# How market scale, government policy and technological advances are impacting the economics of grid-connected, utility-scale, solar PV plants in Asia

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# Topics

- LCOE for a hypothetical utility-scale solar PV plants in Bangkok and Abu Dhabi
- Impacts of plant and industry scale on module and EPC costs of utility-scale solar PV projects
- Chinese and Indian governments as creators and destroyers of solar PV markets
- Advances in solar cell and battery technologies on future costs of solar PV plants
- The direction of Asia's grid-connected, utility-scale, solar PV markets

# Evaluated tariffs for recent solar PV projects awarded in UAE were exceptionally low!

| Location | Project Name | Bidding Consortia | Utility | Bid Date | COD | Installed Capacity (MW$_p$) | LCOE (US¢/kWh) |
|---|---|---|---|---|---|---|---|
| Maktoum Solar Park, UAE | Shuaa Energy 1 | ACWA (41%), TSK (8%), DEWA (51%) | DEWA | July 2015 | 2017/Q2 | 260 MW$_p$ | 5.84 |
| Maktoum Solar Park, UAE | 800 MW Maktoum Solar Park Phase III | ACWA+ First Solar (40%), DEWA(60%) | DEWA | May 2016 | 2018 (200 MW) | 200 MW$_p$ | 3.95 |
| | | Jinko Solar (40%), DEWA (60%) | | | 2018 (200 MW) | 200 MW$_p$ | 3.65 |
| | | Abdul Latif Jameel, Fotowatio Renewable Ventures, Masdar (40%), DEWA (60%) | | | 2018: 200MW<br>2019: 300MW<br>2020: 300 MW | 200 MW$_p$ | 2.99 |
| Sweihan Solar Park, Abu Dhabi | Sweihan Solar Project | Marubeni & JinkoSolar (40%), ADWEA (60%) | ADWEA | Sept 2016 | 2019/Q1 | 350 MW$_p$ | 2.42 |
| | | Masdar, EDF and PAL (40%), ADWEA (60%). | | | | | 2.53 |
| | | Tenaga & Phelan Energy (40%), ADWEA (60%) | | | | | 2.60 |
| | | RWE& B-Electric (40%), ADWEA (60%) | | | | | 2.92 |
| | | JGC/First Solar/Sojitz (40%), ADWEA (60%) | | | | | 3.09 |
| | | Kepco/Q CELLS/GSE ($)%), ADWEAv(60%) | | | | | 3.64 |

## Top 6 Bids for 350 MWp project

The Tariff awarded to Marubeni-Jinko Solar, the lowest bidder, was 2.94 US¢/kWh, which is equal to the Weighted LEC$^{\Sigma}$

| Managing Member | Other Private Sector Consortium Members | | IRR (%) | LEC (US¢/kWh) | Weighted LEC (fils/kWh)$^{\Sigma}$ |
|---|---|---|---|---|---|
| **1. Marubeni** | **Jinko Solar** | | **7.00** | **2.940** | **2.420** |
| **2. Masdar** | **EDF** | **PAL** | **7.00** | **3.080** | **2.533** |
| 3. Tenaga | Phelan Energy | | 7.15 | 3.135 | 2.598 |
| 4. RWE | Belectric | | 7.00 | 3.550 | 2.919 |
| 5. JGC | First Solar | Sojitz | 8.46 | 3.769 | 3.088 |
| 6. KEPCO | Q Cells | GSE | 7.00 | 4.351 | 3.635 |

Σ - Weighted LEC = PV of Bid Tariff/Weighted average NEO of all Bids

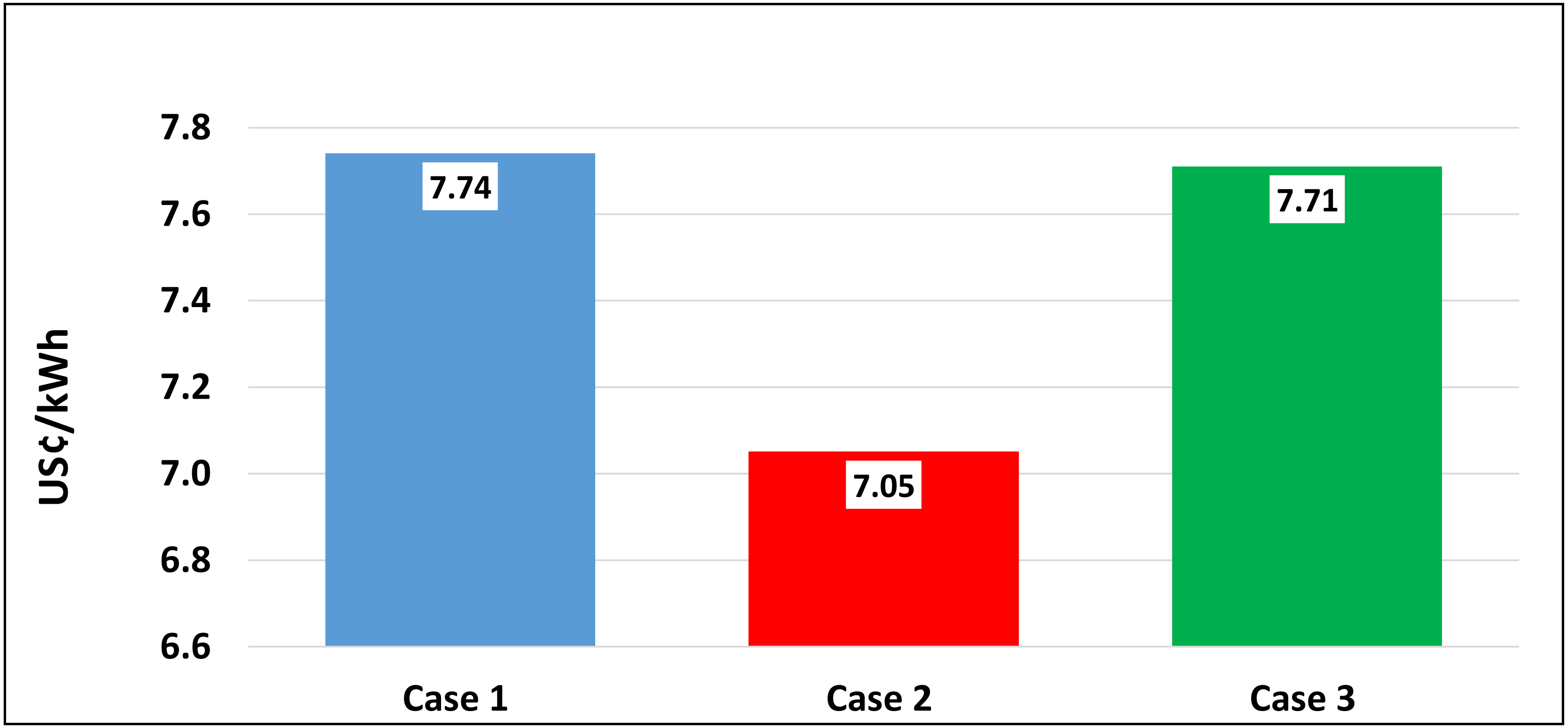
Source: Middle East Solar Industry Association

# LCOE assessment for 150 $MW_p$ solar PV project near Bangkok: Case 1 Assumptions (full details shown in Annex 1 to this presentation)

- NREL System Analysis Model (version 2017-1-17 r4) used to conduct LCOE assessment (latest version 2017-9-5)
- Capacity = 150 $MW_p$
- CF = 18% (DC +DC/AC losses = 14%, 1% annual plant degrade, 3% FO rate, no utility curtailment)
- Project life = 25 yr. with zero salvage value at end of project life
- EPC price = $900 per $kW_p$ x 150,000 $kW_p$ = $135.0 million
- Land, land prep and other non-EPC capex= $ 9.9 million
- O&M cost = $20/$kW_p$-yr x 150,000 $kW_p$ = $ 3.0 million per yr.
- Taxes, inflation and rate of power price escalation = 0
- Financing Terms
  - Equity IRR = 12%
  - Min DSCR = 1.2x
  - Interest rate on loans = 6% + 1.5% Front end fee (FEF)
  - 12 year loan tenor
  - Debt repayment scheme = equal principal, declining interest
  - Loan repayment moratorium = 1 year (1st debt payment due 1 yr after COD)
  - Traditional reserve accounts = 6 months(m) debt repayment + 6 m O&M + 2 m gross revenue for accts receivables

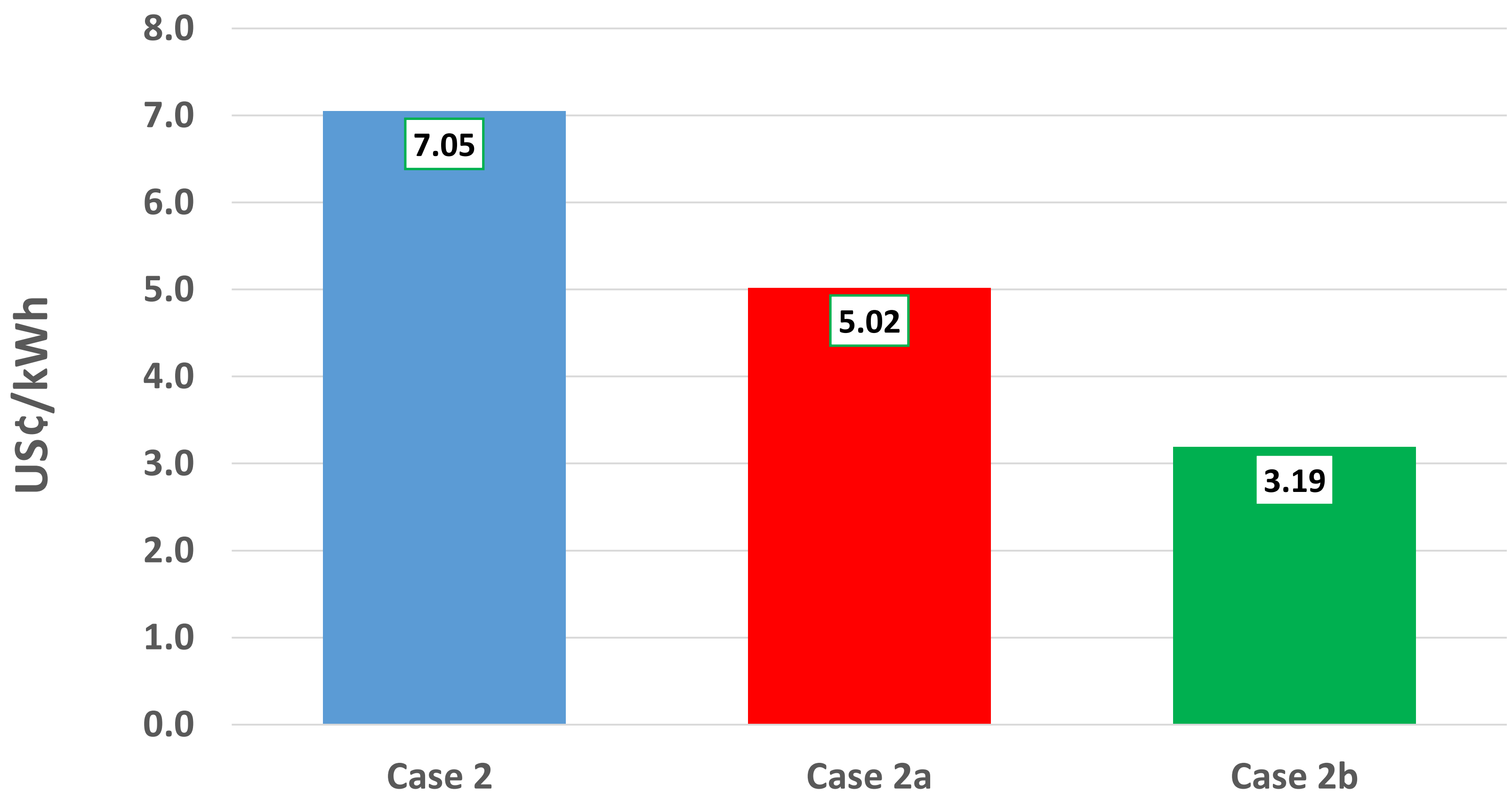
**LCOE for 150 MW grid-connected, solar PV plants located in or near Bangkok**

* Case 1 – Assumptions as per previous slide (D:E ratio = 54:46)
* Case 2 – Improved debt financing terms; i.e., annuity repayment, 18 yr. tenor, no reserve acct. for A/R, D:E ratio =66:44; Lower equity IRR of 10%.
* Case 3 – Case 2 but 10% capacity curtailment (D:E = 56:44)



**LCOEs for 150 MW grid-connected, solar PV plants near Bangkok & Abu Dhabi**

* Case 2 – Bangkok -Same assumptions as Case 2 on previous slide
* Case 2a – Case 2 assumptions except plant sited in Abu Dhabi
* Case 2b – Case 2a with no land costs, DC+DC/AC losses reduced from 14% to 10%, aggressive financing assumptions (equity IRR = 7%; loan tenor = 25 yr, 4% i-Rate, no reserve accounts, no FEF and 75:25 D:E)



# Project vs Market size

## As plant size increases, cost/$kW_p$ decreases

- Between 2015 and 2016, EPC costs for utility-scale solar PV plants decreased by 27% ($1225/kWp to $900/kWp) while cumulative global solar PV module shipments have increased by 34%.
- Over same time period, utility-scale solar PV plants have increased in size from <30 MW to over 50 MW and in many cases above 100 MW.

