The Economics of Solar Power

Solar Roundtable
Kansas Corporation Commission

March 3, 2009

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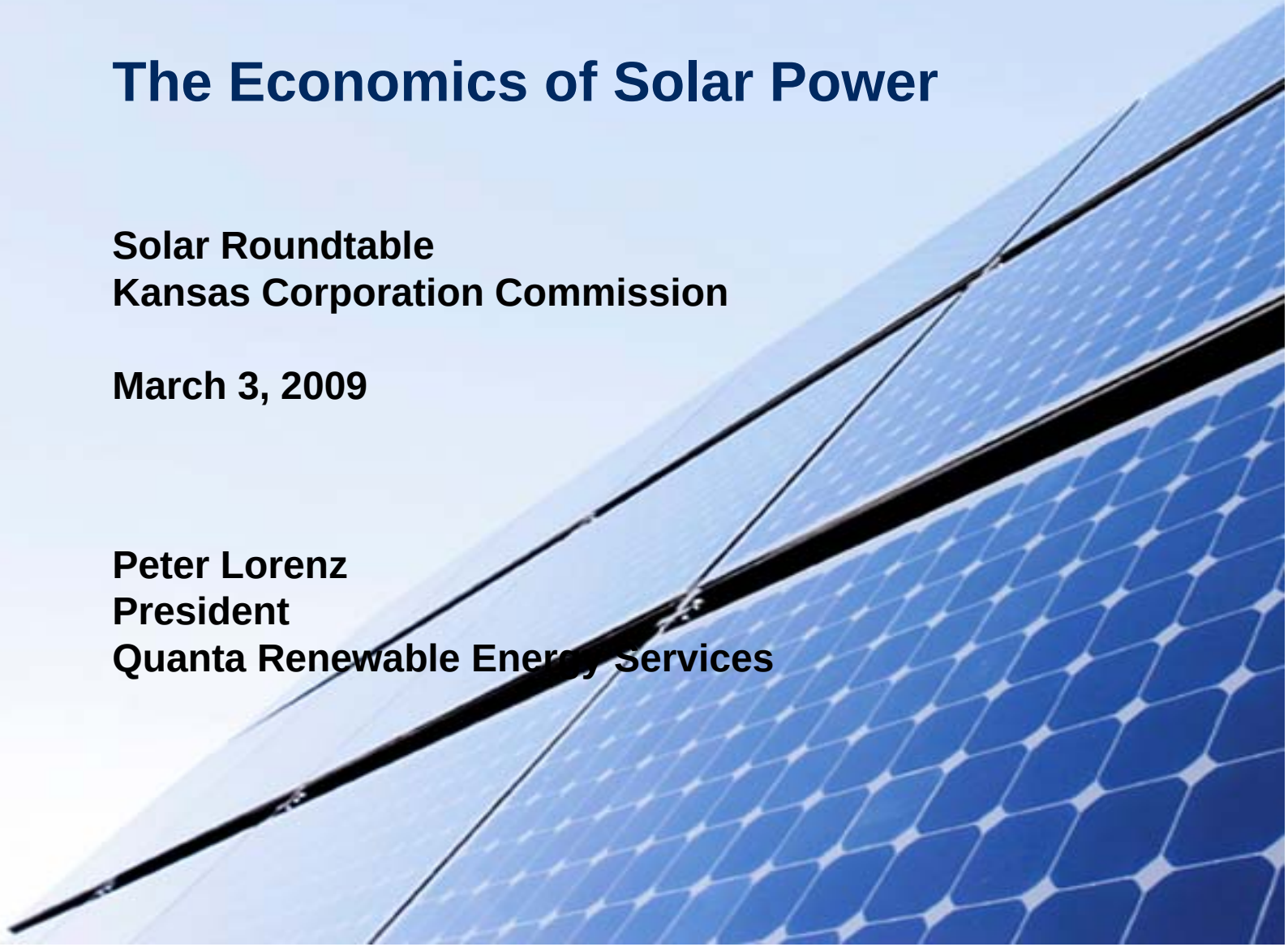
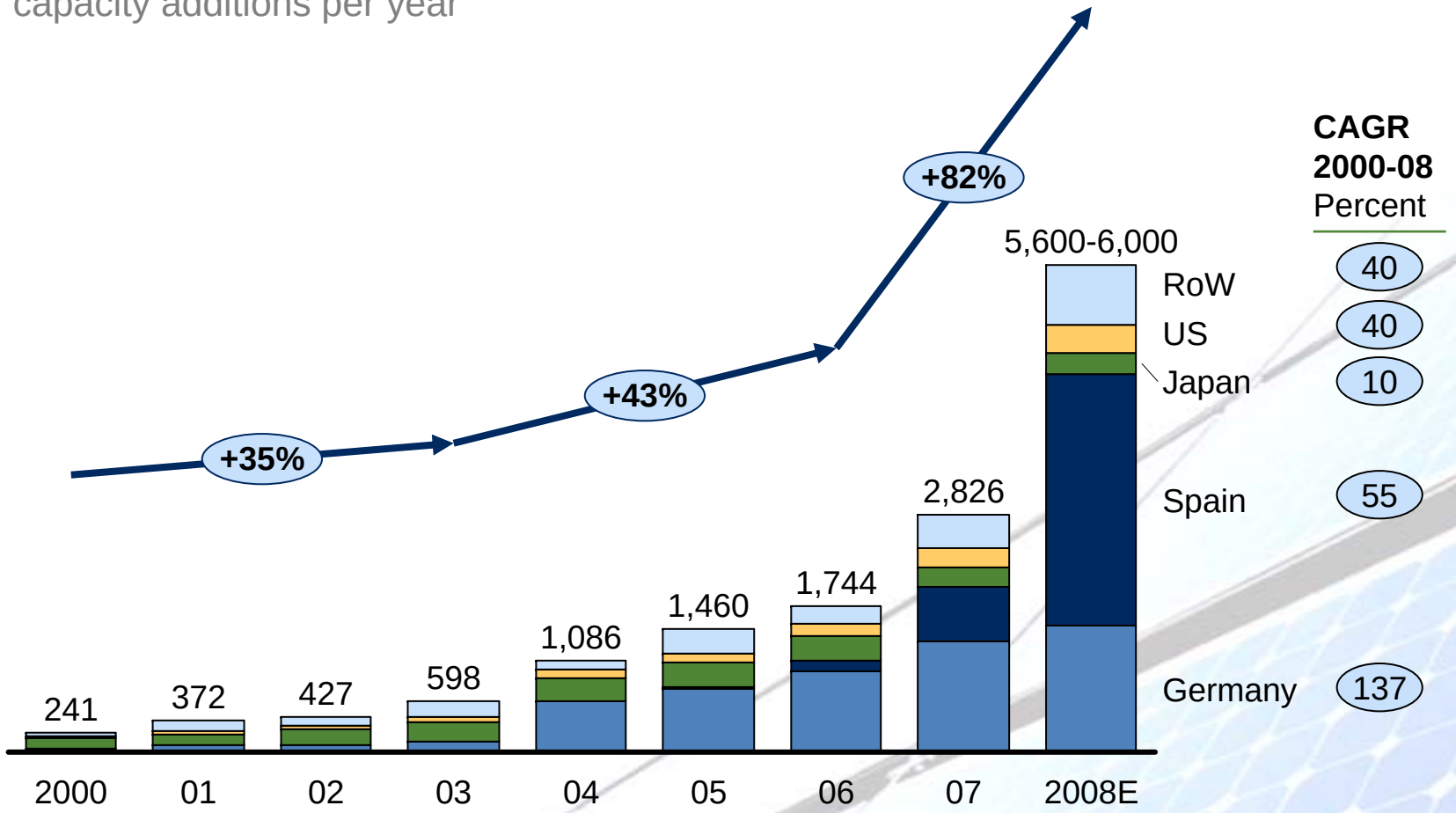


SOLAR POWER - BREAKTHROUGH OR NICHE OPPORTUNITY?

MW capacity additions per year



Demand driven by attractive economics

- Strong regulatory support
- Increasing power prices
- Decreasing solar system prices
- Good availability of capital

Source: McKinsey demand model; Solarbuzz

WE HAVE SEEN SOME INTERESTING CHANGES IN THE U.S. RECENTLY

TODAY'S DISCUSSION

- **Solar technologies and their evolution**
- Demand growth outlook
- Perspectives on solar following the economic crisis

TWO KEY SOLAR TECHNOLOGIES EXIST

	Photovoltaics (PV)	Concentrated Solar Power (CSP)
		
Key characteristics	• Uses light-absorbing material to generate current • High modularity (1 kW - 50 MW) • Uses direct and indirect sunlight – suitable for almost all locations • Incentives widely available • Mainly used as distributed power, some incentives encourage large solar farms	• Uses mirrors to generate steam which powers turbine • Low modularity (20 - 300 MW) • Only uses direct sunlight – specific site requirements • Incentives limited to few countries • Central power only limited by adequate locations and transmission access
Global capacity GW, 2007	~ 10	~ 0.5

Source: McKinsey analysis; EPIA; MarketBuzz

THESE HAVE SEVERAL SUB-TECHNOLOGIES

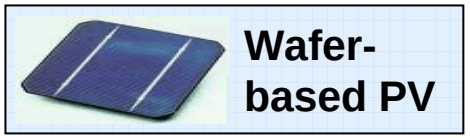
	Key technologies	Sub technologies	Description	Development
Photo Voltaics (PV)	1  **Wafer-based PV**	• Mono-crystalline • Poly-crystalline	• Uses solar cells combined to modules to generate electricity	Commercial
	2  **Thin film**	• Amorphous silicon (a -Si) • Cadmium telluride (CdTe) • Copper indium gallium selenide (CIGS)	• Thin layer of glass, steel, and semiconductor material used to convert light directly into electricity	Commercial
		• Nano • Organic dye	• Mixture of flexible polymer substrates with nano materials • Flexible PV using plastic as substrate	Laboratory phase
	3  **Con-cen-trating PV**	• N/A	• Mirrors used to concentrate light onto cells to increase effectiveness	Pilot
Solar thermal	4  **Para-bolic trough**	• Without storage or hybrid fossil • With storage • With storage and hybrid fossil	• Parabolic mirrors concentrate sunlight on a tube filled with heat transfer fluid • Heated fluid powers steam turbine	Commercial
	5  **Dish-stirling**	• N/A	• Solar energy converted to heat in a dish collector drives stirling engine, a heat engine that does not require water supply	Pilot
	6  **Power tower**	• Without storage or hybrid fossil • With storage • With storage and hybrid fossil	• Sun-tracking mirrors focus sunlight on a receiver at the top of a tower which heats water to produce electricity	Pilot

Source: Research reports; Wikipedia; team analysis

BOTH MAJOR PV TECHNOLOGIES HAVE COMPELLING COST REDUCTION ROADMAPS

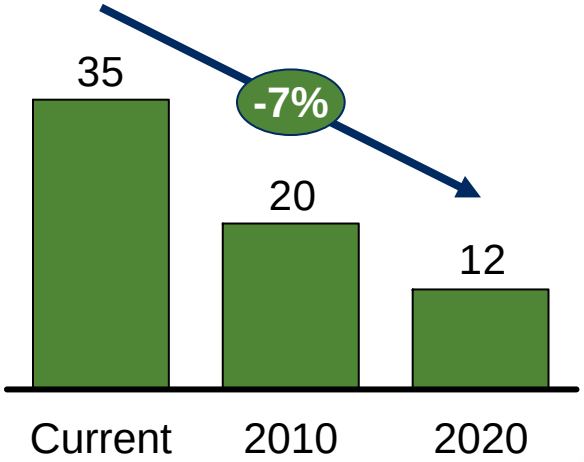
Competes against retail rates
Competes against wholesale rates

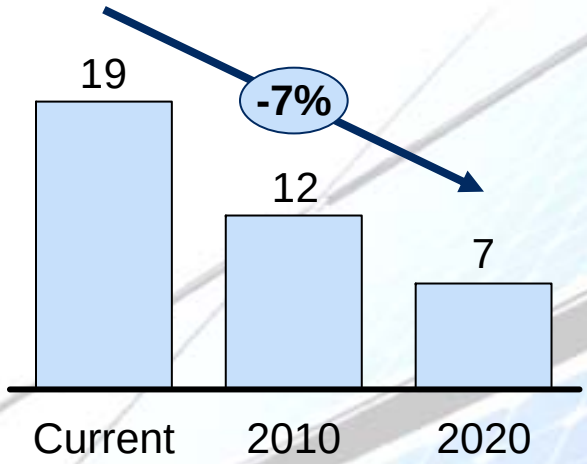
Full generation cost
¢$/kWh



Wafer-based PV

Thin film





Key drivers
1. **Technology evolution**
2. **Manufacturing improvements**
3. **Margin contraction**

* Systems located in Southern California; yearly O&M of 0.25% of initial investment; 1% yearly degradation for c-Si, 2% for thin film; 25 years useful life
** Based on a 10 MW plant; two axis tracking system; $ 5.85/Wp full installation cost for c-Si, $ 5.43/Wp to $ 6.27/Wp of thin film; 10% Investment Tax Credit (assumes tax credit reduction to 10% after expiration of current 30% credit on Dec 31, 2008) and 5 years accelerated depreciation
*** Based on a 3 kW residential system; $ 7.5/Wp full installation cost.
Source: NREL; Fraunhofer Institute; DOE; McKinsey analysis

