

Evolving Economics of Power and Alternative Energy

The Age of Renewables is Beginning – A Levelized Cost of Energy Perspective (LCOE)

- **Show Me Your LCOE!** With power generation decision makers increasingly looking for low cost power, fuel diversity, stable cash flows, and government compliance, investors are increasingly comparing the “economics” of solar, wind, biomass, thermal, tidal, waste, natural gas, nuclear, and coal. We look to LCOE comparisons for insight and perspective into the future of US energy consumption.
- **Renewable Energy is Increasingly Cost Competitive:** Renewables energy, primarily solar and wind, costs continue to decline and are increasingly competitive with natural gas peakers and CCGT plants on an LCOE basis. The drivers of the lower costs are lower construction costs, higher efficiencies, and favorable financing terms (ie, YieldCo, tax equity, non-recourse debt, ABS, and a low interest environment). Meanwhile, natural gas prices have risen and the volatility of natural gas has increased. As a result, renewable's relative LCOE has improved substantially and is not sensitive to energy price volatility.
- **Hydro, Geothermal, and Marine Face Physical Limitations:** While hydro and geothermal are competitive from an LCOE basis, they require unique geological conditions and as a result, many of the remaining potential new sites have less attractive LCOEs. There does not appear to be material opportunities to reduce hydro or geothermal costs other than through the financing market. In addition, marine technologies appear to still be early in their development cycles with an uncertain roadmap to improving economics from the uncompetitive status today.
- **Nuclear and Coal Are Structurally Disadvantaged:** Nuclear and coal are largely viewed as uncompetitive today on an LCOE basis despite the rise in gas prices due to regulatory environment and construction costs. In the US, the recent examples of clean coal plants that comply with environmental requirements have an LCOE that is materially higher than the CCGT baseload generators. With US's nuclear fleet aging and facing shutdown decisions due to challenging economics, the fundamental outlook from a LCOE perspective is grim.
- **Levelized Cost of Energy (LCOE) is Key Metric in Comparing Power Sources:** As solar, wind, biomass, and other power sources gain market share from coal, nukes, and gas, the LCOE metric increasingly becomes important to the new build power generation decision making.
- **Outlook for New Generation:** In peak power generation, solar is increasingly attractive vs. gas peakers from an LCOE and fuel diversity perspective. In baseload generation, wind, biomass, geothermal, and hydro are becoming more attractive vs. CCGT plants but other considerations influence adoption of renewables.
- **Stock takeaways:** Our analysis points us to favor names directly impacted by the renewable theme including project developers SunPower Corp. (SPWR.O; US\$33.15; 1H), SunEdison (SUNE.N; US\$20.33; 1H) and First Solar Inc. (FSLR.O; US\$73.37; 1H); indirectly regulated utilities that are leveraged to transmission opportunities as a result of renewable growth as well as names involved with the renewable theme including Edison International (EIX.N; US\$53.87; 1), PG&E Corp (PCG.N; US\$44.37; 1), Duke Energy Corp (DUK.N; US\$69.08; 1), DTE Energy (DTE.N; US\$71.52; 1) and Westar Energy (WR.N; US\$34.68; 1).

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See Appendix A-1 for Analyst Certification, Important Disclosures and non-US research analyst disclosures.

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A further drill-down into LCOE and Outlook for Power Generation Sources

Below we take a closer look at the
Levelized Cost of Energy or LCOE – a
factor on assessing relative economics

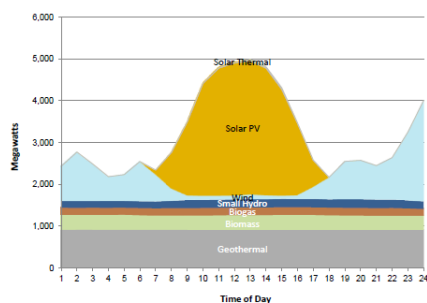
With power generation decision makers increasingly looking for low cost power, fuel diversity, stable cash flows, and government compliance, investors are increasingly comparing the “economics” of solar, wind, biomass, thermal, tidal, waste, natural gas, nuclear, and coal. We look to LCOE comparisons for insight and perspective.

Current State of LCOE Across Fuel Types

In evaluating energy source economics, we differentiate between baseload generators and peaker generators. Baseload generators, typically run throughout the day, and include natural gas CCGT plants, hydro, coal plants, nuclear, geothermal, biomass, landfill gas, and MSW. As a result the baseload generators are benchmarked against CCGT gas plants today. Intermittent power generation is more closely associated with wind, solar, and marine power generation. Wind and marine power generation occurs throughout the day during both peak and off peak load demand periods while solar is more typically a peak generation source. We benchmark peak LCOE based on a gas peaker. As a result of dynamics, geothermal, biomass, coal, nuclear, and MSW have significant hurdles to overcome to effectively gain material market share.

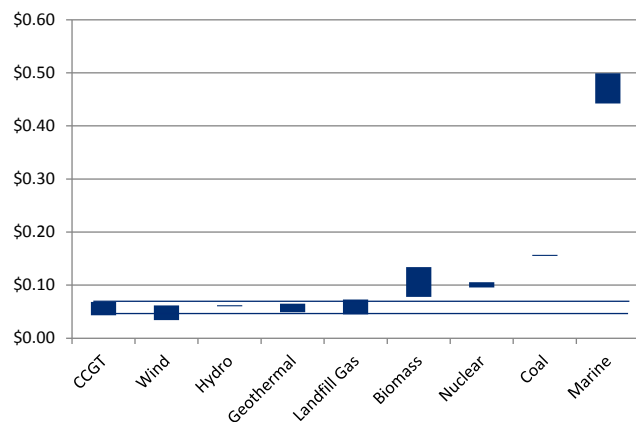
The charts below highlight the key takeaway of the report. Wind, hydro, geothermal, and landfill gas generation is competitive with natural gas CCGT baseload generators today but finding the attractive locations with favorable conditions limit expansion capabilities. In peaker periods, solar is increasingly attractive relatively to natural gas peakers as natural gas prices rise and solar LCOE declines - we expect these trend to continue. Additionally, we predict that solar, wind, and biomass to continue to gain market share from coal and nuclear into the future.

Figure 1. Breakdown of California Renewable Resources (3/3/14)



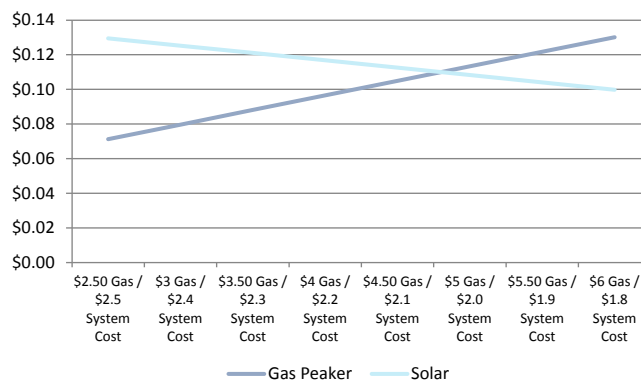
Source: Citi Research, Cal ISO

Figure 2. Baseload Generation Unsubsidized LCOE (\$/kwh)



Source: Citi Research, Bloomberg New Energy Finance, SNL, Company Filings

Figure 3. Peak Generation Unsubsidized LCOE (\$/kwh)



Source: Citi Research

How is LCOE calculated?

The LCOE is a measurement of the average cost of producing a unit of electricity over the life-time of the generating source.

The LCOE considers, on the one hand, the total quantity of electricity produced by the source, and on the other, the costs that went into establishing the source over its life-time, including the original capital expenditure, ongoing maintenance costs, the cost of fuel and any carbon costs.

The LCOE also takes into account the financing costs of the project, both deducting the cost of debt (for an appropriate level of debt-financing) and ensuring that the project generates a reasonable internal rate of return (IRR) for the equity providers.

Solar and Wind are Increasingly Cost Competitive

The LCOE of solar is increasingly attractive in comparison to gas peakers while wind is competitive in certain locations vs. baseload generators. Solar benefits because of its peak shaver characteristics and the declining cost of systems, improved efficiencies, and improved cost of capital. Wind similarly has benefited from lower financing costs, declining turbine costs, but generates power in unpredictable time period, often during non-peak hours.

Geographic Characteristics Limit Mass Expansion of Several Power Generation Types

While the LCOE is attractive for geothermal and hydro, geographic limitations prevent material increases in market share. Geothermal energy has a long term ability to generate power but it requires Pacific Rim type underground heat to fuel operations. Similarly, marine energy requires very specific wave or stream dynamics, but its LCOE is not competitive even at favorable locations. Hydro requires attractive water conditions, which is not as abundant as solar energy.

The Key Barriers to Driving Down LCOE are:

- **Solar:** Improving efficiencies, lowering system costs, and extending life of assets are key to gaining mass adoption, but we are at grid parity in many locations already today.
- **Wind:** Reducing turbine costs and improving efficiencies.
- **Hydro:** There are limitations to finding attractive locations for economic hydro plants. Key drivers are cost of construction, practical water considerations, and operating expenses.
- **Tidal:** The relatively high construction costs and O&M expenses derive uncompetitive LCOEs and inhibit adoption. While several initiatives are underway, industry executives indicate that it will take several years for tidal wave projects to become competitive economically.
- **Biomass:** Reducing operating costs and fuel costs and improving technological advancement. Each biomass technology has unique dynamics.
- **Geothermal:** Requires favorable geographic locations.