*Could the 2016 price drop be the result of plant scale economies?*

- My view: *2016 EPC price decline largely due to Chinese equipment suppliers dumping their panels and inverters below costs to capture market share*
- Economies of scale - likely to be small with cost savings resulting from: (i) volume purchase discounts and (ii) economies of agglomeration.
- Diseconomies of scale + site size constraints will limit size of utility-scale solar PV projects.

## As market size increases, cost/$kW_p$ decreases

- Swanson's Law – Real PV module prices decrease by 20% -23% for every doubling of the cumulative volume of solar PV modules shipped.
- Cost reductions in modules result from
  - economies of scale for plants that produce modules
  - increased industry competition
  - learning = improved methods for producing silicon ingots, solar cells and modules.
- Industry economies of scale for inverters and BOS – less clear and probably small.
- Two questions on every Solar developer's mind
  - Are these price reductions sustainable and continuing?
  - If not, are there signs that market power is shifting back to manufacturers of solar PV modules and inverters and away from customers?

# Arguments for & against economies of scale for utility-scale solar PV plants

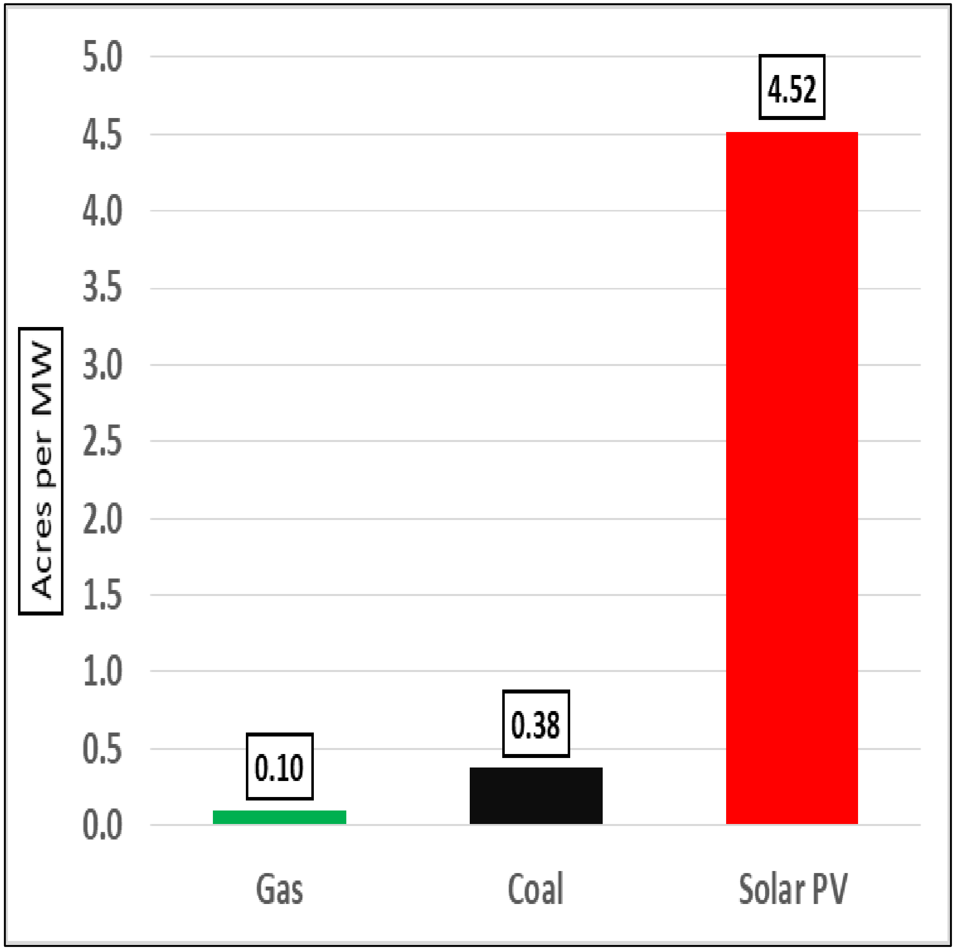
## Pros

- Larger plants allow SPDs to obtain volume discounts on modules and inverters
- EPC prices per $MW_p$ should be lower due to amortization of fixed construction costs (set-up, labor and engineering costs) over larger capacity
- Other cost savings due to contractors having extended on-site experience and over time with the implementation of more projects
- More efficient modules and inverters will allow an increase in plant capacity per ha of land, reducing need for additional land to build larger plants

## Cons

- Plant scale effects will be limited by:
  - the modularity of solar PV plants
  - a shortage of large contiguous plots of land > 500 ha
  - use of single-axis tracking arrays with 25% increase in land requirements compared to fixed rack arrays.
- Cases in Point:
  - Sweihan project increased from 350 $MW_p$ to 1117 $MW_p$; LCOE reduced from 2.99¢/kWh to 2.42¢/kWh, 20% reduction in price for a 1,320% jump in plant size.
  - Sweihan site increased from 641 to 2,156 ha. Limited # of sites this size available in SE and S. Asia.
  - For example, Thailand's industrial parks range in size from 400 ha to 2400 ha.
  - Unlikely that many, if any, large solar PV plant sites >500 ha are available in Thailand, Indonesia and the Philippines for projects >350 $MW_p$ .

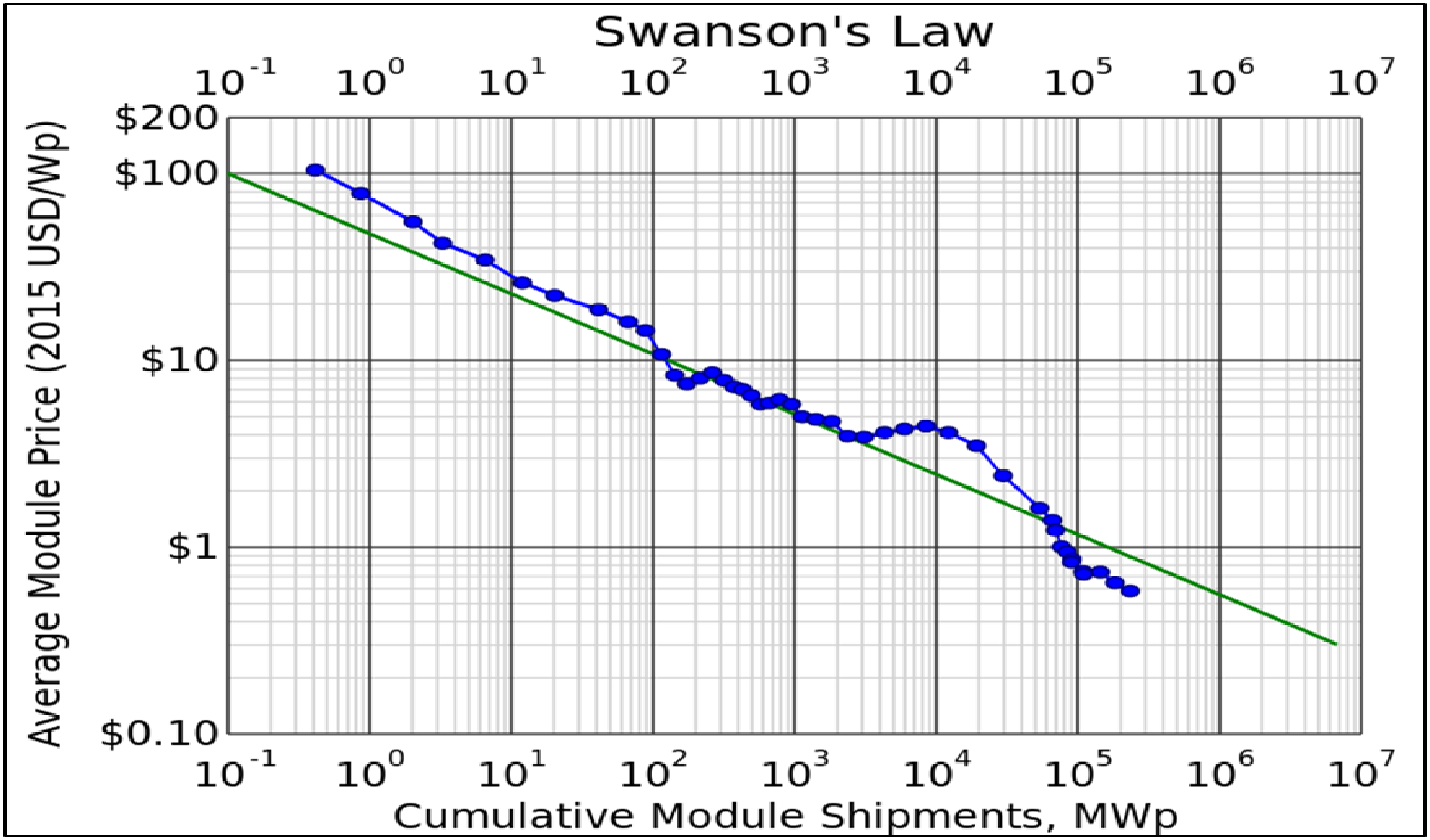
# A utility–scale solar PV plant with single axis tracking requires 11x more land per installed MW than a coal-fired power plant and 40x that of a gas-fired CCGT plant




- Unit land requirements in hectares:
  - solar PV plant = 1.2 - 1.6 ha/$MW_p$
  - coal plant = 0.15 ha/$Mw_{ac}$
  - CCGT gas plant = 0.04 ha/$Mw_{ac}$ .
- Reduction in land requirements will come from use of more efficient modules and inverters.
- But the shift to improved efficiency modules and inverters is unlikely to lead to large reductions in land requirements per MWp.

