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Global Utilities

Does the future of solar belong with Utilities?

Equities

Global

Utilities

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Solar the new paradigm to generate power: scale and implications misjudged

We believe the market underestimates the magnitude (1/4 of global installed base by 2050E vs 4% today) and the implications of the looming solar revolution on the utility industry. Namely, most commentators seem overly focused on the disruptive effects of solar but overlook the opportunities that "going large" on solar can bring to the utility value-chain, thanks to €1trn capex potential by 2025 in large-solar projects, intelligent networks and energy storage. We believe solar will eventually replace nuclear and coal, and establish as the default technology of the future to generate and supply electricity.

Only a fraction of solar to be residential: most to come from large projects

Contrary to common perception, solar is not primarily a residential phenomenon: 80% of solar additions in 2012-13 in US and Europe were either "utility-scale" (ground-mounted) or "utility-like" (developed by or for I&C customers). We believe large-solar will continue to drive global growth, on (i) better economics vs smaller scale, (ii) declining costs/W: we estimate new entrant costs will almost halve vs c€95/MWh today, and (iii) regulatory support to achieve climate targets and energy independence.

Solar to turn into opportunity: 1 MW in 2 owned by Utilities (c20% EBITDA)

Similarly to wind – initially utilities were marginal players, now they own 1 park in 4 – utilities are likely to become lead actors in solar; anecdotal evidence shows the process is already in motion. By 2025, Utilities could account for half of the global solar market. Going "large" on solar could potentially upgrade global sector EBITDA by c20%, after accounting for implications on power prices, smart grids and grid-scale storage.

Going large on solar to redefine the value chain: 10-110% upside for winners

Valuations across the traditional utility value-chain are set to change. Developing large-solar would become a new business line. To this extent we believe that the value of global wind platforms – which could easily be converted into solar ones – is set to rise. We also believe power distribution activities should re-rate given the capex needs in smart grids and storage. EDPR, EGP, Huaneng Rnwbles, EDP, Nextera Energy, Huadian Fuxin and SunEdison offer the best exposure (UBSe 10-110% EPS upside), in our view.

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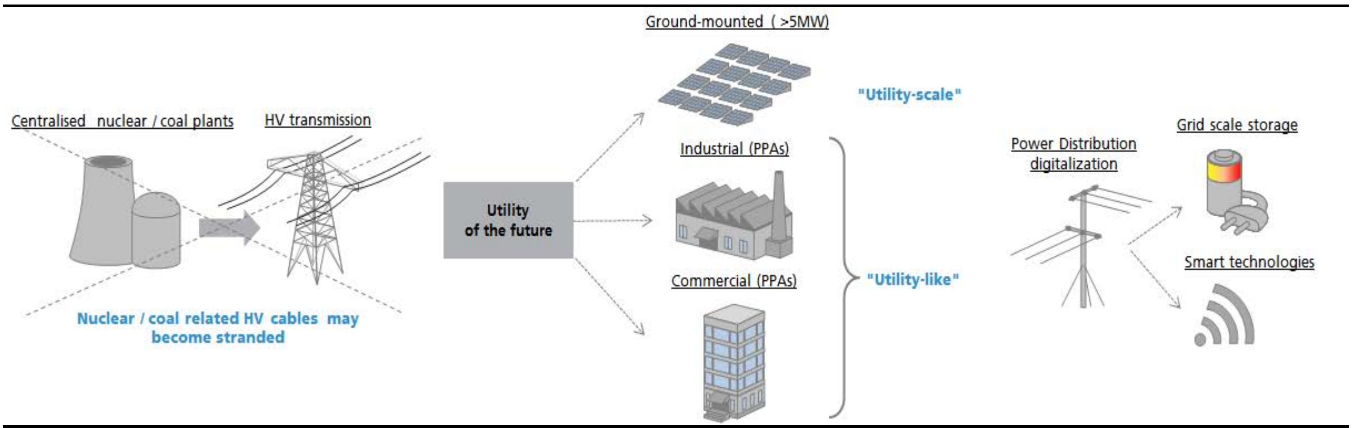
Figure 1: The future of solar belongs with utilities, and could potentially transform the whole value chain



Source: UBSe

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Why read this report

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To the power industry, solar has been a disruptive technology and, for merchant generation activities, this will likely continue to be the case. However, in this report we challenge the popular perception on solar, and argue that this activity will soon be regarded as an opportunity for the utilities industry, for three reasons.

First, *it is our firm belief that – as already seen in wind – Utilities will soon become lead actors in "large-solar". This will turn solar into an opportunity, as opposed to a threat. Companies might develop "utility-scale" projects (5-200MW vs typical residential at 3kW) or "utility-like" ones, which would typically replicate the business model of SolarCity and SunEdison in the US.*

Second, *we believe the financial community and most industry experts largely underestimate the global solar capacity growth, as falling costs, supportive regulation and the opening up of new solar markets seems to go largely unnoticed.*

Third, *valuations across the chain are set to change. Even via batteries, customers will not be able to "get off the grid". Indeed, investments in power distribution are set to accelerate owing to the need to turn the grid into "intelligent" and fit grid-scale batteries. The value of global renewable platforms should also surge, to discount the "solar-conversion-optionality*[1]*". Lastly, the rising penetration of renewables should lead to rethinking the philosophy at the core of merchant markets, which we expect will eventually reconvert into regulated regimes.*

The bigger picture impact on the utility value chain

We see ***renewable platforms*** *and* ***power distribution*** *as the most undervalued activities in the industry. The former – such as EGP and EDPR – could easily become prime solar actors simply by converting their existing global wind platforms; we upgrade EDPR to Buy. The latter should benefit from rising capex needs in intelligent devices and grid-scale storage.*

Longer term, the value of ***transmission assets*** *could de-rate as capex expectations on high-voltage may be set to decline. To explain this, it is enough to think that most big power plants (nuclear, coal) in Western economies will largely disappear on a 20-25y view and the portion of the high voltage infrastructure that connects them to the rest of the system would become largely stranded. In this context, we downgrade REE to Neutral, to also reflect the rising Spanish political risk.*

Lastly, we expect the downward pressure on ***LT merchant power prices*** *to put pressure on hydro/nuclear operators (thermal plants are already cash flow negative and would therefore be subsidized to avoid blackouts)2. Yet, here the end game remains unclear, given the upward optionality from carbon. In a world of rising power bills, the upside risk from carbon might well be capped via regulatory intervention (e.g., windfall taxes, or re-regulation). Conventional generation remains the "extinguishing breed" of the utility value-chain. In this context, we might anticipate more bold moves, similarly to what was announced by EON at the end of last year.*

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[1] We think established wind developers will be able to leverage on their global platforms, to also develop solar, alongside wind capacity.
[2] Thermal profits have largely bottomed; half of fleet is already FCF negative, 21 April 2015

Executive summary in ten points

(1) **Global solar potential largely underrated** – Currently solar accounts for c4% of global capacity (1% of production). Over the coming 10y this could rise to 10%, on UBSe. By 2050, based on our scenario analysis (and with the support of studies by MIT and IEA), solar could become 25% of the global installed base. Solar investments to 2050 could amount to €3trn (€0.5trn by 2025).

(2) **Large solar will be the prevailing industry standard and turn into opportunity for utilities** – During the past three years, some 80% of the global solar additions were non-residential. We see large solar dominating global additions due to cost competitiveness vs smaller projects, and the surge in capex poured in by utilities, thanks to the ongoing reduction in costs and supportive regulation. Hence, similar to the path observed in wind, utilities might pursue large projects and could account for about half of the solar market by 2025 (>€300bn capex).