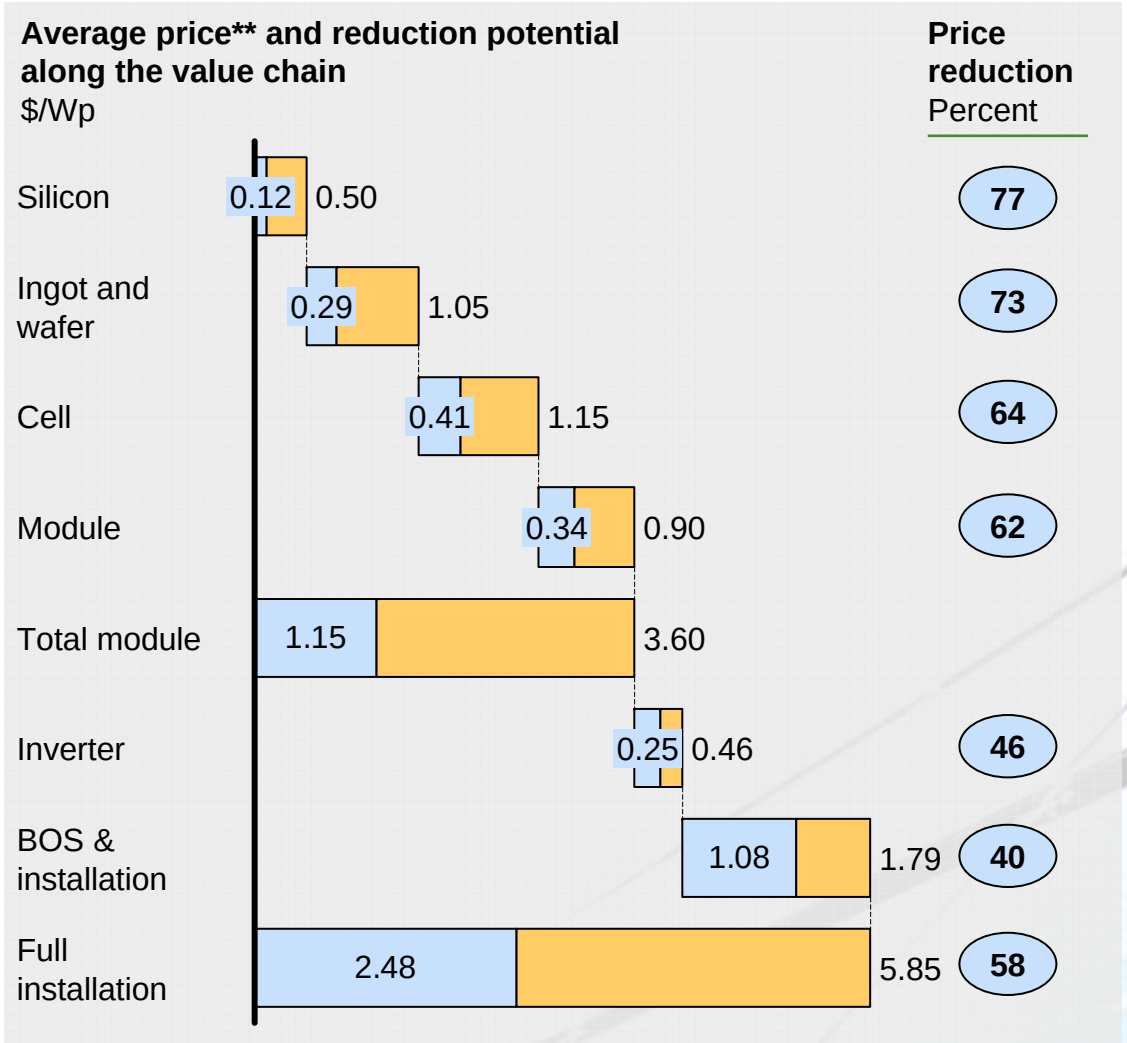
FULL INSTALLATION PRICE FOR WAFER-BASED PV IS EXPECTED TO DECREASE BY ~60% UNTIL 2020

WAFER-BASED PV

Total= 2006 price

2020 price

Price reduction



Key drivers

Technological innovations
- Thinner wafers
- Optimized cell design

Manufacturing improvements
- New manufacturing technology
- Increased automation and scale
- Standardization

Margin contraction
- Silicon supply situation
- Increased competition

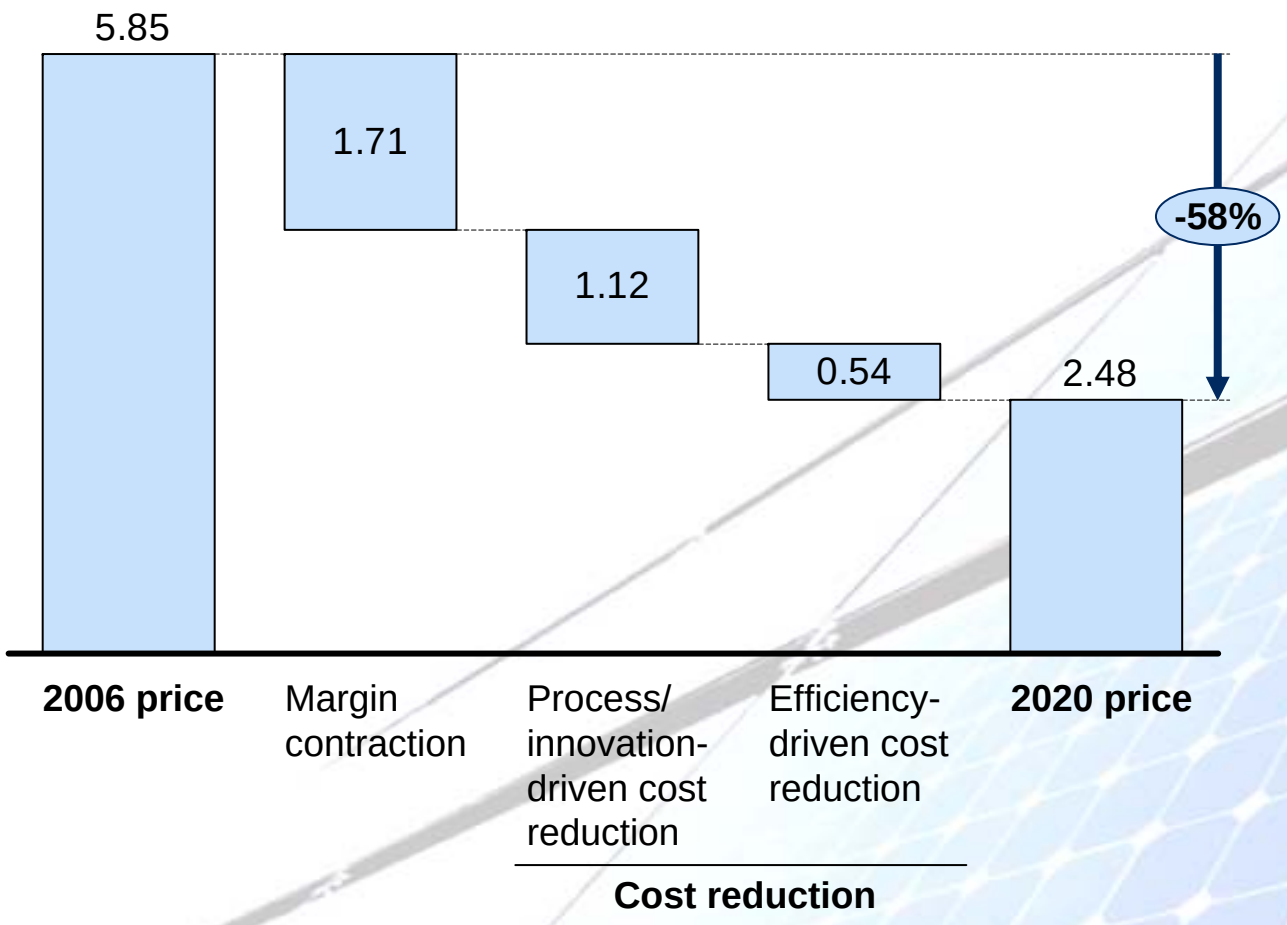
* Based on efficiency gain from 14% to 20%, margin contraction from ~38% to ~21%, 80% market share of wafer-based PV in 2020, ~20% experience curve's progress rate

** Based on cost of large commercial/industrial PV system

Source: DOE; NREL; Photon; McKinsey analysis

EXPECTED PRICE REDUCTION WILL COME FROM COST IMPROVEMENTS AND MARGIN CONTRACTION*

Average system prices and reduction potential
Dollars/Wp

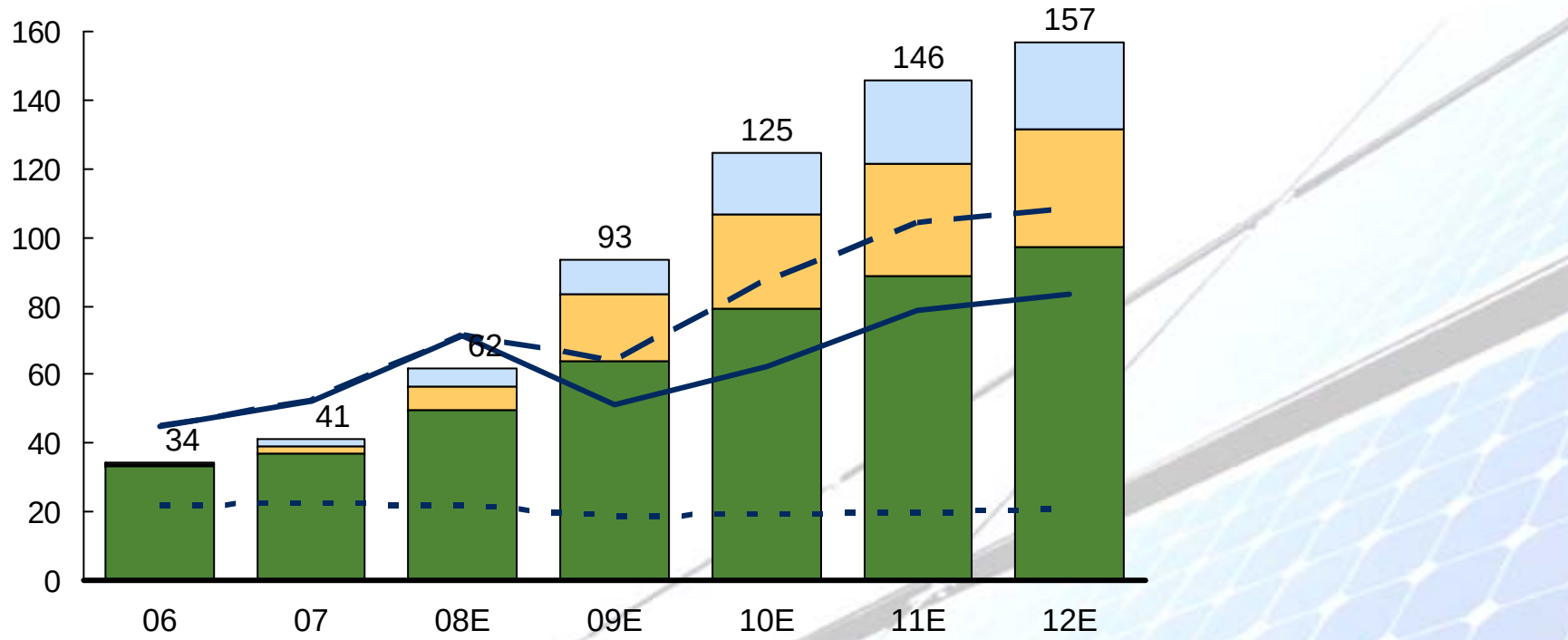


* Based on efficiency gain from 14% to 20%, margin contraction from ~38% to ~21%, 80% market share of wafer-based PV in 2020, ~20% experience curve's progress ratio

Source: DOE, NREL, Photon, Santa Fe Institute, McKinsey analysis

SILICON IS MOVING INTO OVERSUPPLY THROUGH 2012

Total virgin silicon production volume* and demand**
Thousand MT



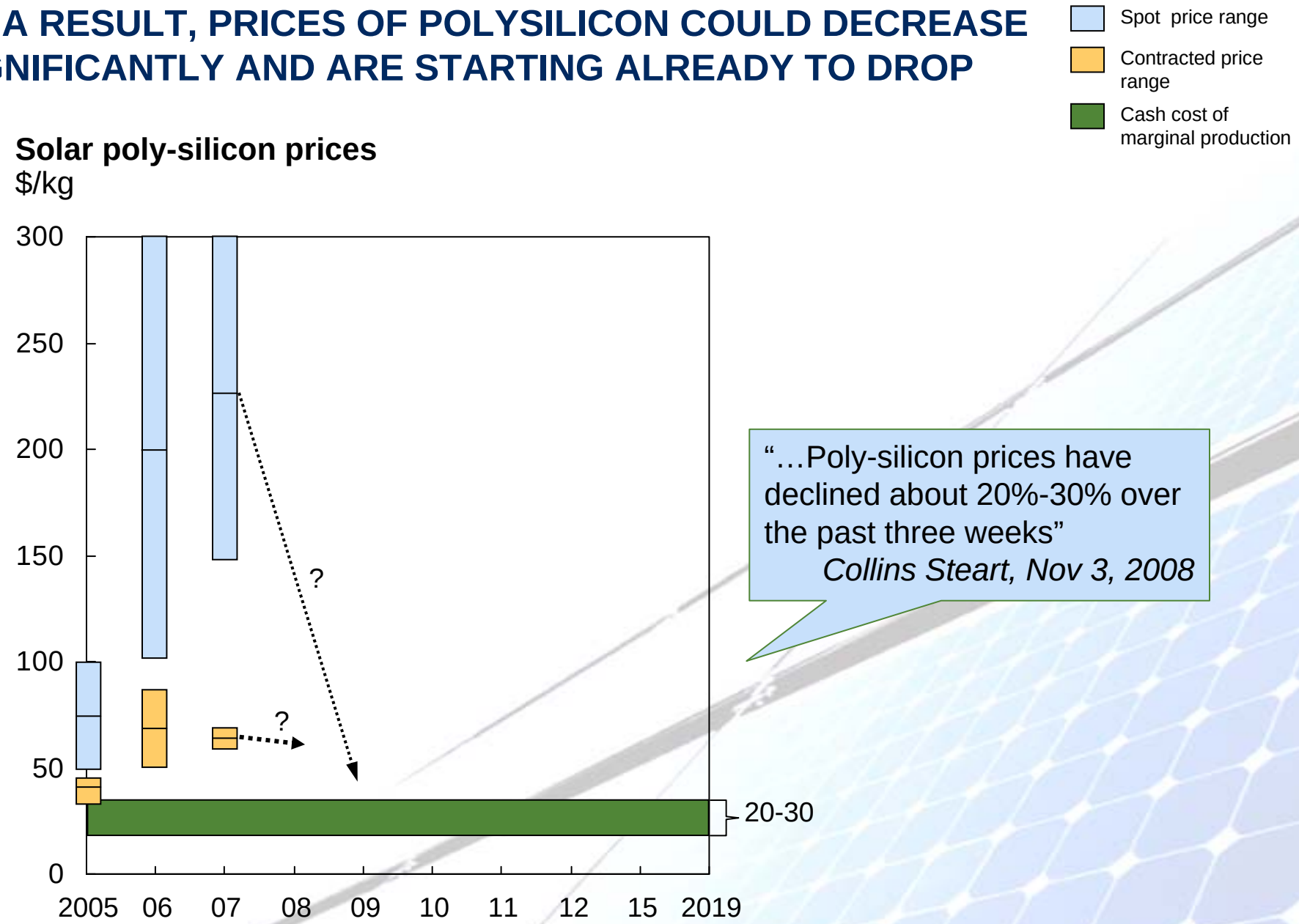
	06	07	08E	09E	10E	11E	12E
PV demand GWp	**1.9**	**2.9**	**5.8**	**4.4**	**6.6**	**9.6**	**11**
(upside)				(6.1)	(10.4)	(13.7)	(15.2)