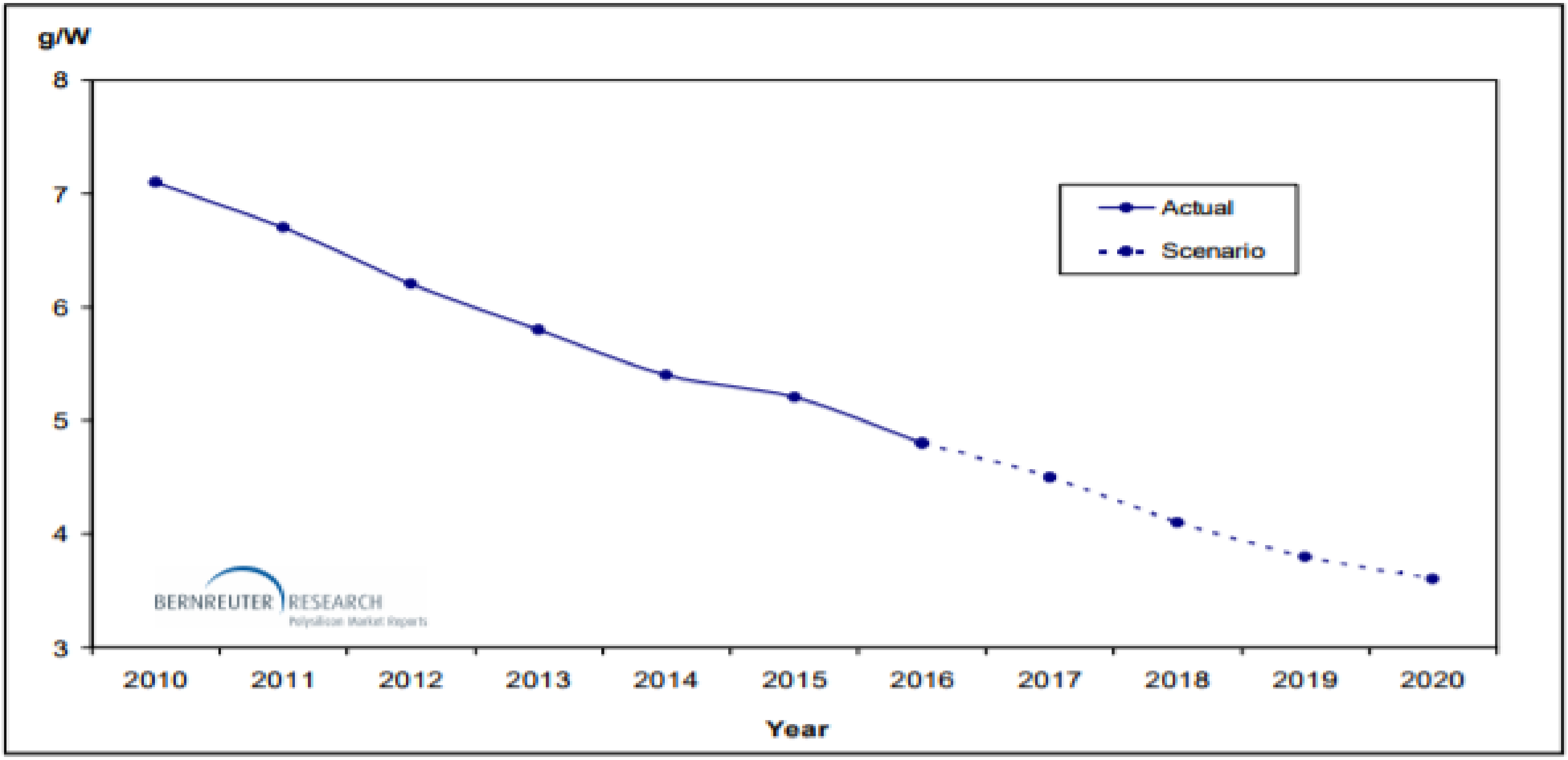
Swanson's Law, the PV industry equivalent of Moore's Law

*"for every doubling in the **cumulative** production of solar modules, there is (approximately) a 20% reduction in the average **"real"** module price.*



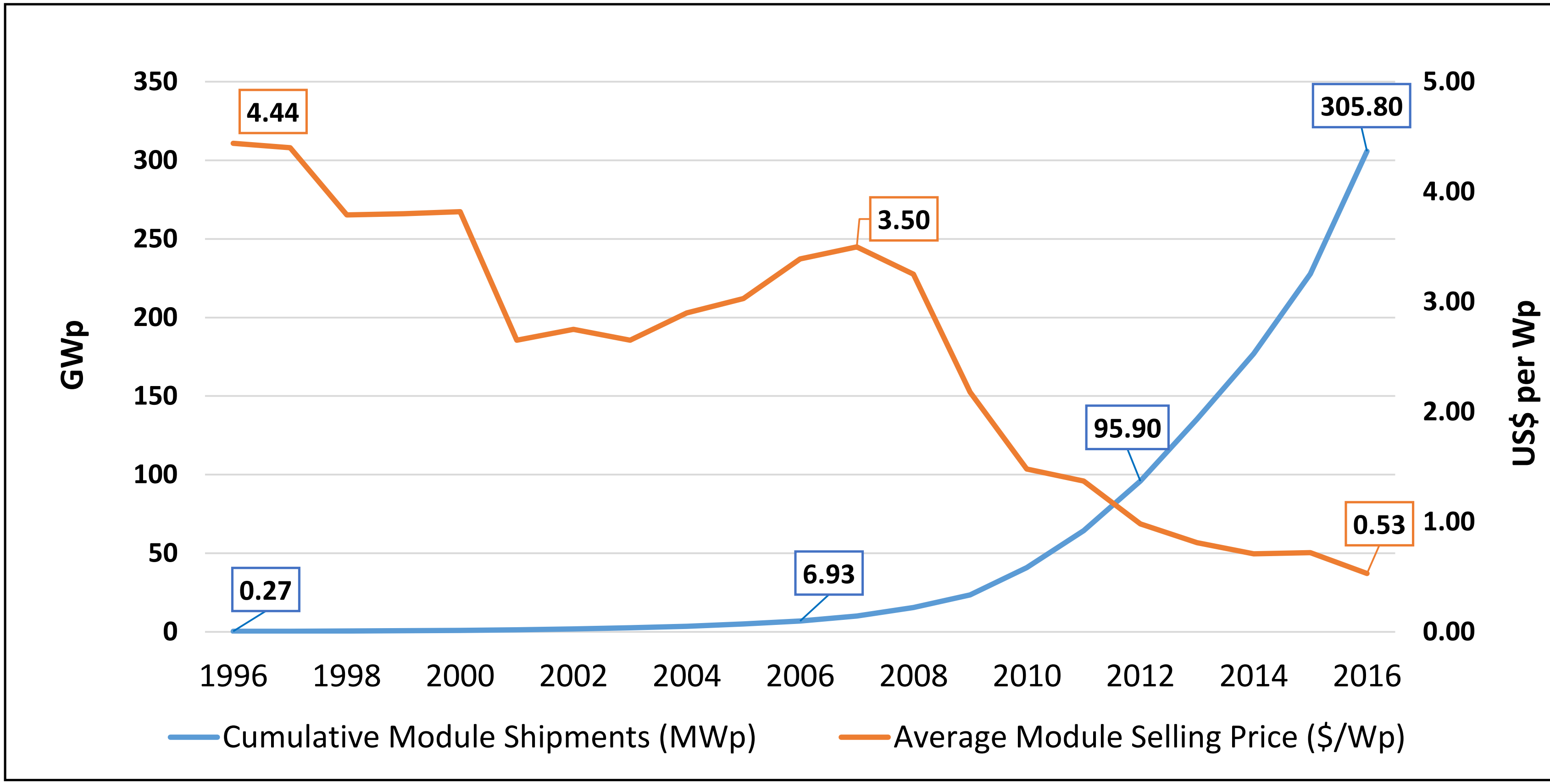
# Wafer producers achieved significant reduction in production costs using diamond saws to slice wafers from silicon ingots.

**Specific silicon consumption for solar cell production 2010 - 2020**



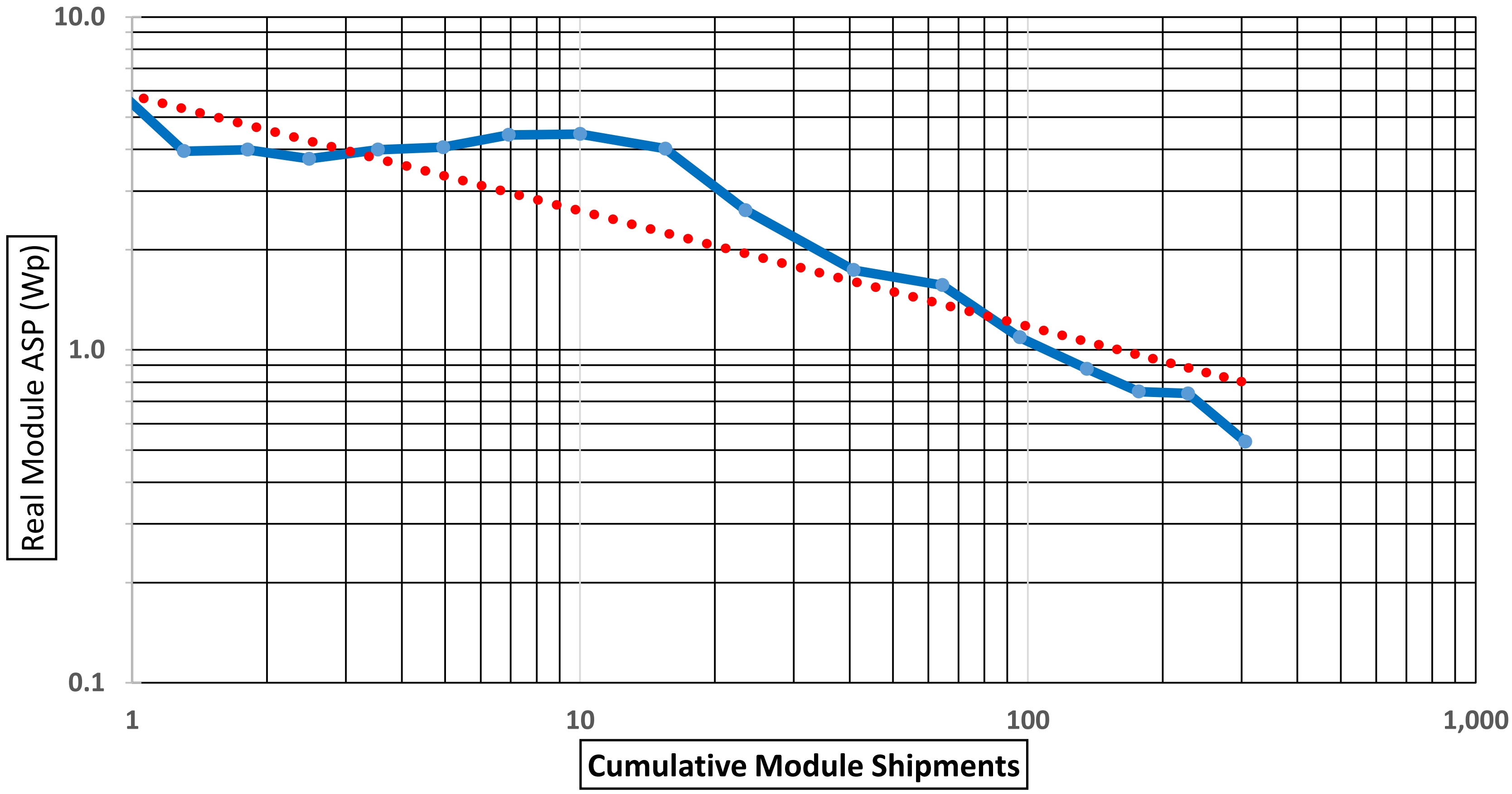

**The specific silicon consumption of the solar industry will halve between 2010 and 2020.**
Graphic: Bernreuter Research

# Over past 20 years, cumulative solar module shipments (LHS) increased 1200x (40%/yr. CAGR) while “nominal” solar PV module prices dropped by a factor of 10 (RHS) (12%/yr. CAGR)




Source: Wikipedia

## Log-Log plot of **real** module ASPs (2016$) and **cumulative** global PV module shipments (1996-2016) indicates that Swanson's Law still applies but over past 2 years industry may have overshot the mark