(3) **Solar new entrant at €55/MWh by 2025** – Our analysis shows a c50% decline in new entrant levels, to €55/MWh by 2025. By then solar would no longer need subsidies. In sunnier regions, solar is already competitive today. Although solar capacity brings externalities (backup needs, further investments in smart grids/storage), we would stress that (i) solar also brings major advantages such as energy independence, and lower emissions; and (ii) the cost curve implies that solar will be a viable choice, even once accounted for such externalities; (iii) investments in smart grids and storage will have a positive cost-to-benefit impact on consumers, over the longer run (savings on opex/maintenance capex and on consumption).

(4) **Global subsidies to peak at just over 1% of power bills** – Global solar subsidies could reach c€70bn in 2025, but would then begin to decline as older subsidized plants would leave room to newer and unsubsidized ones. As a reference, we estimate 2025 power bills to total c€6trn globally, or c6% of GDP.

(5) **Asia to drive growth, US the ideal market for utilities** – Currently Europe is half of the global solar market; yet, going forward Asia will play a lead role and account for about ½ of the additions. The US seems an ideal market due to good radiation and supportive regulation.

(6) **Customers will not "get off the grid"** – We disprove the myth according to which "customers will get off the grid". Given the economics of energy storage, the high concentration of solar production in just a handful of hours during the year and the batteries technical limitations on the number of cycles (charge/discharge), customer will not be able to get off the grid.

(7) **Merchant markets will never be the same** – Rising penetration of RES would lead to rethinking the philosophy of merchant markets. We expect thermal spreads to gradually drop to zero, which would imply negative EBITDA from merchant coal/gas plants. This would have to lead to the introduction of availability-subsidies (€9bn in EU, on UBSe) to avoid mass scale closures, and would effectively imply a re-regulation of generation.

(8) **Smart grids and Storage to also boom** – The intermittency in the supply will require an upgrade in the power distribution network; we estimate

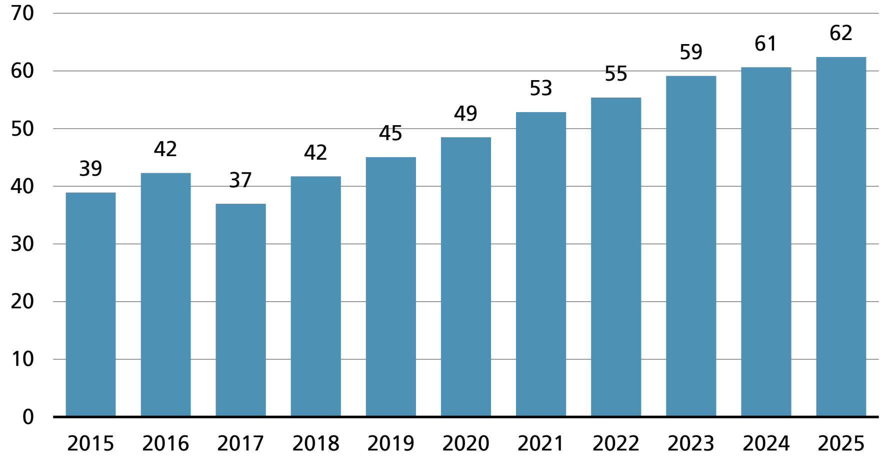
€0.3trn capex by 2025 and up to €3trn by 2050. We also expect a major boom in batteries (both grid-scale as well as residential): the IEA forecasts half a trillion capex to 2050.

(9) **Large intrinsic value in power distribution activities and global renewables platforms** – The power distribution grid will need to become self-balancing, given the rising share of intermittent volumes injected, and the rising frequency-volatility. This will require vast long term investments (smart grids and grid-scale batteries), to the tune of >€3trn by 2050. Thus, we believe that most of the "hidden value" in the utilities space lies in power distribution and in global renewable platforms (even though currently largely devoted to developing wind) as these will soon be converted into 'solar springboards' and fuel larger than expected growth.

(10) **EBITDA upside of up to 20% –** Investments in solar could upgrade global utilities EBITDA by c10% (c20% if we also accounted for smart grids/storage). We estimate that the key winners could benefit from an EPS upside of 10-110%. EDPR, EGP, Huaneng Renewables, EDP, Nextera Energy, Huadian Fuxin and SunEdison are the best plays on the theme, in our view.

Key messages in charts

Figure 2: Global solar annual additions set to accelerate (GW)



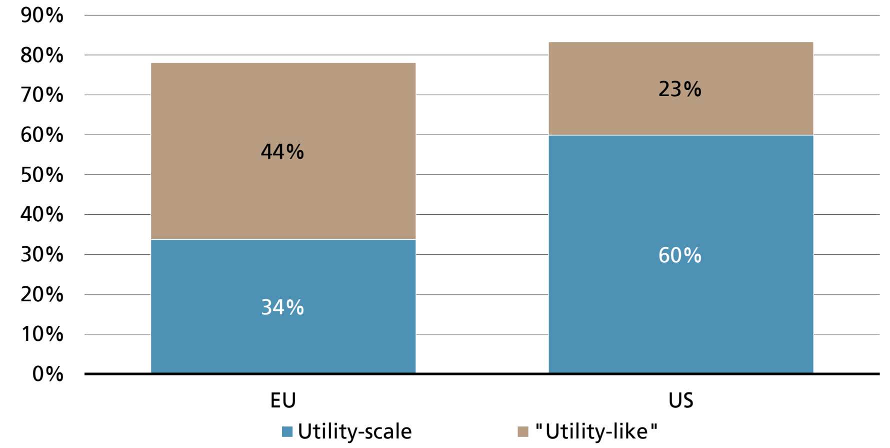
Source: UBSe

Figure 3: Solar could account for 10% of capacity by 2025, and 25% by 2050

	2015E	2025E	2050E Mid
Global installed base (GW)	5,694	7,880	12,159
Solar global capacity (GW)	218	721	2,980
Solar capacity penetration	*4%*	*9%*	*25%*
Global output (TWh)	24,061	28,200	40,917
Solar global output (TWh)	255	896	4,092
Solar output penetration	*1%*	*4%*	*10%*

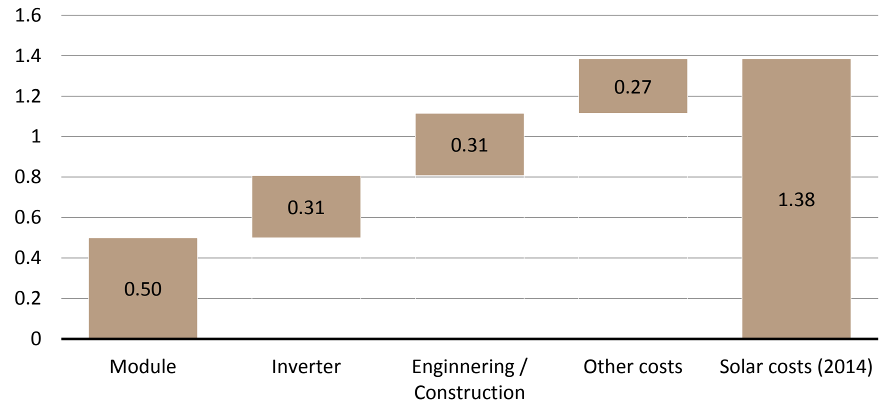
Source: UBSe

Figure 4: Percentage of "large solar" projects added in 2013 was c80%



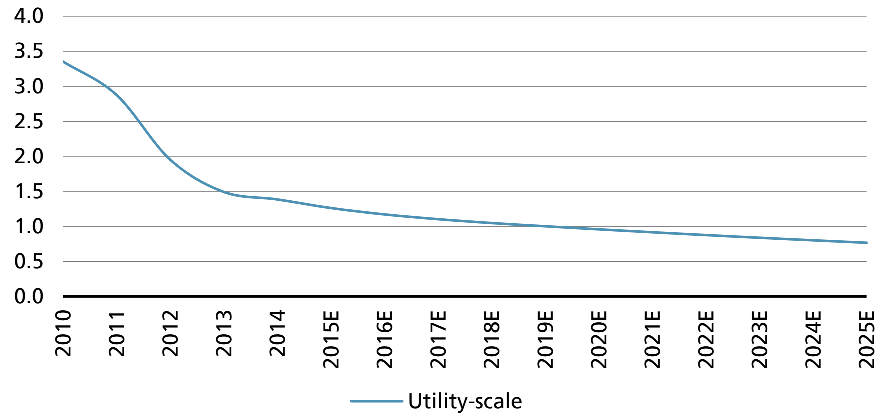
Source: UBSe; Note: global capacity

Figure 5: Solar PV cost in 2014 (large project, €/W)



