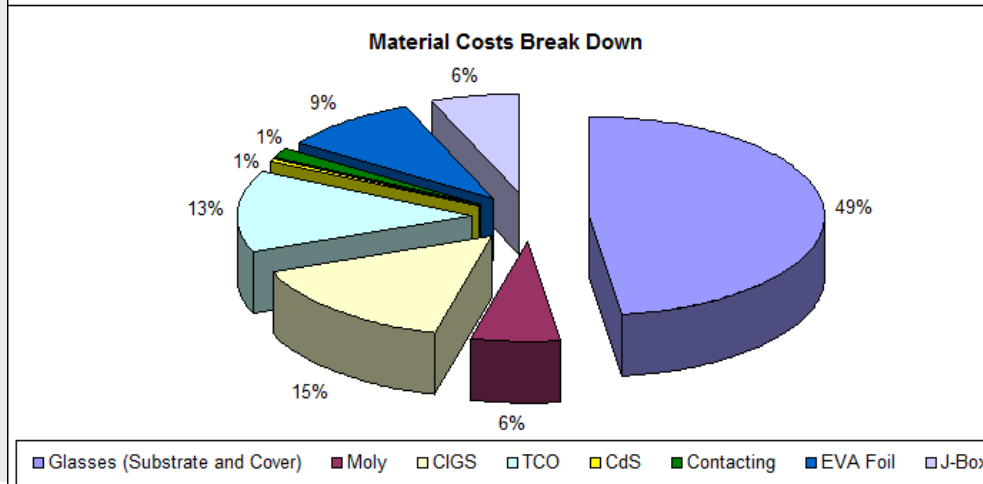
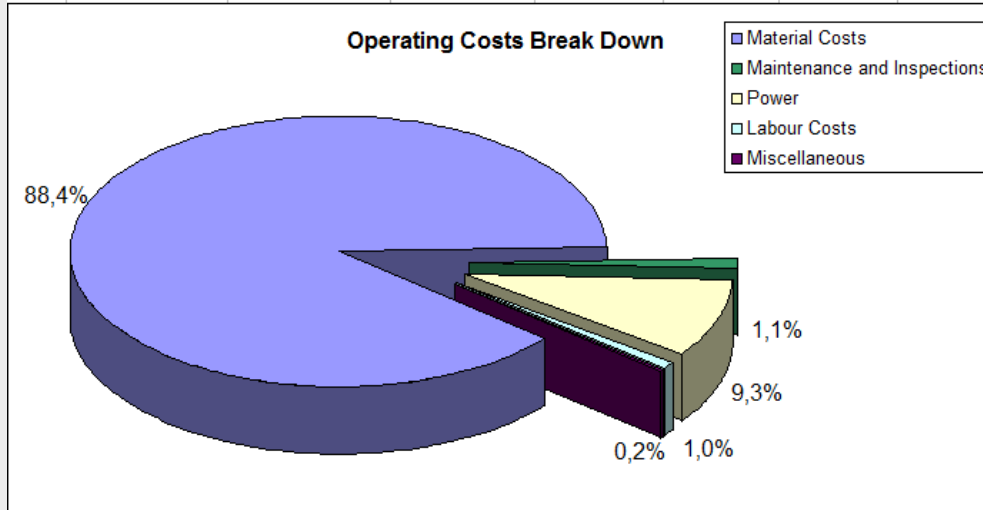


COST | OPERATION COSTS

Operation Costs without depreciation

In the example the line is supposed to run in **China** (low labour cost) and it is very obvious, that the cost/W are clearly dictated by the material costs.

Beside the absorber layers the glass is a major cost factor



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MODULE SIZE | IMPACT ON CAPEX COST