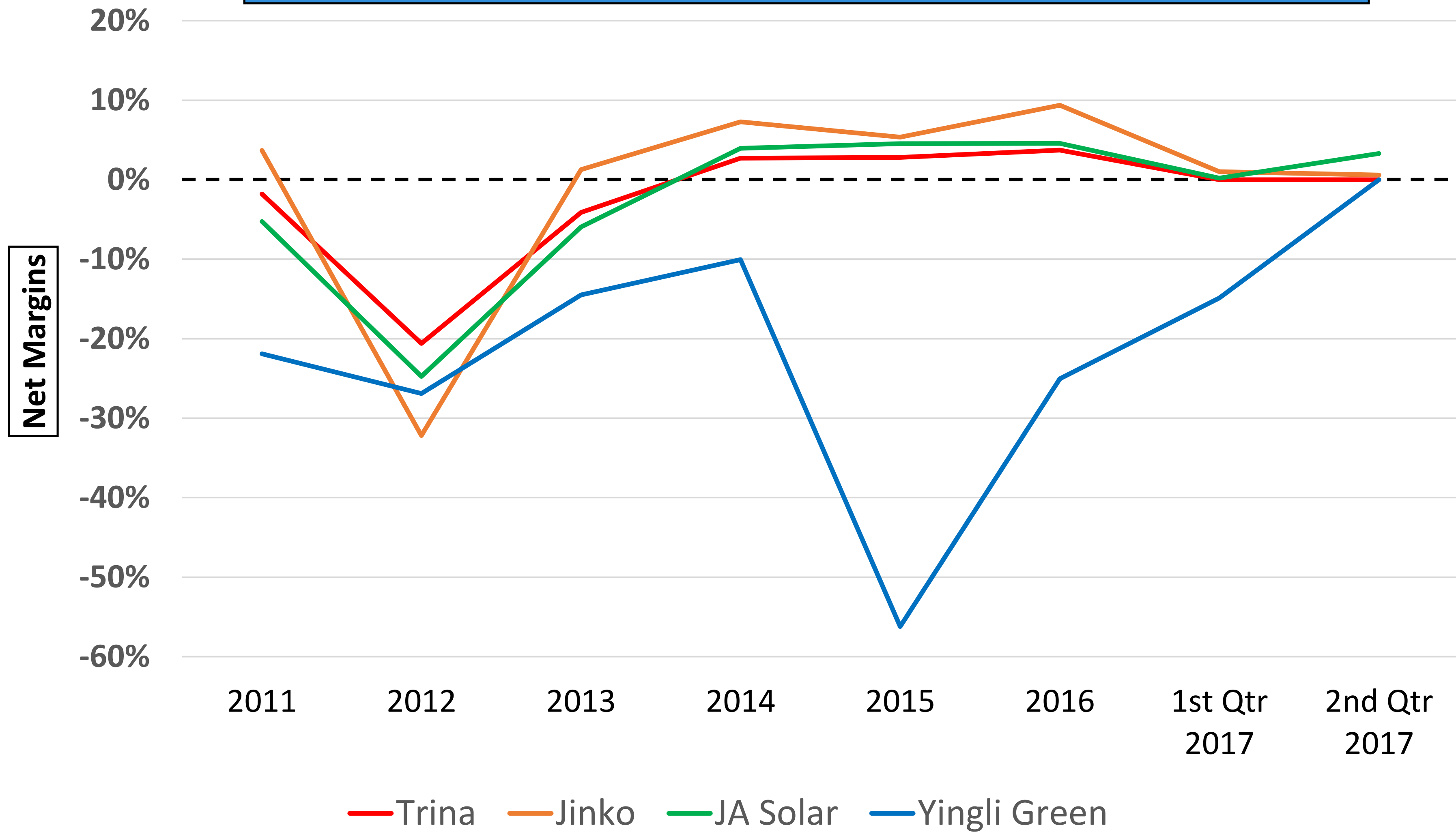
# Two other explanations for the recent (2015/16) steep solar module price declines are (i) “cut-throat” competition by Chinese cell and module manufacturers and (ii) oversupply by the silicon ingot and wafer industry

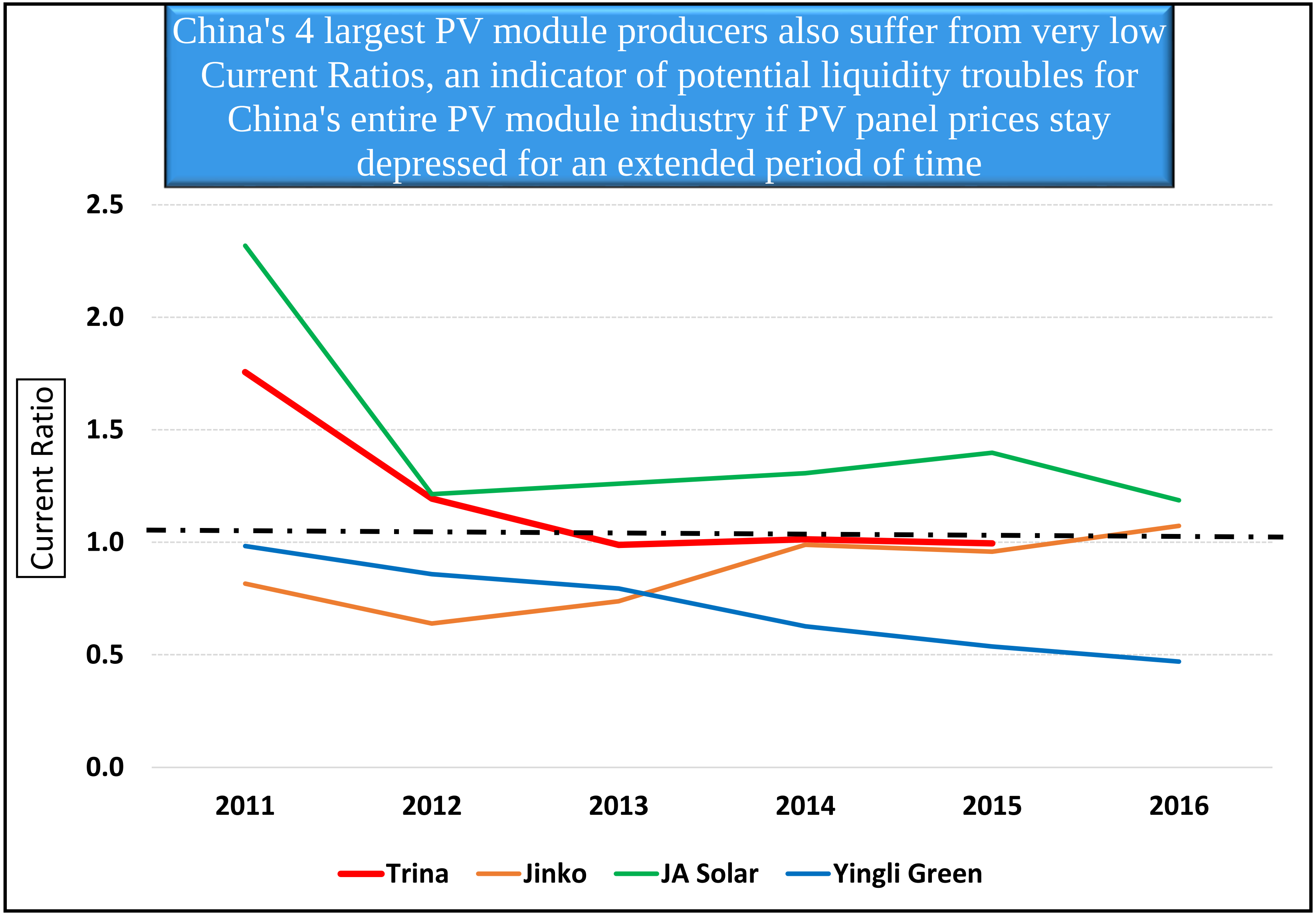
- **Explanation #1: Cut-throat competition**
  - Between 2015 and 2016, Chinese PV producers sold solar PV modules below cost.
  - During 1st H 2017, SPDs rushed to install new solar PV plants in China to benefit from PRC FIT, which was scheduled for downward revision during 2nd H 2017.
- **Explanation #2: Over-supply in silicon industry**
  - Poly-Si manufacturers are experiencing serious over capacity issues coupled with increased use of diamond wire saws for wafer production, reducing silicon requirements for mono-Si and poly-Si wafers by up to 25% and 15% respectively.
  - Bernreuter Research predicting major consolidation of the silicon wafer industry during 2018 and 2019.
- **Bottom-line**
  - Once rationality returns to China’s PV industry, PV panel producers will reduce their production of modules and prices will either increase moderately or stabilize for 1-2 years.
  - More efficient modules and inverters, when they do enter the market, will likely be sold at a premium for the next 2-3 years.

# China's PV industry may experience a major shake-out in 2018 leading to a reduction in PV capacity and higher module prices.

- **SolarWorld AG and Suniva** have already declared bankruptcy due to Chinese predatory pricing. **SunPower** is in a precarious financial position while **Hanwha Q Cells of Korea has** experienced low net margins in 2015 and 2016.
- **All segments of China's PV industry** are suffering financially due to (i) overcapacity, (ii) anti-dumping duties imposed in the US and elsewhere and (iii) low silicon and panel prices worldwide.
- **Yingli** has been in default on several loan agreements since 2012 and is arguably already bankrupt.
- On 22 Sept, **US ITC** voted 4-0 in favor of Suniva's Section 201 trade case, which may result in a minimum module price of $0.78/W$_p$ and/or import quotas on Chinese and Taiwanese modules for up to 4 years. **Ultimate irony:** Suniva is Chinese-owned.
- **Trina, Jinko Solar, and JASolar** - financially weak with high debt levels, low operating and net margins. Except for JA Solar, they all have current/quick ratios at or below 1. (next 2 slides)
- If not for recent rush to implement new PV projects in China, an industry shake-out of China's PV industry would most likely have already occurred.
- **2 wild card events may delay module price increases in Asia:** Suniva 201 judgement and PRC bail-outs

# Low to negative net margins suggest that China's leading PV module producers do not have the internal financial resources to finance research and adopt improved cell production methods




China's 4 largest PV module producers also suffer from very low Current Ratios, an indicator of potential liquidity troubles for China's entire PV module industry if PV panel prices stay depressed for an extended period of time
Current Ratio
2.5
2.0
1.5
1.0
0.5
0.0
2011
2012
2013
2014
2015
2016
Trina
Jinko
JA Solar
Yingli Green

# Asian government Solar PV policies have frustrated SPDs in region

## Chinese Government Energy Policy Making

- Generally, characterized by
  - poor to non-existent planning
  - large and rapid shifts in policies
  - little advance written notice of policy changes
  - Rules and regulations issued by word of mouth
- Provincial and local governments take actions that contradict PRC edicts.
- With respect to China's solar PV policies
  - new solar PV plants curtailed by up to 40% after commissioning
  - cheap loans (3%-4% i-rates) and other subsidies have created excess industry capacity.
- At best, Chinese solar module prices will not decrease this year and next; more likely they will increase above \$1.00 $W_p$.

## Indian Government Energy Policy Making

- Generally characterized by
  - extensive planning and public discussion followed by weak implementation
  - confusing and off-market risk allocation provisions
  - onerous tax provisions relative to other countries
  - lack of follow through by state- central government agencies.
- With respect to India's solar PV policies
  - despite weak policy implementation efforts, govt agencies have implemented many successful solar auctions over past two years
  - numerous state and central government support programs
  - tendency for government. agencies and utilities to attempt to renegotiate bid awards.

# Emerging vs. near-term photovoltaic cell advances

**Pre-commercial, PV cell technologies have cell efficiencies of 35%-40% but are not commercially available**

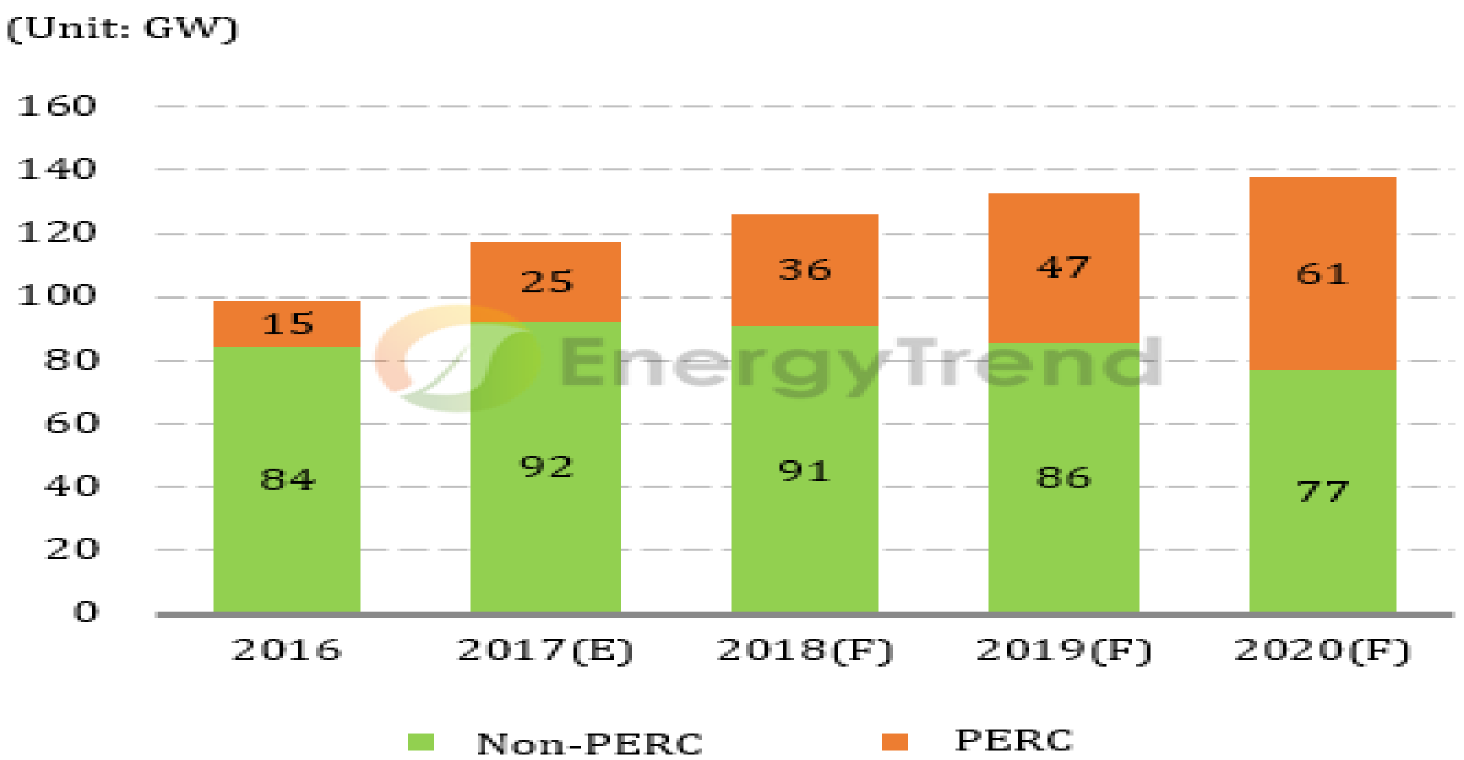
- Copper zinc tin sulfide solar cells (CZTS), and derivatives such as “CZTSe” and “CZTSSe”
- Dye-sensitized solar cells, also known as "Grätzel cells"
- Organic solar cells
- Perovskite solar cells
- Polymer solar cells
- Quantum dot solar cells