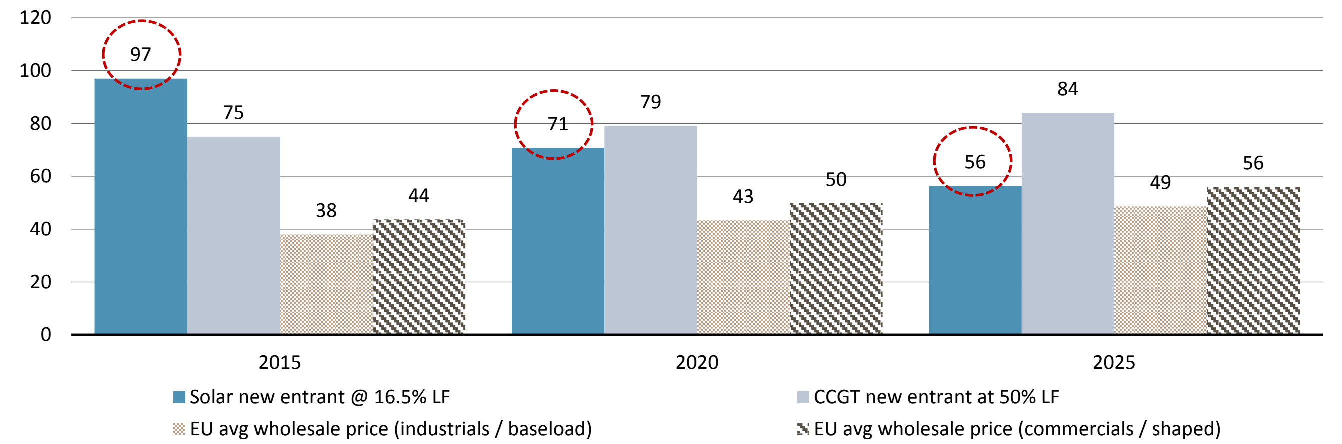
Source: UBSe, MIT

Figure 6: Utility-scale solar capex per W to fall by c5% pa (€/W)



Source: UBSe

Figure 7: New entrant costs – solar cheaper than thermal by 2020 (€/MWh)



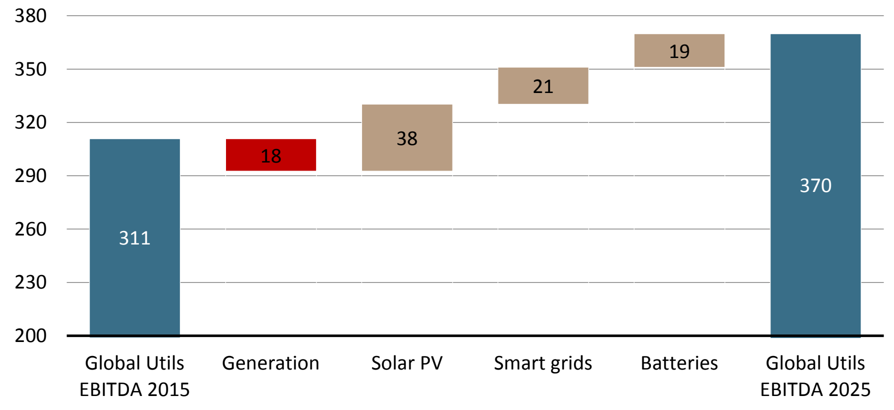
Source: UBSe

Figure 8: Solar payback period and savings by customer (Southern Italy, 2025E)

	Single house	Building	Commercial	Industrial
Size (kW)	2	20	200	400
Output (MWh)	2.2	22.3	223	447
Own consumption	55%	55%	55%	55%
Capex (eur)	2,695	24,255	194,040	368,676
Solar Opex pa (eur)	81	728	4,851	7,374
Annual bill (eur)	1,238	12,375	91,383	162,458
Gross savings if sys costs variable	681	6,806	50,261	89,352
Net savings if sys costs variable	465	4,866	35,708	64,903
Payback	6	5	5	5

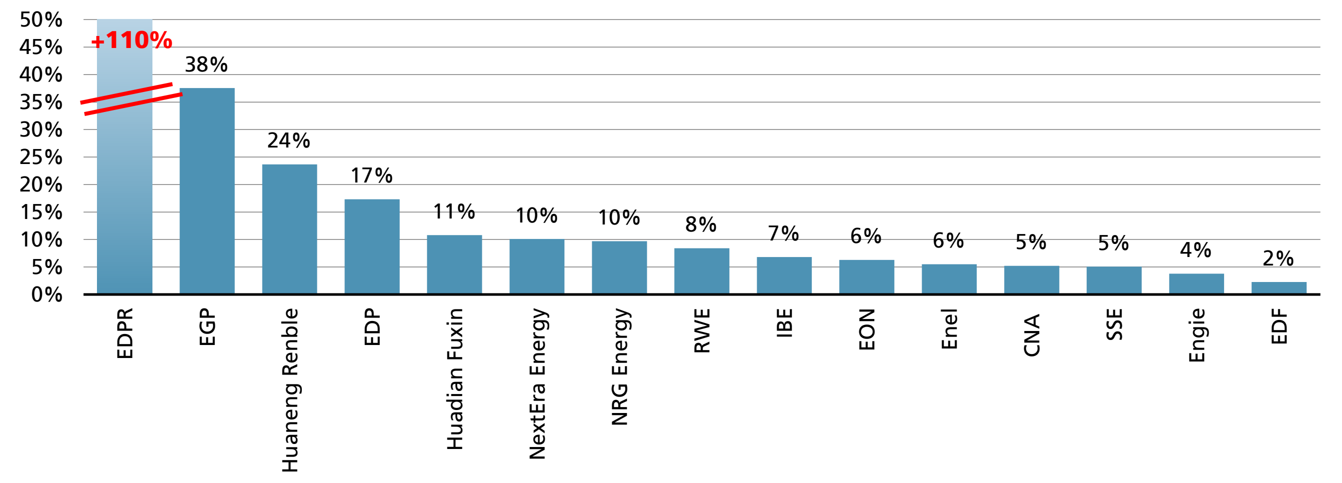
Source: UBSe

Figure 9: Global Utilities EBITDA upside from solar boom (€bn)



Source: UBSe

Figure 10: EPS upside potential from investing in large solar (by 2025E, vs 2015E base)

