

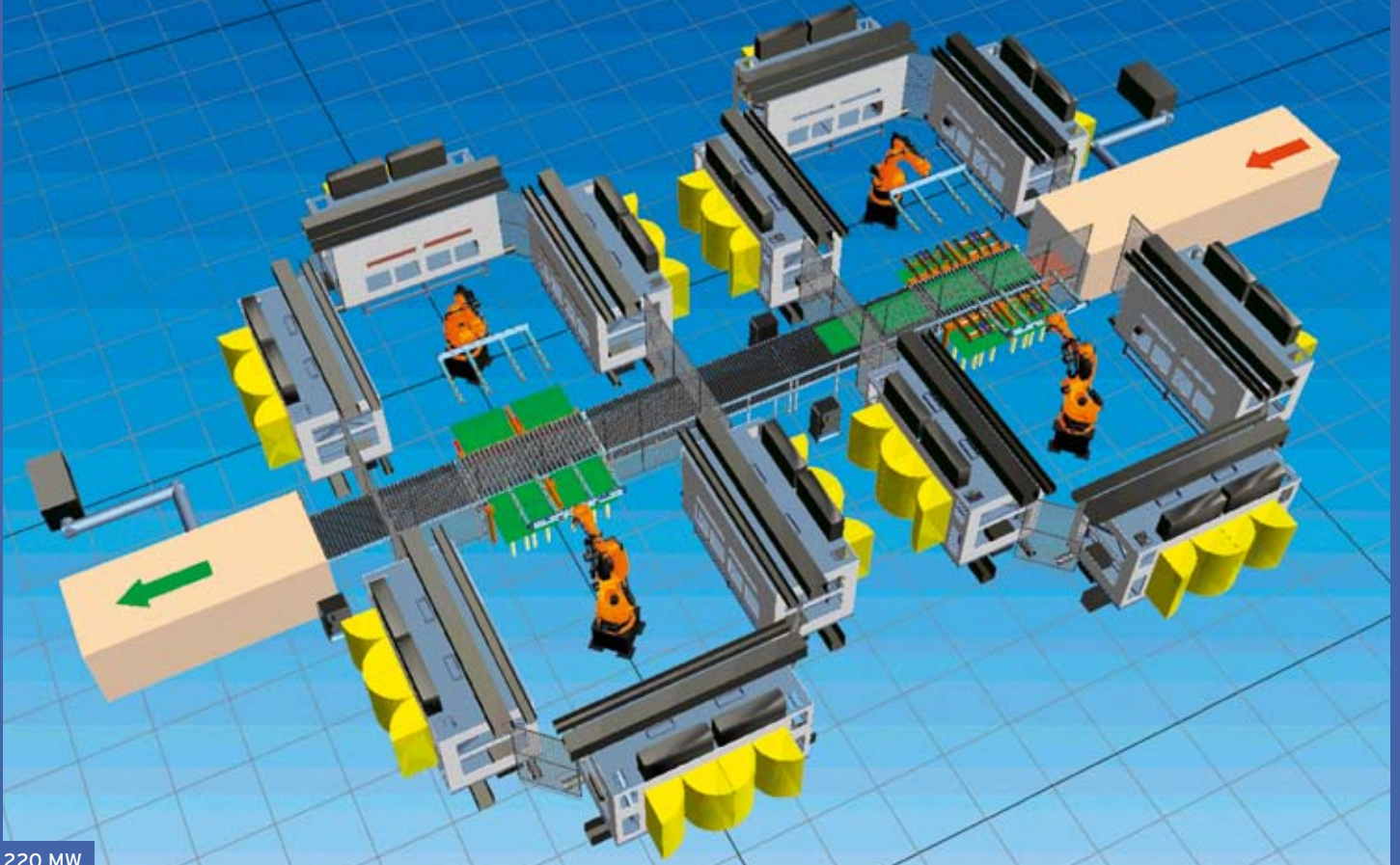
TENUIS GEN 2

New Generation of Wet Process Equipment for
Economic Processing of CdS/Alternative Buffer Layer
for CIS/CIGS/CIGSSe Solar Cells