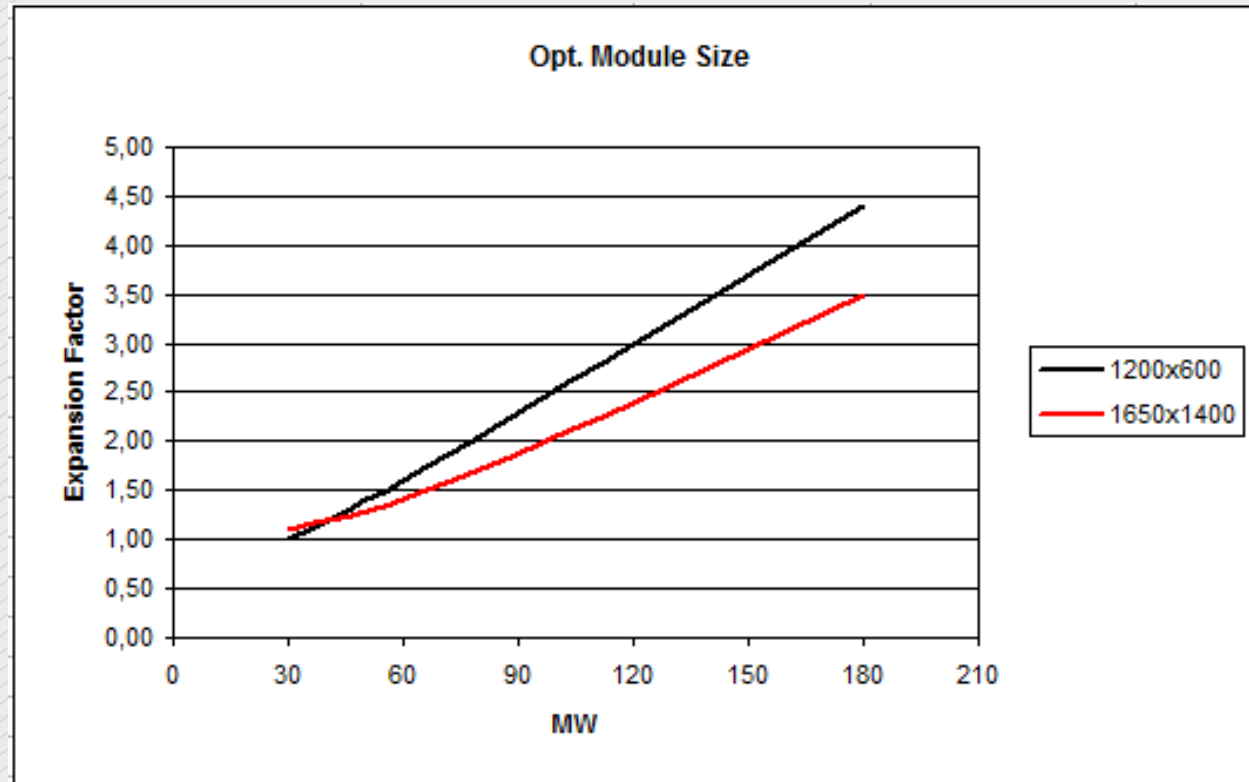
What impact has the module size on the CAPEX?

With the same deposition equipment and an increased output and module size the costs are more competitive for bigger modules.

The reason is more active surface and less equipment mainly in the backend

* Optimum weight and handling for installation and electrical properties are not taken into consideration

** To be investigated : Cost increase in case of deposition equipment for bigger surfaces



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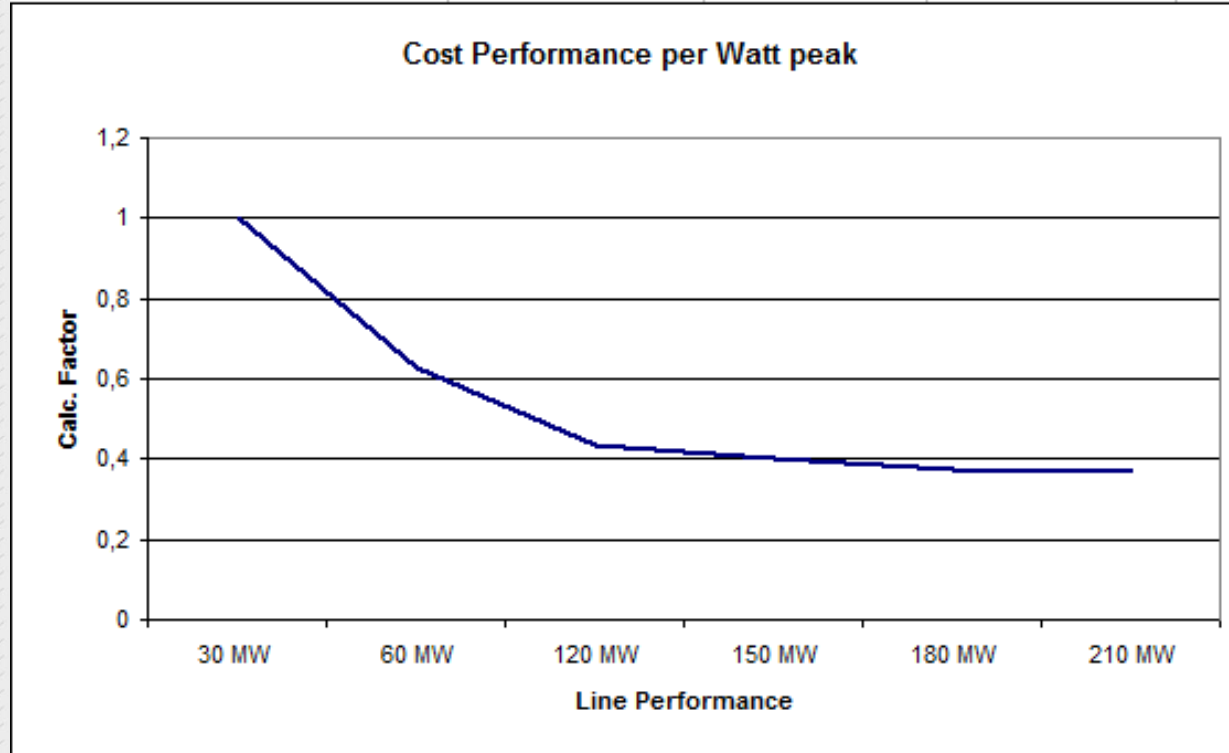


