PROSPECTS AND POTENTIAL FOR COST REDUCTIONS IN PV SYSTEMS

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- After commercialization in the mid 1970's, PV systems have been characterized by high market growth rates and decreasing costs
- PR of PV modules between 1976 and 2001 is about 80%
- Diffusion outside the niche market of isolated applications is dependent on incentives and subsidies
- Main point: Will PV systems ever reach the break-even price for market competitiveness and then compete without incentives?

- What is the break-even price of PV systems?
- Different break-even prices for different applications (e.g. building-integrated applications, intermediate-load generation in central-power systems, etc.)
- Break-even price for BIPV (building integrated photovoltaics): the Levelized Electricity Cost of the PV System has to be equal to the retail cost of electricity (if there is net metering)

Break-even prices of PVV Systems ($/Wp): Sensitivity Analysis for a target Levelized Electricity Cost of $0.15/kWh (BIPV Applications)

Real discount rate	Capacity factor[b]		
	0.17	**0.20**	**0.23**
5%	3.13	3.68	4.23
7.5%	2.47	2.91	3.35
10%	2.01	2.37	2.72
AVERAGE break-even price of PV systems	2.99		
AVERAGE break-even price of PV modules	1.49		

- Biggest potential for cost reductions: components that are the result of manufacturing activities, such as modules and inverters.
- Reductions in manufacturing costs determined by two factors: economies of scale and technological innovation.
- Specific opportunities for reducing costs are:

- Increasing the efficiency and throughput of cell production processes;
- Less costly methods for packaging and integrating modules;
- Standardizing manufacturing equipment;
- Increasing the annual capacity production of manufacturing plants.

Economies of scale

- MUSIC FM Study: with a manufacturing plant of 500 MW_p annual capacity, the production costs of crystalline-silicon modules would decrease from current levels (about $\$3/W_p$) to $\$0.91/W_p$.
- Scaling up PV thin-film factories from 10 to 100 MW_p/yr of capacity would determine a 40% reduction in unit manufacturing costs.
- Opportunity for reducing costs = PECVD reactors in thin-film modules plants

Reduction of material costs

- Less expensive materials would allow to cut significantly the costs of PV modules
- Thin-film technologies (amorphous silicon, $CuInSe_2$, CdTe, etc.) have costs per W_p installed lower than crystalline-silicon modules (but lower conversion efficiencies)

Power conditioning equipment

- One of the top priorities of the PV industry is the increase in the performance and reliability of inverters
- Inverters have often shown problems of reliability and their replacement significantly increases O&M costs
- Recent evidence of increase in performance and reduction of costs.

Cost reduction opportunities in BIPV systems

- BIPV products such as shingles and slates could substitute expensive construction materials used in roofs
- Optimization of PV yield in solar facades: splitting the solar facade into two-three parts oriented towards different directions (e.g. south, south-east and south-west)
- Increase in the PV yield = more electricity generated for the same capacity installed and therefore a lower LEC

Reduction of O&M Costs

- Costs of labor related to installation and O&M expenses can range from 10 to 40 percent of total system costs. The more skilled and experienced the installers, the lower the installation costs
- Development of a skilled and well-trained labor force is essential in reducing PV system costs; this process has already started where there is a sustained market demand (e.g. Germany, Japan)

CONCLUSIONS

- There is a big potential for further reductions of PV system costs.
- Even if it is still uncertain how fast and to what extent this potential could be tapped by the PV industry, there is enough evidence to indicate that PV systems in grid-connected building-integrated applications will be able to reach the break-even price and then compete without incentives with fossil-fuel electricity.