**Already commercial PV cell technologies offer cell efficiencies of 25% w/very low PID and LID but for a premium price**

- *Passivated Emitter and Rear Contact (PERC) cells achieve higher efficiencies (~ 1% absolute) and* a module power increase of ~ 15 W compared to standard panels by capturing sunlight reaching backside of module and converting it into electricity.
- Other passivation technologies exist such as:
    - Passivated Emitter Rear Totally Diffused [PERT]
    - Passivated Emitter Rear Locally Diffused [PERL]
- Heterojunction (HJT) bi-facial cells
    - Highly efficient with excellent passivation
    - Low temperature coefficient
    - Immune to PID and LID

Roll-out of modules using PERC and HJT cells has been slow. PERC cells were first demonstrated in a university lab in 1983. By 2018, PERC cells are forecast to account for only 31% of the global production capacity of PV cells.

**Figure: Global Production Capacity for PV Cells, 2016~2020**




Source: EnergyTrend, Jan., 2017

# Will recent advances in laboratory-type solar cell and battery technologies save the Chinese solar PV industry?
# Short Answer: Unlikely. Instead, one must look to industry consolidation over the next 5 years

## Specific "Emerging" PV Cell Technologies

- Researchers at **Technion Israel Institute of Technology** recently announced a breakthrough in solar cell technology that could boost the efficiency of PV cells to 30%.
- **The Masdar Institute-MIT Research Team** has developed a two-layered "step" solar cell that with conversion efficiency of 35% at a much lower cost than existing multilayered solar cell technology.

## New Battery Technologies
## Many proposed; few pass muster

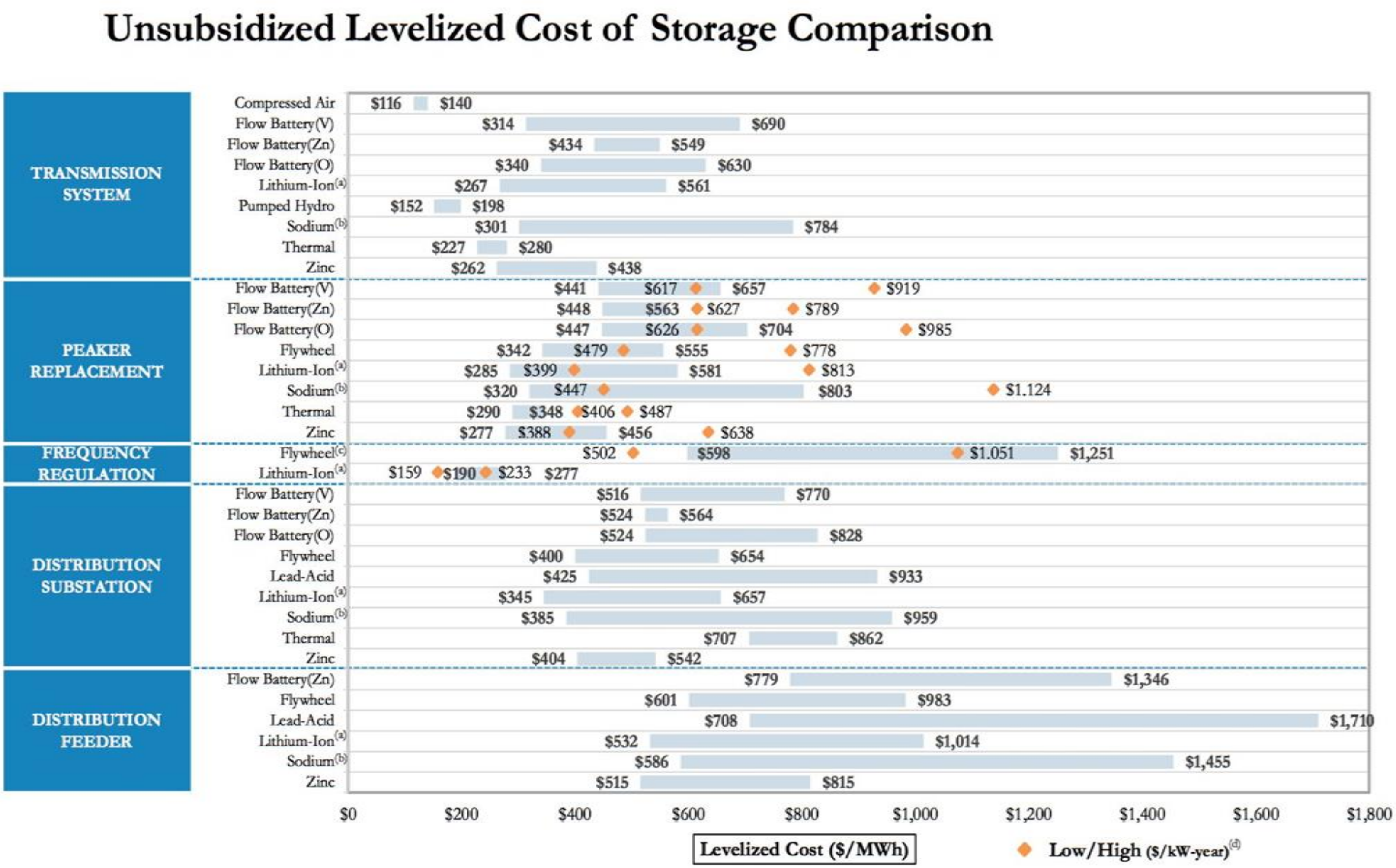
- Lithium Air – still under development by PolyPlus
- Lithium Sulfur – still being developed at LBNL
- Vanadium and Zinc-Iron Redox/Flow – reported to be commercially available from:
  - ✓ ViZn Energy
    - IESO, Ontario 2 MW/6 MWh, 2017
    - India: 1 MWh
  - ✓ UET Energy Storage
    - State of Washington, 2 MW/8 MWh, 2016
    - Dalian, China, 200 MW/800 MWh, 2018
  - ✓ Eos Energy Storage
    - No projects listed on website

# Challenges currently limiting use of batteries

- Li-ion batteries have very high RTE (ac-ac) ~85% but short lifetimes (10-12 years) and suffer from (i) capacity fade, (ii) DOD limits and (iii) fire and explosion risks.
- Li-metal, Li-sulfur and Na-S batteries are still not commercially proven and safety issues are a concern
- Flow-redox batteries - considerable progress in reducing costs without Li-ion performance issues. However, still early days for this battery energy storage system (BESS).
- Assessing the economics of BESS projects requires detailed understanding of:
    - project specific application(s) that BESS may serve range from frequency regulation to pure energy applications such as load shifting and peaker replacement.
    - Point of application; i.e., coupled behind the meter of PV solar plant or operated as a stand-alone system
    - relationship between BESS costs (CAPEX, replacement and O&M costs) and technical performance (RTE, DOD, battery lifetime and capacity fade)
    - The power tariff that a BESS owner must pay to recharge its batteries.

- The lack of operating experience with large-scale battery systems compounds the technology comprehension issue.

# Each year, Lazard publishes its assessment of LCOS for various stand-alone apps of batteries and other storage options for different end uses




Source: https://www.lazard.com/perspective/levelized-cost-of-storage-analysis-20/

# The direction of Asia's grid-connected, utility-scale, solar PV markets

- LCOEs for utility-scale, PV solar systems have decreased dramatically since 2013. However, a significant portion of the decreases reported by some countries, such as Abu Dhabi and most recently Saudi Arabia, may be based on non-transparent evaluation methodologies that create artificially low LCOEs.
- In addition, in 2016, Chinese suppliers of solar PV modules have priced their modules and inverters at levels that are not sustainable.
- Unless the Chinese government provides large financial subsidies, China's PV industry will experience significant consolidation during 2018, leading to a reduction in surplus production and increases in panel and inverter prices.
- Asian government solar PV policies and regulations are confused and counter-productive, causing delays in expanding solar PV capacity throughout SE and South Asia.
- Over the next 10 years, PERC, black silicon, HJT bi-facial cells and other improvements in cell technology will lead to incremental improvements in cell performance. However, it is unlikely that "game-changing" exotic cell technologies will be commercially available prior to 2030.
- Two important issues that need to be resolved before utility-scale solar PV plants can compete on an equivalent price basis against base load, coal and gas-fired IPP plants:
    - the intermittent availability of the solar resource
    - the lack of low cost solar PV sites in SE Asia.

# Asia's grid-connected, utility-scale, solar PV markets (cont.)

- WRT resource intermittency, low cost storage options have thus far focused on pumped hydro and a few small Li ion BESS projects. These niche options are allowing a limited number of solar PV plants to compete on an equivalent LCOE basis against base-load, fossil fuel-fired power plants.
- Significant BESS projects implemented in Asia as of November 2017.
  - AES's 10 MW standalone Li ion battery project at its Masinloc (Luzon) coal-fired power project
  - UET/Rongke's 200 MW/800 MWh vanadium flow battery project reportedly being installed near Dalian, China
  - Samsung's 24MW/18MWh Li-ion BESS project at a Kepco substation in South Korea
  - LG Chem's 132 MW / 51 MWh Li-ion BESS project, at 5 KEPCO substations in South Korea.
- BESS economics remain uncertain due to:
  - limited commercial operating experience
  - many revenue generating applications per project that batteries may serve
  - complex relationship between BESS costs and BESS performance metrics by battery type and end use application.
- Although BESS for Li-ion and flow batteries have shown significant cost reductions and improvements in performance, at this point in time, the promise of cheap battery storage still appears to be "five years over the horizon".
- Due to high land costs and unavailability of large sites in developed urbanized areas, utility-scale solar PV plants in SE Asia will be located in remote rural areas where land for siting the PV plant will be more readily available.
- This opens up an intriguing market possibility for developers of grid connected, utility scale PV plants - their co-location with the many base load coal and gas plants located and still operating in remote rural areas.
- Co-location will allow synergies to be achieved whereby solar PV plants can, for a price, utilize the spare generation, transmission and O&M capacities of base load coal and gas power plants during periods when the solar resource is weak or unavailable.

