

PV Technology and Trends



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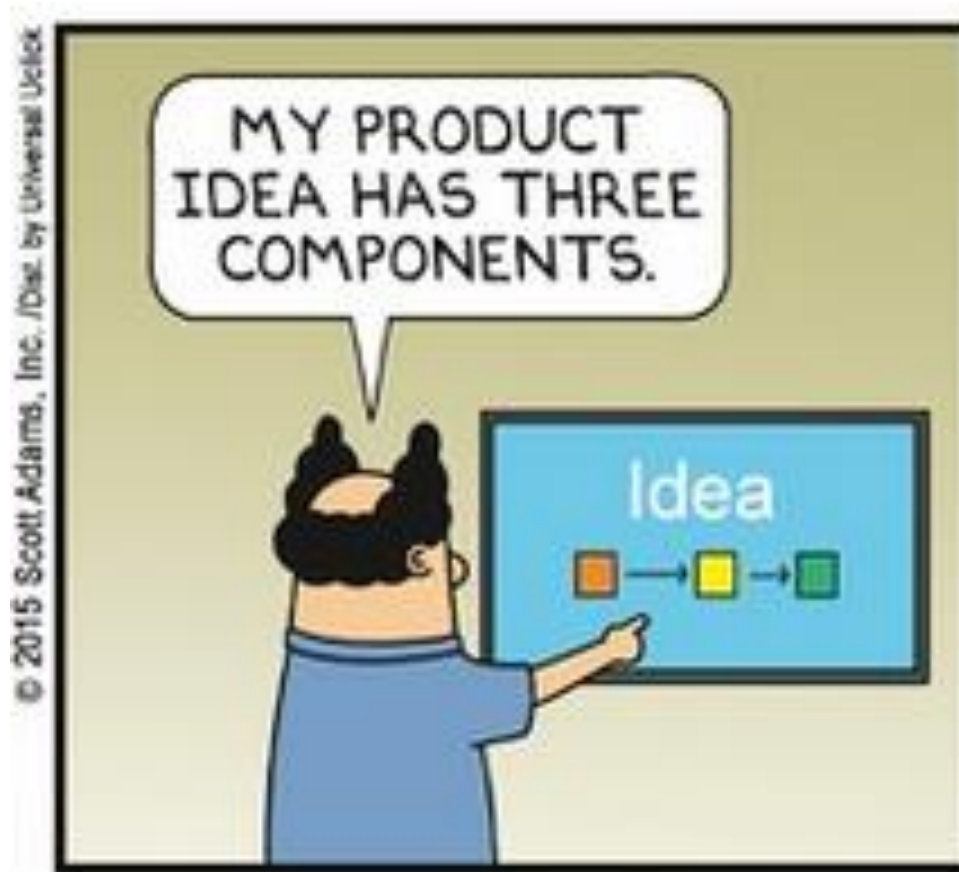
Dr. Arnulf Jäger-Waldau
DEDE Thailand and IEA PVPS
workshop
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Stimulating innovation
Supporting legislation

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Technology Trends



Thin Films

Commercial CdTe modules

Q1/2012 (12.4%)

Q2/2015 (15.4%) +24.2%

Commercial CIGS modules

2010: between 7 and 11%

2015: between 12 and 15.1%

Commercial silicon tf modules

2010: between 5 and 8%

2015: between 5 and 11%

Crystalline Silicon

Polysilicon

Siemens Process 2014: 65–120 kWh/kg

FBR 2014: 20– 30 kWh/kg

Power Output per Wafer

mc : 2011 (4.02W) 2014(4.33W) +7.7%

mono : 2011 (4.27W) 2014(4.63W) +8.4%

Polysilicon consumption of wafers

mc : 2011 (5.92g) 2014 (5.00g) –15.5%

mono : 2011 (5.71g) 2014 (4.52g) –20.8 %

Crystalline Silicon

Average Cell Efficiency

mc : 2012 (17.0%) 2014(17.8%) +4.7%

mono: 2012 (18.6%) 2014(19.4%) +4.3%

Average Module Efficiency (no ARC)

mc : 2012 (15.1%) 2014(15.7%) +4.0%

mono: 2012 (15.6%) 2014(16.4%) +5.1%

Average Module Efficiency (ARC)