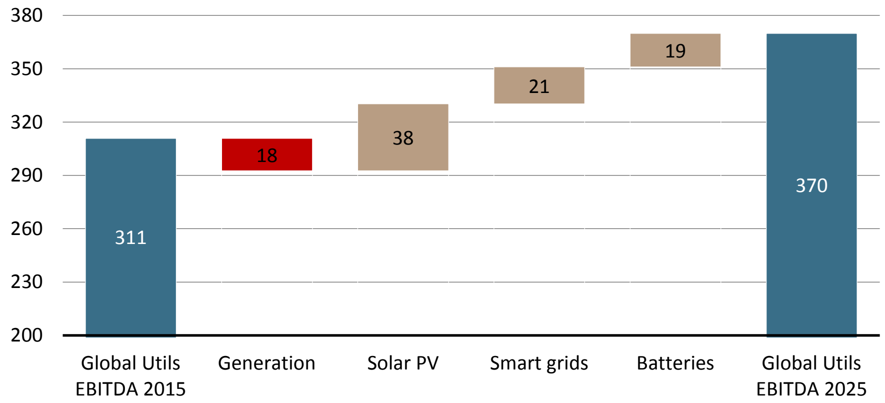


Source: UBSe; Note: large-solar impact only; this is before any negative on power prices and positive from smart grids and storage

Winners & Losers from the solar boom

Although rising solar penetration will continue to put downward pressure on merchant generation prices, we believe the positives from large-solar capacity growth, as well as additional capex in smart grids and storage, could potentially upgrade sector EBITDA by as much as 20%, by 2025.

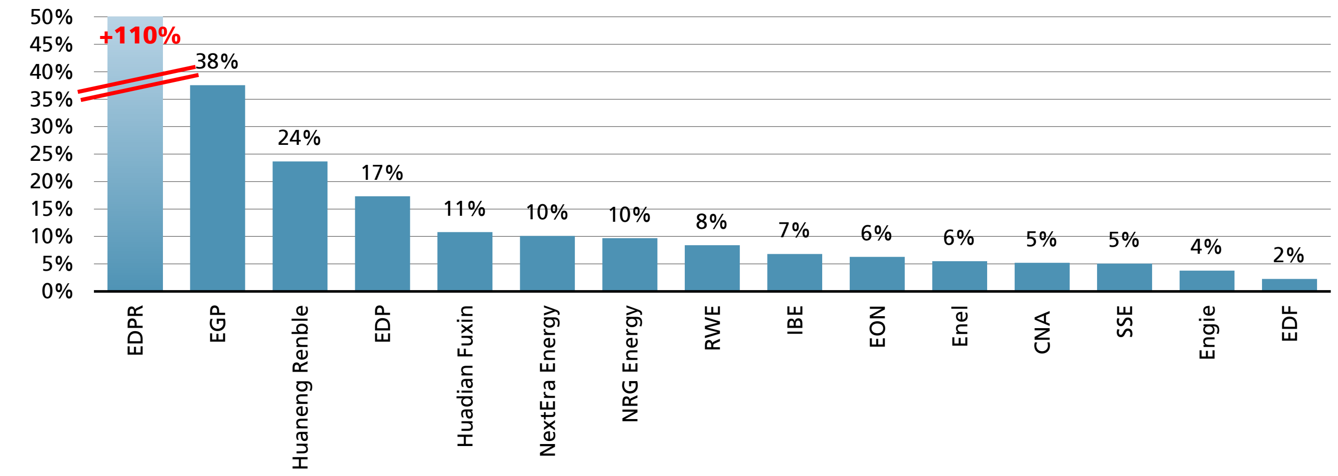
Figure 11: Global Utilities EBITDA upside from solar boom (€bn)



Source: UBSe

By company, we think the main beneficiaries would include renewable developers that diversify from wind into solar. We also see vast opportunities for companies pursuing the "solar-leasing" model such as Solar City or SunEdison. The EPS impact from exclusively additional solar investments shows major differences, and is summarized hereby.

Figure 12: EPS upside potential from investing in large solar (by 2025E, vs 2015E base)



Source: UBSe; Note: large-solar impact only; this is before any negative on power prices and positive from smart grids and storage

Potential winners from the solar boom

- **EDPR (Buy, PT €7.50)** – We upgrade the stock to Buy (see EDPR note) on three main factors (1) we believe the intrinsic value of the global wind platform is set to rise, as it could be easily converted into a leading solar-platform, which would turn EDPR into a solar "early mover" (possibly c5.3GW installed base by 2025E). We see a potential LT EPS upside of >100% (c50% EBITDA upside); (2) valuation discount to infrastructure utilities keeps widening and appears unjustifiable to us, once accounted for returns, asset life and growth-outlook (sub-7x EBITDA by 2017E); (3) we forecast double digit EBITDA annual growth through to 2020 and c20% annual EPS growth.

- **Enel Green Power (Buy, PT €2.20)** – EGP is a major multi-technology renewables developer, with already a sizeable existing asset base in solar (>450MW mostly in Europe and Chile). In its latest strategy plan, management unveiled a capex acceleration that will affect solar (25% of upcoming additions vs 10-15% in previous plans). We estimate LT EPS upside from global solar additions to be +38% by 2025E. Overall, we reiterate our positive stance on the stock, owing to its (1) double-digit value accretive growth (estimated 10% EBITDA CAGR with IRR locked above WACC); (2) improving risk profile (volume exposure to IT Wholesale prices to drop from 35% to <25% by 2018E); (3) strong cash flow generation.

- **Huaneng Renewable (Buy, PT HK$4.10) -** We like Huaneng Renewable because we expect strong capacity growth in renewable energy, including solar and wind. Although solar is still a small part of the company at around 6% of the total installed capacity, management is actively exploring new solar projects with good return potentials. We forecast a 3-year solar capacity CAGR of 24%. We think current valuations are attractive because investors have been overreacted to the decline in wind speed last year, which in our view would only affect short term earnings but not the long term returns and growth potential of the company's renewable projects.

- **EDP (Buy, PT €3.80)** – EDP invests significantly in renewables through its subsidiary EDPR – Considering the large existing asset base and expertise in wind and therefore the potential from solar, we think the LT upside potential for EDP could reach +17%. We have a Buy rating on EDP, for three reasons: (1) the valuation is at discount to peers (2017E PE below 13x vs integrated at >14.5x); (2) we note the DY may not grow for 2-3y, but is attractive at 5.2%; (3) assuming no major negative developments in Greece, we believe Portugal should be a key beneficiary of QE.

- **Nextera (Buy; PT $118 PT)** - On a long-term basis, we expect Nextera to remain a leader in the North American renewables space. We acknowledge investor concerns around the lack of incremental renewables pipeline in 2017/2018 but view this as coming in time. Nextera began 2015 on the right foot with a strong earnings beat and successful conversion for renewables development to the backlog from the forecast (pipeline). While unlikely to add additional solar to its backlog for 2015/2016 given the extended development cycle, there is still approximately ~7 months left to secure wind deals by ~November to achieve a YE16 COD; we suspect 2Q and 3Q updates could yet see further awards (hence the 900-1,100MW in '15/'16 still pending). We attribute some of the weakness to few updates, amid anxious investors for further deals and contracts. This lack of new additions is likely driven by an abundance of caution; management expressed particular confidence in Ontario

procurements of solar, wind, and storage as particularly intriguing. Unlike renewable development peers, NEE is more conservative.

- **Huadian Fuxin (Buy, PT HK$5.80)** - We like Huadian Fuxin because it is a diversified clean energy company with a key focus on developing renewable power projects. We believe the growth potential for solar is strong given it only accounts for 6% of the company's total capacity, and we forecast its solar capacity to grow at around 20% CAGR in the next three years. We also like its diversified assets portfolio which reduces risks from particular fuel type, and its conventional power businesses including coal and hydropower can provide good cash flow to fund the renewable projects. We think valuations are attractive because investors have been overly concerned on the risks regarding its coal-fired assets, but ignored the strong growth and good return potential from the renewable segments of the company.