* Production volume estimated based on company announcements with adjustments to production from new entrants

** Demand includes both semiconductor and solar PV industry; Assuming demand from semiconductor industry drop by 16% in 09 and grows at 4% afterwards; Demand from Solar PV assumes silicon usage of 8.2 g/Wp in 2008, 7.4 g/Wp in 09 with continuous improvement through 2012

Source: Prometheus; Solarbuzz LLC; Company announcements; McKinsey analysis

AS A RESULT, PRICES OF POLYSILICON COULD DECREASE SIGNIFICANTLY AND ARE STARTING ALREADY TO DROP

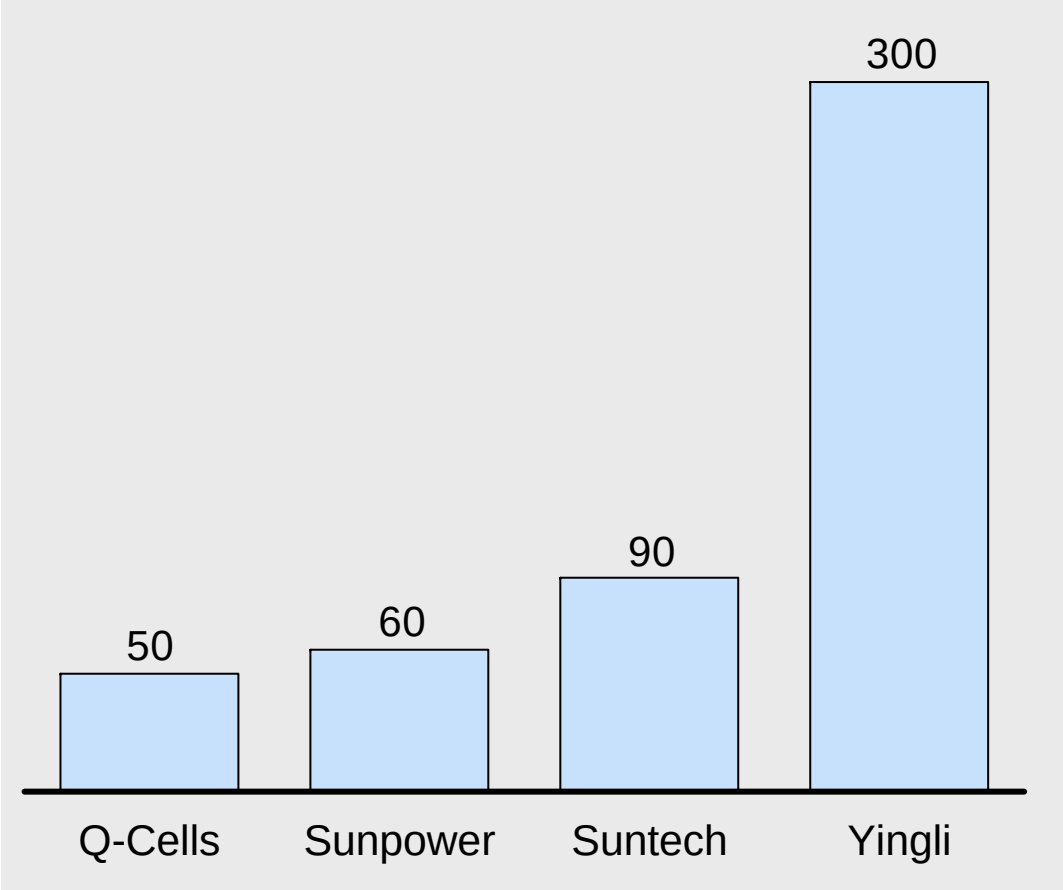


Source: Team analysis

AND THE SILICON COST POSITION OF LEADING C-SI PLAYERS COULD SIGNIFICANTLY CHANGE

ESTIMATE

Silicon price, $/kg



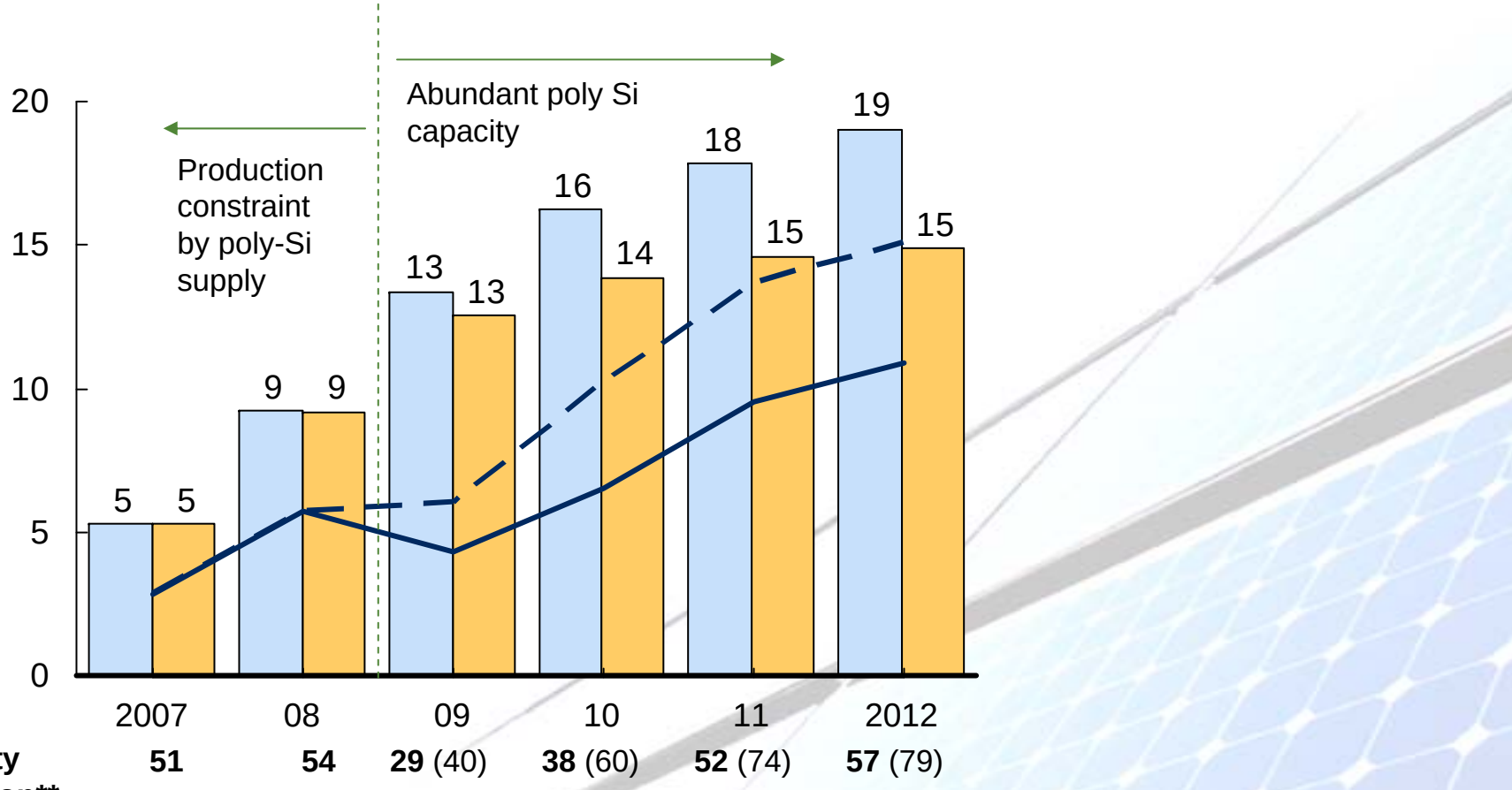
- Q-Cells and Sunpower secured long-term silicon supply contracts at relatively low cost before other players entered the market
- Suntech has a mix of long-term supply contracts and higher priced short-term contracts to fill the gap
- Yingli almost exclusively buys silicon on the spot market due to late market entry

Note: Does not take into account differences in silicon usage and cell efficiency

CELL AND MODULE OVERCAPACITY INTENSIFY WITH EASE OF FEEDSTOCK SHORTAGE

c-Si Cell and Module Average Production Capacity* and Demand

GWp



* Average capacity is average of year-beginning and year-end capacity; capacity based on company announcements with adjustments made to new capacity in 09 onwards as many companies announced reduction of capex in 09 and postpone of future capacity addition

** C-Si module capacity utilization based on total PV demand and assumed thin film market share of 15%-22% throughout 2012; Numbers in brackets represent utilization rates with lower range of demand

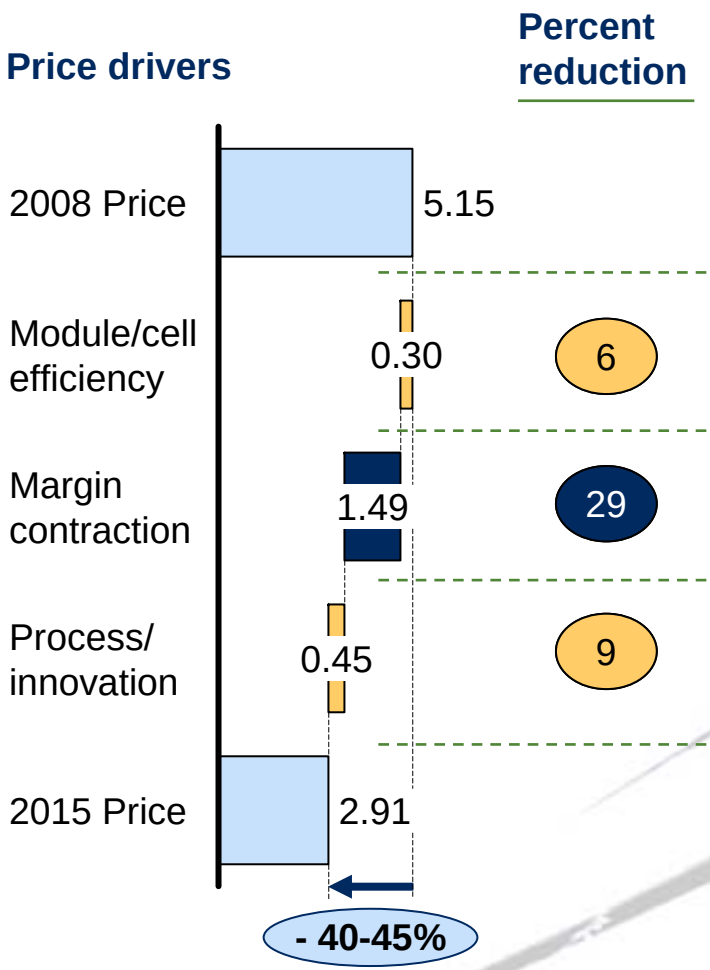
Source: Prometheus; Solarbuzz LLC; iSuppli; company announcements; McKinsey analysis

CDTE TECHNOLOGY IS PROJECTED TO SEE A ~45% COST REDUCTION

PRELIMINARY

$/Wp

Average prices and reduction potential



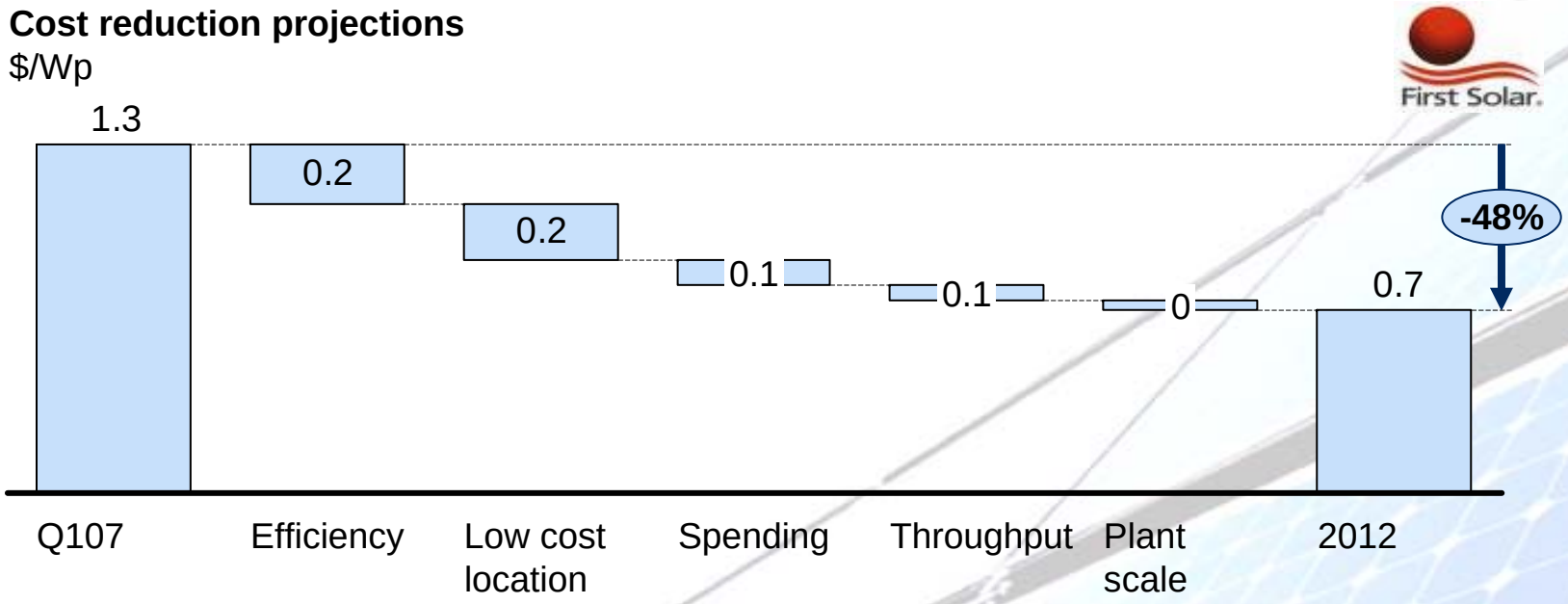
Drivers*

- Efficiency increase from 9.5% to 11%
  - More transparent glass
  - Reduced operating temperatures
  - Reduced resistive power losses
- Margin contraction from ~39% to ~19%
  - Wafer-based PV price declines will force thin film prices to follow in order to remain competitive
- Process and innovation driven improvements could result in 10%+ cost decrease
  - Reducing cycle time (module in to module out)
  - Increasing yield and uptime
  - Recycling active materials
  - Thinner CdS window
  - Better electron transportation and current collection
  - Larger modules