ECONOMY OF SCALE | OPTIMUM OUTPUT

What is the optimum line size in terms of output?

Because of the use of several tools in parallel for certain production steps the curve flattens above 100 MW and after 180 MW there is almost no change anymore.

A good size of such a CIGS production line starts at 100 MW output.



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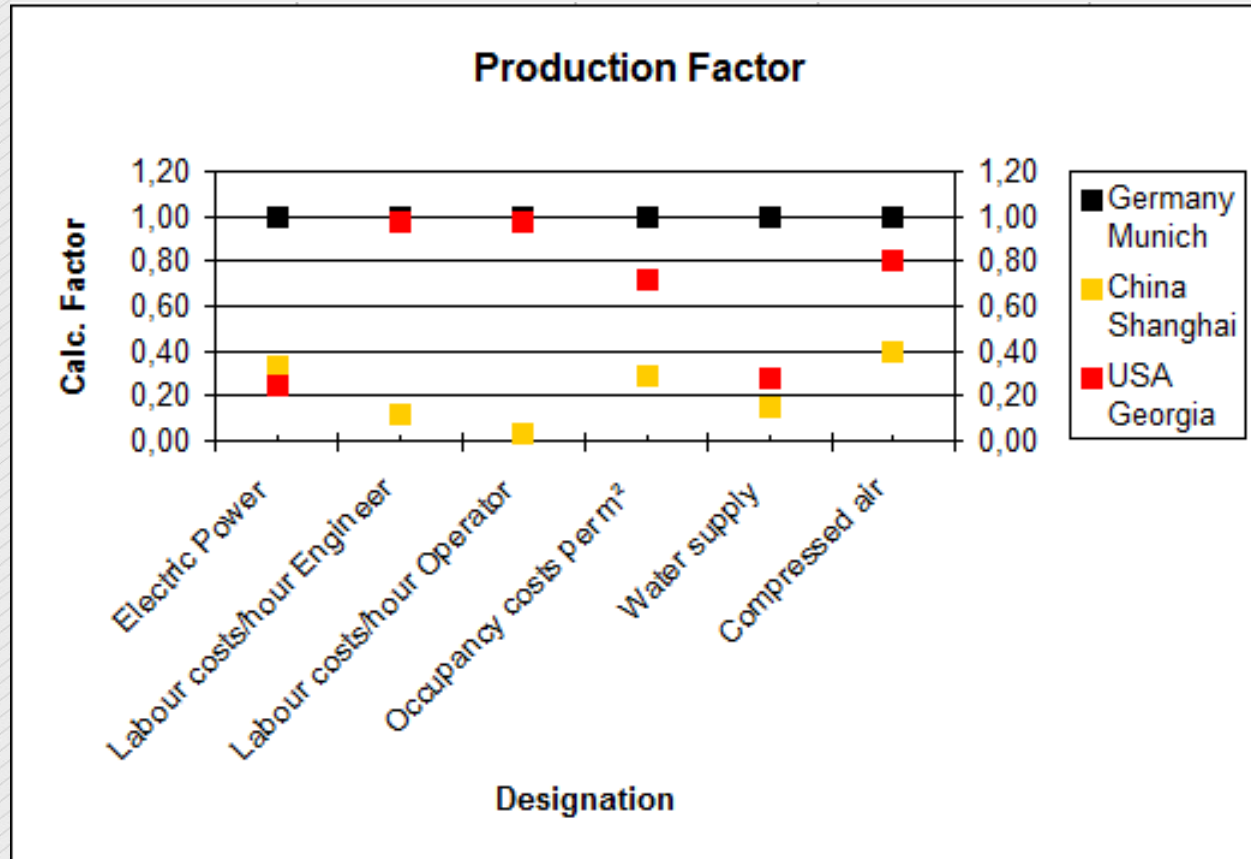
LOCATION | ASSUMPTIONS

Main cost drivers in three different locations?