- **SunEdison (Buy; PT $32 PT)** - SunEdison is well positioned to capitalize on growing solar ambitions both domestically and internationally, targeting 4GW/yr of development by 2017 (off a 1GW in 2014). We expect a litany of positive datapoints around both organic execution and deal generation throughout 2015. The story is one of quarterly execution. We believe the stock will continue to grind higher as management delivers on their targets. Execution on contracts through 2015 would help firm up the **5.2GW** backlog of projects, with the real upside from incremental execution into 2017, as management targets **3.75-4GW/yr** (we assume this is the long-term new run-rate) despite the rolling off of tax credits in the US. Altogether, executing on management's growth targets could provide upside to the ~$50/sh context over time. Our baseline $32 PT effectively assumes execution through its stated plan at high discount rates to account for execution risk.

- **Enel (Buy, PT €5.00)** – Enel invests in renewables through its subsidiary Enel Green Power (see above) – Considering the recently announced capex acceleration, we think the LT upside potential for Enel could reach +6% from solar investment only. Also, Enel is the largest power distributor in Europe, with a RAB of c€40bn. Hence, the company would be a main beneficiary of the digitalization process. This could add further c10% EPS upside, we estimate. We reiterate our Buy rating on (i) solid growth: 7% EPS CAGR (company target +10%) and +13% DPS CAGR on UBSe, supported by rising capex, cost savings and refinancing; (ii) portfolio simplification and optimization – divesting Eastern Europe to expand in the Americas, in our view – should also support multiple expansion, and (iii) ongoing unreasonable discount to peers and to the overall market (2017E PE c13x, EV/EBITDA c7x).

- **Iberdrola (Buy, PT €6.40)** – Iberdrola is a leading global wind developer, with an installed base of c14GW (mostly Iberia and USA). Moreover, management has made clear that it considers renewables as a key segment to drive growth (along with T&D). Therefore we see it ideally positioned to capture significant LT EPS upside (we estimate +7%) from the continuation of the "solar boom". Thanks to its large exposure to power distribution, we also believe that IBE would benefit from the smart grids boom. Relative to the rest of the sector, we believe multiples will keep expanding on three reasons: (1) the business will increasingly be exposed to premium-regions such as UK and US (regulated), (2) profits are more and more regulated / contracted as this is where all growth capex will be allocated, and (3) growth is visible and outpaces sector average.
- **Light (Neutral, PT R$20) –** Light is a Brazil-based vertical electric utility that owns a 16% stake in pure renewables player Renova Energia (not rated, US$1.3bn market cap, 770MW operational wind, small hydro, solar assets, 1.7GW backlog, 15GW pipeline). Light entered preliminary agreements to sell this 16% stake to SunEdison, and we note that Renova Energia signed last month a $500m agreement to (i) sell 3 small hydro power plants (42MW) and 14 wind farms (294MW) to TerraForm Global - this is SunEdison's YieldCo in emerging markets. The final agreement also gives SunEdison Right of First Offer for 1.87GW of renewable energy projects (0.53GW are operating, 1.34GW backlog) plus future pipeline projects at unknown prices. Note that last year Renova already signed a JV with SunEdison including the development of 1GWp of utility-scale solar projects. We see upside from the solar boom in Brazil too: there is 19MW installed capacity today, another 123MW to be added by 2016YE, additional 890MW in 2017 (these benefit from 20-year PPAs at cUS$85/MWh price), plus expected auctions for another 1-2GW this year (at what seems to be attractive terms) for start-up as early as 2018-19. In a recent solar auction in Brazil there were 10GW of projects registered, mostly by solar suppliers. Suggested SunEdison deal valuations in LatAm indicate >10% fair value upside to Light should it decide to monetize its renewables assets today.

Potential losers from the solar boom

Calpine (Neutral; PT $23) – As a large holder of merchant gas-fired units, CPN is poised to suffer from increased renewables penetration into its California fleet. We see the latest talk of increasing the California Renewable Portfolio Standard to 50% by 2030 as potentially kick-starting stalled utility-scale procurement efforts, with distributed generation putting downward pressure on power prices throughout the forecast period. This is expected despite the coming rate tier reform and tax credit step-down by 2017/18. As a possible offset, CPN expects to get involved in renewables once tax credits expire, with the playing field more level among peers. We suspect CPN's angle around development will be to offer a full 'firm' product, with renewables backstopped with contracts supported by its existing gas portfolio. In particular, we see opportunities for the company to sell firm products in California, especially given the governor's push for a 50% renewable standard and the need there for increased grid stability. However, in Texas, the biggest long-term threat to CPN's recently announced gas-fired new-build is merchant solar for utility-scale projects. Good solar geography coupled with generous transmission interconnection policies position the state well in this capacity. After more than a -10% slide post-1Q results, CPN shares look better, but we still emphasize caution and our Neutral rating with a $23 PT based on a 2016E sum-of-the-parts. Down the line (~2019/20), we see potential value around EPA's carbon reduction proposals, but for now, we see less to be excited about given increased Texas development amidst compressed spreads there and a more mild summer forecast.

Fortum (Sell, PT €17) – Fortum has just completed the disposal process of its regulated distribution networks in Scandinavia. The "new Fortum" is largely unregulated, and wholesale power prices are the #1 earnings driver. The long-term trend towards more must-run renewables (mainly wind) is likely to destroy the upside case for power prices in the Nordics. Coal and gas as marginal sources of power are likely to get pushed "over the cliff", which implies that over time, also the carbon price (which we think is set to rise) becomes largely irrelevant. Even though the end game could be a re-regulation of conventional power generation in the long-term, we think the transition period will be painful and can last decades. Fortum's earnings power should drop to €0.7/share in 2016 on depressed power prices, well below the latest €1.10 regular DPS. Even re-leveraging the balance sheet (we see €5-6bn headroom for M&A) is highly unlikely to drive EPS above €0.9-1.0, in our view. In light of the deteriorating risk profile (less regulated assets, more Russia, M&A growth in unregulated generation), we think Fortum shares no longer deserve their vast valuation premium vs. EU utility peers.

RWE (Neutral, PT €22.50) – RWE is embracing the future decentralised energy world, putting its distribution networks and the end customer business (it is the largest downstream utility in Germany) at the core of its strategy. The issue is the legacy: RWE owns the largest generation fleet in Germany, and it is the company with the highest CO_2 emissions in Europe. Even though parts of RWE's generation fleet will become increasingly remunerated under capacity schemes over time (UK capacity auction, German strategic reserve), the company is likely to continue suffering from depressed wholesale prices, shrinking power demand, and a hostile stance of the German government on carbon-intense generation assets. Even more importantly, €13bn of provisions related to nuclear decommissioning/waste and lignite mining are a big drag to RWE's balance sheet. At c4.5x economic net debt/EBITDA and zero FCF from the power generation business at current power forwards (RWE guidance), we think the company remains strategically cornered.

The balance sheet doesn't provide substantial headroom for growth investments, for example in regulated renewables.

…in depth analysis…

Why solar may become the "new nuclear"

We believe LT solar growth could well exceed our expectations as – similar to what happened in nuclear since 1970s – solar could become a "default" choice to support global climate change targets, promote energy independence and also due to the fact that the technology is still relatively young, which may suggest ongoing reduction in costs.

