International Technology Roadmap for Photovoltaic (ITRPV)

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ITRPV – Methodology

Working group today includes > 30 contributors from Asia, Europe, and US

> 50+ parameters are discussed in the 7th edition

Parameters in main areas are discussed

→ Diagrams of median values

→ Maturity assessment (for some parameters)
Shipments /avg. price at years end:

- 2014: 39.3 GWp / 0.62 US$/Wp
- 2015: 50 GWp / 0.58 US$/Wp

Approximately 90% c-Si based

- > price 09/2016: 0.44 US$/Wp

2015 o/a shipment: 234 GWp
2015 o/a installation: 227 GWp
2016 shipments (estim.): ≈ 290 GWp

200 GWp landmark was passed!

Historic LR 21.5% (1976 … 2012)

> Learning continued
Cost consideration

> Price reduction 2014 > 2016: ≈ 20% in 2 years
> Reduction 06/2016 > 10/2016: ≈ 33% in 4 months

Dramatic price drop during last months

Module pricing share > 50% today

continue further cost reduction by:
- increase efficiency (material + machine utilization),
- optimize products for special markets (niche vs. high volume),
- improve module power by increasing cell efficiency + optimizing CTM
Mainstream: 180μm

- only slight reductions during the next years

Cell:

180μm = preferred thickness since 2009

- Down to 160μm are possible by today (Grey)
- 150μm /140μm handling solutions are known (Yellow)

Module

- 150μm are possible with current technologies (Grey)
- < 150μm needs development (Red)
- New module technologies needed to enable further thickness reduction

Source: Fhg-ISE
Products: Wafer types

- Casted material is dominating today with >60%
- Mono share is expected to increase (driven by n-type)
- p-type material is expected to dominate
Products – cell efficiency / module power in mass production

- Cell efficiency enhancement continues during the next years
- HP-mc-Si PERC cells will surpass 20% (around 2020)
- 60 cell mc-Si modules to exceed 310 Wp

→ N-type cells / modules for high power applications w/ >320 Wp after 2018

Average stabilized efficiency values for Si solar cells (156x156 mm²). Predicted trend curve for module power of 60-cell modules for different c-Si cell types.
Processes – manufacturing: cell production tool throughput

Synchronization of front- and back-end tool throughput

Efficient use of production equipment is mandatory
- increase: tool throughput
  - tool up time (SEMI E10)
  - yield
  - utilization
  - eta of standard cell

Progressive scenario = new high throughput tools

Wet processing is leading w/ ≈7500 wf/h (Grey)
- solutions exist for up to 10.000 wf/h (Yellow)

Thermal: capable up to 5000 wf/h (Yellow)
- 5000 not yet ready for production (Red)

Metallization: no solutions for > 7000 wf/h (Purple)
• System cost expected to decrease > 30% until 2026

• Module and inverter show highest relative cost reduction

Relative system cost development for systems > 100kW in Asia (2015 = 100%).
PV Systems: Levelized Cost of Electricity (Systems >100kWp)

LCoE reduction = key for future success of PV

LCoE

→ 2016: 4.4 - 9 $cent
→ 2026: 3.1 - 6 $cent are expected

Extended service live to 30 years → further LCoE reduction expected

Calculated LCOE values for different insolation conditions. Financial conditions: 80% debt, 5%/a interest rate, 20-year loan tenor, 2%/a inflation rate, 25 years usable system service life.
Thank you for your attention!

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Full version of 7th edition available at:

www.itrpv.net