In the example it is very obvious, that Western Europe is the most expensive region. China has cost advantages in almost all segments.

Lines with a lower level of automation in China have an even bigger cost advantage.

* Normalised against conditions in Munich, Germany



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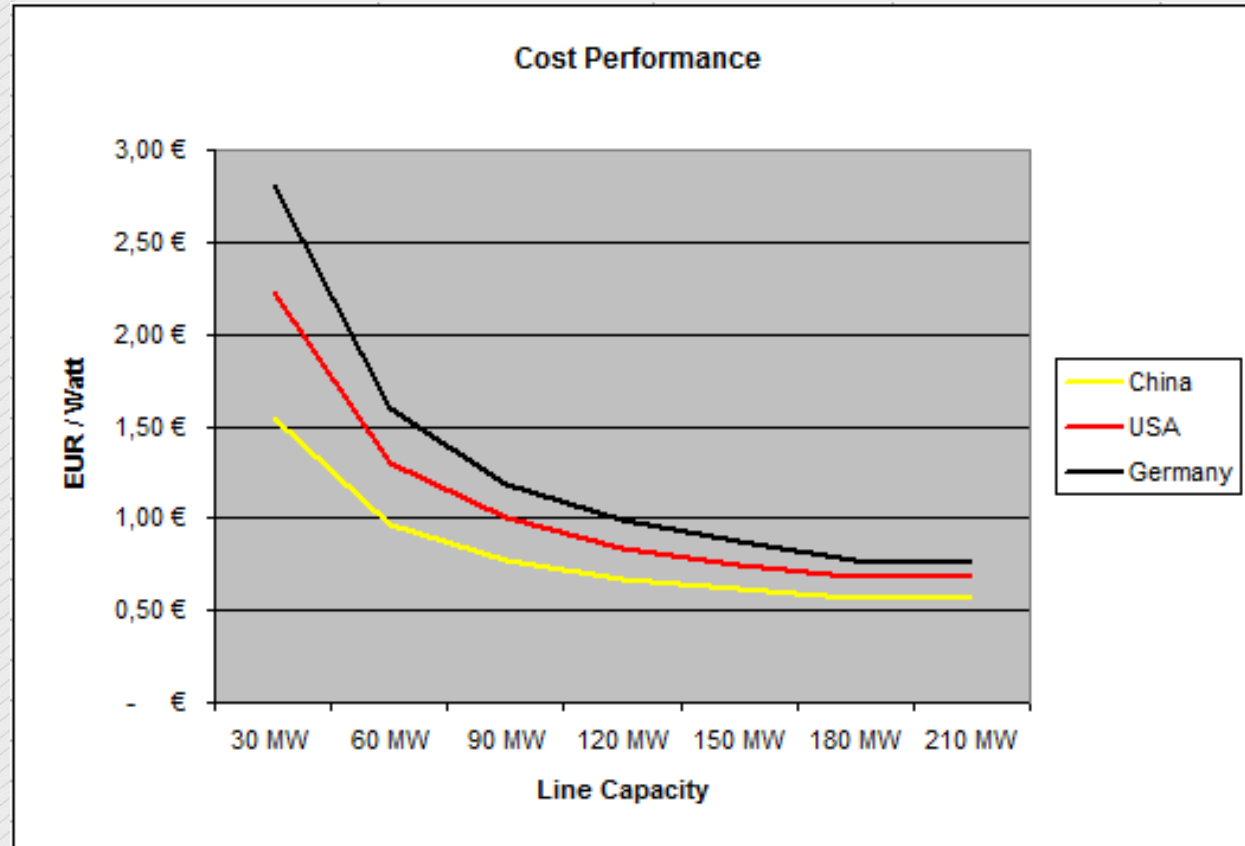


LOCATION | COMPARISON

China seems to be the best location

The comparisons shows that for the line layout used for the TCO China has a clear cost advantage. The higher the output of the line, the closer are the costs