* 8.8% market share in 2015, 15% experience curve's progress ratio

Source: DOE; NREL; Prometheus; Photon; analyst reports; team analysis

LEADING CDTE PLAYER TARGETS 48% REDUCTION IN MODULE COST BY 2012



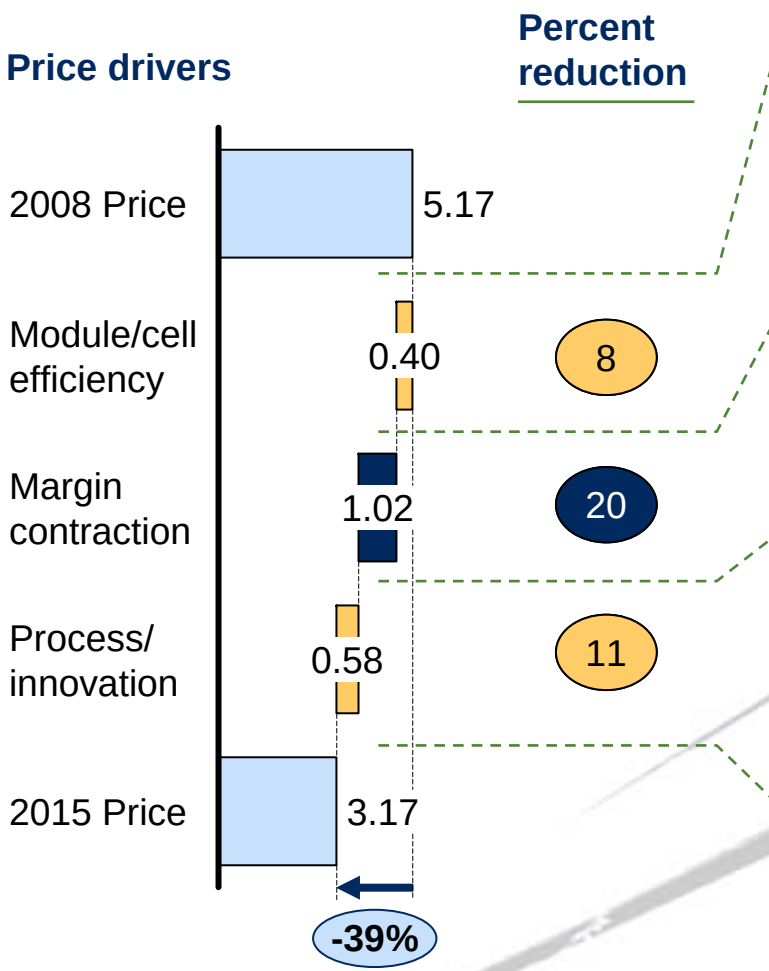
Source: Company websites; analyst reports

A-SI IS PROJECTED TO SEE A ~40% COST REDUCTION

PRELIMINARY

Dollars/Wp

Average prices and reduction potential



Drivers*

- Efficiency gain from 7.6% to 9.2%
  - More transparent and textured glass
  - Reduced resistive power losses
  - Reduce operating temperature through encapsulations
- Margin contraction from ~28% to ~14%
  - Wafer-based PV price declines will force thin film prices to follow in order to remain competitive
  - More competitors will drive prices down
- Increased purchasing power
- Reduction in capital expenditure per watt
- Faster deposition speeds
- Wider substrates
- Installation cost reduction

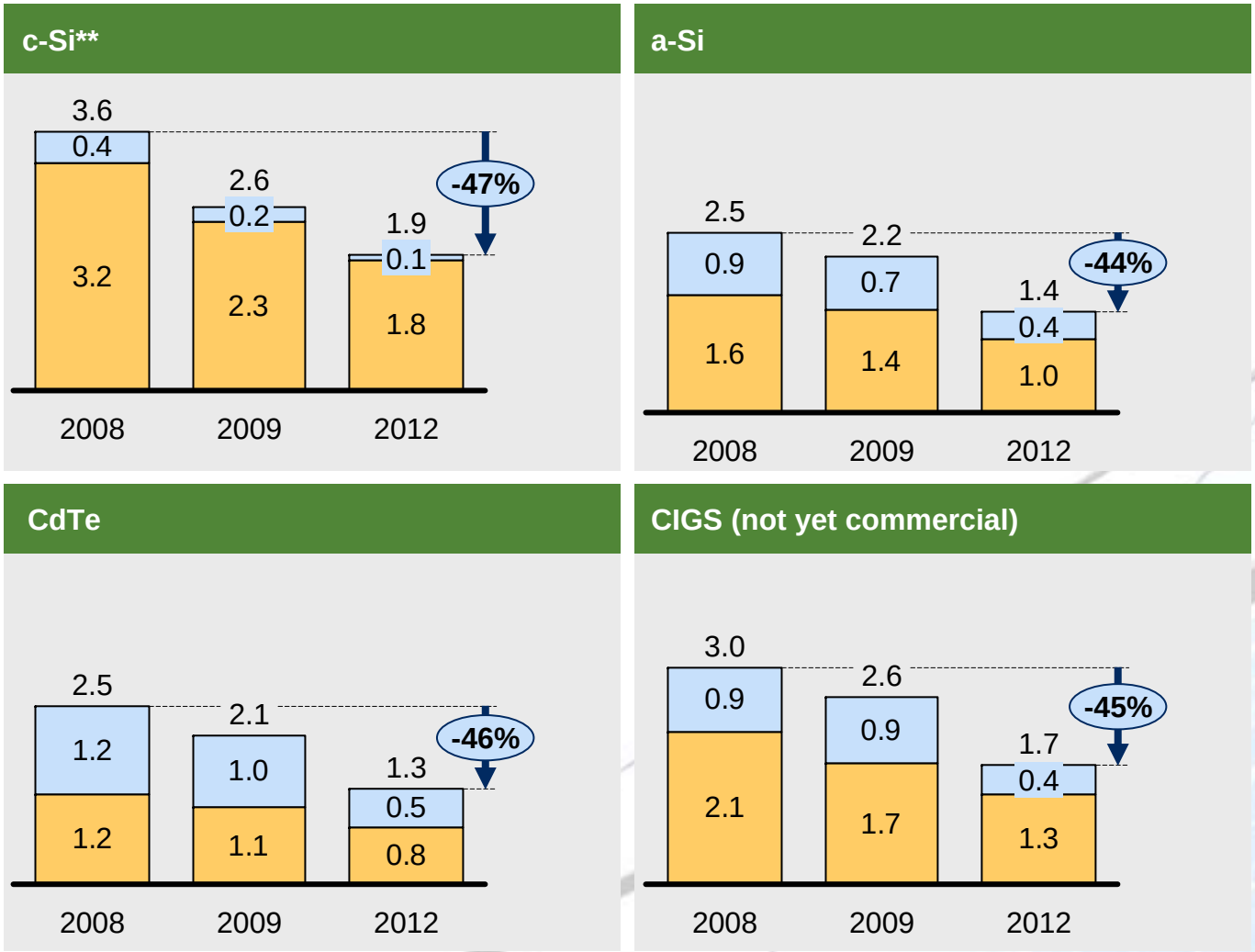
* 22% market share of thin film PV in 2015, 19% experience curve's progress raio

Source: DOE; NREL; Prometheus; Photon, analyst reports; team analysis

MODULE PRICES AND COST ARE EXPECTED TO DECREASE RAPIDLY IN THE NEXT 4 YEARS

PRELIMINARY

Average module price and cost by technology*, $/Wp



* Actual prices and costs range based on product characteristics (e.g. size, efficiency, sub-technology), markets, and customer segments

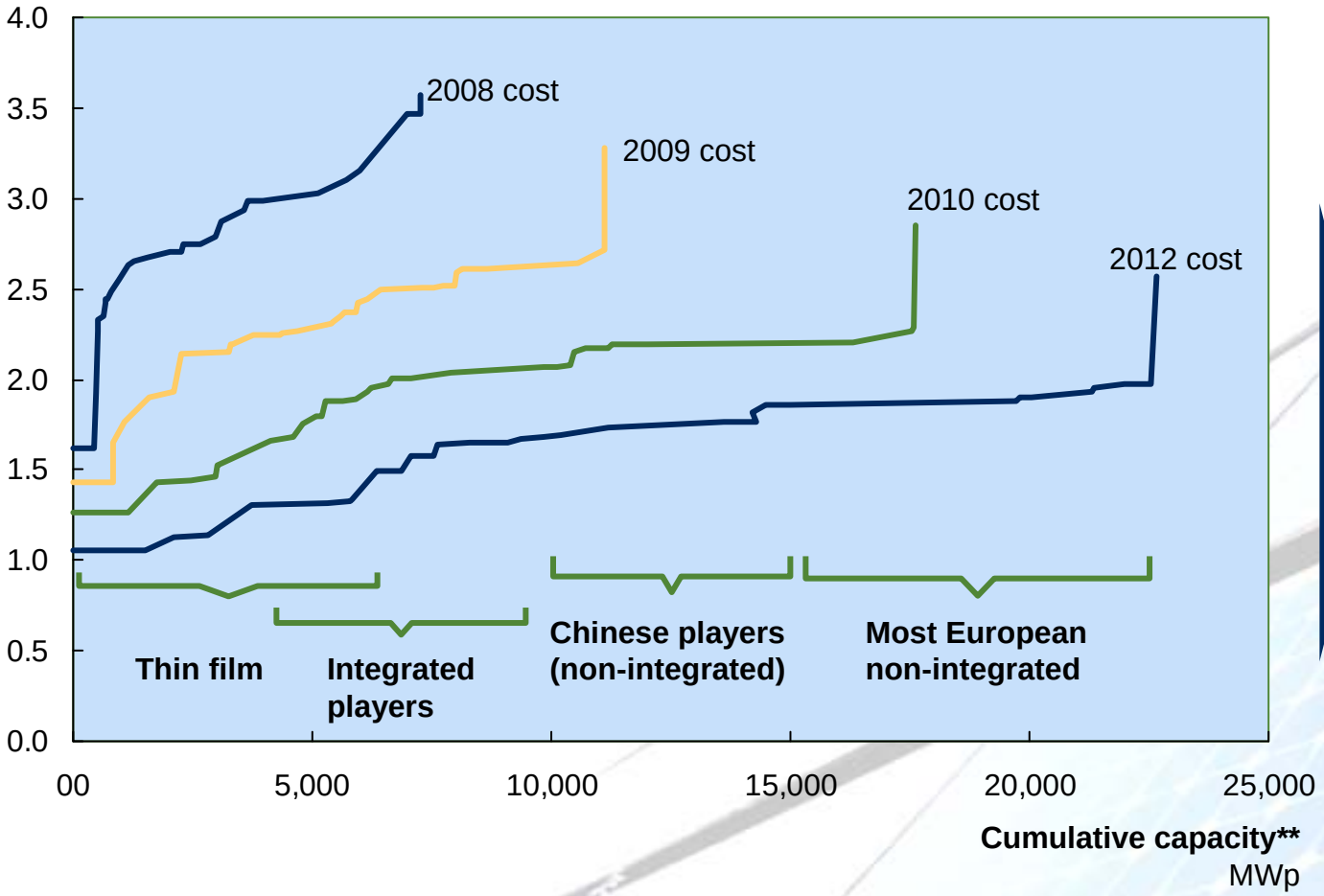
** Considers only the margin of the module producer. Some additional margin is captured by silicon, wafer and cell players along the value chain

Source: Deutsche Bank; Merrill Lynch; Nomura, Solarbuzz; McKinsey analysis

MODULE COST CURVE IS FLATTENING DRIVEN BY DECREASE IN SPOT SILICON PRICES AND THIN FILM EXPANSION

PRELIMINARY

Module production operating cost
$/Wp, Efficiency adjusted *



- Abundant Si supply will unlock capacity and drive down cost significantly
- Continued expansion of thin film
- No winning technology yet
- Pressure on European/U.S. nonintegrated players

* Adjustment made based on estimated difference in balance of system cost driven by efficiency
** Productive capacity in 08 and 09 constraint by Si supply and average module capacity for 2010 and 2012

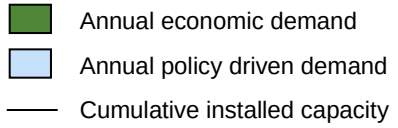
Source: Company announcements; Prometheus; McKinsey analysis