Figure 13: Solar scenarios: 2025E and 2050E

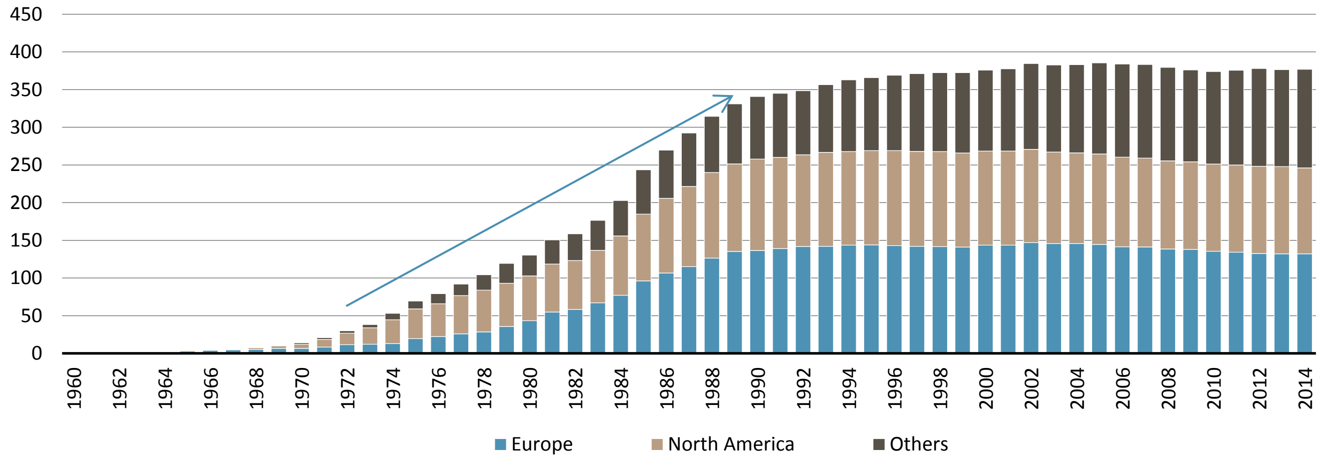
	2015E	2025E	2050E
Global installed base (GW)	5,694	7,880	12,159
Solar global capacity (GW)	218	721	2,980
Solar capacity penetration	*4%*	*9%*	*25%*
Global output (TWh)	24,061	28,200	40,917
Solar global output (TWh)	255	896	4,092
Solar output penetration	*1%*	*4%*	*10%*
Cumulative capex in today's money (€bn)		519	2,651

Source: UBS, IEA, MIT

Just like nuclear before it, solar-rationale is very strong

Figure 14 shows a technological boom that we believe could show some similarities with solar. Specifically, in this chart we show the GW evolution of nuclear around the world. In the 1960s this technology wasn't really part of the global generation mix. In the 1970s nuclear started to quickly develop and peaked in less than 20 years. Today, nuclear accounts for c12% of global production, but the share is much higher in western economies such as US (c20%) and Europe (c30%).

Figure 14: Global nuclear capacity evolution – from zero to 12% of global output in less than 20 years (GW)

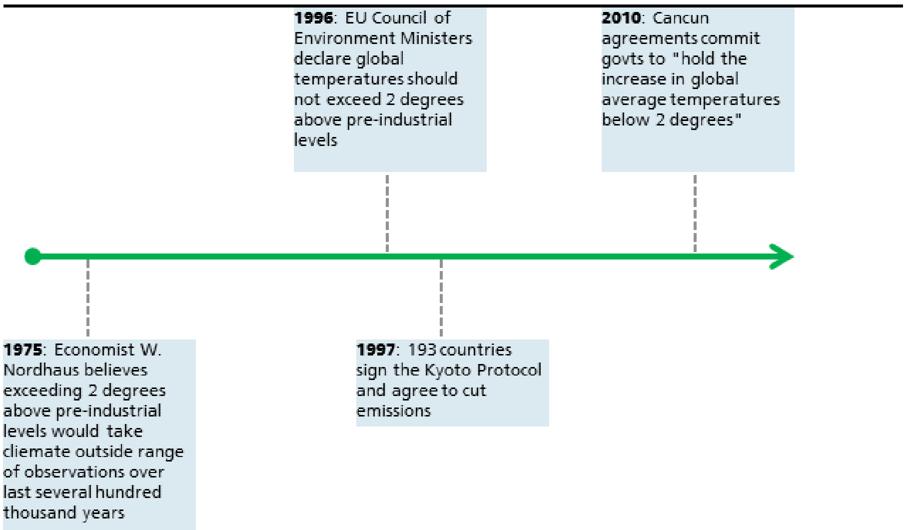


Source: UBS, Company data

The reasons why we firmly believe in the "solar revolution" are three.

- **[1] Global climate change**. Ever since the ratification of the Kyoto protocol in 1997 and the introduction of regional targets (EU, US), several countries have been relying on solar as one of the key technologies to transition to a "carbon free power generation world". The 2010 Cancun agreement to maintain the increase in temperatures below 2 degrees has perhaps consolidated the global commitment to fight global warming on a global basis. In this context, we believe solar PV will be a main actor.

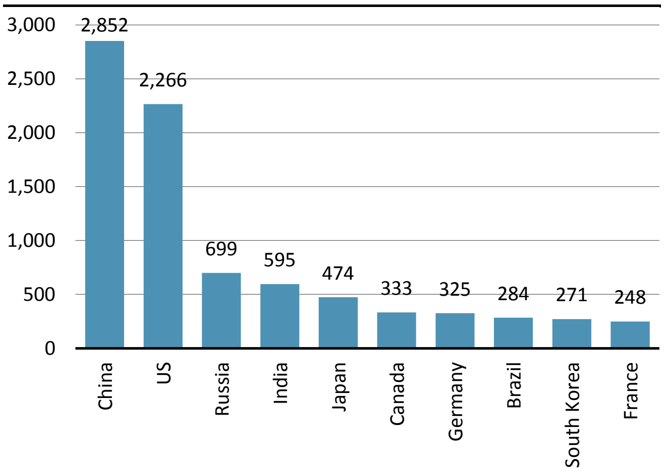
Figure 15: Key steps in the "2 degrees Celsius" global warming debate



Source: The Carbon Brief, UBS

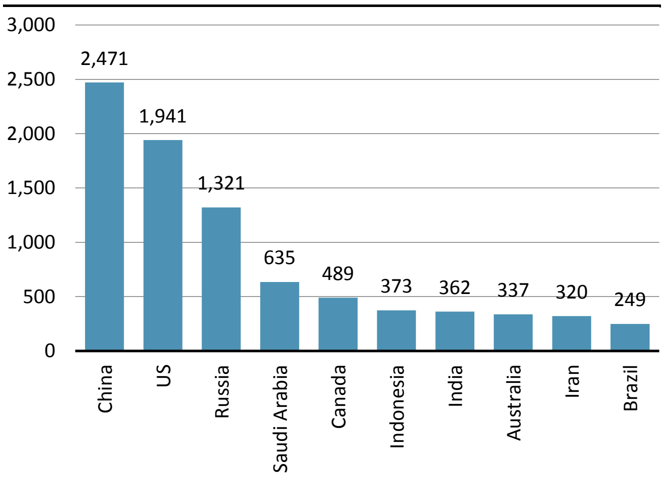
- **[2] Energy independence.** The "solar fuel" is abundant and free. Hence, developing solar will improve energy independence of any country. As a reference Figures 16-17 map the largest consumers and producers of primary energy. The mismatch between users and producers could push the former to purse an "energy preservation" strategy, which may well see solar at its core.