* Yield and quality are assumed to be the same



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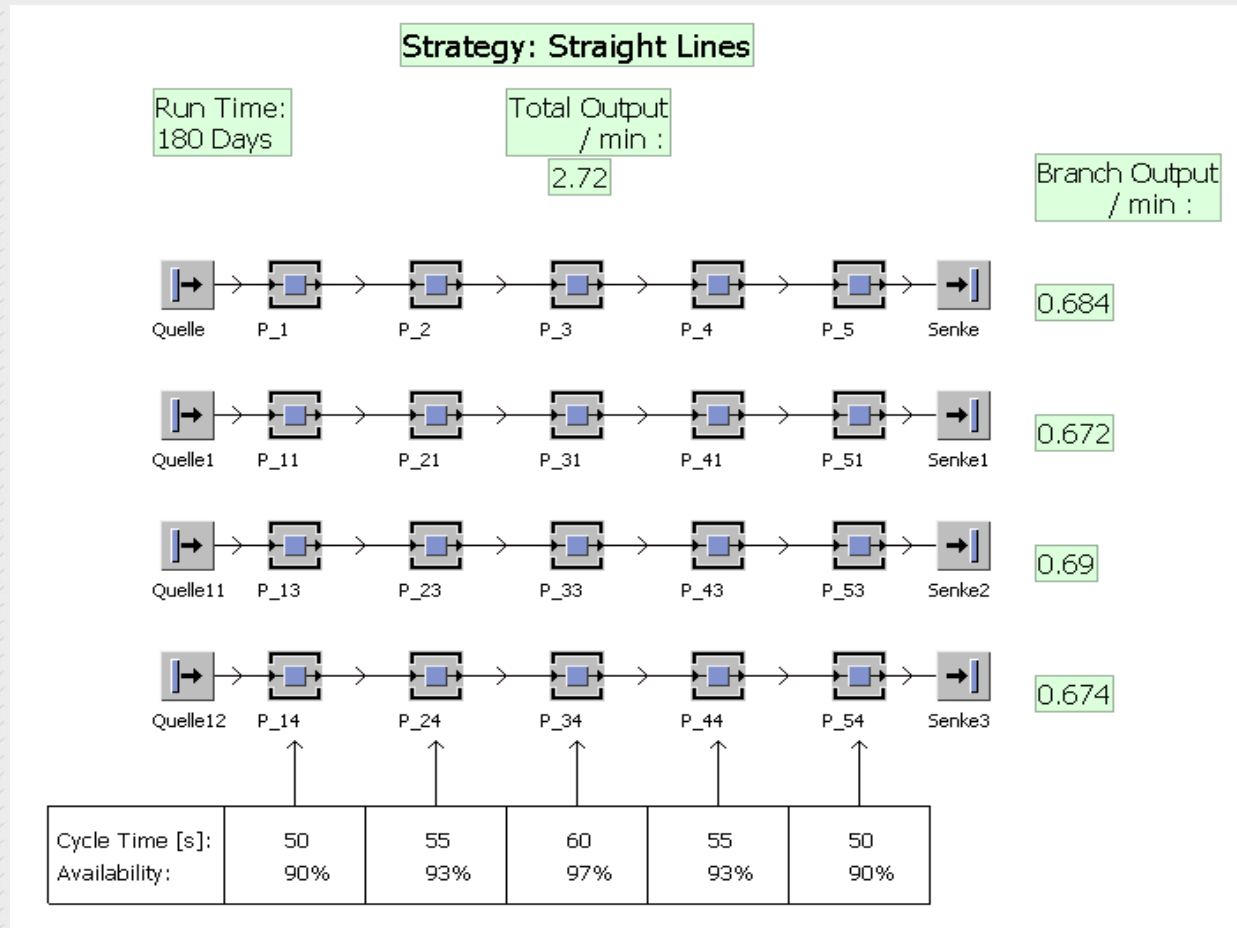
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LINE CONCEPTS | STRAIGHT LINE

Straight Line Concept

Large-scale lines (> 100 MW) comprise several parallel and autonomous lines with inline junctions