TODAY'S DISCUSSION

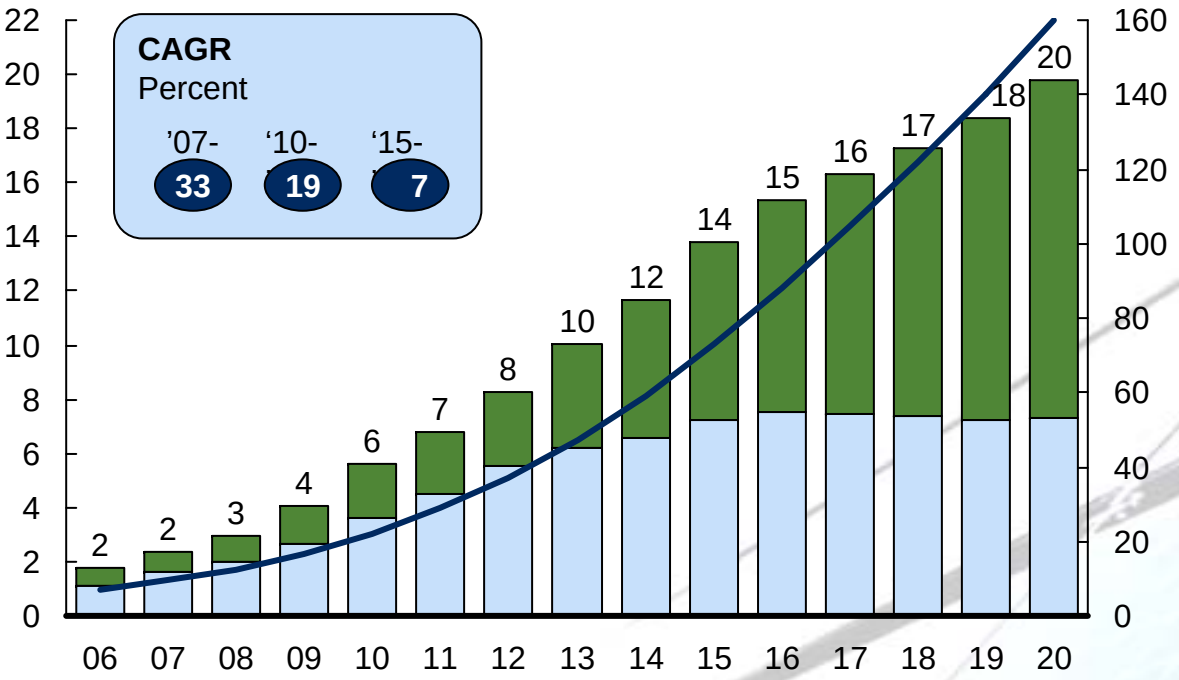
- Solar technologies and their evolution
- **Demand growth outlook**
- Perspectives on solar following the economic crisis

WE EXPECT TOTAL INSTALLED BASE OF 160 GW FOR SOLAR AND ANNUAL PV ADDITIONS OF ~20 GW BY 2020

McKINSEY BASE CASE MODEL



Annual PV capacity additions
GW



Cumulative installed PV capacity
GW

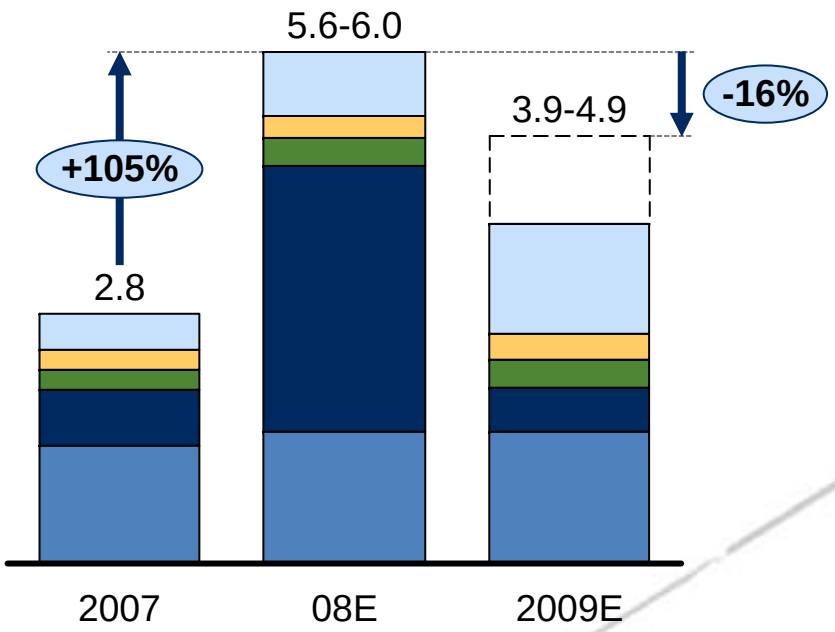
Aggressive case

- Total installed base of ~300GW
  - ~8 GW by 2010
  - ~43 GW by 2020
- Short-term growth
  - Favorable/additional programs (e.g., Mexico, Australia, India)
  - PV included in utilities rate base in U.S.
- Medium to long-term growth
  - Strong momentum for climate change in developing countries (e.g., India, China)
  - System optimization through distributed generation

Source: McKinsey proprietary demand model

GLOBAL PV DEMAND IS LIKELY TO RETURN TO HISTORICAL GROWTH TRACK IN 2009

GW capacity additions per year



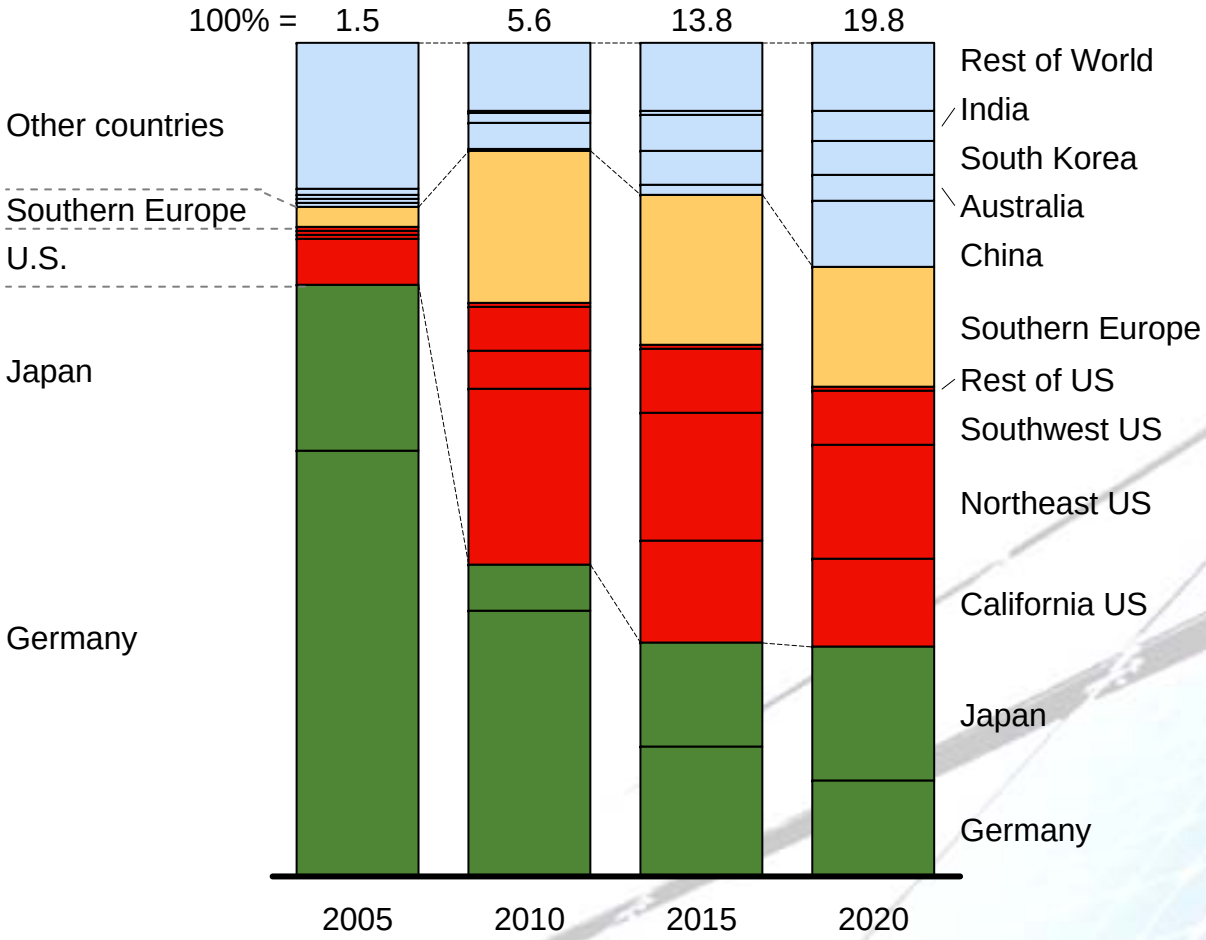
	2007	08E	2009E
YoY growth Percent	62	105	-24
YoY growth (excl. Spain) Percent	34	28	42

- Significant influence of Spain on 2008 global demand
- 2009 global solar demand dependent on
  - Continued legislative support in Germany, Italy and U.S.
  - New tariff introductions in Greece, India and Japan
  - Significant system cost reductions
  - Availability of high-leveraged project financing in key markets

Source: German PV Association; Spanish PV regulator; EPIA; Solarbuzz; Merrill Lynch; Bank Sarasin; PVNews; press search; McKinsey analysis

U.S. AND SOUTHERN EUROPE WILL BECOME KEY GROWTH MARKETS

Annual capacity additions
GW

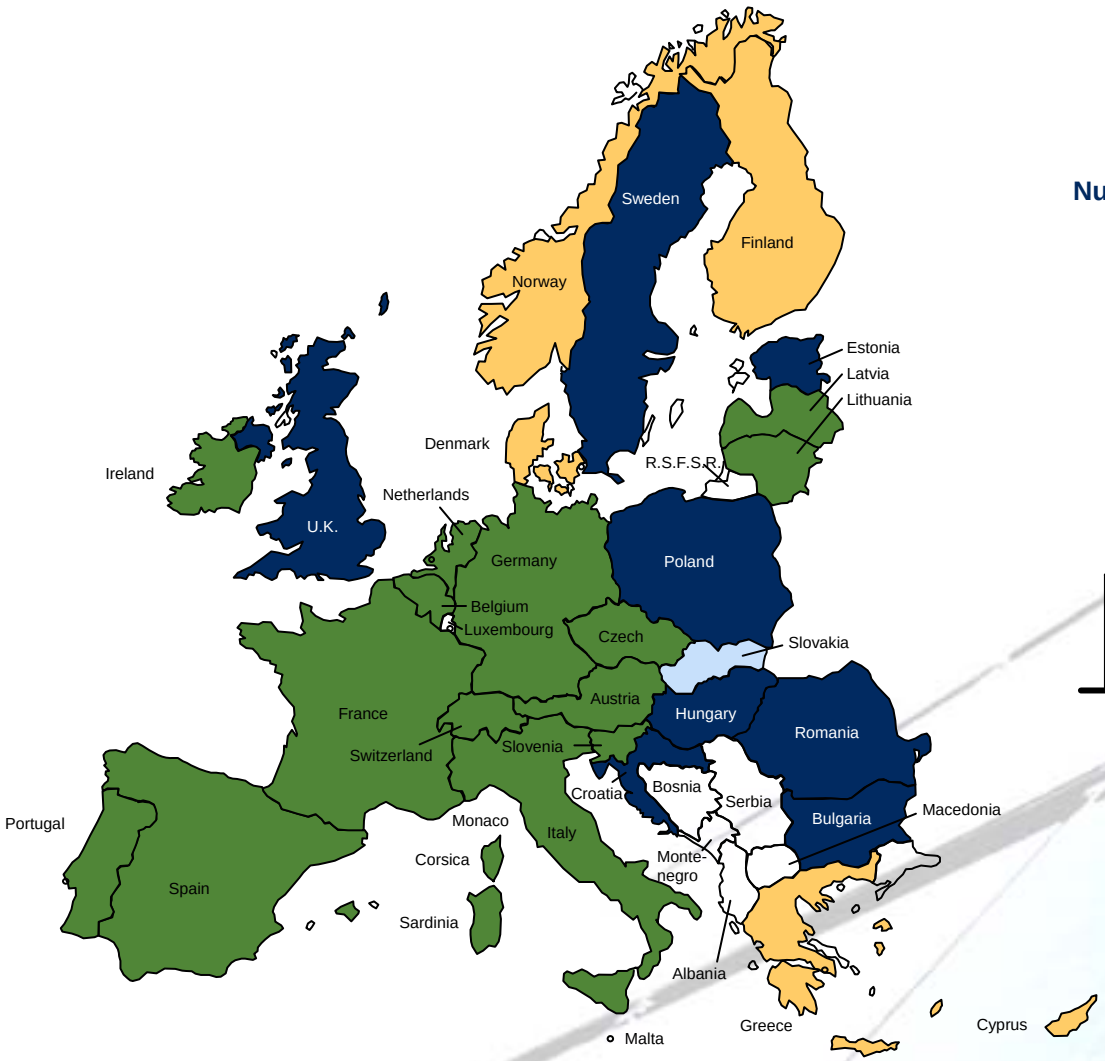


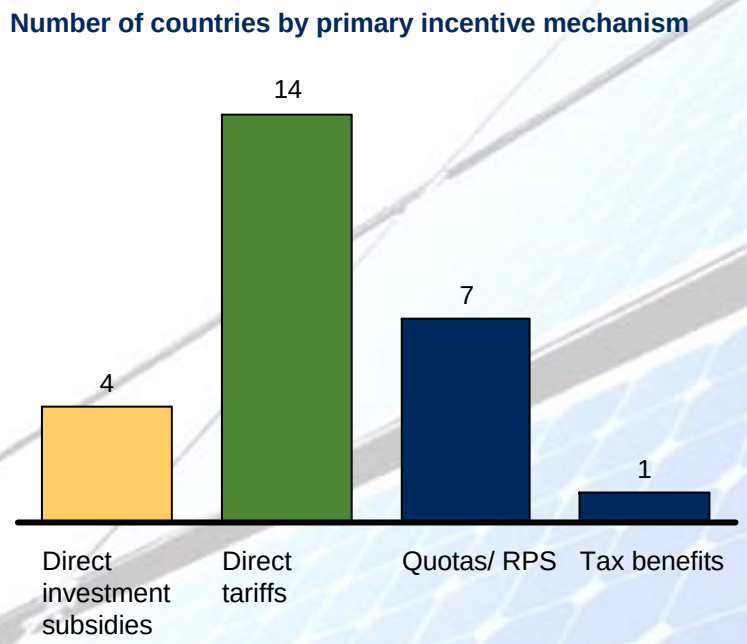
Market share of Germany, Japan to decline from ~70% in 2005 to ~20% in 2020