mc : 2012 (15.4%) 2014(16.0%) +3.9%

mono: 2012 (15.8%) 2014(16.7%) +5.7%

Crystalline Silicon

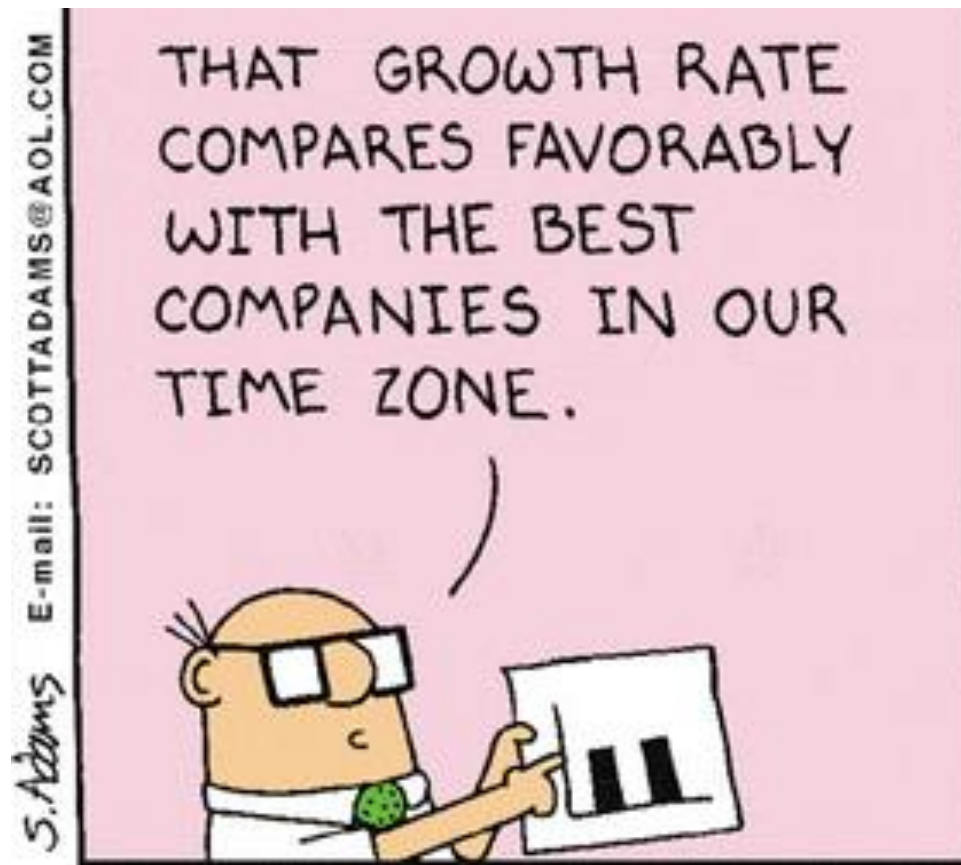
Emerging Production Technologies

- **Passivated Emitter Rear Cells (PERC)**
- **4 and 5 busbar solar cells (4BB, 5BB)**
- **Heterojunction Solar Cells**
- **Bifacial Solar Cells**