Sensitivity analysis – Deeper Dive in Power Generation Economics

To assess the competitiveness of various power sources compared to gas-fired power, we use the 'levelized cost of electricity' (LCOE) as the relevant comparator. The LCOE quantifies the average cost of producing a unit of electricity from different sources of power.

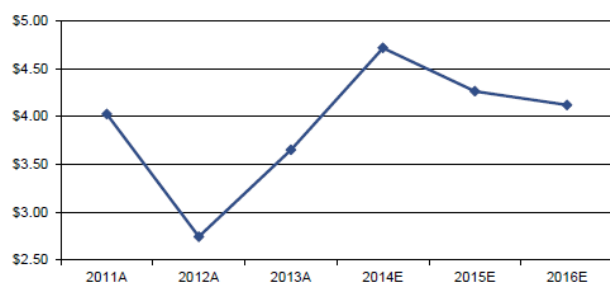
Gas-fired Plant are the Key Source of New Generation – Becoming Less Competitive Economically with Gas Prices Rising

LCOE is the relevant comparator

To assess the LCOE of gas-fired power, the key input assumption is the natural gas costs for the power plant, with secondary input assumptions on the fixed and variable opex, the carbon price, the life-time of the gas-fired power plant and the IRR. These inputs will vary with different gas assets ranging from highly efficient, low heat rate CCGTs to less efficient, high heat rate gas peakers.

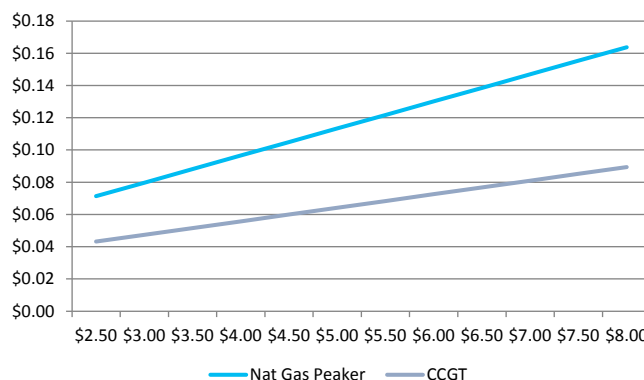
Of the input assumptions, the LCOE is most sensitive to the natural gas costs.

Figure 4. US Natural Gas Forward Curve (3/7/14)



Source: Citi Energy Trading, Citi Research

Figure 5. Sensitivity of gas-fired LCOE to natural gas costs



Source: Citi Research

At a natural gas price of \$4.00 /mmbtu, the LCOE of a gas peaker is \$0.10/kwh and a CCGT plant is \$0.06/kwh. The \$4/mmbtu assumption is based on the forward curve for 2016. **If we use Citi's commodity team's long term gas price forecast of \$5.50, the implied LCOE is \$0.12/kwh for natural gas peaker or \$0.07/kwh for a CCGT plant.** These numbers set the bar for alternative energy.

Besides natural gas, other key assumptions are the fixed costs, variable O&M costs, plant life, gross thermal efficiency, and IRR. Below are these inputs for CCGT and Gas peakers.

Figure 6. Other Assumptions

	Peaker	CCGT	
System Cost	0.132	1.167	\$/w
Size	236	600	MW
Availability	15.0%	70.0%	
Gas price	5.5	5.5	\$/MMBtu
CO2 Price	0.0	0.0	\$/t
Fixed O&M Cost	6.8	10.0	\$/kW
Variable O&M Cost	13.60	0.53	\$/MW h
Plant Life - Minimum	40	40	Years
Construction Time	2	2	Years
Gross Thermal Efficiency (Power)	22.8%	45.5%	
Debt to Capitalization	50.00%	50.00%	
IRR	10.00%	10.00%	
Cost of debt	5.50%	5.50%	

Source: Citi Research

Natural Gas LCOE Outlook Tied to Gas Prices – As the above analysis suggests, the strong correlation between LCOE and gas prices is the material driver of the outlook for natural gas LCOE. The price outlook for natural gas in the US is tied to natural gas production, LNG exporting, consumption patterns, electric vehicle adoption, energy efficiencies, and infrastructure constraints. Given the large expected increase in demand for gas, offset by production gains, gas prices are expected to rise over the long term. As a result, the bar for renewables and other fuel sources to cross continues to rise, thus making it easier for alternatives to gain market share.

The threshold for renewables to beat is becoming lower.

In addition, natural gas price volatility decreases the demand for new gas plants because it reduces the reliability and ability to predict future power prices. In monte-carlo simulations, the total power generation system is more susceptible to challenges if it is heavily dependent on natural gas prices and commodity experiences period of high price fluctuations. **Therefore, several key constituents may consider factors outside of expected LCOE in considering the economics of natural plants, both CCGT and gas peakers.**

Solar Economics Continue to Improve – Lower Costs, Greater Efficiencies, and Cheaper Capital

With solar rapidly gaining market share in the US and the rest of the world, we dive deeper into its levelized costs. Over the past year, many of key input costs have held relatively constant after a period of rapid decline, with the exception of financing costs, but the outlook is very attractive for solar.

To assess the LCOE of solar, the key input assumptions are

1. The system costs of the solar installation (polysilicon, wafers, cells, and balance of system) which we revisit below
2. The quality and quantity of the solar resource at the location of the installation – as measured by the solar insolation
3. Financing costs as measured by cost of equity and debt on the project level

The additional input assumptions being the life-time of the solar installation, operating costs (opex), and the degradation rate.

Sensitivity Analysis of Solar LCOE

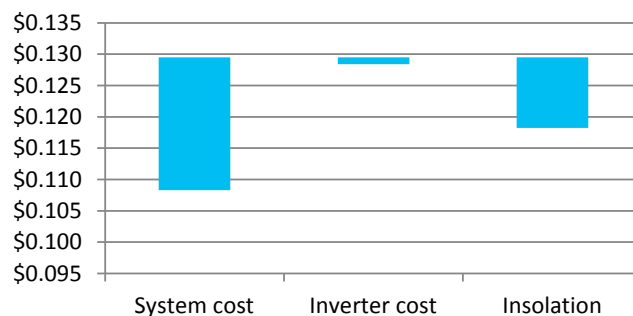
To assess the sensitivity of the LCOE of solar power to its input assumptions, we compare reasonable current assumptions with those achievable by 2016. While we are using specific illustrative assumption, we argue that each location is unique and costs are very different based on unique system features.

Figure 7. LCOE illustrative scenario assumptions

	Base case	Near Term Upside	Long Term Upside (2016)
System cost	\$2.50	\$2.25	\$2.00 \$/w
Inverter cost	\$0.17	\$0.17	\$0.12 \$/w
Insolation	2,100	2,200	2,300 kWh/Kw/yr
IRR	9.0%	9.0%	9.0%
Pay back period	25	25	25
LCOE	\$0.13	\$0.11	\$0.10

Source: Citi Research

Figure 8. LCOE Sensitivity



Source: Citi Research

Outlook for Solar LCOE

The outlook for solar LCOE is favorable but the devil lies in the details. The system costs are comprised of module costs plus balance of systems (BOS). System costs vary based on end user, location, and other factors. As the end of 2013, average selling prices are \$1.96/W, \$3.57/W, and \$4.59/W for utility scale, commercial, and residential systems. The raw input prices (poly, ingot, wafer, cell) are subject to global markets and an industry learning curve while BOS costs are more specific to location. Insolation and solar inefficiencies are driven by location specifics and technological advancements. Solar LCOE is also sensitive to secondary inputs such as module lifespan, opex, degradation, and IRR.

System Costs

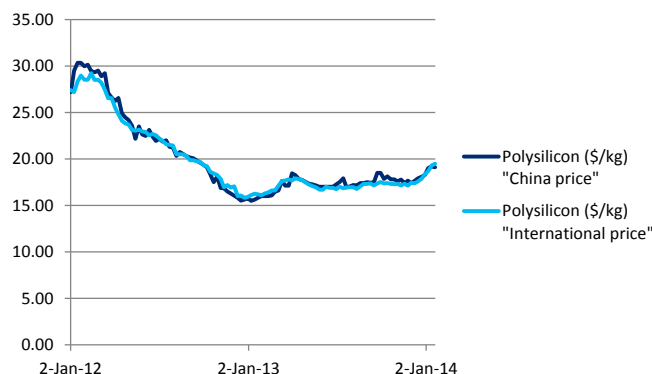
Module

A critical and ever changing input of the system cost is the PV module which continues to be reduced as cumulative PV installations increase. There are several types of modules including CdTe, mono crystalline, and multi-crystalline. Each has a different cost decline expectation but, in general, we expect material cost declines in the future utilizing Moore's Law. Within module costs are raw input costs such as solar grade poly-silicon and non-poly costs which are made up of the ingot and cell - items necessary for the construction of a PV module.

Module costs expected to decline due to lower cost of production and lower material costs.

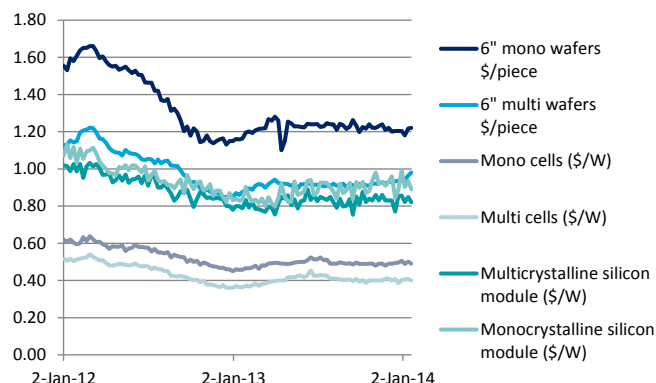
Module prices continue to evolve in the growing industry. Modules costs have declined significantly until early-2013 due to a shift in manufacturing to China and margin contraction. In 2013, prices remained relatively stable as the supply chain adapted to market conditions. Our outlook is for module costs to decline approximately 11% per year over the next five years driven primarily by lower cost of production. We touch on the inputs to module costs below.