# Annex 1- Detailed Assumption used for LCOE analysis

# Technical assumptions for hypothetical 150 $MW_p$ utility-scale solar PV plant located near Bangkok

| Technical Assumptions | Units | Assumed Values | Remarks |
|---|---|---|---|
| Capacity | $MW_p$ | 150 | DC plant capacity |
| $CF_{(ac/dc)}$ | $NEO_{ac}$ /($Capacity_p$ x 8760) | 18% | 100% of NEO assumed delivered to grid. No curtailment and 1.1 DC-AC sizing ratio |
| Scope of Supply | N/a | N/a | (i) Premium Mono-Si Modules (20% Eff) and Inverters (96% Eff)<br>(ii) BOS Equipment includes single axis tracking arrays w/backtracking)<br>(iii) Installation Labor and Commissioning<br>(iv) Lump-sum, date certain EPC Contractor |
| System Degradation | % of $Capacity_p$ / year | 1% | But could be as low as 0.8% |
| Land Requirement | Acres (A) (Hectares (Ha)) | 616 A (247 Ha) | 4.11 A (1.65 Ha) per $MW_p$ |
| Other Pre-COD Technical Requirements | • Land preparation and grid connection<br>• Permitting, environmental and engineering studies, developer overhead | | |

# Pre-COD cost assumptions for a hypothetical 150 $MW_p$ utility-scale solar PV plant near Bangkok

| Pre-COD Cost Parameter | Units | Assumed Values | Remarks |
|---|---|---|---|
| EPC price | Million US$ | $ 135.0 million | EPC Price based on unit price of $900/kWp:<br>(i) Modules + Inverters = $400/$kW_p$<br>(ii) BOS Equipment = $350/$kW_p$<br>(iii) Installation = $ 50/$kW_p$<br>(iv) EPC Margin (12.5% x $800) = $100/$kW_p$ |
| Contingency | Million US$ | $ 2.7 million | 2% of EPC Price or $18/$kW_p$ |
| Land costs | Million US$ | $ 1.8 million | Cost of land =$3000/A x 600 A= $1.8 million |
| Land preparation and grid connection costs | Million US$ | $ 0.6 million | SWAG #/ Probably on the low side ($1000 x 600A = $600,000) |
| Indirect, pre-COD costs | Million US$ | $ 0.8 million | $ 5/$kW_p$ to cover costs of (i) permitting, environmental and engineering studies and (ii) developer overhead ($5/$kW_p$ x 150,000 $kW_p$), |
| Development costs | Million US$ | $ 5.0 million | 3.7% of EPC Price ($135 million x 0.037 = $5 million) |

# Post-COD assumptions for a hypothetical 150 $MW_p$ utility-scale solar PV plant near Bangkok

| Post-COD Assumptions | Units | Assumed Values | Remarks |
|---|---|---|---|
| O&M Costs | US$/$kW_p$-yr | \$20/$kW_p$-yr | Current figure used in Asia |
| Insurance Costs | Million US$ | | % of installed cost/yr; Swag # 0.5% x EPC costs |
| Reserve Accounts | Debt Service Reserve | 6 m of Debt Service | Typical values for IPP Projects in Asia |
| | Working Capital Reserve | 6 m of O&M costs | |
| | Receivables Reserve | 2 m of Power Payments | |
| Taxes | n/a | n/a | No taxes assumed for the project (No Corporate Y Tax, Property Tax, Import Duties on equipment |
| Inflation/ Power Price Escalation | None | | |
| Project Life | 25 years | | |
| Salvage Value | -0- | | |

# Financing terms for hypothetical 150 $MW_p$ utility-scale solar PV plant near Bangkok

| Financing Terms | Units | Assumed Values | Remarks |
|---|---|---|---|
| Debt to Equity Ratio | # | Calculated value based on DSCR and IRR | Same for Construction and Operating Periods |
| IRR on equity | % per year | 12% | Nominal IRR = Real IRR |
| Minimum (Min) DSCR | # | 1.20x | • **Min DSCR =** Earnings Before Interest, Taxes, Depreciation and Amortization (EBITDA)/**annual loan payments** (interest + principle)<br>• **Min 1.2x DSCR** means project earns sufficient EBITDA to meet 120% of its annual loan payment. |
| Loan Tenor | Years | 12 | Operating Period |
| Loan Repay. Method | n/a | n/a | Equal Principal, Declining Interest |
| Loan Interest rate | % | 6% | Annual rate, compounded semi-annually, same for construction and operating periods |
| Grace Period before loan repayment starts | months | 12 | Months after COD when 1st operating period loan payment is due |
| Front-end fee | % | 1.50% | % of debt principal paid at financial close |
| Other loan costs | $ | $50,000 | Lump sum catch-all amount paid at financial close |

**LCOE for 150 MW grid-connected, solar PV plants located in Abu Dhabi**

* Case 2 –Bangkok assumptions as per previous slide
* Case 2a –Same assumptions as Bangkok Case 2 except Abu Dhabi location
* Case 2b –Better financing terms (Equity IRR – 7%, Debt: 25 year tenor, 4% I-Rate, no FEF, no res. accts, DE=75:25)

**Bottom-line:** Tariffs recently announced for Sweihan projects in Abu Dhabi require (a) highly concessionary financing terms, (b) a very low equity IRR, and (c) possibly low forward EPC prices.

| | **Case 2** | **Case 2a** | **Case 2b** |
|---|---|---|---|
| Location | **Bangkok** | **Abu Dhabi** | **Abu Dhabi** |
| Land Cost and Non-EPC Capex | $9.9 mill | $9.9 million | $1 million |
| Equity IRR | 10% | 10% | 7% |
| Min DSCR | 1.2x | 1.2x | n/a |
| D-E Ratio | 53 : 47 | 54 : 46 | 75 : 25 |
| Loan Terms | | | |
| Tenor (years) | 18 | 18 | 25 |
| Debt Repayment scheme | Annuity | Annuity | Annuity |
| Loan repayment moratorium | 1st debt payment due 1 year after COD | | |
| Reserve Accounts | 6 months of Debt & O&M Payments | | None |
| **LCOE** | **7.05** | **5.02** | **3.19** |

# Annex 2 Ratio Analysis for 4 Chinese PV solar producers

# Trina Solar 3rd Qtr 2016 Earnings Report

## P&L Summary

| (US$ mm, except margin) | September 30, 2016 | June 30, 2016 | September 30,2015 |
|---|---|---|---|
| Net Revenues | 741.1 | 961.6 | 792.6 |
| Gross Profit | 125.6 | 176.3 | 138.2 |
| Gross Margin (%) | 16.9% | 18.3% | 17.4% |
| Total Operating Expenses | 70.6 | 92.6 | 132.3 |
| Operating Margin (%) | 7.4% | 8.7% | 0.7% |
| Interest Expenses | (28.6) | ( 25.5 ) | (13.1) |
| Income tax benefit (expense) | (5.9) | (16.5) | 3.1 |
| Net income (loss) attributable to Trina Solar Limited | 27.1 | 40.3 | (20.0) |
| Net Margin[1] (%) | 3.7% | 4.2% | (2.5%) |