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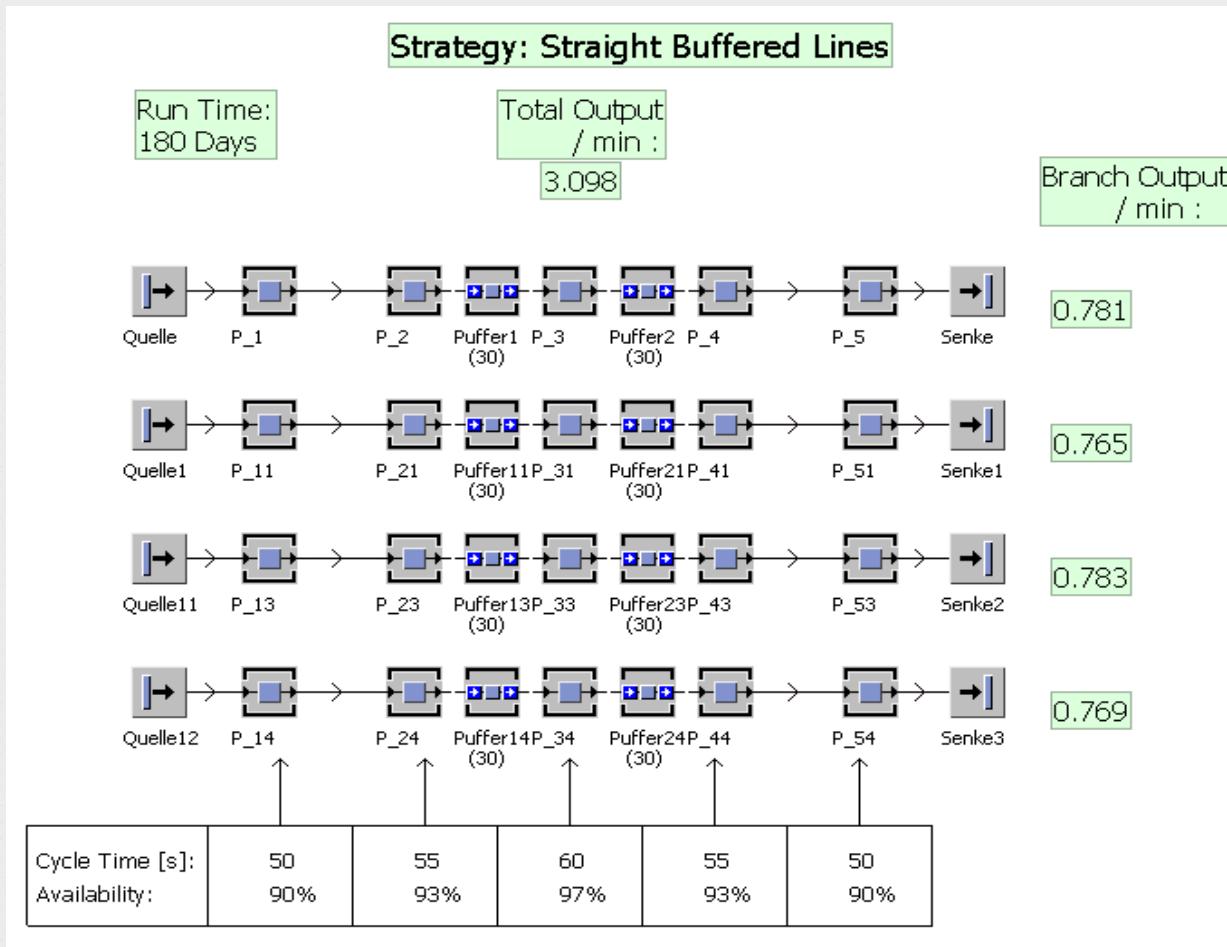
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LINE CONCEPTS | STRAIGHT BUFFERED LINES

Straight Buffered Line Concept

Large-scale lines (> 100 MW) comprise several parallel and autonomous lines with inline junctions and buffers at important process tools