Figure 9. Polysilicon Costs Trends (\$/kg)



Source: Citi Research

Figure 10. Modules Costs (Wafers, Cells, etc)(\$/watt)



Source: Citi Research

Over the longer term, we expect poly pricing to decline – albeit at a more tempered pace than pre-trough levels.

Polysilicon

Similar to module prices overall, poly prices declined rapidly and then stabilized in 2013 and now we expect prices to decline further in the future. Since 2011, solar grade polysilicon prices have declined by approximately 60% from \$51/kg to around \$21/kg today. Since the bottoming of pricing in late 2012, we've seen polysilicon costs stabilize from trough levels of \$16 - \$17/kg one year ago – signaling improving industry fundamentals. Using a conversion factor of 5.4g/W (which is conservative), current poly costs contribute approximately \$0.11/W to the system. As a data point, Poly prices have risen around ~\$3.50/kg since March 11th, 2013 – an approximate \$0.01 - \$0.02 increase in module prices. We expect poly pricing to revert to more normal levels in the near term and experience cost declines similar to other components of the solar value chain. As poly pricing environment improves in the near term, it will be offset by several factors including lower conversion factors/higher efficiencies (i.e. less grams/watt needed to produce panels) versus historical standards and the removal of costs elsewhere in the system (BoS). Over the longer term, we expect poly pricing to decline – albeit at a more tempered pace than pre-trough levels.

Ingot/Wafer

The balance of module costs is composed of cell and wafer costs (i.e. non-poly cost per watt). Since mid-2011, costs for cells and wafers have been reduced by 50% and 53%, respectively. However the past year, we've seen pricing for multicrystalline cells and 6" multicrystalline wafers remain relatively flat – supporting our view of 2013 as the year of stabilization. Current spot market prices as of March 3, 2014 are \$0.41/w and \$0.26/w; adding current poly costs (~\$0.11/w) gives us an average module cost of \$0.78/watt. Like polysilicon prices, we believe the pricing trend for cells and wafers will experience a steady decline in 2014 and beyond – in line with the percentage declines with other components of the PV system. As of Q4, a Chinese company achieved a milestone of a cost per watt below \$0.50 – as the industry matures and technology becomes more efficient, we expect costs to continue to come down approximately 30% over the longer term. See [Rising Sun: Implications For US Utilities](#) which details our solar cost reduction scenarios.

Like polysilicon prices, we believe the pricing trend for cells and wafers will experience a steady decline in 2014 and beyond

BoS Costs

The remaining costs of a system are comprised of the balance of system costs (BoS); and these are difficult to forecast because they vary considerably across

installations. BoS cost varies dramatically depending on whether the installation is of a residential-scale (e.g. on the rooftop of a home or small business) or of utility-scale (e.g. constructed by a utility and grid connected).

Historically, BoS costs have comprised less than 40% of the total installed cost for residential-scale solar, and less than 25% of the total cost for utility-scale solar. However, BoS costs have not kept up with plummeting module costs in recent years, and BoS now typically stands around ~60% of the cost of utility-scale solar.

Balance of System cost are expected to continue to fall as well

We see ample scope for significant reductions in BoS costs, through streamlining and standardizing the installation process. To forecast these reductions, we apply an annual discount of 6% to residential scale BoS costs, and an annual reduction of 8% to utility-scale BoS costs, which we think are very conservative given recent rapid cost reductions.

Figure 11. BoS Forecast for 10MW Fixed Tilt c-Si in US

U.S. Utility BOS Costs	2012E	2013E	2014E	2015E	2016E
Inverter	\$0.18	\$0.17	\$0.14	\$0.11	\$0.10
Structure	\$0.18	\$0.17	\$0.15	\$0.14	\$0.14
Foundations	\$0.10	\$0.09	\$0.09	\$0.08	\$0.08
Labor	\$0.27	\$0.25	\$0.24	\$0.22	\$0.20
EBOS	\$0.22	\$0.20	\$0.19	\$0.18	\$0.16
Misc	\$0.22	\$0.22	\$0.20	\$0.19	\$0.18
Total	\$1.17	\$1.10	\$1.01	\$0.92	\$0.86

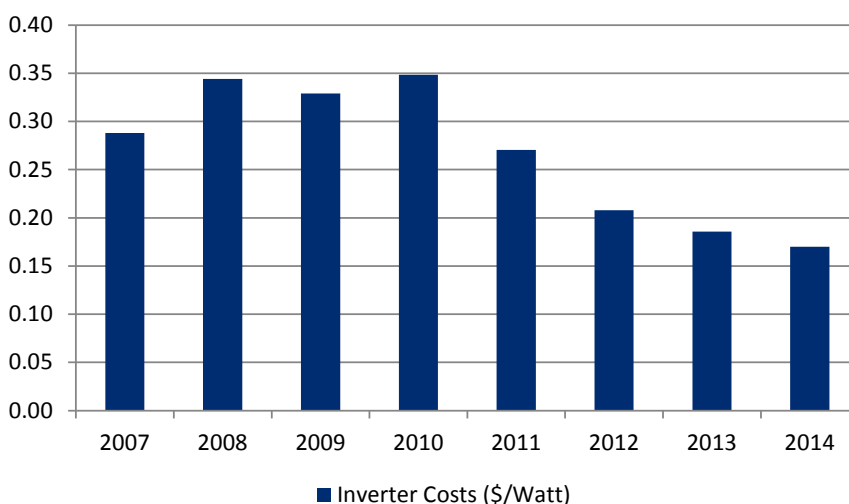
Source: Citi Research, Greentech Media

Figure 12. BoS Forecast Comparison by Geography for 10 MW c-Si Fixed Tilt Project

	2012E	2013E	2014E	2015E	2016E
US	\$1.17	\$1.10	\$1.01	\$0.92	\$0.86
Europe	\$0.98	\$0.95	\$0.92	\$0.89	\$0.86
Asia	\$0.90	\$0.85	\$0.82	\$0.80	\$0.76

Source: Citi Research, Greentech Media

Figure 13. Inverter Costs (\$/Watt)



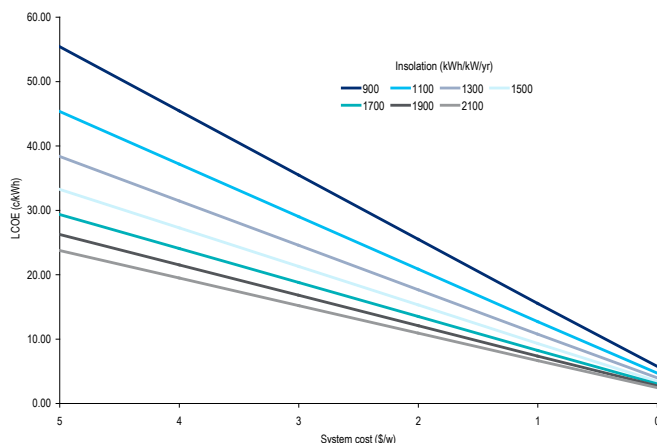
Source: Citi Research

Module life

Depending on the manufacturer, a solar panel may last 20 years or 30 – the base case for our LCOE model is 25 years (also the industry average). As technologies continue to improve and the industry matures; module lifespans are expected to increase. However, one factor to consider when evaluating module lifespans are degradation rates (i.e. how much are module efficiencies reduced after wear and

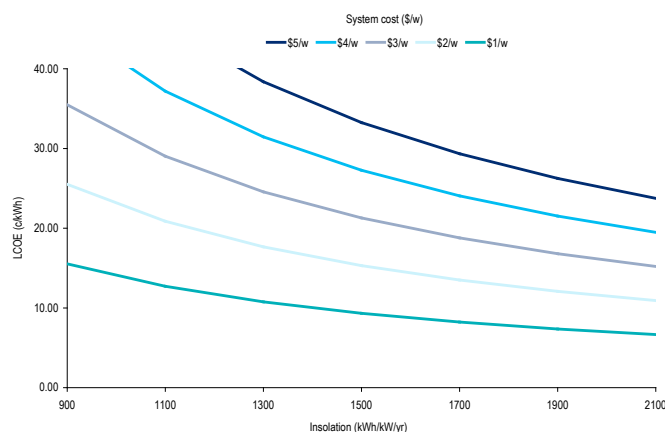
tear). A longer lifespan is positive because it means longer exposure to sunlight and greater energy harvest throughout the module's life; but if degradation rates are high, conversion efficiencies would be reduced – lowering overall energy harvest of the solar system. The current industry average and base case for degradation rates in our LCOE calculation is 0.5%/year. In order for solar to achieve a lower LCOE; module lifespans will need to increase while degradation rates decline to not offset the increasing sunlight exposure. As some tier two manufacturers exit the industry, we expect overall module lifespans and degradation rates to improve and move toward our more optimistic assumptions as the industry continues to mature.

Figure 14. Sensitivity of solar LCOE to solar insolation



Source: Citi Research

Figure 15. Sensitivity of solar LCOE to system price



Source: Citi Research

Solar is still early in the growth cycle and in many countries – Germany, Spain, Portugal, Australia, and the South-West US – residential scale solar has already competed with average residential electricity prices. In 2013, solar was the second-largest source of new generation capacity behind natural gas – its prospects look bright in 2014 and beyond as costs continue to decline and improve the LCOE picture.