U.S. and Southern Europe likely to gain ~45% market share in the next 5-10 years

Source: McKinsey proprietary demand model

MAJORITY OF EUROPEAN COUNTRIES HAVE IMPLEMENTED TARIFFS AS PRIMARY INCENTIVE MECHANISM*



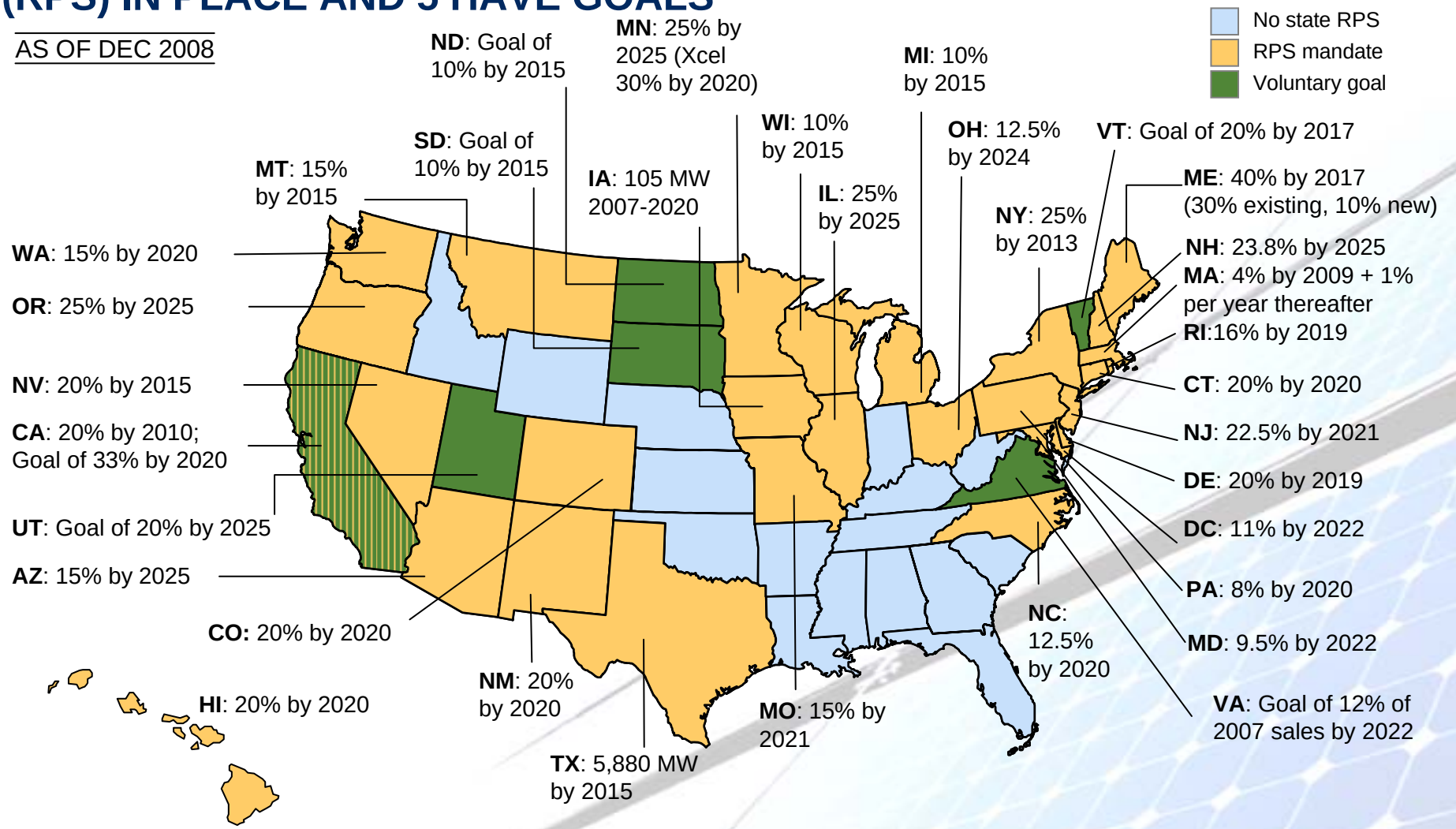


* Primary incentive mechanism illustrated for countries with multiple incentive mechanisms

Source: EU PV Policy Group; government websites

29 STATES HAVE MANDATORY RENEWABLE PORTFOLIO STANDARDS (RPS) IN PLACE AND 5 HAVE GOALS

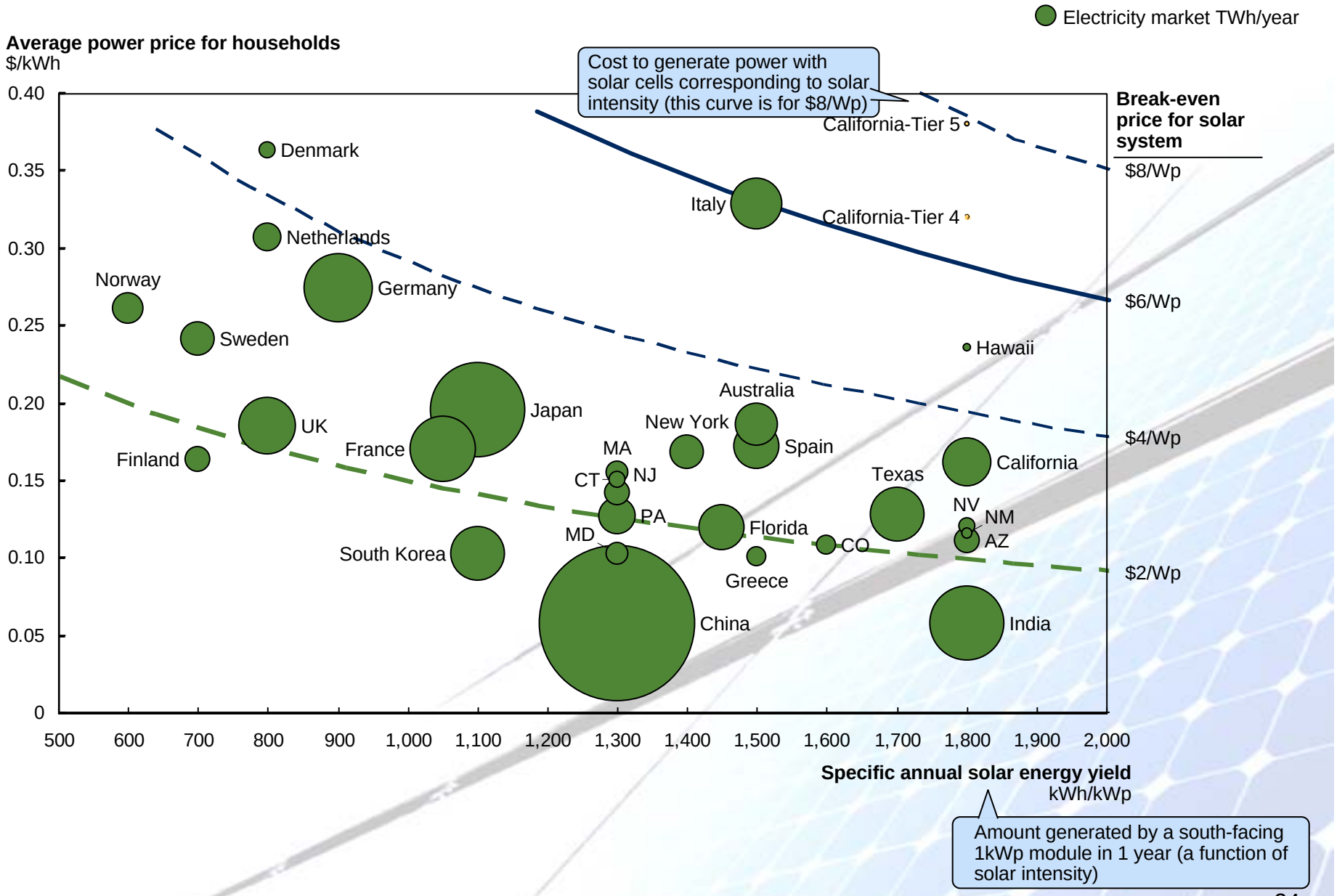
AS OF DEC 2008



Note: Unless otherwise noted,in states with multiple classes of renewables, large hydro, DG, DSM, or clean coal classes are NOT included; Maine RPS comprised of 30% “old” (pre-2005) and 10% new renewables and allows hydro up to 100 MW; Minnesota allows hydro up to 100 MW; Vermont allows hydro up to 200MW.

SOURCE: Interstate Renewable Energy Council; Regulatory Research Associates; state Web sites; SNL Interactive; McKinsey Analysis

GRID PARITY COULD SOON BE REACHED IN MANY COUNTRIES



Source: Eurostat; PV Policy group; PG&E; CIA country files; Public policy Institute New York; EIA; team analysis

U.S. IS LIKELY TO SEE A SIGNIFICANT UTILITY MARKET FOR SOLAR

McKinsey 2008 model

Solar generation capacity* added in U.S. (2015)

GW

Typical size		Mounted panels	BIPV**
10 – 500 MW	Utility	2.3	0.6
10 kW – 10 MW	Commercial	0.6	
1 – 10 kW	Residential	2.5	0.2
< 2 kW	Off-grid	0.3	0.1
		5.7	0.9

Product segments

* Includes PV measured in Wp and solar thermal measured in We

** BIPV = Building integrated photovoltaics

Source: McKinsey analysis; Yole report

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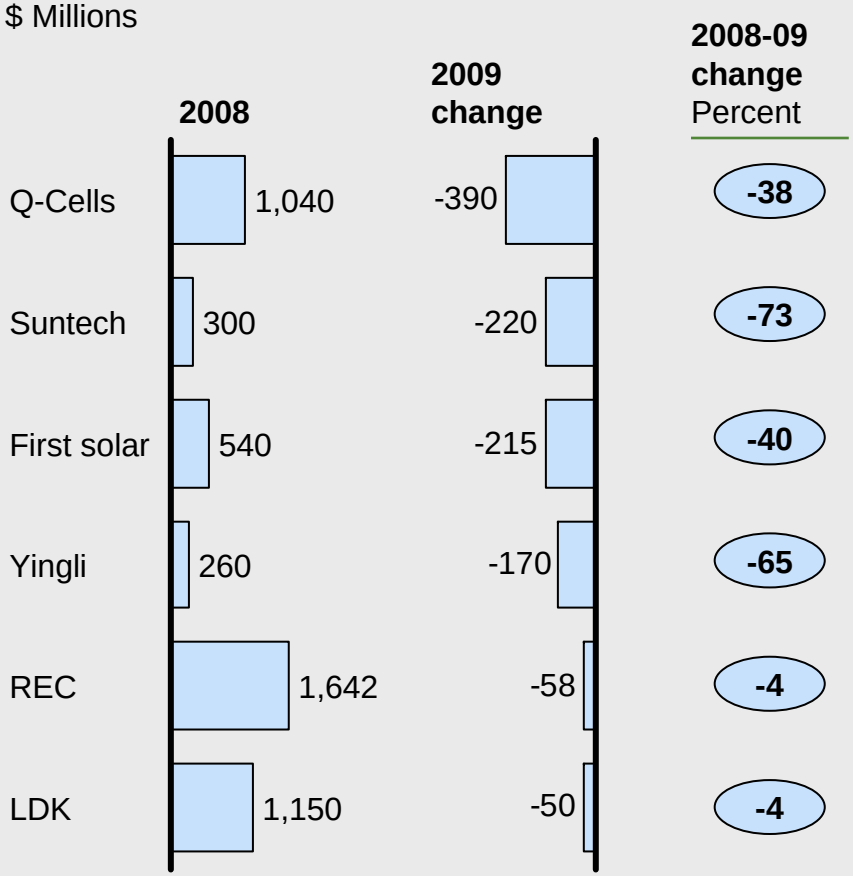
- **Perspectives on solar following the economic crisis**

ECONOMIC DOWNTURN IS PUSHING PROMINENT SOLAR PLAYERS TO CUT CAPEX PROJECTIONS AND CANCEL PROJECTS

Prominent players across the value chain are revising their capex projection downward . . .