Figure 16: Top 10 primary energy users (mtoe, 2013)



Source: BP, UBS

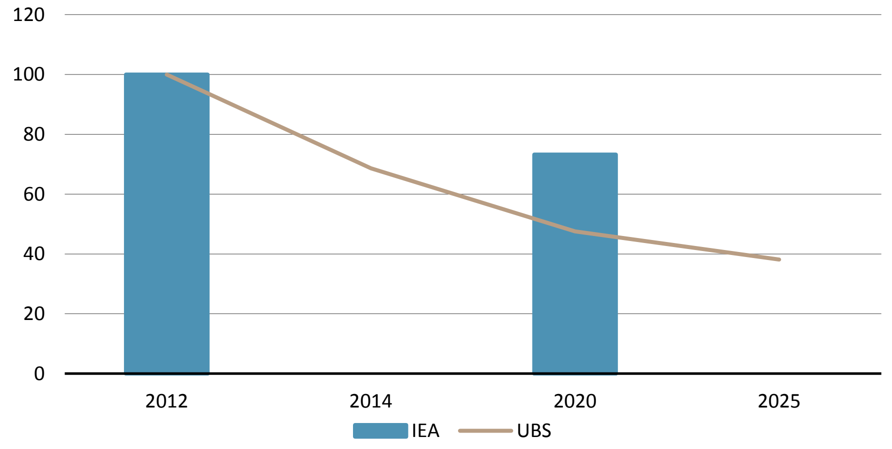
Figure 17: Top 10 primary energy producers (mtoe, 2013)



Source: BP, UBS

- **[3] Economics**. As we detail later in the report, it is very hard to forecast the evolution of solar PV costs. As a reference, the IEA 2012-20 projections on cost / W proved overly conservative. Indeed, the agency was targeting 25-30% cumulative reduction. Yet, said decline was already achieved by 2014, in just over 2y. During 2015-25 we target c4.5% annual decline due to economies of scale and better processes. This will improve the economics on solar and lower the needs for subsidies.

Figure 18: Solar capex/W: IEA 2020 targets already hit in 2014 (rebased to 100)

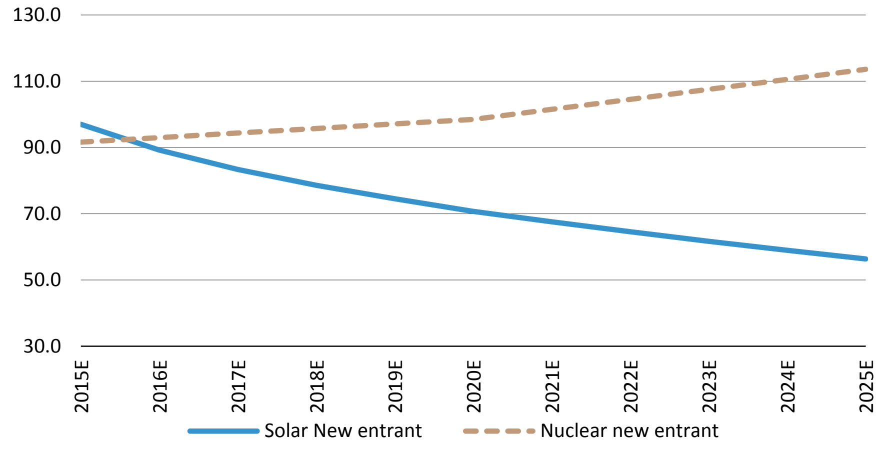


Source: UBS, IEA; Note: 2012 rebased to 100

Solar already cheaper than nuclear as of next year and gap widens…

Figure 19 shows that the new entrant cost for solar will be cheaper than nuclear, as of 2016. And the gap is set to expand, on our estimates.

Figure 19: Solar new entrant below nuclear by 2016E; gap widening (€/MWh)



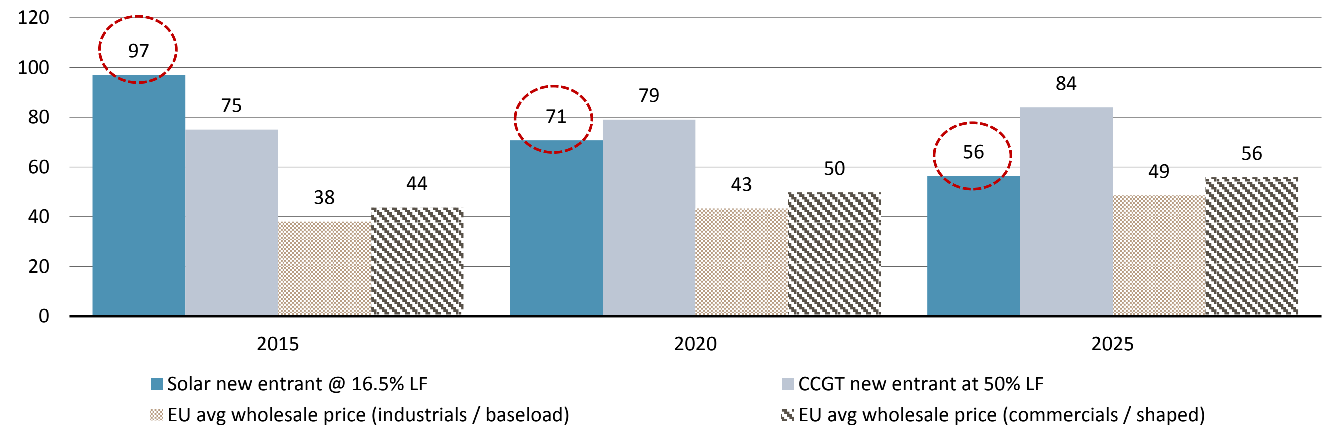
Source: UBSe; Note: solar LF 16.5%

Solar at €55/MWh within ten years

Our global solar-economics model suggests a steep decline in break-even prices (defined as prices that, throughout the life of the assets, allow to achieve a contractually set in stone, pre-tax return of 6%) which in turn implies a drop in subsidies needed. This market is largely regional, given the major differences in capacity factors – the Southern Western part of the US and some regions in Latam are already profitable on an ex-subsidies basis, today. For Europe, Asia and some other regions in the US we estimate that subsidies will keep falling to about zero by 2025. And this is based on prudent commodity assumptions and a conservative evolution in capex per Watt installed.

As already explained, we see global average new entrant costs for large solar at c€70/MWh by 2020 and at c€55/MWh by 2025, based on a 6% pre-tax return (which we assume would be achieved via LT contractual agreements, such as 20-25-year PPAs). Assuming 70% leverage, this would be equivalent to an equity post tax return >9%.

Figure 20: Solar new entrant vs baseload vs shaped power prices (€/MWh)



Source: UBSe; Note: CCGT new entrant costs assume carbon costs (€8/t in 2015, €15/t in 2020, €25/t in 2025), as if every region were to implement something similar to a carbon tax

Although solar capacity brings externalities (backup needs, further investments in smart grids/storage), we would stress that (i) solar also brings major advantages such as energy independence, and lower emissions; and (ii) the cost curve implies that solar will be a viable choice, even once accounted for such externalities; (iii) investments in smart grids and storage will have a positive cost-to-benefit impact on consumers, over the longer run (savings on opex/maintenance capex and on consumption).

Large solar UBS modelling

Figure 21 summarizes our utility-scale new entrant calculation, at an average load factor of 16.5% and a target project ROIC of 6% (ROE 9%). This model allows us to identify the price needed throughout the life of the project (LCOE) to achieve such return. Given the "inflation-benefits" embedded in the LCOE, we turn that metric into a new entrant price in "today" money. Our key operating assumptions include.