Insolation

Of the input assumptions after model costs, the LCOE is most sensitive to the cost of solar insolation.

What is solar insolation?

Solar insolation, measured in kWh/kW/year, gauges the total quantity of sunlight that hits a solar array over the course of a year, and so determines how much energy (in kWh) is produced per unit of solar power capacity (in kW) of the solar array each year.

The solar insolation depends on both the amount and intensity of sunlight in the location and the angle at which the solar array is tilted towards the sun. For our analysis, we take typical values for each.

Note that an equivalent unit of insolation is kWh/m²/year; it is equivalent because solar panels are rated in terms of their power output per unit area under certain standard conditions.

While there is no expectation of the sun changing, the solar industry is expected to capture more energy via improved systems over time. Solar companies can move the panel throughout the day which increases efficiency levels. Certain systems can capture sunlight when partially shaded and other cannot. Factors such as humidity and others also come into play. Over time, we expect insolation levels to improve.

Insolation is an important metric for solar LCOE and newer more efficient panels may capture more sunlight over time.

This metric is equivalent to capacity factors that utility investor typically look at. With no fuel costs, solar plants generate energy whenever the sun shines. As a result, this metric can be viewed as a capacity factor. See the below example for an explanation.

Figure 16. Insolation Comparison

Capacity Factor Method		Insolation Method	
MW	300	MW	300
Capacity Factor	24%	Utilization	100%
Hrs per year	8760	Insolation	2100
Generation (kwh)	630,000,000	Generation (kwh)	630,000,000

Source: Citi Research

Solar financing costs have improved significantly

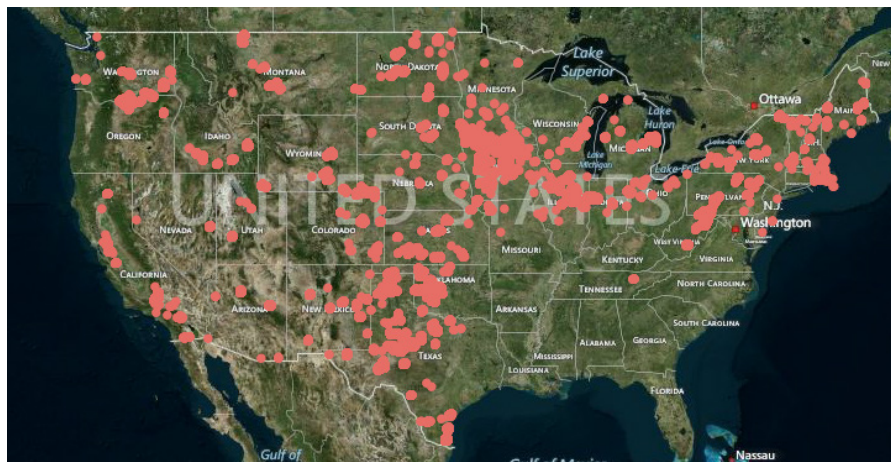
Financing Costs

The cost of capital has improved over the last few years. There are several reasons including the introduction of ABS, YieldCo, tax equity, and a lower interest rate environment. In the current market, the cost of capital is approximately 6-7% WACC with ~5% cost of debt, 9% of cost of equity, and ~8% for tax equity. A typical capital structure today is 70% for debt and 30% for equity. With a lower cost of capital solar becomes much less expensive to finance and develop. In general the growing financing market for solar has recognized the strong cash flow and low risk profile that is characteristic with solar projects.

Attractive LCOE of Wind but Geographic Limitations

To assess the LCOE of a wind project, the key factors include 1) wind turbine costs and 2) financing costs. The costs of operation are minimal, although there are geographic limitations. In the US, wind generation is primarily in the central corridor (Midwest to Texas) with some wind power in the Northeast and West coast.

Figure 17. US Wind Farms



Source: Citi Research, US Geological Survey

Turbine costs continue to decline

While turbine costs have declined over the last few years, the prices have remained steady in recent months. The economics of wind are heavily dependent on the rate of acceleration down the cost curve. The average price of turbines per MW is much lower on larger turbines than smaller ones. For example, turbines that are over 100MW are ~11% cheaper on a \$/MW basis than turbines that are less than 100MW. As a result, we observe cost declines as the trend toward larger turbines continues. In addition, the industry continues to innovate and move to aggressively invest to improve the economics of the turbines.

Figure 18. Historical Wind Turbine Costs Trends



Source: Bloomberg New Energy Finance, Citi Research

Figure 19. LCOE (\$/kWh) Sensitivity Analysis to System Costs

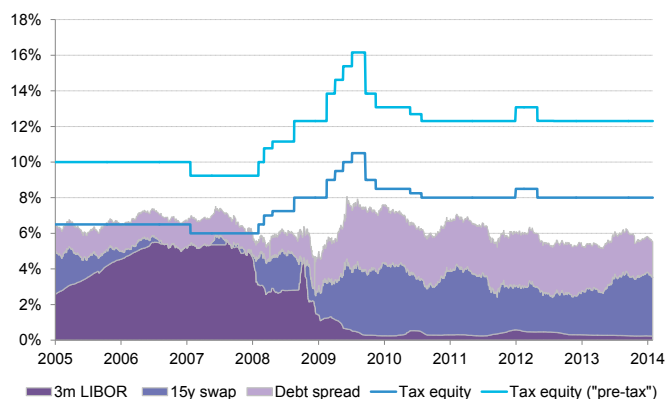
System Costs	Price Decline	LCOE
\$0.96	0%	\$0.048
\$0.86	10%	\$0.044
\$0.77	20%	\$0.041
\$0.70	30%	\$0.038
\$0.63	40%	\$0.036
\$0.56	50%	\$0.034

Source: Bloomberg New Energy Finance, Citi Research

Wind financing costs have improved

In addition to cost of construction, financing costs and contract structure are important to the LCOE calculation. As the asset class for wind continues to grow and mature, the financing yield spreads have contracted modestly. The advent of YieldCo(s) and the contracted renewable energy drop down story is further reducing the cost of capital for these assets. In addition, interest rates are at historic lows due to macro issues which also improved wind financing costs. Overall, cheap financing costs for wind are likely to improve wind's ability to compete for market share in power generation.

Figure 20. Wind Financing Costs



Source: Bloomberg New Energy Finance, Citi Research

Figure 21. LCOE (\$/kwh) Sensitivity to Cost of Equity/Debt and Project Life / Contract Length

Time Period						
Cost of Equity @ 5% cost of debt		15	20	25	30	35
6.0%	\$0.053	\$0.047	\$0.043	\$0.041	\$0.041	
7.5%	\$0.054	\$0.048	\$0.045	\$0.043	\$0.042	
9.0%	\$0.056	\$0.050	\$0.047	\$0.045	\$0.044	
10.5%	\$0.057	\$0.051	\$0.048	\$0.046	\$0.046	
12.0%	\$0.059	\$0.053	\$0.050	\$0.048	\$0.047	
Cost of Debt @ 9% cost of equity		15	20	25	30	35
4.0%	\$0.054	\$0.048	\$0.044	\$0.042	\$0.042	
5.0%	\$0.056	\$0.050	\$0.047	\$0.045	\$0.044	
6.0%	\$0.058	\$0.052	\$0.049	\$0.047	\$0.046	
7.0%	\$0.060	\$0.054	\$0.051	\$0.049	\$0.049	
8.0%	\$0.062	\$0.056	\$0.053	\$0.051	\$0.051	

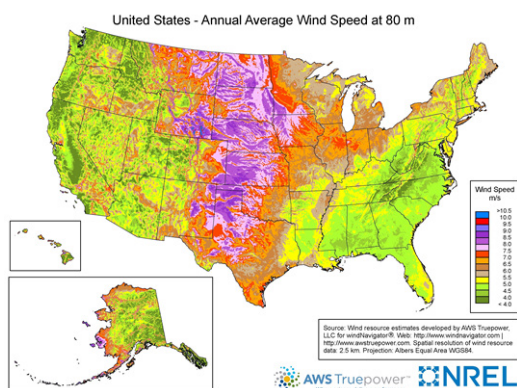
Source: Bloomberg New Energy Finance, Citi Research

With industry increasingly looking to transact wind assets to YieldCo(s), we would expect contract terms to extend and further reduce cost of capital. These financing vehicles are dependent on stable cash flow generating contracts. As Yieldco(s) become the marginal buyer of these assets and the highest paying buyer, they may have influence over how contracts are negotiated in wind development. Ultimately, we expect the longer contract lengths to further reduce the cost of capital and improve LCOE calculations.

Location matters for wind

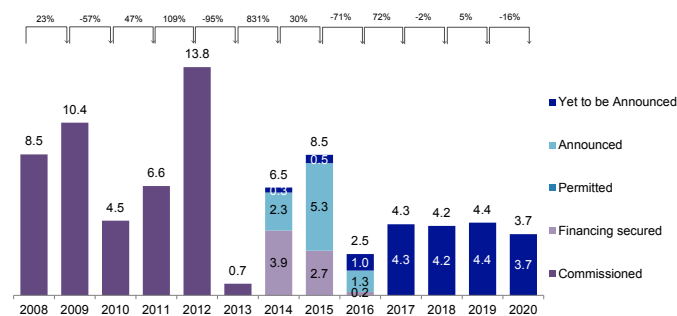
While LCOE may decline, the outlook for wind is also dependent on the wind levels in the areas it will be built and the cost of base load alternatives. With gas prices forecasted to rise, the LCOE of wind is becoming more competitive with CCGT alternatives. Despite this, many of the most attractive wind sites are in use and government incentives come into play which reduces the outlook for wind.