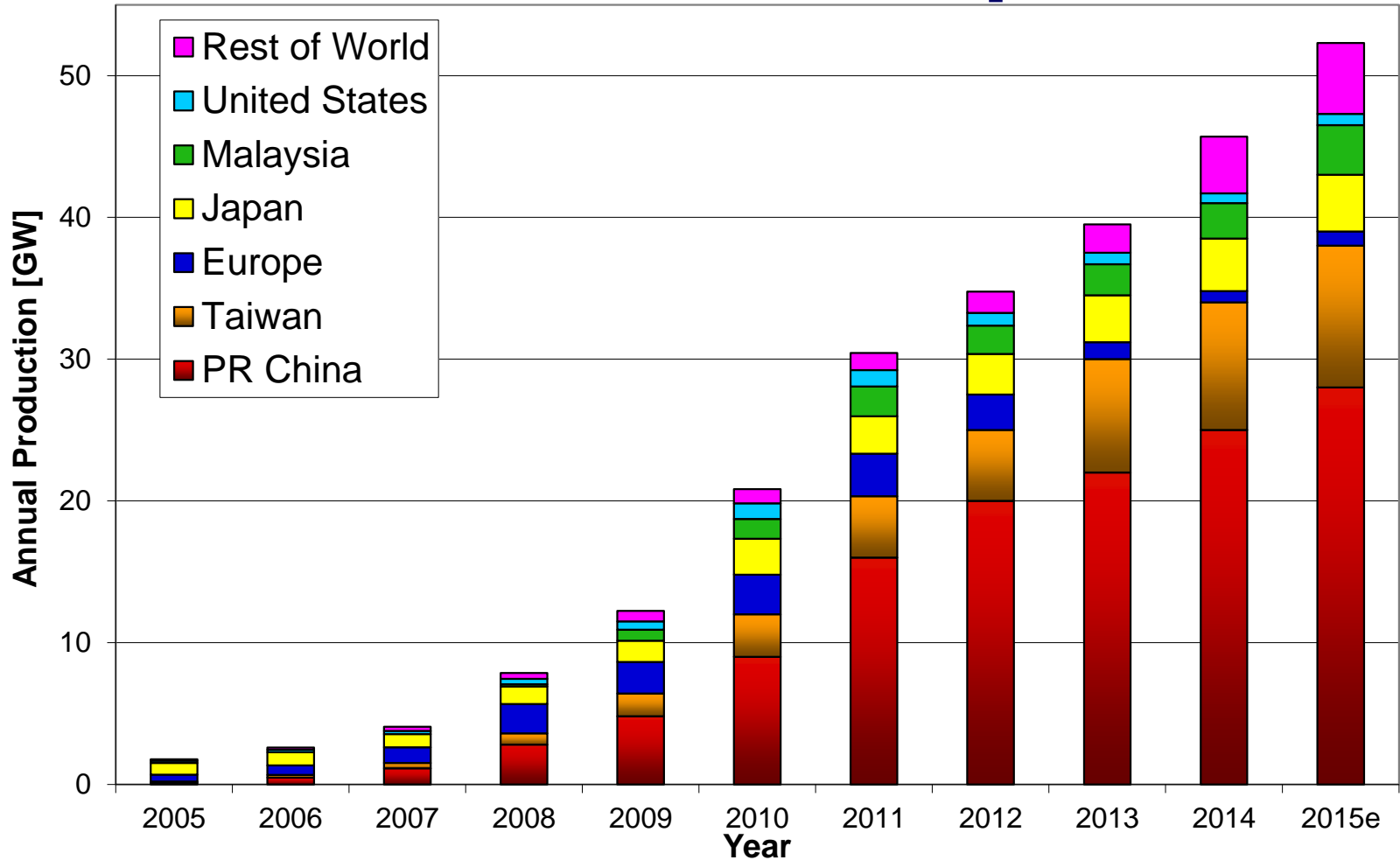
Possible Efficiency Gain

- **PERC: 4-5% relative, 0.7 – 1.0% absolute**
- **4BB: about 0.3% absolute**

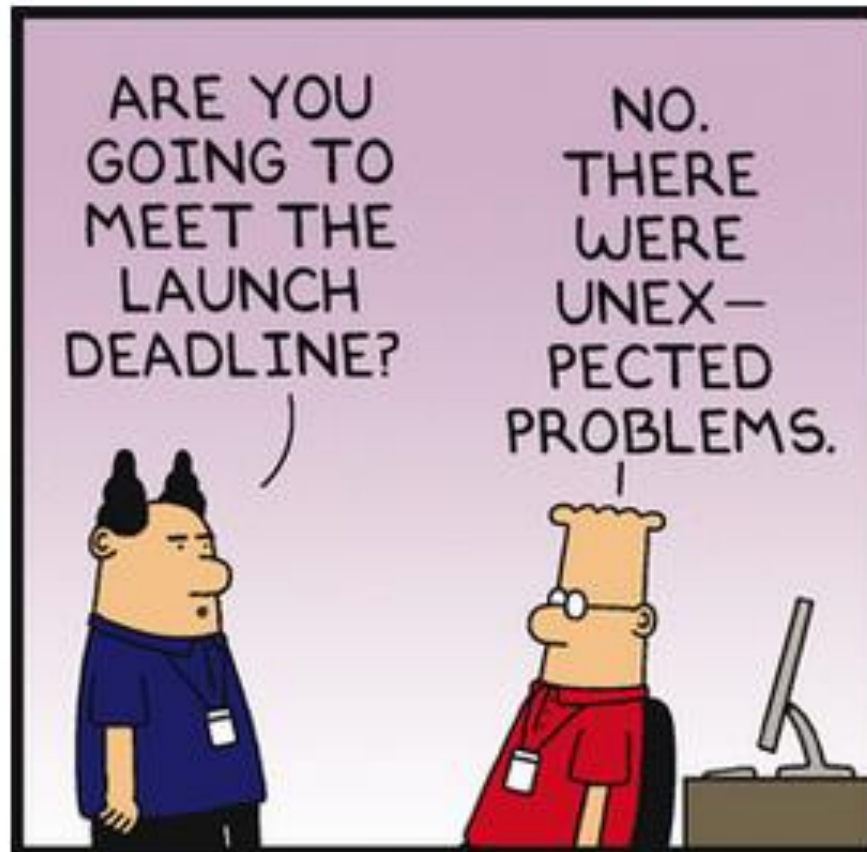
Manufacturing



PV cell and thin film production



Capacity Expansion



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Capacity Expansion

Nameplate Capacity

End of 2013: ~ 62 GW

End of 2014: ~ 88 GW

Operational Capacity

End of 2013: ~ 45 GW

End of 2014: ~ 66 GW

Announcements 1H 2015

c-Si cells: ~ 2.9 GW

Thin films: ~ 5.1 GW

Integrated cell/module: ~ 7.1 GW

Capacity Expansion Technology (in order of announced MWs)

- **PERC**
- **"standard c-Si technology"**
- **CdTe**
- **CIGS**
- **HJ**
- **Bifacial**

Capacity Expansion

**Where are the new plants build
(top 5 in order of announced MWs)**

- **India**
- **South Korea**
- **China**
- **Thailand**
- **Malaysia**

Conclusions

- PV technology has made significant progress. In all technologies the progress has been greater than predicted in various roadmaps.
- Further material reduction per Wp ongoing.
- PV cell and thin film capacity still larger than demand.
- Shift of PV production.

Thank you for your attention!