Capex forecast
$ Millions



. . . and some other players cancelling their capacity commitments

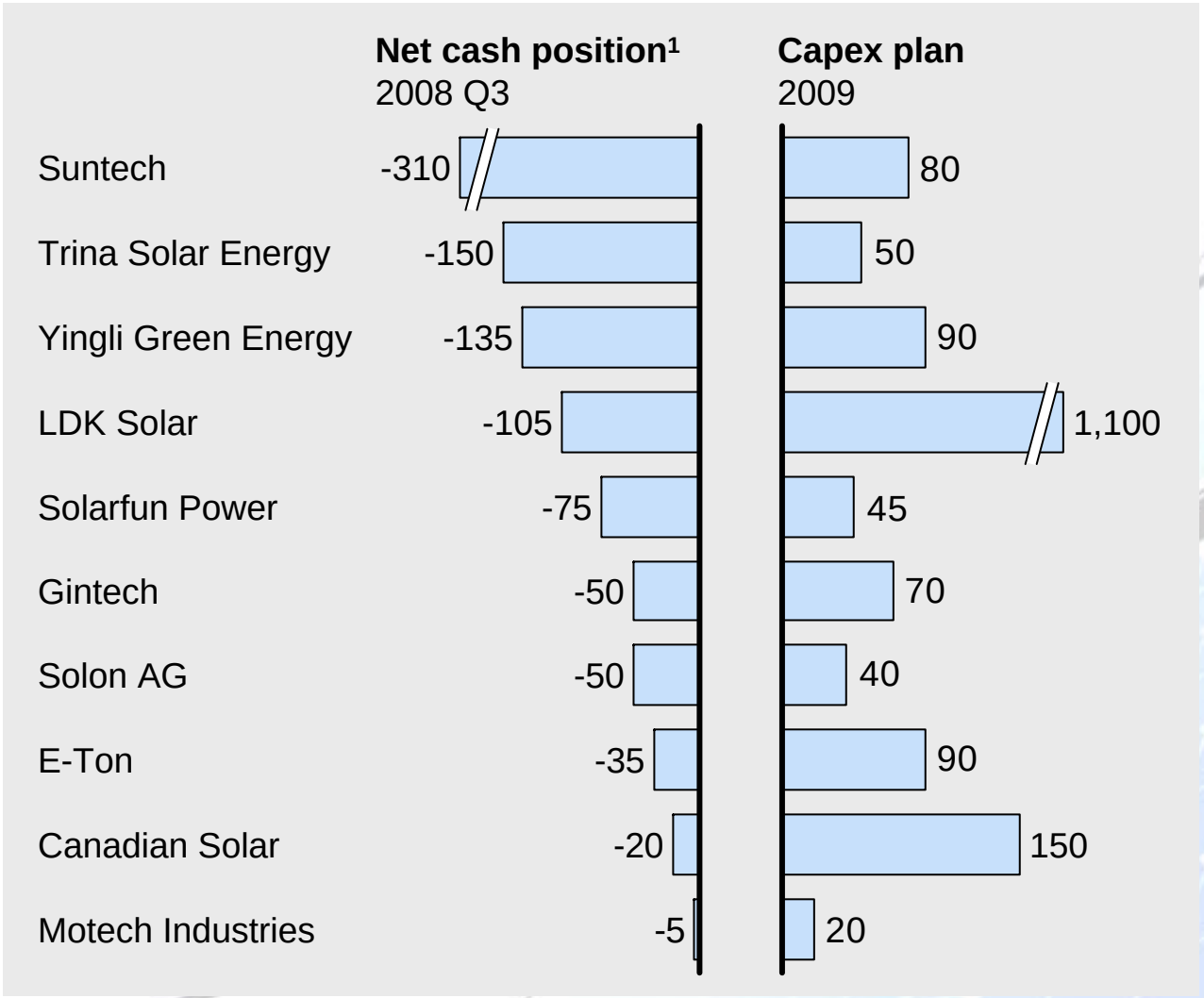
Recent announcements of project cancellation/delay

- CEO stated potential delay/reduction of investment in planned new Si plant , due to short of customer prepayment
- Canceled a $97 million plan to expand manufacturing in Maryland
- Freeze capacity at 1 GW throughout 09
- Announced plan to subcontract production to Asia instead of building own capacity
- Announced to hold 2009 capacity expansion plan

Source: Company announcements; Merrill Lynch; team analysis

MANY SOLAR COMPANIES ARE LIKELY TO HAVE CASH CONSTRAINT TO FUND CAPEX IN 2009

$ Millions

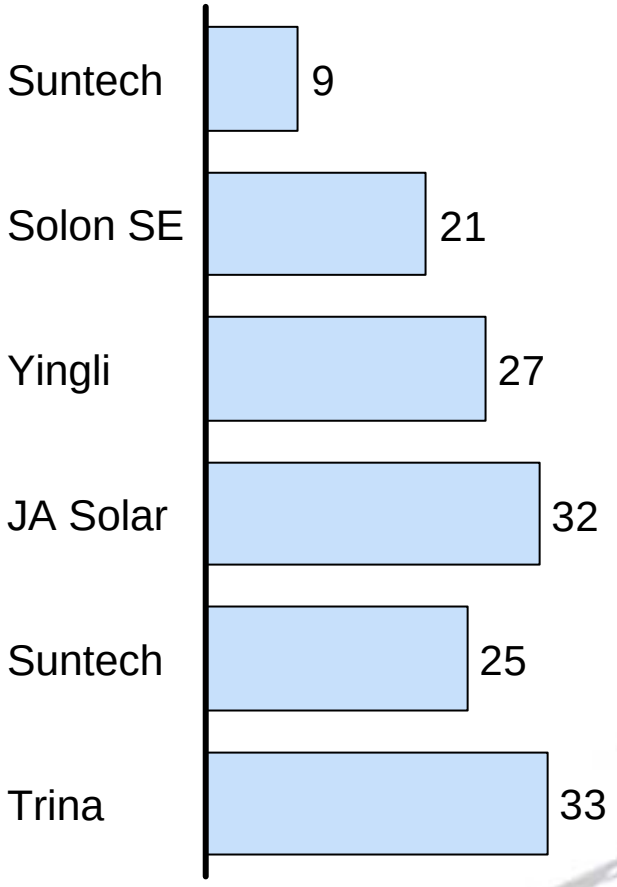


* Cash – short-term debt

Source: Bloomberg; company announcements; team analysis

SOLAR COMPANIES HAVE PAID PREMIUM FOR DEBT SINCE END OF LATE 2007

Recent bond issuances
Yield, percent



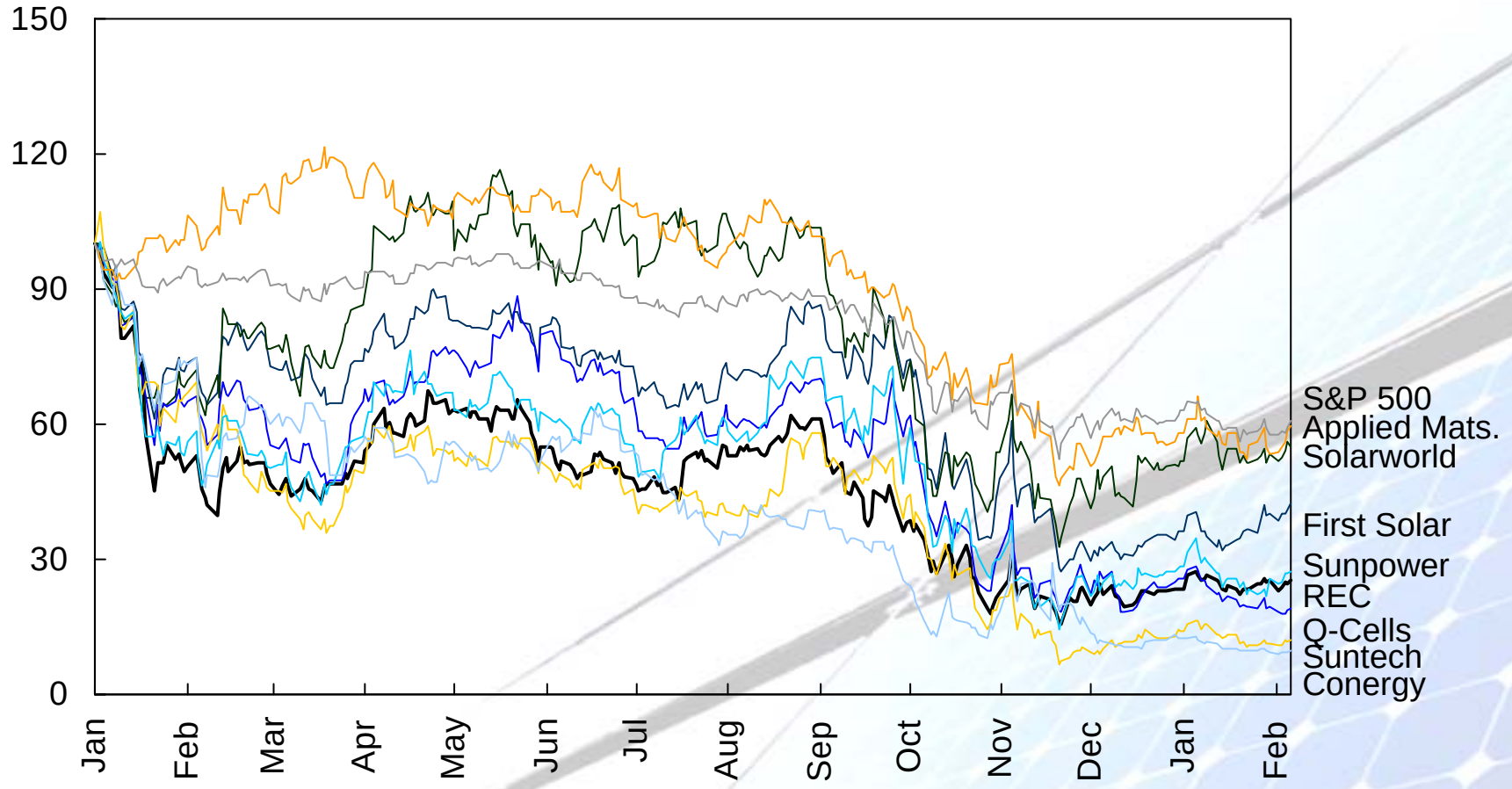
Date	Issuance amount $ Millions
31-Aug-07	500
6-Dec-07	173
13-Dec-07	260
19-May-08	400
17-Jun-08	575
17-Jun-08	138

- Increasing perceived risks from investors push up cost of debt for solar companies
- Lack of access to alternative financing vehicles

Source: Bloomberg; company announcements; team analysis

CONSEQUENTLY, COMBINED WITH THE ECONOMIC CRISIS, SOLAR PLAYERS SAW THEIR STOCK PRICE DECLINE OF 40%-80% IN 2008

Daily TRS (indexed to 100 as on 1st Jan 2008)