Figure 22. Map of Attractive Wind Areas



Source: Citi Research, NREL, AWS Truepower

Figure 23. US Wind Development Outlook (in GW)



Source: Bloomberg New Energy Finance, Citi Research

Regulatory Actions Prompt Coal to Become Uneconomic in the US

Regulatory environment is challenging for coal

Coal burning plants' economics and strategic decisions (to build, maintain, retrofit or retire) will be largely driven by evolving regulatory landscape in the US. The approaching compliance deadline for the MATS rule will lead to substantial coal fired capacity retirements in 2015-2021 timeframe, primarily affecting units that lack FGD and SCR equipment. Ongoing implementation of the Regional Haze rules will put additional pressure on units lacking NOx controls. Other developing initiatives, most notably Rule 316(b) aimed at regulating water use and a possibility of imposing CO2 standards (see our [EPA Carbon Rule](#) for details) on existing power plants are creating uncertainty around coal economics.

While we believe that plants currently under construction are likely to be grandfathered for CO2 rules, mounting regulatory pressures and uncertainties, coupled with attractive natural gas economics, are likely to hinder incremental coal power plant development, in our view.

Figure 24. New Coal Plants in Various Stages of Development – Small Piece of the Generation Mix

Power Plant	Technology Type	Ultimate Parent	Planned Capacity (Mw)	Development Status	Year Online
CIRI IGCC Power Plant	Integrated Gasification	Cook Inlet Region, Incorporated	100	Announced	2015
Great Lakes Energy & Research Park IGCC	Integrated Gasification	M&M Energy LLC	125	Announced	NA
WMPI Pty LLC (Gilberton Coal to Clean Fuels)	Other	Waste Management & Processors, Inc.	41	Announced	NA
Sub-total:			266		
Beech Hollow Power Project	Steam Turbine	Robinson Power Company LLC	150	Early Development	NA
Greene Energy Resource Recovery Project	Steam Turbine	Wellington Development Corp	525	Early Development	NA
Hypereon Energy Center IGCC	Integrated Gasification	Hypereon Refining, LLC	532	Early Development	2015
Red River Parish-PAC	Steam Turbine	ADA-ES Inc.	18	Early Development	NA
South Heat Hydrogen Project	Integrated Gasification	Multi-Owned	175	Early Development	2017
Sub-total:			1,400		
Hydrogen Energy California (HECA) IGCC	Integrated Gasification	SCS Energy LLC	431	Advanced Development	2018
Lake Charles Cogeneration	Integrated Gasification	Multi-Owned	670	Advanced Development	2016
Lima Energy IGCC	Integrated Gasification	USA Synthetic Fuel Corporation	580	Advanced Development	NA
Mercedosia	Steam Turbine	Multi-Owned	168	Advanced Development	2017
Texas Clean Energy Project IGCC	Integrated Gasification	Multi-Owned	400	Advanced Development	2015
Sub-total:			2,249		
Plant Washington	Steam Turbine	Power4Georgians LLC	850	Construction Begun	2016
Holcomb	Steam Turbine	Multi-Owned	895	Construction Begun	2017
Merom	Steam Turbine	Hoosier Energy Rural Electric Co-op Inc.	13	Construction Begun	2013
Sulphur Cogeneration Facility	Steam Turbine	Rain CII Carbon LLC	36	Construction Begun	2013
Two Elk Energy Park (One)	Steam Turbine	North American Power Group, Ltd.	300	Construction Begun	2016
Rogers City (Wolverine)	Steam Turbine	Multi-Owned	600	Construction Begun	NA
Plant Ratcliffe IGCC (David)	Integrated Gasification	Southern Company	596	Construction Begun	2014
Sub-total:			3,291		
Total Coal Under Development:			7,206		
Coal as a % of Total Generation Under Development:			2.09%		

Source: Citi Research, SNL Energy

Compliant coal LCOE is not competitive today

These issues cause the LCOE of new clean coal plants to become much higher than CCGT gas plants. As the below chart illustrates, coal is at \$0.156/kwh which is much higher than the gas plant alternative.

Figure 25. LCOE of Recent New Construction Coal Plant

		I GCC/ CCS
System Assumptions		
System Cost	\$/w	\$6.649
System Size	Mw	582
Gas Price	\$/Mmbtu	\$0.0
Fuel Cost at 100% Efficiency	\$/Mwh	\$19.1
Fixed O&M Costs	\$/Kw	\$58.0
Variable O&M Costs	\$/Mwh	\$1.3
Insolation	kWh/Kw/yr	
Inverter Cost	\$/w	
Financial Assumptions		
Equity	%	50.0%
Debt	%	50.0%
Cost of Debt	%	5.5%
Tax Rate	%	35.0%
LCOE	\$/ kwh	\$0. 156

Source: Citi Research

New Construction Nuclear Not Expected on a Merchant Basis Due to Challenging Economic Outlook

With the US nuclear fleet continuing to age and the challenging power price environment continuing, many people have questioned the nuclear plants economic viability. The cost structure of nuclear is characterized by high capital (fixed) costs and lower fuel (variable) costs, resulting into high operating leverage to power prices and capacity factor, and lower sensitivity to fuel prices compared to other types of generation.

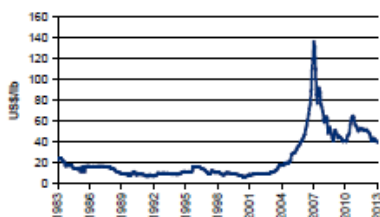
Nuclear power plant profitability is a function of quark spreads and non-fuel costs such as maintenance and non-fuel operating expenses. Quark spread is defined as the difference between the wholesale around the clock (ATC) electricity price and the cost of nuclear fuel needed to generate the electricity and represents plant's gross margin. While quark spreads are driven by wholesale power prices and nuclear fuel prices, non-fuel operating costs are influenced by plant age and an array of other items.

Recent precedent suggests that the cost of construction for new nuclear is relatively expensive and the construction process can difficult to manage. The Southern Company and Georgia Power led new construction plant has been closely watched by the industry and has resulted in several cost overruns. The Vogtle plant near Augusta, GA, is now slated to cost ~\$15 billion which is much higher than original estimates. This project is in a regulated jurisdiction and there is very little interest in new construction nuclear in a merchant climate.

On an LCOE basis, our analysis assumes \$5,000/watt construction costs, 97% capacity factor, 40 year project life, \$6.5 per Mwh of fuel price, \$85/kW of fixed O&M Cost, \$11.40/Mwh variable O&M costs, and a 10% cost of equity. Based on these assumptions, our LCOE of \$105.4/MWh (~\$0.11.KWh) is relatively expensive vs. CCGT gas plants and solar and wind. As a result, we do not expect nuclear to effectively compete on economic merits. Despite this LCOE dynamic, there is merit to increasing fuel diversity and supporting lower carbon generation.

Overtime, we do not expect material changes to the economic drivers of nuclear LCOE. The outlook for construction costs is relatively stable although we expect there to be some learning curves realized during the Vogtle construction process. Both fuel and non-fuel costs are expected to rise modestly over time and thus

Figure 26. Uranium Prices



Source: Citi Research

With high initial investment and operating expenses – nuclear LCOE is unattractive today

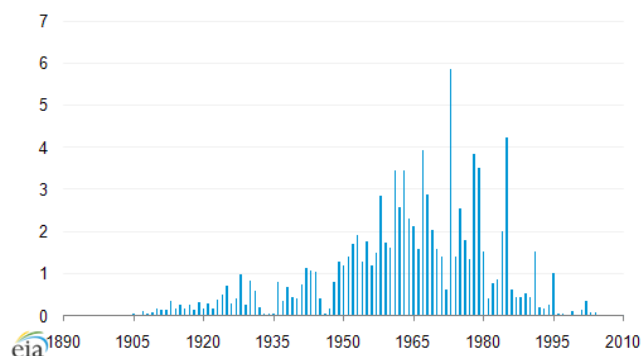
increase the LCOE. The cost of financing market is relatively inexpensive given the low interest rate environment. In the future, financing cost are likely to rise which would hurt the LCOE attractiveness of a high construction cost generating source like nuclear.

For additional information on our outlook for nuclear, see [Nuclear Shutdown](#) and [Trust in Nukes? A Nuclear Decommissioning Trust Report](#).

Hydro is Competitive Today – Physical Resources Limit Growth

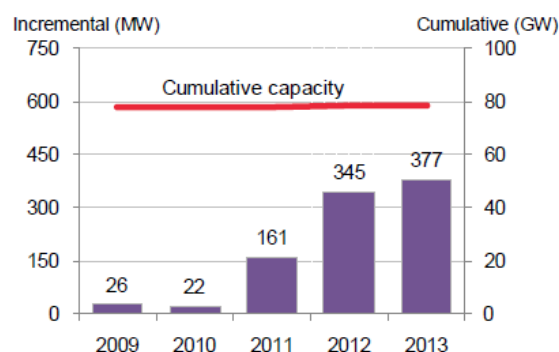
In the US, hydropower represents approximately 7% of power generation with 79GW of installed capacity (101GW including contributions from storage projects). It is concentrated in California, Washington, and Oregon and typically the waterflow is impacted by snowmelt, rainfall, and other factors. For example, select hydro assets on the west coast have been challenged by a recent drought (see our [hydro impact study note](#)). In terms of new construction hydro, there has been a large decline in new additions since the 1980s. While recently there have been few new installations, developers have received licenses or exemptions from FERC for 610MW of new capacity. The key considerations are available debt financing, government incentives, and site specific characteristics.