[1] Net Margin=Net income attributable to Trina Solar Limited / Net Revenues

Trinasolar

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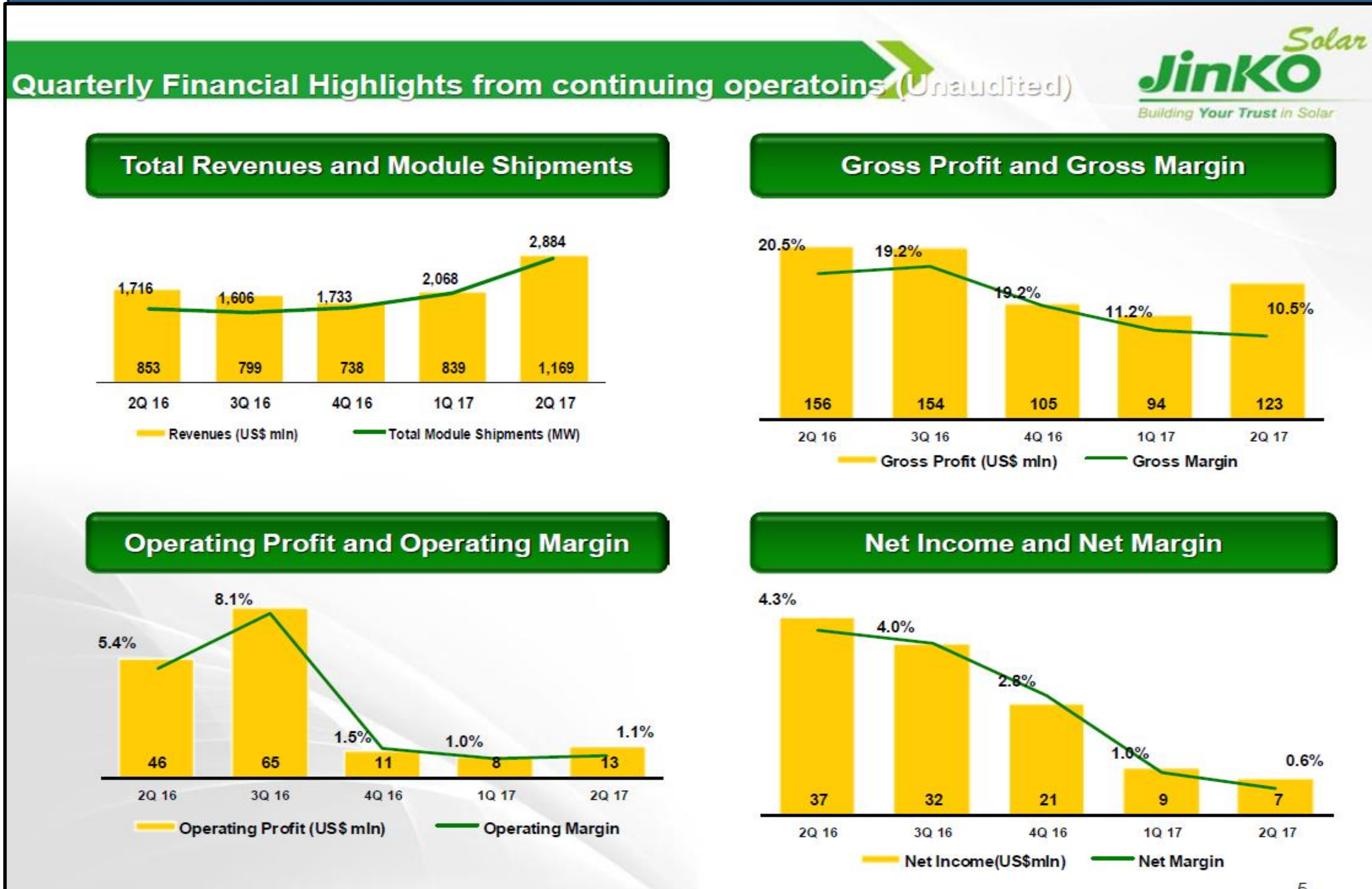
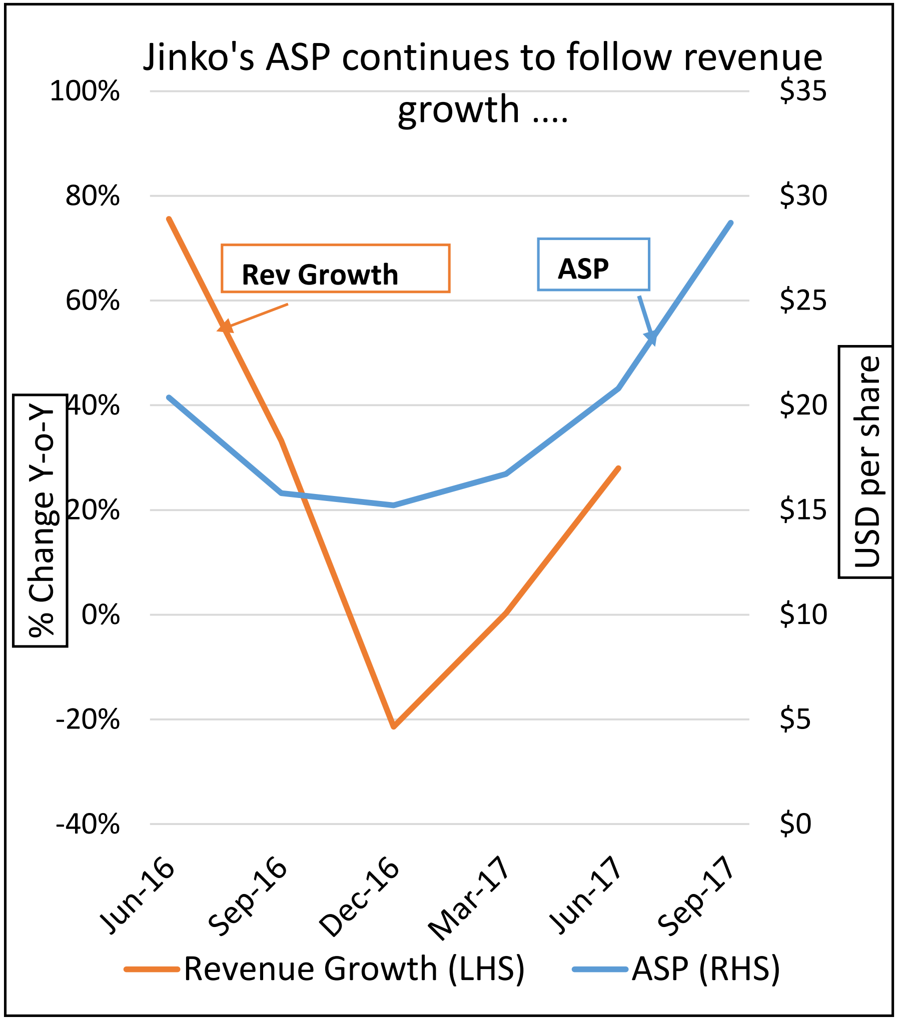
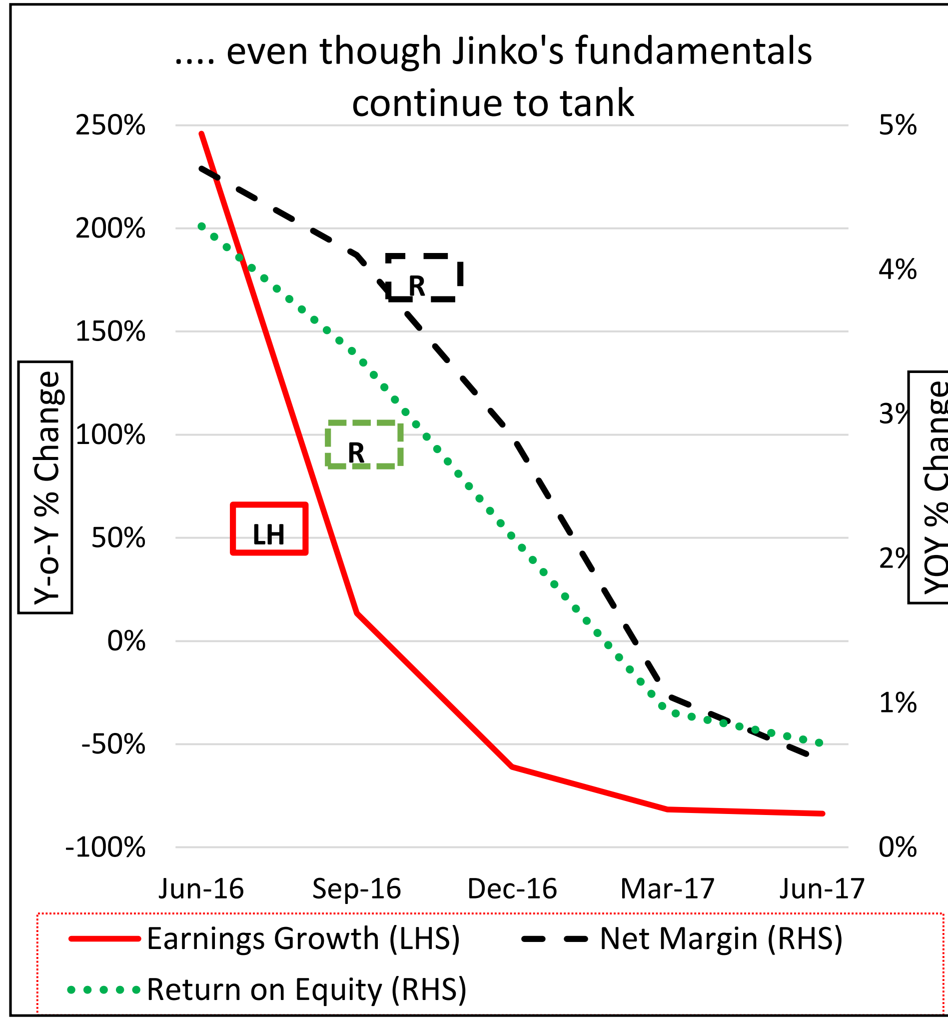
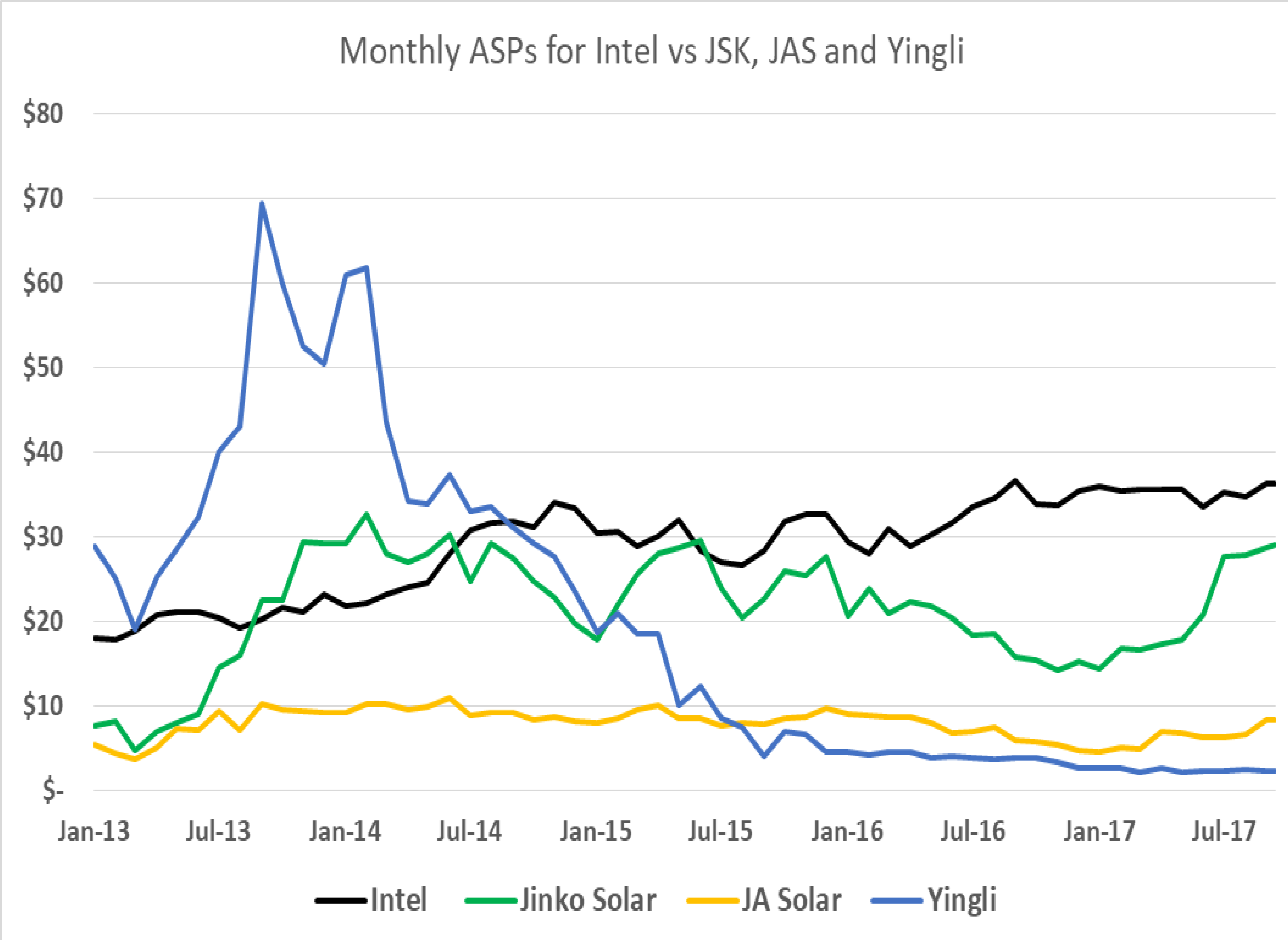
# Jinko Solar 1st Qtr 2017 Earnings Report



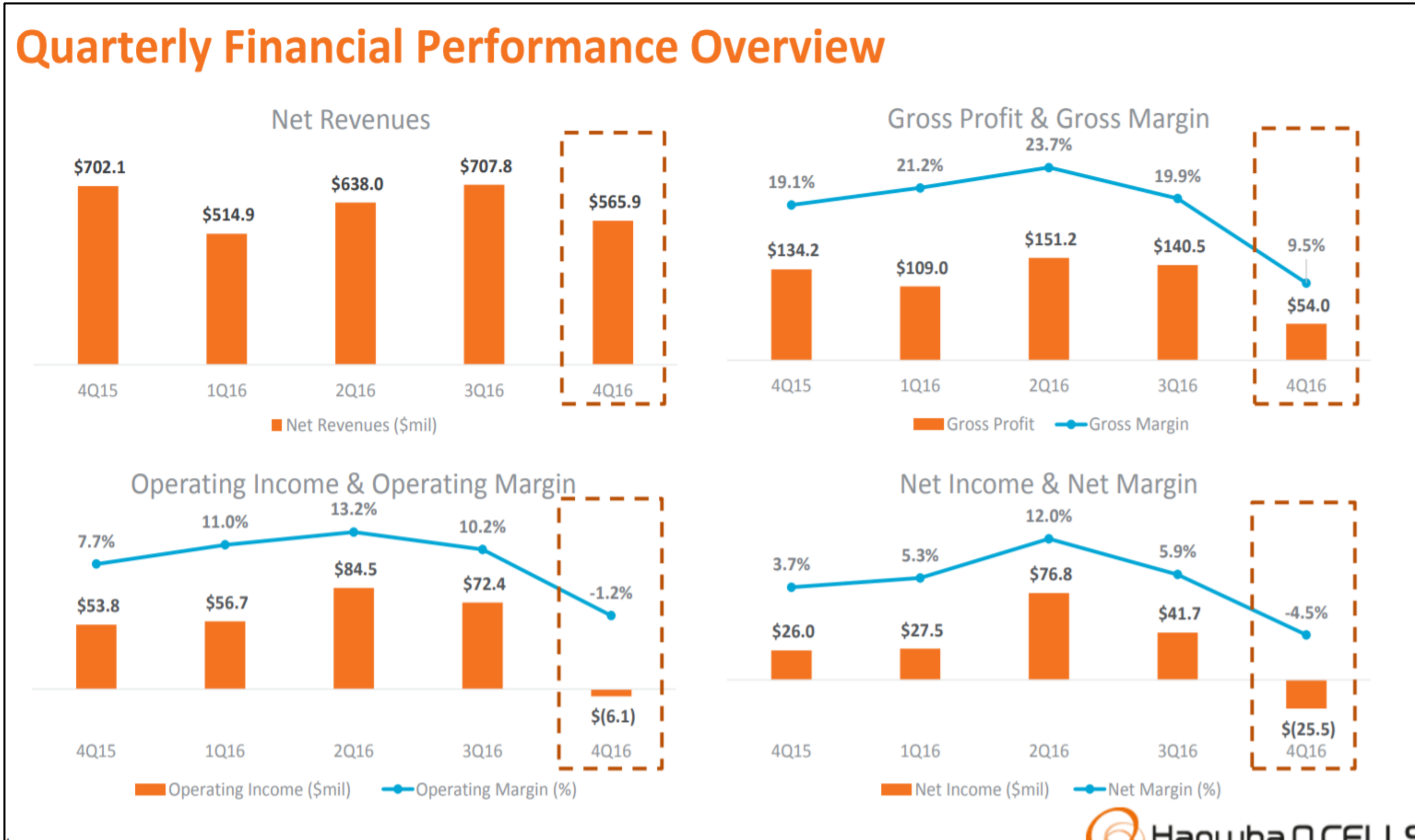

Jinko's ASP continues to follow revenue growth ....
100%
80%
60%
40%
20%
0%
-20%
-40%
$35
$30
$25
$20
$15
$10
$5
$0
% Change Y-o-Y
USD per share
Rev Growth
ASP
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Sep-17
Revenue Growth (LHS)
ASP (RHS)


.... even though Jinko's fundamentals continue to tank
250%
200%
150%
100%
50%
0%
-50%
-100%
5%
4%
3%
2%
1%
0%
Y-o-Y % Change
YOY % Change
R
R
LH
Jun-16
Sep-16
Dec-16
Mar-17
Jun-17
Earnings Growth (LHS)
Net Margin (RHS)
Return on Equity (RHS)