TENUIS GEN 2

Process System for the Application of Buffer Layer for Thin Film Solar Cells



220 MW

SINGULUS TECHNOLOGIES presents a promising new development on the way to the efficient wet-chemical coating of thin film solar modules made of copper-indium-gallium-diselenide (CIGS) on glass: the second generation of the TENUIS production line has a modular cluster build basis and enables both significant savings in terms of required floor space and the simultaneous one-side coating of two substrates. The TENUIS GEN 2 also provides advantages upon commissioning and in the ramp-up stage. Because of the new cluster design the commissioning can commence modularly after a short installation time and the first substrates can be coated. The following cluster can be assembled simultaneously or consecutively. Correspondingly, the TENUIS GEN 2 meets the ever increasing demands of the market with respect to the reduction of the commissioning and ramp-up times.

SINGULUS offers wet processing systems from R & D over pilot use to full production range 60, 120, 180 and more MW.

Due to new and unique concepts in terms of dosing and temperature control, the developers at the subsidiary SINGULUS STANGL SOLAR were successful in reducing the process time by up to 20 %, which has a positive effect and a considerably higher output in production. The new TENUIS generation offers substantial cost advantages in the production of high performance CIS/CIGS thin film solar cells. Furthermore, the costs are significantly reduced by temperature profiles adjusted to the process and by very efficient use of process chemicals, so that the new system consistently exploits the savings potential in the manufacturing of thin film solar cells.

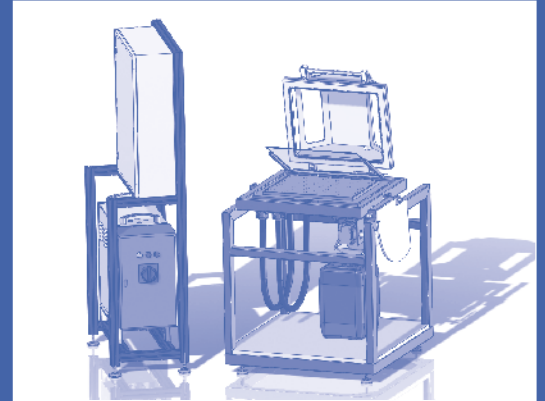
Compared with its predecessor the TENUIS GEN 2 version not only reduces the production time but also the required floor space by 30 % and saves footprint and maintenance costs accordingly. Due to the space-saving design the new system is easily integrated into existing production lines. For a higher throughput several production machines can be combined to a large production complex.

TENUIS GEN 2

Systems from R & D over pilot use to full production range

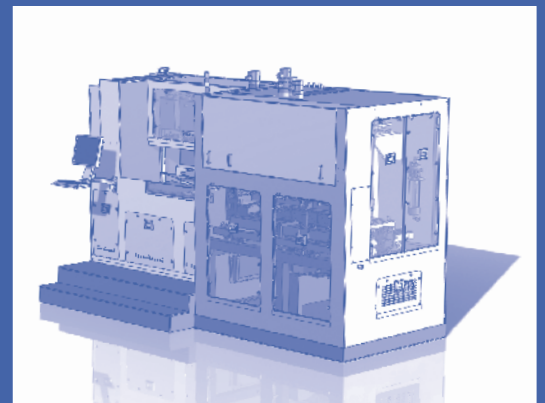
Manuel experimental setup for process evaluation and R&D:

- _ Substrate size for foil and glass:
 - _ 300 x 300 mm² up to 500 x 400 mm²
- _ Manual loading
- _ Automatic heating (fluid heating)
- _ Automatic wobbling (movement)
- _ Manual dosing
- _ Process transfer to production line 1:1 possible
- _ Option for Fumehood and automatic dosing modus possible