Figure 27. Capacity of Hydro Generation by initial year of production



Source: Citi Research, EIA

Figure 28. US Hydropower Project Build



Source: Citi Research, BNEF

Hydro has an attractive LCOE

From an LCOE perspective, hydro generation appears attractive. With LCOE of approximately \$62/MWh, driven by assumptions of construction costs of \$2.6M/MW and 50% capacity factors, hydro is a viable fuel source that is competitive today. The return economics are sensitive to construction costs and capacity factors but we reiterate that expansion of hydro is dependent on finding suitable locations. Given these sensitivities, the return profile could be further augmented by extending the useful life of hydro assets beyond our conservative 25 year assumption.

Figure 29. Equity IRR Sensitivity to Construction Cost (in millions) and Capacity Factor
Assuming \$0.062/kwh LCOE

	30%	40%	50%	60%	70%
\$1.0	20%	33%	46%	60%	73%
\$1.5	9%	18%	27%	35%	44%
\$2.0	2%	10%	17%	23%	30%
\$2.5	-3%	5%	11%	16%	22%
\$3.0	-8%	1%	7%	11%	16%

Source: Citi Research

Attractive locations hard to find – hydro
growth limited

As a result of the limited number of bodies of water in the US, we do not expect material growth in hydro generation. The project economics are driven by the availability and consistency of water resources and the cost of materials and the location. There are a few new projects that have been announced throughout the country including a large 600MW project in Alaska under the direction of the Alaska Energy Authority.

Geothermal Generates Attractive Economics But Requires Favorable Geographies

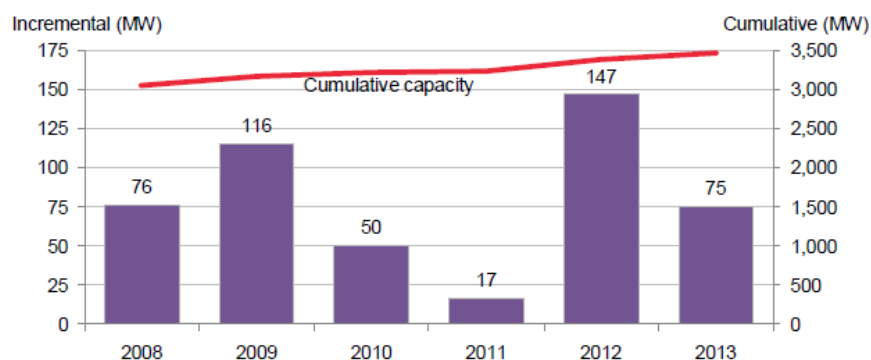
In geothermal, the US is the leader in the world but there is currently only 3.5GW of installed geothermal capacity in the US and growing at only ~2% per annum. Geothermal is a baseload generator that is considered reliable and more predictable than solar or wind generation. Steam is produced below the Earth's surface from reservoirs of hot water and then the steam is piped directly from the underground production wells to the power plants and used to spin turbine to make power.

Geothermal is a stable attractive
baseload generation source

The geothermal assets produce relatively constant power by utilizing injected water in addition to using underground resources. The generation is typically on land that is long term with several options to extend the contracts lives in the future. The geothermal reserves have extremely lengthy life expectations that are expected to extend several decades. For example, Calpine (non-covered) indicated that their reserves should continue to generate sufficient steam until at least 2068.

While there are several desirable characteristics, geothermal technology has not advanced as rapidly as solar or wind and geothermal development is considered more risky and lengthy.

Figure 30. US Geothermal Project Build

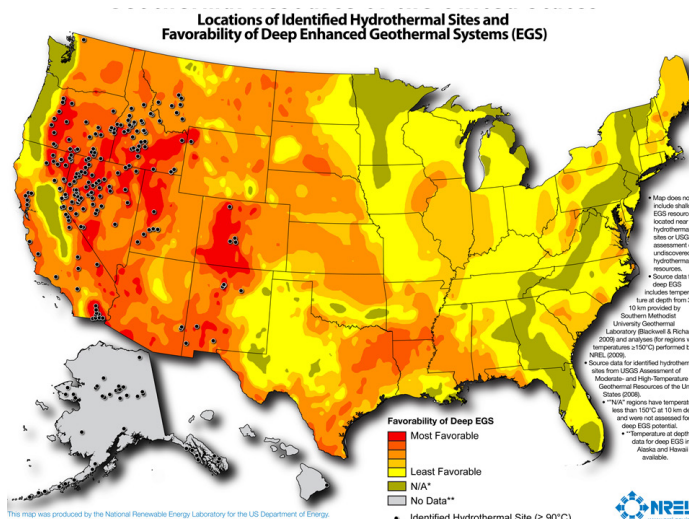


Source: Citi Research, Bloomberg New Energy Finance.

On an LCOE basis, geothermal generation is competitive but is very location specific and most locations are not cost competitive today. As a result, we expect pockets of advancement growth but do expect geothermal to gain a material market share of power generation from natural gas, coal, nuclear, solar, or wind in the next several years.

Location is critical to geothermal

Figure 31. Geothermal Resource of the US



Source: Citi Research, National Renewable Energy Laboratory for the US Department of Energy

We focus our LCOE analysis on reducing the cost of initiating geothermal projects. Projects costs are dependent on drilling costs, land, knowledge and physical characteristics of the resource, environmental and government regulation, timing, risk, and execution. Another dynamic at play, is if the project is the first in a particular area which may require additional learning for all parties involved in the process. As displayed in the chart below, geothermal is competitive today but the nature of construction costs suggests that the LCOE outlook is relatively stable over the forecast time horizon.

Figure 32. LCOE Sensitivity to Baseline Capex and Capacity Factor of Geothermal Generation (\$/kwh)

Capacity Factor	Discount to Capex				
	0%	5%	10%	15%	20%
95%	\$0.049	\$0.047	\$0.044	\$0.042	\$0.040
85%	\$0.052	\$0.050	\$0.047	\$0.045	\$0.042
75%	\$0.059	\$0.056	\$0.053	\$0.050	\$0.048
65%	\$0.068	\$0.065	\$0.061	\$0.058	\$0.055
55%	\$0.080	\$0.077	\$0.073	\$0.069	\$0.065

Source: Citi Research

Biomass Energy Generation – Technological Progress and Commercialization Needed to Improve Outlook

Biomass is a material part of the renewable energy picture today and EIA forecasts it to experience strong growth in the next several years primarily in the Southeast US due to increased co-firing technology and increased government incentives despite relatively high LCOE on an unsubsidized basis.

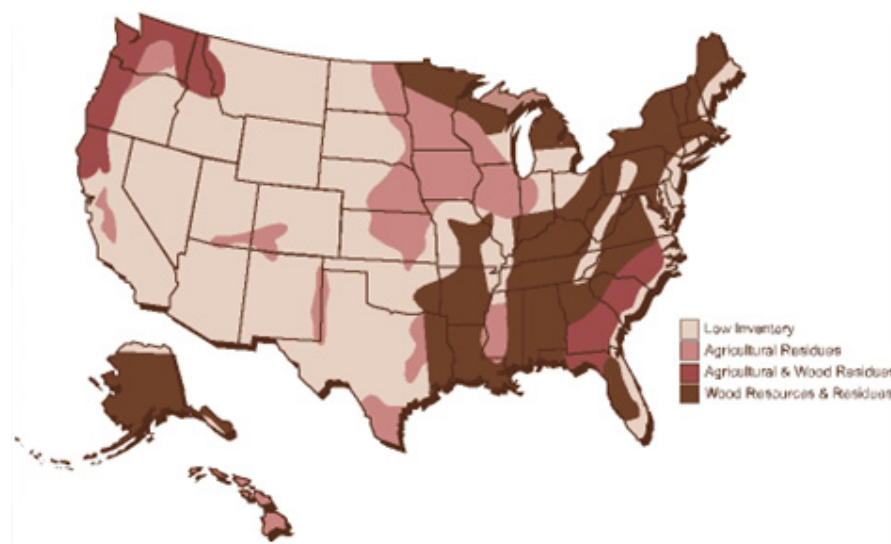
What is biomass? There are several biomass technologies and methodologies used in power generation. Biomass power generation includes anaerobic digestion, incineration, and gasification. Anaerobic digestion is a biological process in which microorganisms break down biodegradable material in the absence of oxygen. Biomass incineration refers to incineration of MSW, C&D, TDF (tire derived fuel), and other resources for power generation. Biomass gasification refers to gas production from manure, wastewater treatment facilities, or other sources for use in electricity generation and transportation fuel. While there is a range of technological processes they are generally characterized with relatively high initial investment and high operation / fuel costs and material capital expenditure requirements.

Where is biomass in the US?

Biomass located primarily in Northeast and Southeast within the US

While biomass plants have a potential to locate throughout the US, there has been more biomass generation in the east coast. As a matter of fact, in some regions (PJM, NH, Maine, CT, MI) most of the new RPS compliance is being in the form of biomass, which actually is eligible for PTC, but has a high fuel and variable cost.

Figure 33. US Biomass Resources



Source: Citi Research

Is it Competitive from an LCOE Perspective?