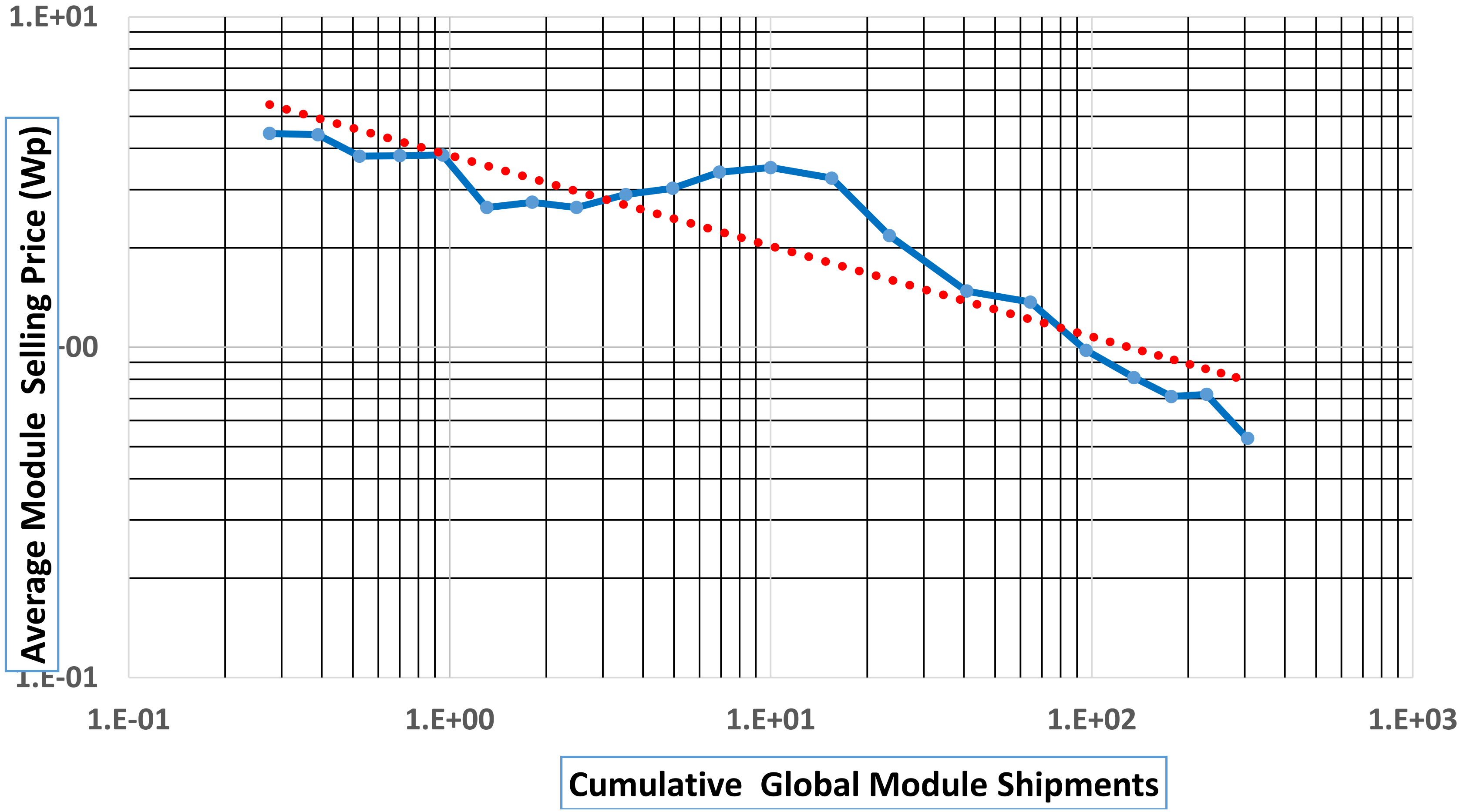
Monthly ASPs for Intel vs JSK, JAS and Yingli
$80
$70
$60
$50
$40
$30
$20
$10
$-
Jan-13
Jul-13
Jan-14
Jul-14
Jan-15
Jul-15
Jan-16
Jul-16
Jan-17
Jul-17
Intel
Jinko Solar
JA Solar
Yingli

# Non-Chinese solar PV players such as Hanwha Q-cells, are also suffering

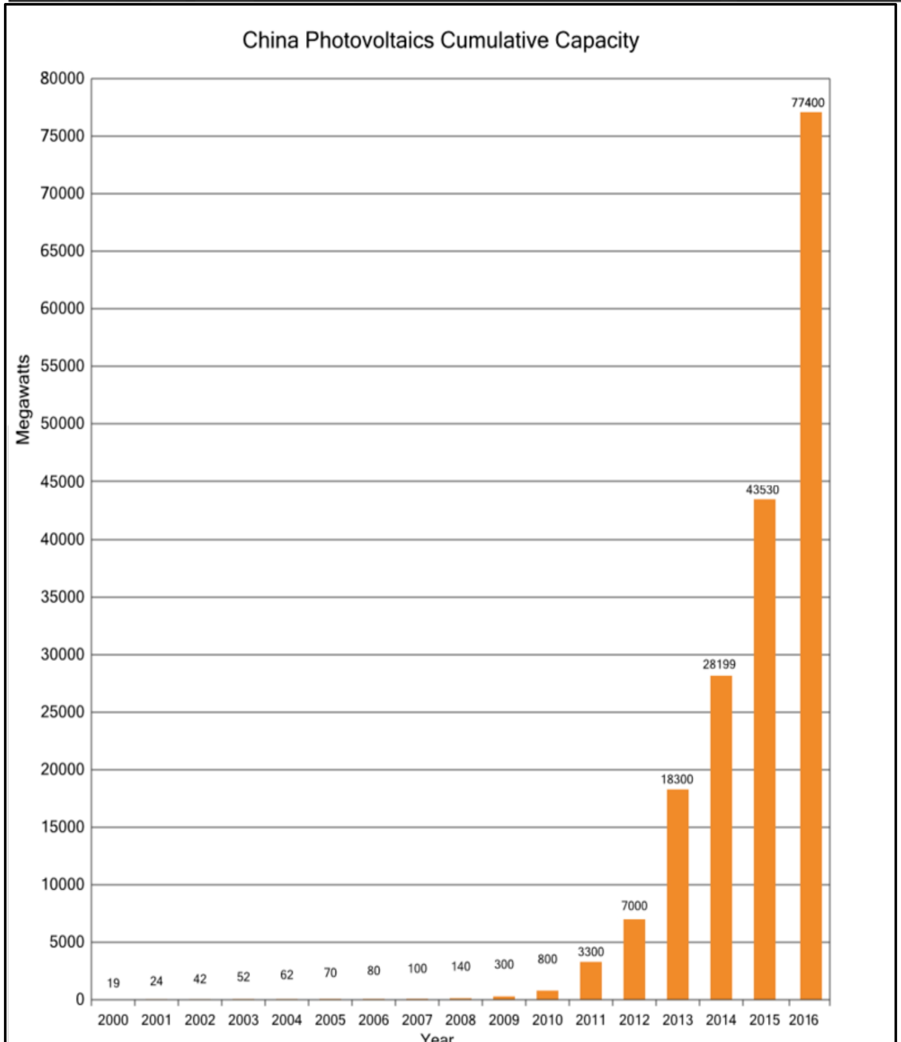


# Annex 3 Other Slides

# Log-Log Plot + Trendline of Module Nominal ASPs and Cumulative Global Module Shipments using 1996 to 2016 data



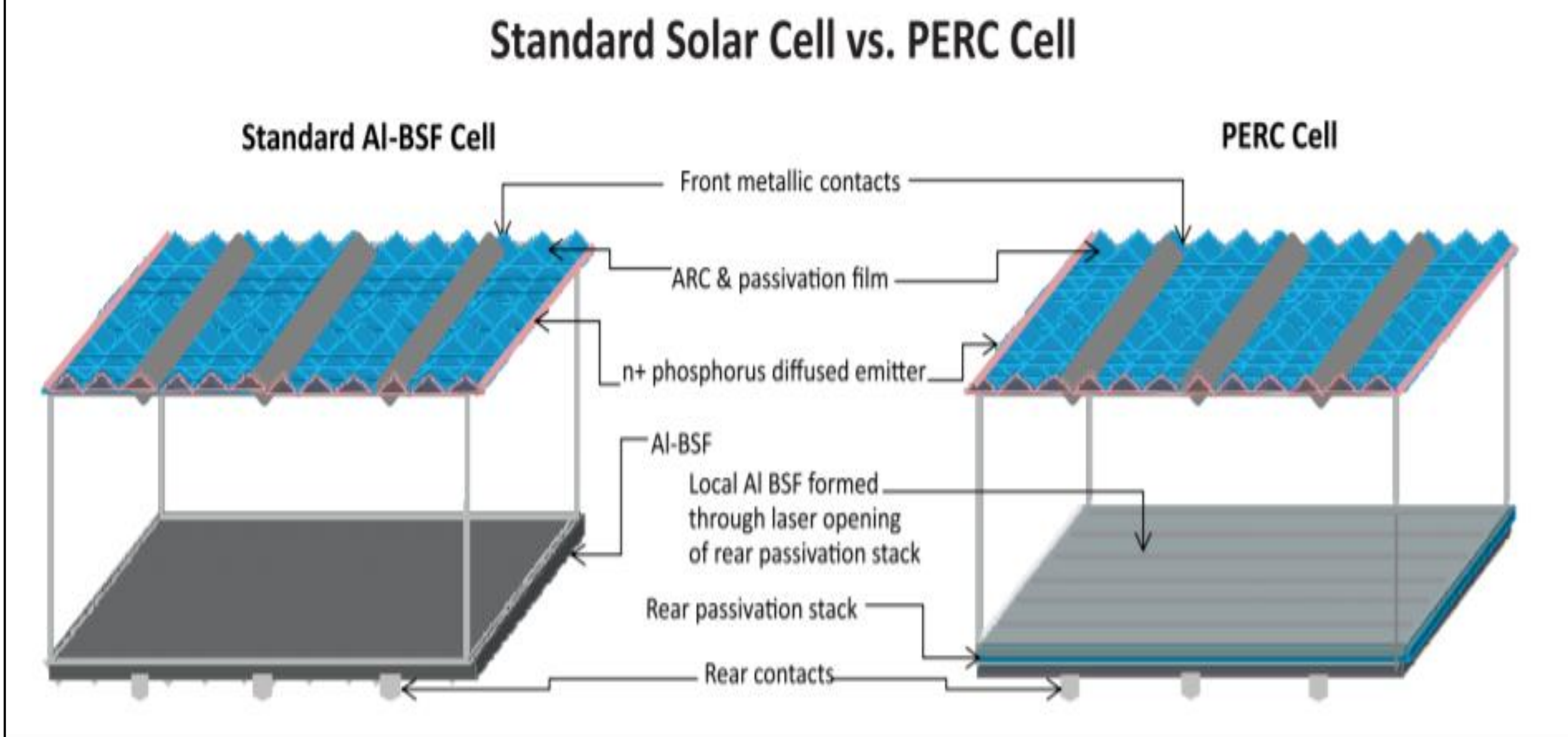
## Tremendous growth in the Chinese PV industry has reinforced SPD belief that panel prices will continue to drop




## However, China's PV industry is on verge of major shake-out that will lead to a reduction in PV industry capacity and lead to price increases.

- **SolarWorld AG and Suniva** declared bankruptcy due to Chinese predatory pricing.
- **SunPower** is in a precarious financial position while **Hanwha Q Cells of Korea is** experiencing low margins
- **All segments of China's solar PV industry** are suffering financially due to (i) overcapacity, (ii) anti-dumping duties imposed in the US and elsewhere, and (iii) low silicon and panel prices worldwide.
- **Yingli** has been in default on several loan agreements since 2012 and is arguably already bankrupt.
- On 22 Sept, **US ITC** voted 4-0 in favour of Suniva's Section 201 trade case; may result in a minimum module price of $0.78/W$_p$ and/or import quotas on Chinese and Taiwanese modules for up to 4 years. **Ultimate irony:** Suniva is from PRC.
- **Trina, Jinko Solar, and JASolar** - financially weak with high debt levels, low net margins. Except for JA Solar, they all have current/quick ratios at or below 1. (next 2 slides)
- If not for recent rush to implement new PV projects in China, an industry shake-out of Chinese PV industry would most likely have already occurred.
- **Higher prices = Cure to what ails PRC PV industry.**

* *PERC technology has required 30 years between proof of concept in the lab and its nascent commercial implementation.*
* *Hard pressed solar PV cell manufacturers will need to invest in new equipment to make transition to PERC cells.*




*Few changes: The PERC architecture is all about adding rear surface passivation to the standard cell, as shown in this graphic.*