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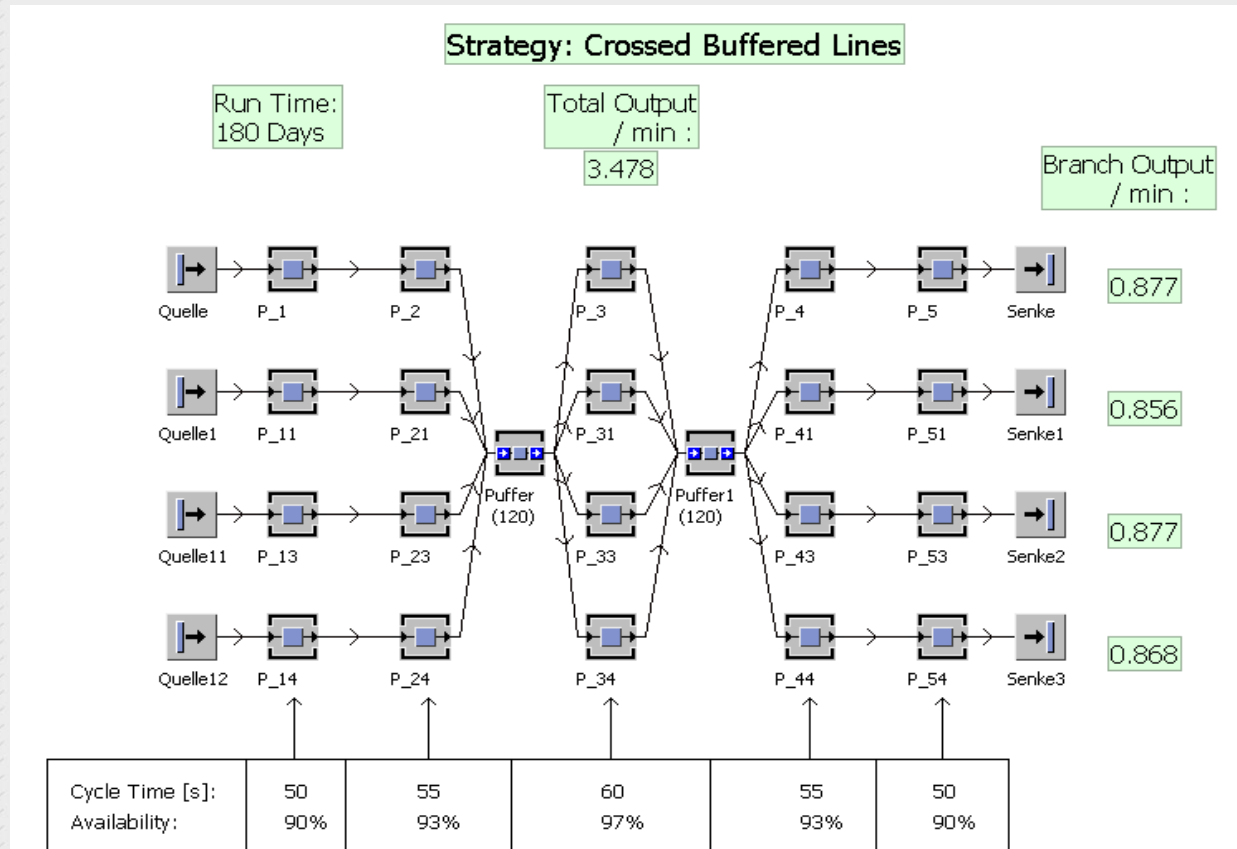
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LINE CONCEPTS | CROSSED BUFFER LINES

Smart Inline Concept (Crossed Buffered Lines)

Large-scale lines (> 100 MW) comprise several parallel and autonomous lines with inline junctions. Crossover lines with section specific accumulators.



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LINE CONCEPTS | CENTRAL STORAGE

Central Storage Concept

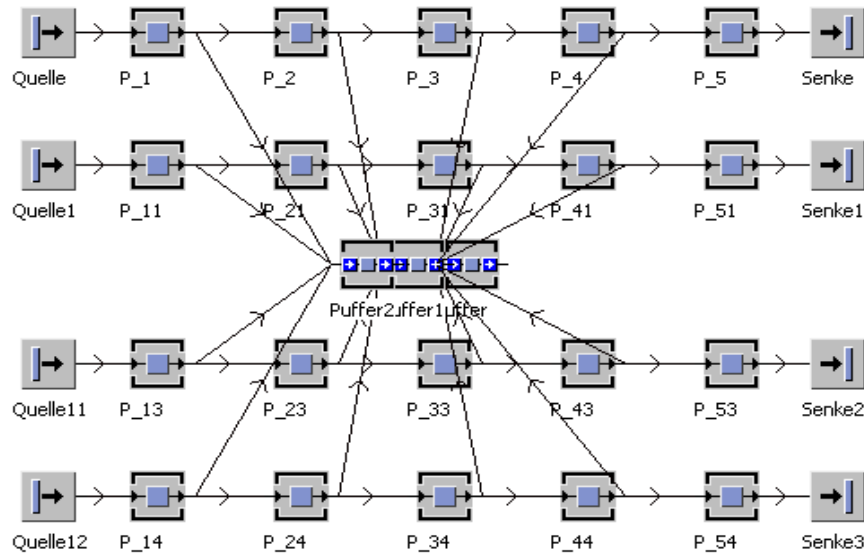
Large-scale lines (> 100 MW) comprise several parallel tools, all served from a central storage system.

Strategy: Central Store

Run Time:
180 Days

Total Output
/ min :
3.707

Branch Output
/ min :
0.938



0.938

0.918

0.933

0.919

Cycle Time [s]:	50	55	60	55	50
Availability:	90%	93%	97%	93%	90%

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LINE CONCEPTS | SUMMARY

Summary

Comparing the three different line concepts. The Smart Inline Concept offers the best price performance ratio.