Without subsidies, biomass marginally uncompetitive from an LCOE perspective but has attractive diversity and baseload characteristics

On an unsubsidized level, biomass is largely uneconomic today and would need material declines in construction costs to achieve a competitive LCOE. The operating costs consist of the raw biomass and then the cost of processing into energy. The procurement of biomass can be uncertain as the forest and agriculture residual can be difficult to readily procure. The cost of procurement is not expected to materially decline in the near future. While it may have an elevated LCOE, it is typically viewed as baseload and thus has higher reliability and less dependence on natural gas or coal supplies. In addition, biomass has been helped by US government incentives, which partly explains its growth.

Figure 34. LCOE Sensitivity to Construct Cost Declines (\$/kwh)

	Base Case	20%	40%	60%
Biomass - anaerobic digestion	\$0.134	\$0.118	\$0.102	\$0.086
Biomass - incineration	\$0.120	\$0.109	\$0.097	\$0.085
Biomass - gasification	\$0.125	\$0.109	\$0.094	\$0.078

Source: Citi Research

Figure 35. IRR at \$115 LCOE with Sensitivity to Cost Declines

	IRR vs Cost Declines @ \$115 LCOE				
	0%	10%	20%	30%	40%
Biomass - anaerobic digestion	3%	5.3%	8.7%	12.9%	18.4%
Biomass - incineration	8%	10.2%	12.4%	15.3%	19.2%
Biomass - gasification	6%	9.0%	12.6%	17.1%	23.2%

Source: Citi Research

MSW and Landfill Gas

The growth in MSW and landfill gas generation has driven by government incentives, RPS standards, power prices, and public sentiment. The US government has provided incentives in the form of the PTC, valued at \$11/MWh for projects that began construction by the end of 2013. While government has been important, we focus on the fuel source's LCOE.

Landfill Gas – Attractive LCOE but Limited Growth Prospects

Landfill gas (or Biogas) is generated during the natural process of bacterial decomposition of organic material contained in MSW landfills. The output of landfill gas is 50% methane and 50% carbon dioxide, water vapor, and small amounts of Nitrogen, Oxygen, and Hydrogen. The energy content is approximately 500-600btu per mcf and can be converted into natural gas streams or if upgraded as a substitute for CNG or LNG in transportation.

Landfill gas economics tied to natural gas prices

As a result of its economics being tied to the outlook for natural gas pricing, we expect the return profile to move with natural gas prices. The report [New American Century](#) discusses Citi's commodity team's long term view of natural gas prices. With the forward curve for natural gas suggesting that the economics are becoming more favorable, we expect investment is likely to continue. Since 2008, there has been roughly \$1.8Bn invested in the biogas market. While attractive, there are limitations on growth in the US as there are about 2GW of projects in operation and approximately 850MW of new candidates throughout the US as identified by the EPA. While each project has unique dynamics and outlooks, the US landfill gas growth is likely to be limited by available landfills that produce enough methane to justify infrastructure investment requirements and have environmental and government support.

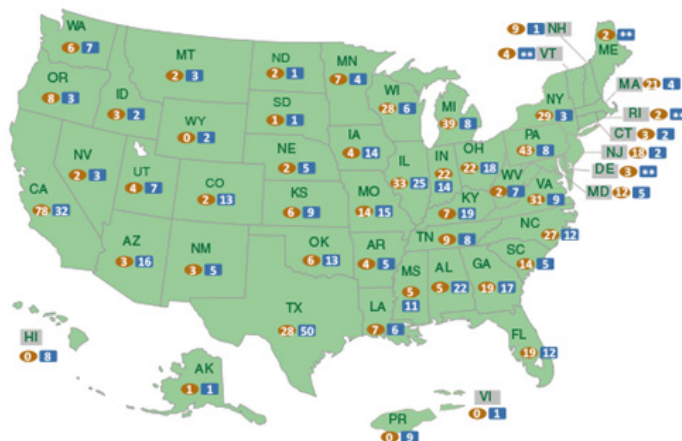
Figure 36. Landfill Gas Levelized Cost of Energy (LCOE in \$/ kwh) (Capex \$ in Million)

Landfill Gas				
Capacity Factor	CAPEX			
	\$1.50	\$2.00	\$2.50	\$3.00
60%	\$0.067	\$0.081	\$0.095	\$0.109
70%	\$0.057	\$0.070	\$0.082	\$0.094
80%	\$0.050	\$0.061	\$0.071	\$0.082
90%	\$0.045	\$0.054	\$0.064	\$0.073

Source: Citi Research

In addition to economics, we note that landfill gas has benefited from RPS standards (renewable energy treatment), the Energy Policy Act (2005), and the Energy Independence and Security Act (2007).

Figure 37. US State Lists of Landfill Gas Projects (621 Operational – 1,978MW / 311mmscfd; 450 Candidate landfills - 850MW / 470 mmscfd)



Source: Citi Research, EPA

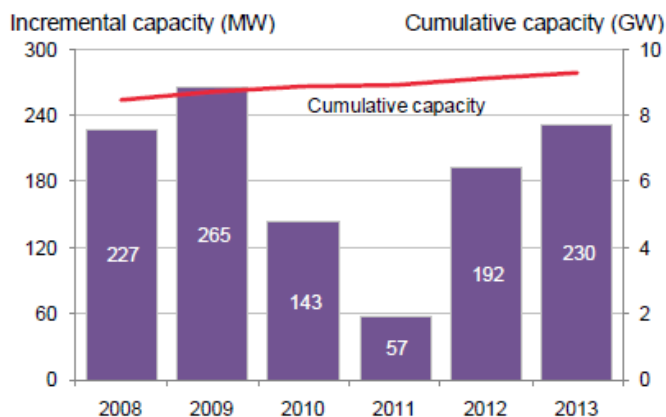
MSW – Reasonable LCOE but Limited Growth Potential and Faces Headwinds

While Europe has average recovery for waste of ~40%, the US is at ~8% and has material challenges. The number of waste to energy plants has declined in the US from ~180 to 86 facilities over the last 30 years in the US. Today, these facilities are mostly located in the Northeast US and collectively produce 2,720MW of power per year and consume 28 million tons of waste per year. However, several states are converting over 15% of generation to energy (ME, CT, MA, PA, NJ, NY, MD, NH, and FL).

Waste to energy has less favorable LCOE than competing fuel sources due to its capital expenditure costs, operating costs, and energy revenues. The majority of the operating costs are fixed with relatively high capacity factors of 80%.

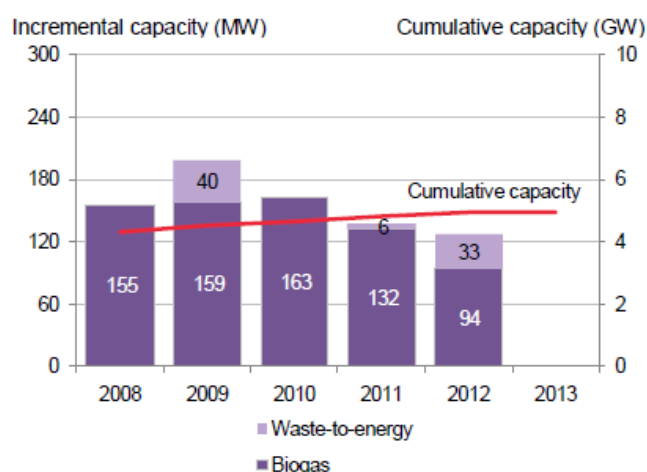
There are several barriers to material investment in MSW to energy projects in the US including depressed power prices, low landfill gate fees, and absence of favorable legislation. Power prices in PJM have declined over the last several years due to the growth of the Marcellus, limited gas takeaway capacity, and flat or low load growth. We continue to expect power prices to be depressed over the next few years with seasonal basis differentials to further impede the market. Gate fees for waste-to-energy in the US are ~\$68/ton compared to average landfill gate fees \$45/ton. While contracts and business models vary on a project by project basis, the gate fees are not expected to materially decline with improvements in technology. Lastly, the introduction of MACTs and tax law changes has negatively impacted MSW to energy development. While MSW to energy generation is recognized as renewable energy in the majority of the US states (31 states and 2 territories) for RPS standard purposes, it does not have mandated requirement for its use or large tax incentives for adoption.

Figure 38. US Biomass to Power Build



Source: Citi Research, Bloomberg New Energy Finance

Figure 39. US Biogas and Waste to Energy Build



Source: Citi Research, Bloomberg New Energy Finance

Marine Energy Not Competitive on an LCOE Basis Today – Meaningful Technological Progress Needed

Marine based power generation is in early innings despite having some government support, no fuel costs, and increased public awareness. The technologies use turbines underwater to convert tidal movements or river flows into electricity. Alternatively, wave technologies use buoys to convert the up and down movements of waves into power for consumption. This power generation source is intermittent but predictable in timing.

Marine energy is in early innings

While demand outlook is uncertain for these technologies, Siemens' Marine Current Turbine indicated that it aims to build a 10MW array (tidal) in Whales in 2015/16 and a 8MW array at Kyle Rhae in 2016 and Atlantis Resources (not covered) expects tidal generation to start its MeyGen project in 15/16 pending capital issuances. In wave technology, there are several companies including Ocean Power Technologies, Carnegie Wave Energy, Oceanlinx, Aquamarine Power, and Seabased that are moving forward with initiatives in this space.

At this stage in the development cycle, there a wide range of potential outcomes. We focus our sensitivities on a range of construction costs and O&M expenses that drive the current economics of these projects. The resulting levelized cost of energy (LCOE) is relatively expensive and not cost competitive today.

