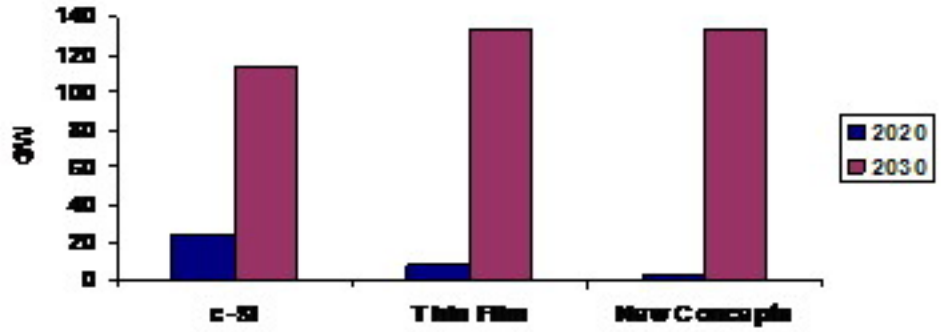
TABLE: 2003 world cell/module production by cell technology

Technology	Production (MW)					%
	US	Japan	Europe	ROW	Total	
Polycrystalline	13.42	271.23	114.50	60.65	**459.80**	61.79%
Single crystal flat-plate	68.00	44.17	71.15	17.15	**200.47**	26.94%
Single and polycrystalline total	81.42	315.40	185.65	77.80	**660.27**	88.73%
Amorphous silicon	7.10	0.01	7.70	3.00	**17.81**	2.40%7
Amorphous silicon indoor use	0.00	5.00	0.00	3.00	**8.00**	1.00%
Amorphous silicon total	7.10	5.01	7.70	6.00	**25.81**	3.40%
Crystal silicon concentrators	0.70	-	-	-	**0.70**	0.10%
Ribbon (silicon)	6.80	-	-	-	**6.80**	0.90%
Cadmium telluride indoor	0.00	0.00*	-	-	-	-
Cadmium telluride outdoor	3.00	-	-	-	**3.00**	0.40%
Copper indium diselenide	4.00	-	-	-	**4.00**	0.54%
Microcrystalline Si/single Si	-	13.50	-	-	**13.50**	1.82%
Si on low-cost substrate	0.00	-	-	-	**0.00**	0.00%
A-Si on Cz slice	-	30.00	-	-	**30.00**	4.00%
Total	**103.02**	**363.91**	**193.35**	**83.80**	**744.08**	**99.89%**
Total indoor use (8.0 A-Si + 1.5 CdTe)					**9.60**	
Total terrestrial production					***734.48***	

*Source: Paul Maycock, **PV NEWS Annual review of the PV market 2004***

Figure 5: Possible Production by Technologies in 2020 and 2030



"The market share of thin films has remained at very modest levels over the past decades and reduced from 15% in 1995 to 5% today, as amorphous silicon did not fulfil quality and efficiency expectations. Thin films have the important potential to extend the PV learning curve beyond the point which may be reached by crystalline silicon technology. CIGS, as an emerging technology, could compete with c-Si but further development and scaling up of manufacturing is necessary. Thin-film technologies further allow for specific applications (flexible modules, semi-transparent modules, etc.). <u>To realise the potential of thin films, the PV industry and research sectors have to work together closely to solve both fundamental and technological problems</u>. After 2010, the share of thin-film technologies is expected to increase" (*PV Track – 2004*)

Thin film

Thin film modules are constructed by depositing extremely thin layers of photovoltaic materials on a low cost backing such as glass, stainless steel or plastic. Individual 'cells' are formed by then scribing through the layers with a laser. Thin film cells offer the potential for cost reductions. Firstly, material costs are lower because much less semiconductor material is required and, secondly, labour costs are reduced because the films are produced as large, complete modules and not as individual cells that have to be mounted in frames and wired together.

The most fully developed thin film technology is hydrogenated amorphous silicon. This is the material normally used in consumer applications, although it is used, but less frequently, in power modules. The efficiency of commercial amorphous silicon modules has improved from around 3,5 % in the early 1980's to over 7% currently. The most efficient modules are made with multiple layers of photovoltaic material, for instance three layer amorphous silicon modules with germanium added to two of the layers (a-Si/a-SiGe/a-SiGe) which have a record cell efficiency of 13,5 %. Other types of thin films can be made using polycrystalline silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS).

Typical and maximum module and cell conversion efficiencies (at Standard Test Conditions, i.e., 1 000 Wm-2, 25 degrees Celsius, solar spectrum AM1.5) are given in the table below for some of the commercially available PV technologies.

Typical and maximum module and cell conversion efficiencies at Standard Test Conditions

Type	Typical module efficiency [%]	Maximum recorded module efficiency [%]	Maximum recorded laboratory efficiency [%]
Single crystalline silicon	12-15	22,7	24,7
Multicrystalline silicon	11-14	15,3	19,8
Amorphous silicon	5-7	-	12,7
Cadmium telluride	-	10.5	16.0
CIGS	-	12,1	18,2

(International Energy Agency -Photovoltaic Power Systems Programme)