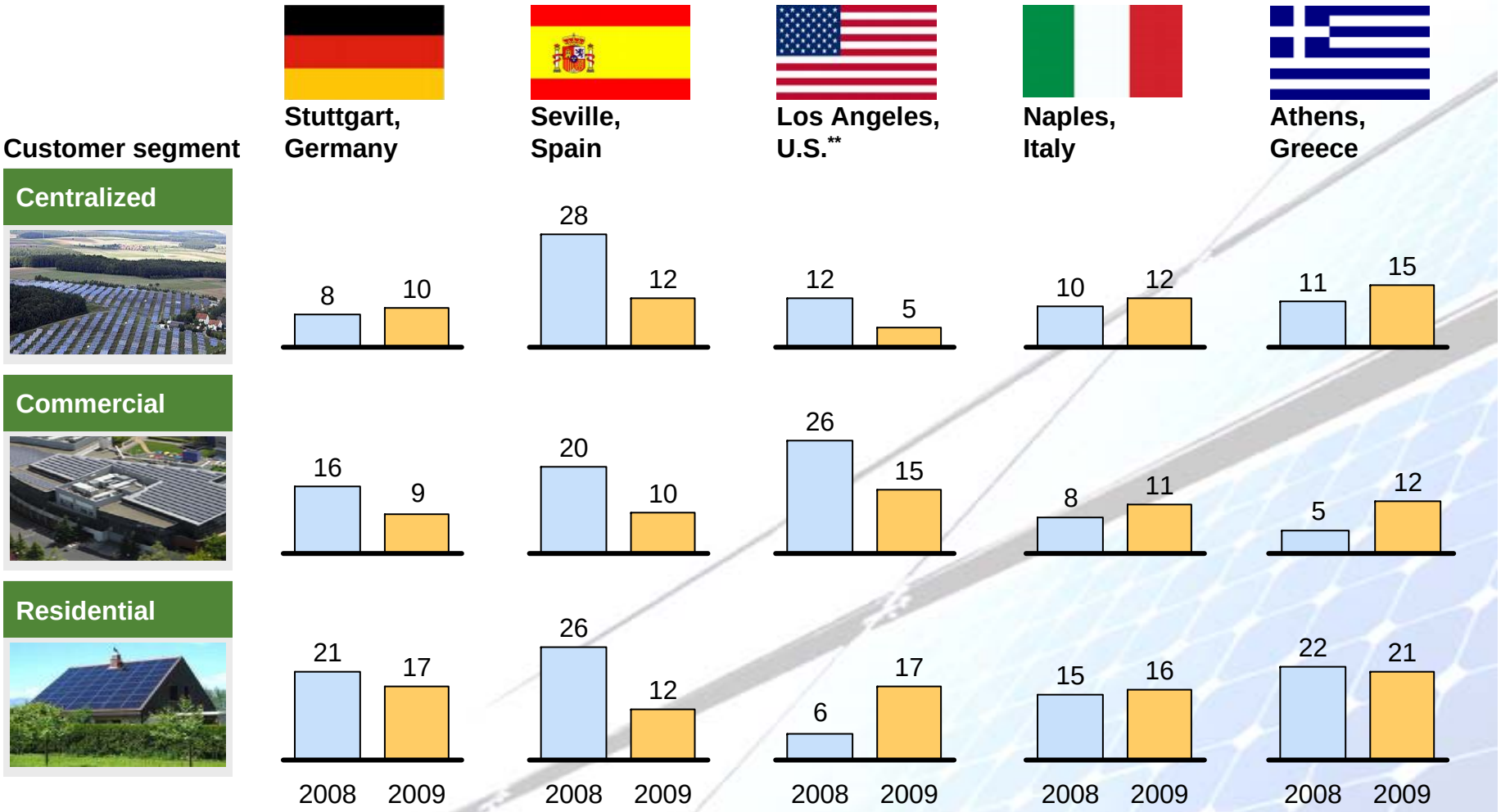


Source: Datastream

ECONOMICS OF SOLAR POWER ARE LIKELY TO DETERIORATE IN SOME KEY MARKETS

c-Si EXAMPLE

IRR*, percent



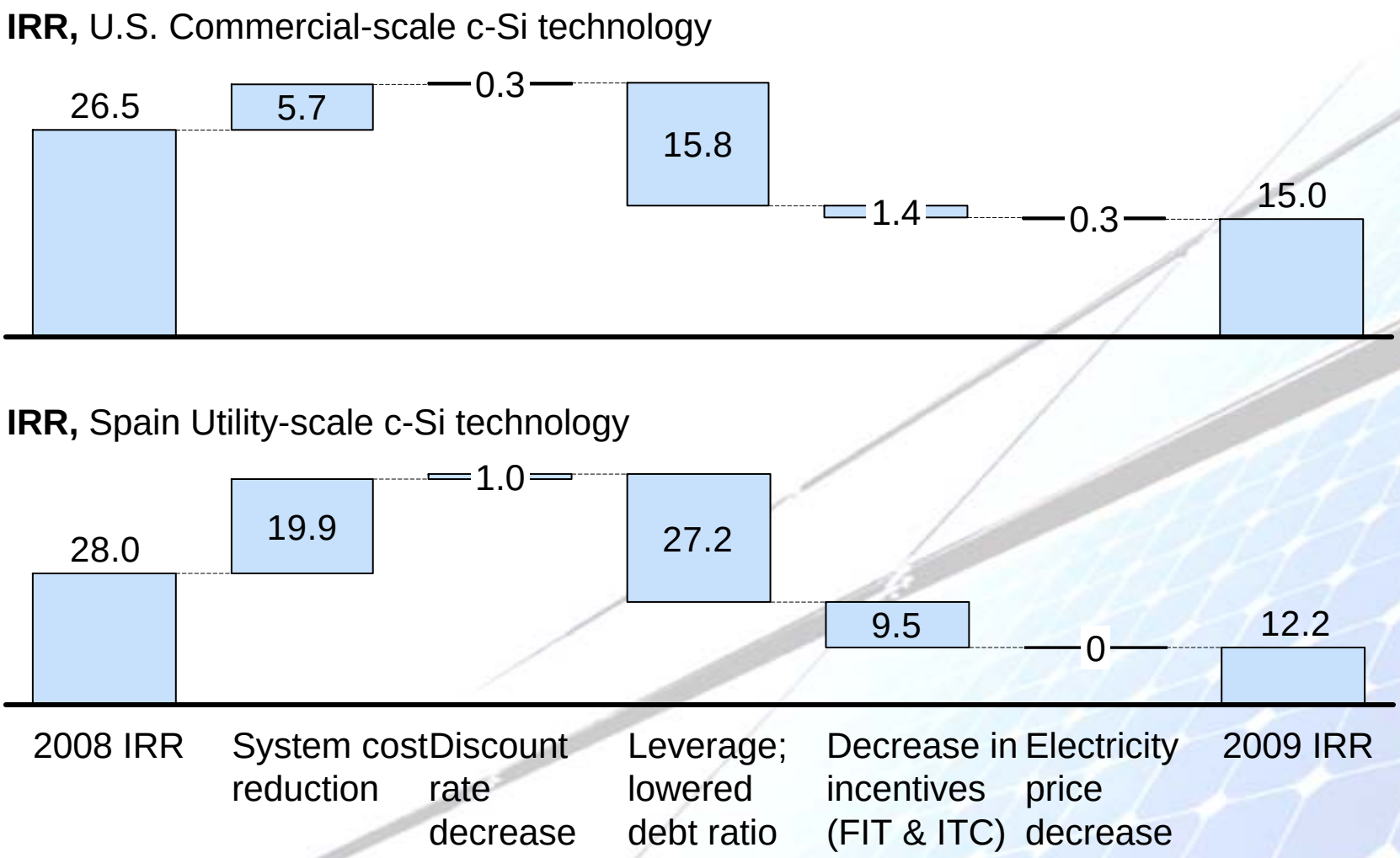
* Assumes ~20% system price reduction and 85% debt/15% equity in 2008 and 65% debt/35% equity in 2009

** Includes California PBI incentives

Source: Photon International; NREL; Solarbuzz; company websites; team analysis

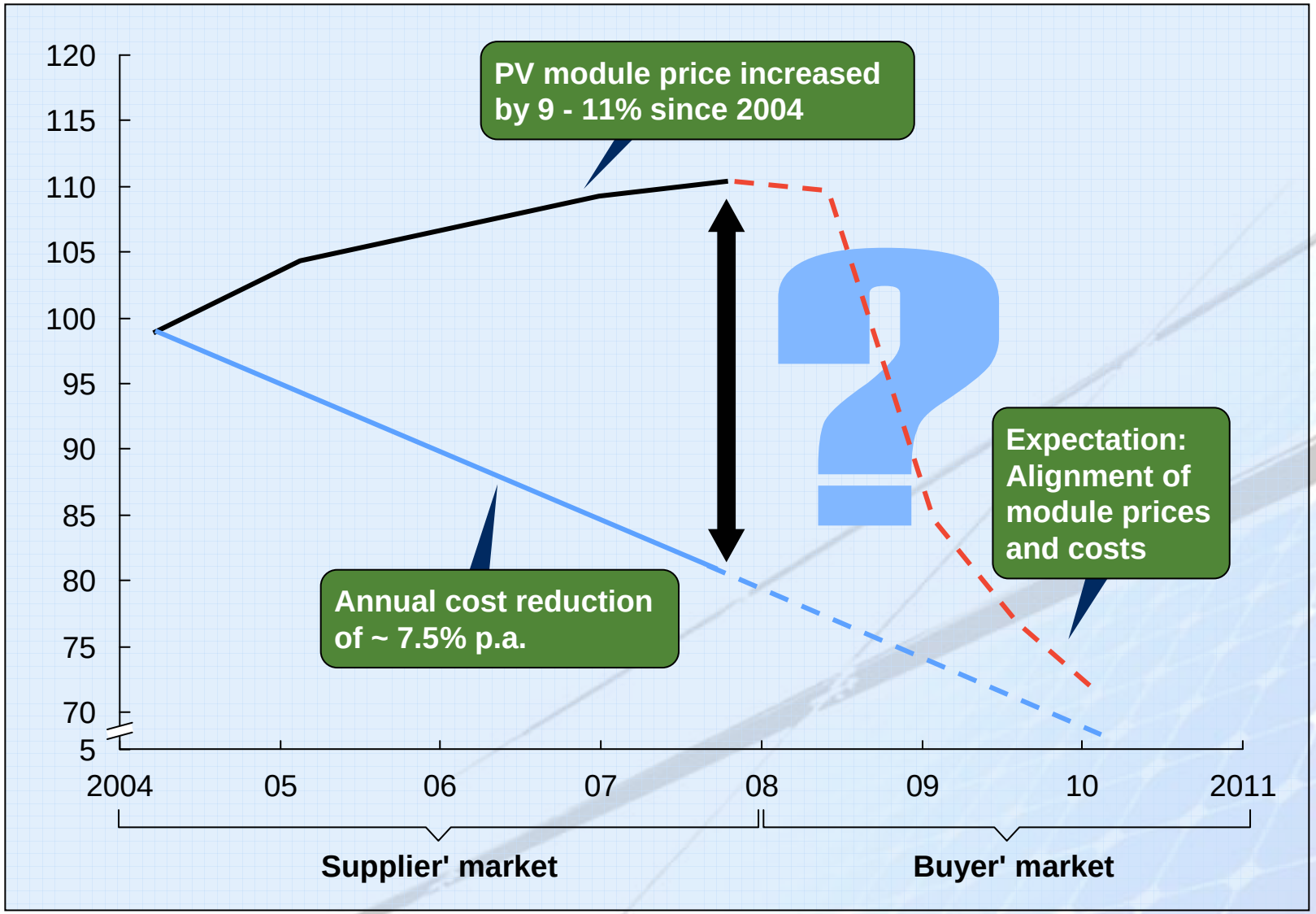
IRR CHANGES FROM 2008 TO 2009 ARE DOMINATED BY CHANGES IN SYSTEM COSTS, FINANCING AND INCENTIVES

Percent



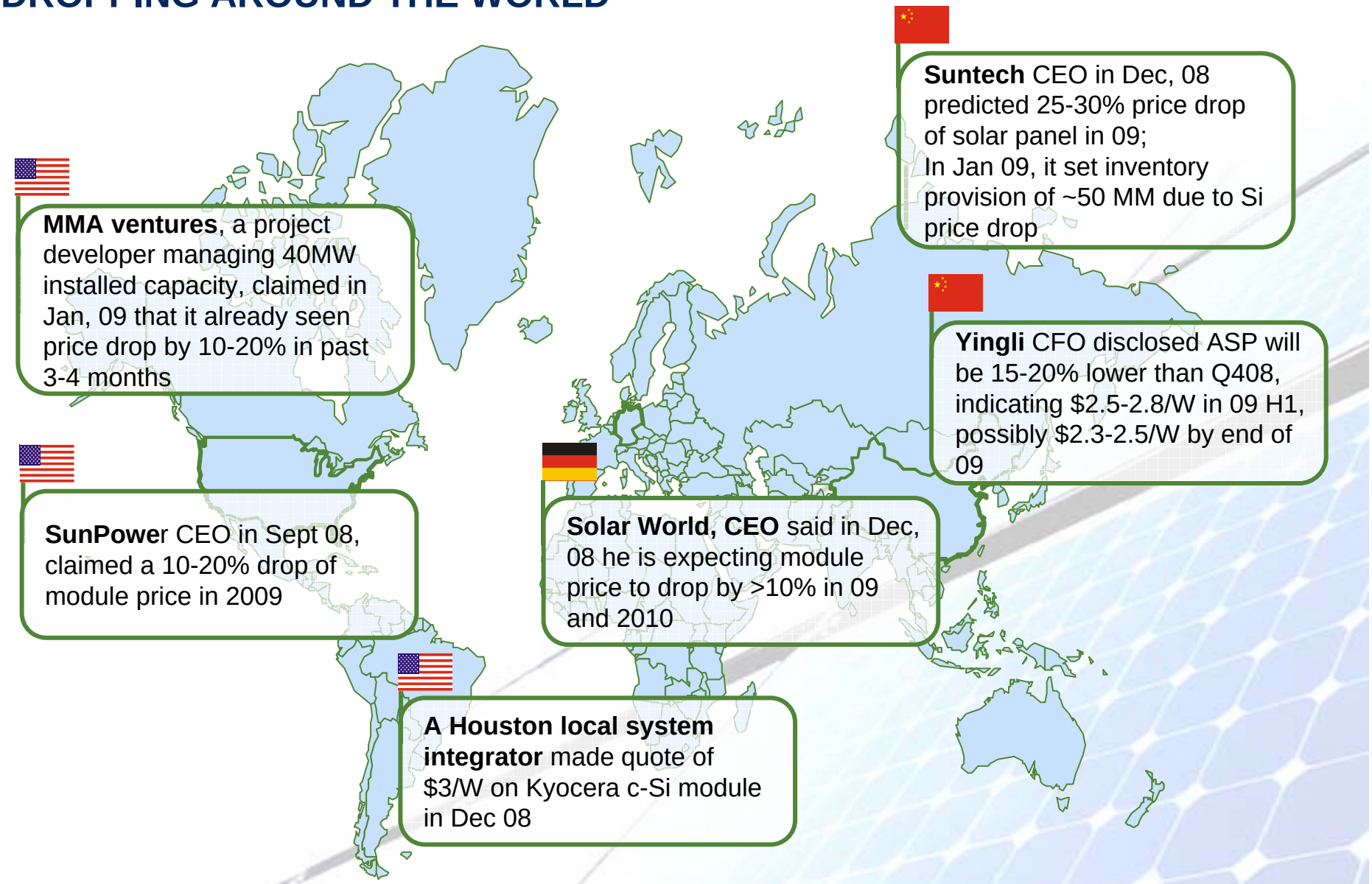
Source: McKinsey

PRICES HAVE NOT COME DOWN DESPITE COST REDUCTIONS



Source: Team analysis

INDUSTRY IS REACHING CONSENSUS THAT MODULE PRICES ARE DROPPING AROUND THE WORLD



Suntech CEO in Dec, 08 predicted 25-30% price drop of solar panel in 09;
In Jan 09, it set inventory provision of ~50 MM due to Si price drop

MMA ventures, a project developer managing 40MW installed capacity, claimed in Jan, 09 that it already seen price drop by 10-20% in past 3-4 months

Yingli CFO disclosed ASP will be 15-20% lower than Q408, indicating $2.5-2.8/W in 09 H1, possibly $2.3-2.5/W by end of 09

SunPower CEO in Sept 08, claimed a 10-20% drop of module price in 2009

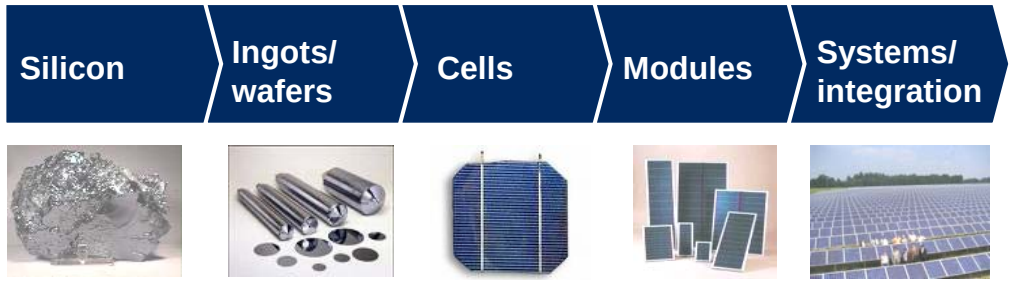
Solar World, CEO said in Dec, 08 he is expecting module price to drop by >10% in 09 and 2010

A Houston local system integrator made quote of $3/W on Kyocera c-Si module in Dec 08

Source: Interviews; press releases; company websites

SOLAR PLAYERS ARE DEVELOPING DOWNSTREAM CAPABILITIES TO DEVELOP THE MARKET IN THE U.S.

NOT EXHAUSTIVE



		Downstream move
Leading solar players	REC	Acquired 20% of Mainstream Energy
	Q.CELLS	Developing large-scale projects with internal capabilities; supply agreement with Sunedison
	SUNPOWER	Acquired PowerLight
	First Solar	Acquired DT Solar
	SUNTECH	Acquired MSK and EI Solutions; Gemini JV with MMA Ventures
New entrants	AES, RIVER STONE	Formed JV to develop solar farms
	QUANTA SERVICES	Developing large-scale projects with internal EPC capabilities

Source: McKinsey analysis; company websites

The Economics of Solar Power

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