Figure 40. Marine LCOE

Technology	Capex (\$/MW)			Capacity factor (%)			Fixed O&M (\$/MW)	Fuel costs (\$/mmbtu)	Heat rate (mmbtu/MWh)	Debt / equity split (%)	Cost of debt (bps to LIBOR)	LCOE, central scenario (\$/MWh)
	Lowest	Central	Highest	Lowest	Central	Highest						
Marine - tidal	6.73	9.28	13.00	25%	35%	45%	130,000	-	-	0%	-	442
Marine - wave	5.48	8.78	16.05	25%	30%	35%	150,000	-	-	0%	-	499

Source: Citi Research, Bloomberg

What Stands in the Way of Significant Growth?

There are several challenges that stand in the way of tidal development including 1) financial, 2) engineering execution, and 3) limited connections to the grid.

The LCOE for tidal development is currently over \$440/MWh (\$0.44/KWH) and would need to decline ~80% to compete on an unsubsidized basis with natural gas, coal, wind, or solar. We are assuming that no available debt financing market is available, construction costs are ~\$9million per MW of generation and fixed costs are ~\$130K per year per MW of generation. With such a large divide, the development of tidal energy projects are largely unprofitable today with the largest 12 companies generating accumulated losses of \$735M and many venture capital investors reporting losses investing in the space. As a result many companies and governments have been reevaluating their tidal energy investments because there is not a visible path toward cost parity with other full sources.

Figure 41. Tidal Energy LCOE Sensitivity to a Decline in Construction and O&M Costs (\$/kwh)

O & M Cost	Capex				
	0%	20%	40%	60%	80%
0%	\$0.442	\$0.355	\$0.275	\$0.196	\$0.116
20%	\$0.427	\$0.347	\$0.268	\$0.188	\$0.109
40%	\$0.419	\$0.340	\$0.261	\$0.181	\$0.102
60%	\$0.412	\$0.333	\$0.253	\$0.174	\$0.094
80%	\$0.405	\$0.325	\$0.246	\$0.166	\$0.087

Source: Citi Research

Significant engineering progress is needed to advance the technology. The cost of development has been more costly and time consuming than many industry executives expected a few years ago. Each step including prototyping, building MW-scale demonstration models, testing in tanks, test-deploying at sea, installing, maintaining, decommissioning, and connecting to grid has faced several obstacle. To date, only one MW-scale machine has been completed (MCT's SeaGen) and they have not built a second.

Infrastructure is required to connect to grid. In addition, many of the best tidal locations are not always located near existing transmission infrastructure. As a result, many projects need to gain support for new grid connections to enable the possibility of tidal generation to reach end users. This is a problem in Northern and Western Isles in the UK.

Figure 42. Utility Comp Sheet

		Rating	Target Price	Current Price	ETR	Diluted Shares	EPS - Citi				EPS - Consensus			P/E - Citi			P/E - Consensus		
							2014	2015	2016	CAGR	2014	2015	2016	2014	2015	2016	2014	2015	2016
Regulateds																			
AEP	American Electric Power	Neutral	49.00	50.20	2%	485	3.38	3.49	3.88	4.4%	3.34	3.48	3.59	15.0	14.4	13.7	15.0	14.5	14.0
ED	Consolidated Edison	Neutral	58.00	58.05	8%	295	3.88	3.99	4.08	2.5%	3.74	3.88	4.03	14.5	14.0	13.7	15.0	14.5	13.9
DTE	Detroit Edison	Buy	9.00	71.78	7%	172	4.34	4.80	4.84	5.8%	4.32	4.59	4.89	16.5	15.6	14.8	16.8	15.8	14.7
D	Dominion Resources	Neutral	64.00	69.40	-4%	574	3.62	3.77	4.17	8.7%	3.53	3.74	3.89	19.2	18.4	16.7	19.8	18.8	17.8
DUK	Duke Energy	Buy	77.00	70.88	13%	574	4.80	4.89	5.07	4.3%	4.58	4.75	4.92	15.4	14.5	14.0	15.8	14.9	14.4
EIX	Edison International	Buy	56.00	52.37	10%	330	3.58	3.54	3.70	-0.8%	3.65	3.51	3.78	14.8	14.8	14.1	14.3	14.9	13.9
GXP	Great Plains Energy	Buy	28.00	26.27	10%	151	1.88	1.74	1.93	6.0%	1.85	1.71	1.87	15.8	15.1	13.8	16.0	15.4	14.0
NEE	NextEra	Neutral	83.00	81.39	-8%	420	5.16	5.80	5.81	5.4%	5.31	5.85	5.99	17.7	16.3	15.7	17.2	16.2	15.3
PCG	Pacific Gas	Buy	52.00	44.06	22%	425	3.07	3.28	3.44	8.2%	3.02	3.15	3.21	14.3	13.4	12.8	14.8	14.0	13.7
POM	Pepco Holdings	Neutral	20.00	20.39	3%	230	1.21	1.31	1.41	7.3%	1.22	1.32	1.45	16.8	15.8	14.4	16.7	15.4	14.1
PNW	Pinnaole West	Neutral	59.00	55.85	9%	111	3.75	3.90	4.15	4.4%	3.71	3.88	4.00	14.8	14.3	13.4	15.0	14.4	13.9
SO	Southern Company	Neutral	43.00	42.35	8%	880	2.78	2.88	2.98	3.2%	2.78	2.87	2.98	15.2	14.7	14.2	15.3	14.8	14.3
WR	Westar	Buy	37.00	34.22	12%	127	2.38	2.41	2.57	4.0%	2.31	2.38	2.49	14.5	14.2	13.3	14.8	14.5	13.7
Average					7%					4.9%				15.7	15.0	14.2	15.8	15.2	14.4
Integrateds																			
ETR	Entergy	Sell	59.00	63.82	-2%	178	4.80	4.77	4.83	-8.3%	5.32	4.87	4.83	13.3	13.4	13.2	12.0	13.1	13.2
EXC	Exelon	Sell	21.00	30.41	-27%	819	2.25	2.23	1.91	-7.6%	2.38	2.33	2.11	13.5	13.8	15.9	12.9	13.1	14.4
FE	FirstEnergy	Sell	28.00	30.78	-4%	419	2.53	2.74	2.46	-5.6%	2.63	2.84	2.78	12.2	11.2	12.5	11.7	10.5	11.1
PPL	PPL Corporation	Buy	34.00	32.29	10%	582	2.17	2.22	2.22	-2.7%	2.17	2.19	2.23	14.8	14.6	14.5	14.9	14.8	14.5
PEG	PSE&G	Buy	38.00	36.86	8%	507	2.48	2.29	2.57	-1.9%	2.65	2.49	2.54	14.8	16.0	14.2	13.9	14.7	14.4
Average					-3%					-5.2%				13.7	13.8	14.1	13.1	13.2	13.5
YieldCo																			
NYLD	NRG Yield	Neutral	44.00	38.18	18%	65	0.81	0.87	0.87	245.0%	1.21	1.22	1.77	47.2	44.0	44.0	31.4	31.2	21.8
Other																			
AWK	American Water	Buy	49.00	44.84	12%	178	2.45	2.58	2.64	7.0%	2.40	2.59	2.70	18.3	17.5	17.0	18.7	17.3	16.8

Source: Citi Research

Figure 43. Global Renewable Coverage

Company Name	Currency	Analyst	Rating	Risk	Price 28/2/14	Target price	Upside / Downside	MktCap (\$mm)	P/Bbook	EV/Sales	EV/EBITDA	P/E
2013 2014 2015 2013 2014 2015 2013 2014 2015 2013 2014 2015												
SOLAR - POLYSILICON												
Wacker	EUR	Andrew Benson	3		97.85	60.00	-39%	7044	2.2	2.1	2.0	258.7
REC	NOK	Jason Channell	3	H	4.47	2.50	-44%	1721	2.5	2.7	2.8	28.9
GCL Poly	HKD	Timothy Lam	1	H	2.92	3.00	3%	5827	2.3	2.0	1.8	-39.8
OCI	KRW	Timothy Lam	1	H	207000.00	233000.00	13%	4629	1.7	1.6	1.6	-59.2
SOLAR - EQUIPMENT												
Meyer Burger	CHF	Jason Channell	2	H	16.65	6.60	-60%	1594	2.1	2.3	2.3	15.0
SMA Solar	EUR	Jason Channell	2	H	43.41	31.00	-29%	2079	2.0	2.0	1.9	-35.0
Advanced Energy	USD	Shahriar (Shar) Pourreza, CFA	1	H	27.44	33.00	20%	1097	2.4	2.1	1.7	2531.9
SOLAR - DOWNSTREAM												
SunEdison	USD	Shahriar (Shar) Pourreza, CFA	1	H	18.36	21.00	14%	4895	21.3	13.8	7.4	603.4
First Solar	USD	Shahriar (Shar) Pourreza, CFA	1	H	57.07	63.00	10%	5679	1.1	1.0	0.9	42.6
SunPower	USD	Shahriar (Shar) Pourreza, CFA	1	H	33.13	39.00	18%	4027	3.4	3.0	2.5	11.5
SOLAR - MANUFACTURER												
Trina Solar	USD	Shahriar (Shar) Pourreza, CFA	2	H	16.03	11.50	-28%	1265	1.5	1.7	1.8	-56.0
Yingli Green	USD	Shahriar (Shar) Pourreza, CFA	2	H	6.18	6.00	-3%	968	5.0	10.7	40.0	-13.1
Motech	TWD	Timothy Lam	1		52.20	68.00	30%	755	1.6	1.5	1.3	12.9

Source: Citi Research

Appendix A-1

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