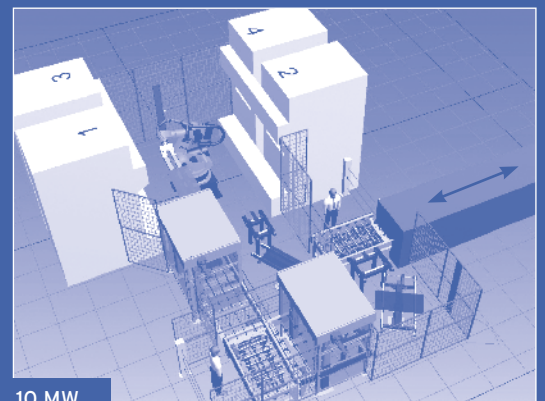
Semi-Automated Experimental Setup for process evaluation:

- _ Substrate size for foil and glass: 600 x 900 mm² up to 1400 x 1100 mm²
- _ Manual loading
- _ Automatic heating
- _ Automatic wobbling (movement)
- _ Automatic dosage



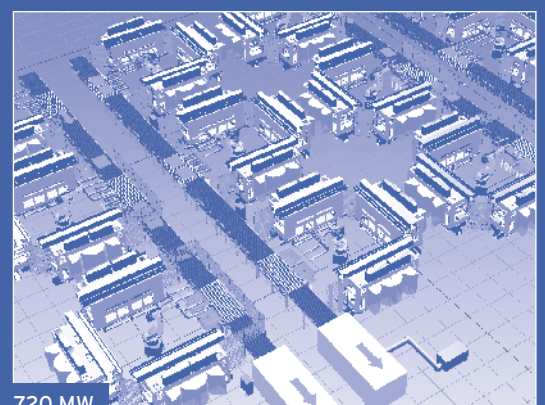
Fully-Automated Experimental Setup for a semi commercial line:

- _ Substrate size for foil and glass: 600 x 900 mm² up to 1400 x 1100 mm²
- _ Automatic loading
- _ Automatic heating
- _ Automatic wobbling (movement)
- _ Automatic dosage
- _ Automatic Buffer system
- _ Automatic dosage



Modular production system for capacities up to 60, 120, 220 and 720 MW

- _ Modular system
- _ Reduced footprint of up to 30 %
- _ Reduced Maintenance costs
- _ New processes of alternative buffer (ZnS)
- _ Aggressive uniform temperature ramps (even shorter process time)
- _ New software surface and applications for more flexibility





Headquarters

SINGULUS TECHNOLOGIES AG
Hanauer Landstrasse 103
D-63796 Kahl, Germany
Tel. +49 6188 440-0
Fax +49 6188 440-110
sales@singulus.de
www.singulus.de

Affiliated Companies

China
SINGULUS MANUFACTURING
GUANGZHOU LTD.
Tel. +86 20 34885010
frank@singulus.com.cn

France
SINGULUS TECHNOLOGIES
FRANCE S.A.R.L.
Tel. +33 3 893111-29
singulus@club-internet.fr

Germany
SINGULUS STANGL SOLAR GMBH
Tel. +49 8141 3600-0
stangl@singulus.de

Great Britain
SINGULUS TECHNOLOGIES UK Ltd.
Tel. +44 1793 7842-00
brian.walsh@singulusuk.com

Italy
SINGULUS TECHNOLOGIES ITALIA S.r.l.
Tel. +39 071 79303-12
info@singulus.it

Latin America
SINGULUS TECHNOLOGIES
LATIN AMERICA LTDA.
Tel. +55 1121 6524-10
rodolfo.mignone@singulus.com.br

Netherlands
SINGULUS MASTERING B.V.
Tel. +31 407 5014-00
info@singulus.nl

Singapore
SINGULUS TECHNOLOGIES
ASIA PACIFIC PTE LTD.
Tel. +65 674 119-12
sales@singulus.com.sg

Spain
SINGULUS TECHNOLOGIES IBERICA S.L.
Tel. +34 936 7500-25
singulus@singulusib.com

Taiwan
SINGULUS TECHNOLOGIES TAIWAN LTD.
Tel. +886 2 274833-66
sales@singulus.com.tw

United States and Canada
SINGULUS TECHNOLOGIES INC.
Tel. +1 860 68380-00
sales@singulus.com

SINGULUS 

SINGULUS
STANGL SOLAR 