Example			
Concept	Throughput	%	Cost
Straight Inline Concept	2,72 Module/min	100,0%	100,0% *
Buffered Inline Concept	3,10 Module/min	114,0%	110,0% *
Smart Inline Concept	3,48 Module/min	127,9%	115,0% *
Central Storage Concept	3,71 Module/min	136,3%	135,0% *
Simulted Production Period: 180 days			
Same cycle times and uptimes of all process tools in all 4 simulations			
* Costs are only related to the automation part			
Estimated percentage of automation equipment of total investments : 5%			
Supplement for Smart Inline in relation to the total investment: appr. 0,75 %			

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CONCLUSION

Conclusion

Summary of the most important messages of the presentation

- Material costs dictate mainly the cost of CIGS modules
- Bigger module sizes help to optimize the cost
- Starting from 100 MW output the CAPEX is ok and reaches the optimum after 180 MW.
- Locations with low labour cost and cheap infrastructure (electrical power, etc.) like China are the best locations.
- Lines with an output of more than 180 MW already allow to optimize the layout and increase the throughput.

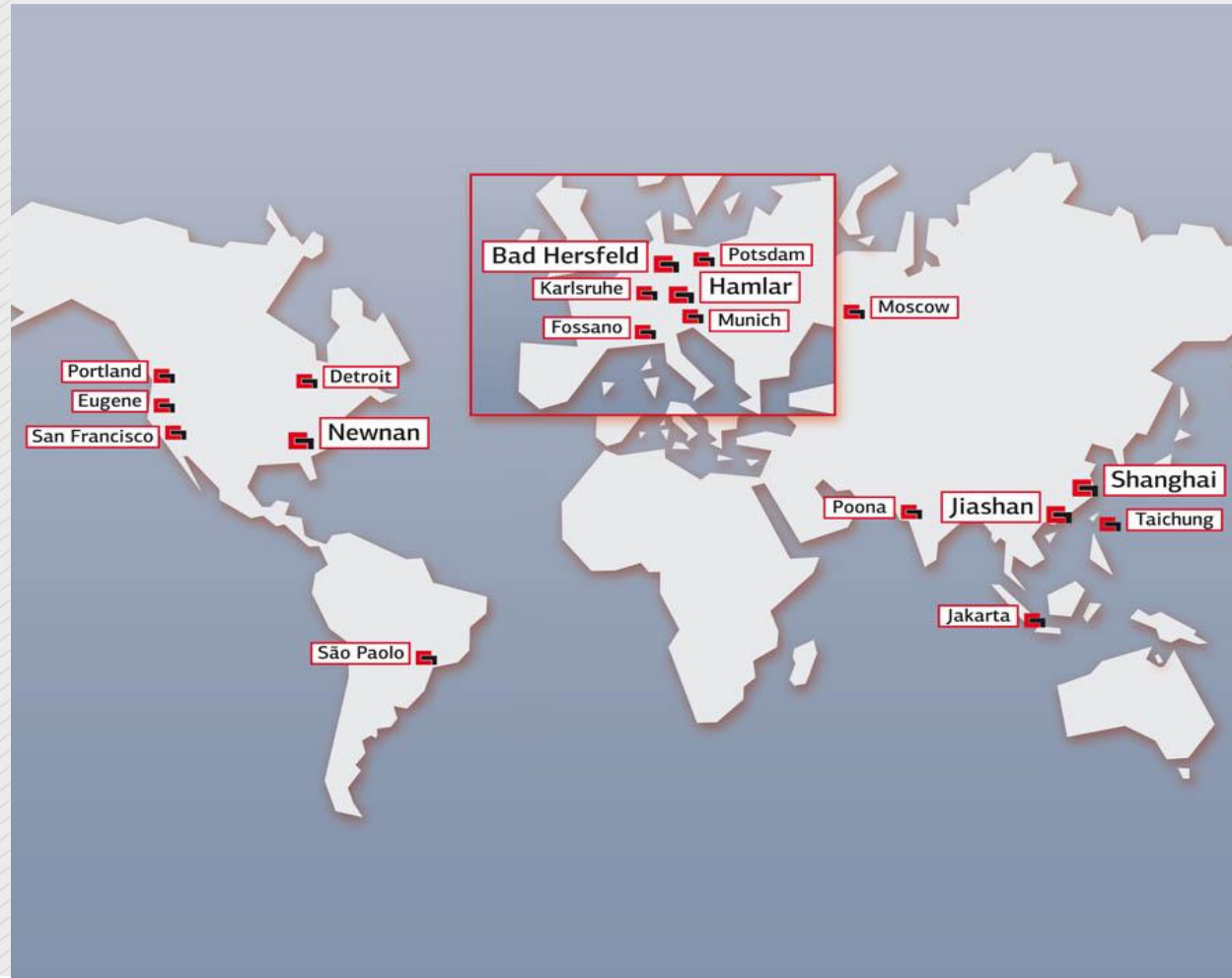
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