- **Capex per Watt installed** to fall from c€1.25/W to €0.96/W by 2020 and to €0.77/W by 2025, equivalent to c5% decline pa.
- **Useful life** of solar parks at 25 years

- **Performance** factor gradually rising to 85% and cell **decay** at 0.35% pa
- **Opex** at 1.5% of capex (year 1)

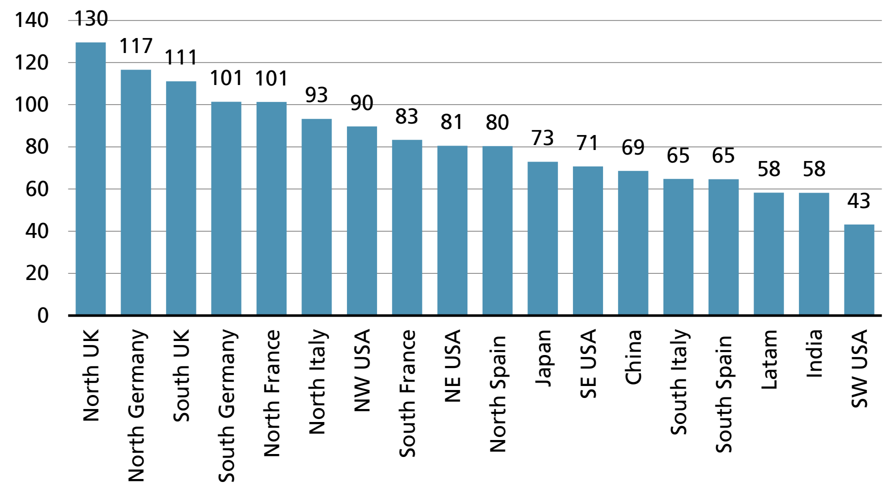
Figure 21: UBS global solar economics model summarized

	2015E	2016E	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Cost / W (eur)	1.26	1.17	1.10	1.05	1.00	0.96	0.92	0.88	0.84	0.80	0.77
Asset life	25	25	25	25	25	25	25	25	25	25	25
Performance	81%	82%	83%	83%	84%	85%	85%	86%	86%	86%	86%
Cell decay	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%	0.35%
Load Factor	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%
ROIC (pre tax)	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
Opex as % of capex	1.50%	1.52%	1.55%	1.57%	1.59%	1.62%	1.64%	1.66%	1.69%	1.72%	1.74%
Output per 1MW (MWh)	1,168	1,180	1,192	1,205	1,217	1,229	1,232	1,236	1,239	1,243	1,247
inv-capital per 1MW (em)	1.3	1.2	1.1	1.0	1.0	1.0	0.9	0.9	0.8	0.8	0.8
Target EBIT (e/MWh)	64.8	59.5	55.5	52.2	49.4	46.8	44.6	42.5	40.5	38.7	36.9
Opex (e/MWh)	16.2	15.1	14.3	13.6	13.1	12.6	12.2	11.8	11.4	11.1	10.7
Depreciation (e/MWh)	43.2	39.7	37.0	34.8	32.9	31.2	29.7	28.3	27.0	25.8	24.6
Target LCOE (e/MWh)	124.2	114.3	106.8	100.6	95.4	90.6	86.5	82.7	79.0	75.5	72.2
New entrant today (e/MWh)	**97.0**	**89.2**	**83.4**	**78.6**	**74.5**	**70.7**	**67.5**	**64.5**	**61.7**	**58.9**	**56.3**
Average EU baseload price (e/MWh)	38.0	39.1	40.1	41.2	42.2	43.3	44.3	45.4	46.5	47.5	48.6

Source: UBSe

The disparity in capacity factors is at the core of the divergence in new entrant solar PV prices, which – on a 2020 basis – vary from €45/MWh in the sunniest parts of the US, to €100-130/MWh in the UK and Germany.

Figure 22: 2020E new entrant costs by region (€/MWh)

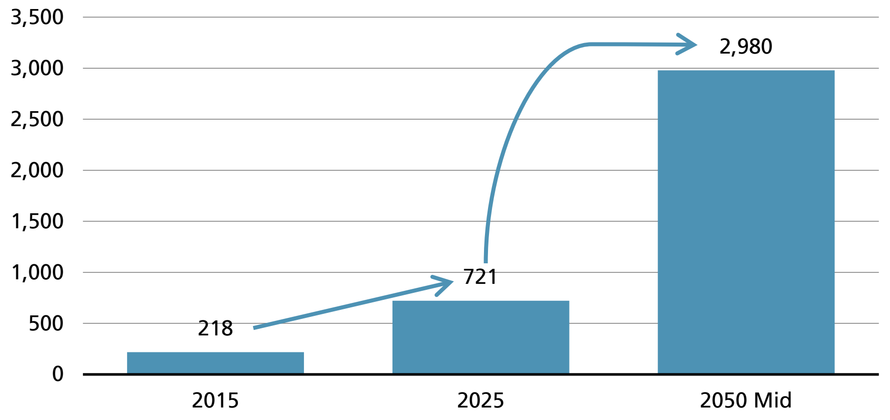


Source: UBSe

The 2050 solar scenario

Using data by the IEA and MIT, coupled with our own estimates, we show that the 2050 solar capacity could surge fourteen times (c8% pa compounded) to c3,000GW. By then, solar would account for ¼ of the global installed base and c10% of output. Such growth profile could, if anything, prove conservative and imply cumulative investments of – in today's money – c€3trn. In cooperation with the MIT, we investigate the main constraints on "scaling up solar" (land, raw material, social pressure on tariffs) and conclude that solar could potentially power the entire planet without any land or material bottleneck.

Figure 23: Global solar PV installed base (GW)



Source: UBSe

Solar at ¼ of 2050 installed base

As explained earlier in the report, we estimate that the global solar PV market could more than treble by 2025. By 2050, we present four scenarios where we assume low solar penetration (5% of global output), a mid-case scenario (10% penetration), a high scenario (25%) and a "Dream" scenario of 50%. Taking our mid-scenario, we can see that the solar PV market could increase by 14 times from current levels. On this basis, global solar installed base would be 3,000GW, or about half of today's total installed base (renewables as well as conventional) in the world, and ¼ of the total capacity by then.

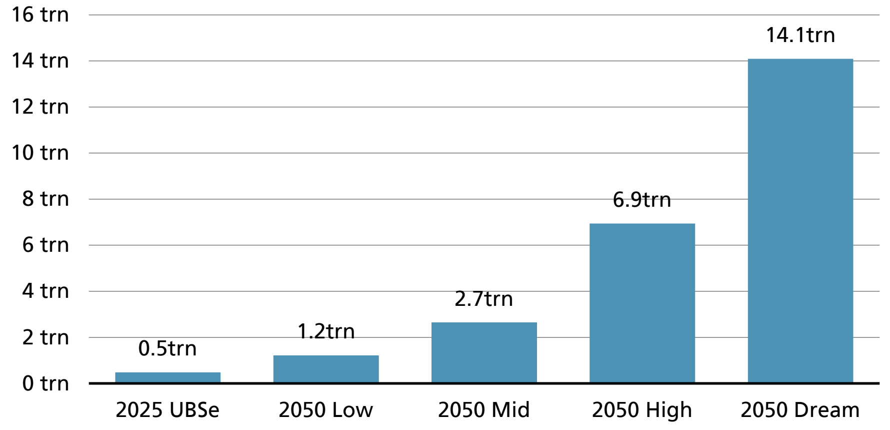
Figure 24: UBS 2025 base case and 2050 scenarios – solar market could increase by 14 times by then

	2015	2025 UBSe	2050 Low	2050 Mid	2050 High	2050 Dream
Global power demand (TWh)	24,061	28,200	40,917	40,917	40,917	40,917
Solar penetration (% output)	1%	3%	5%	10%	25%	50%
Solar global production (TWh)	255	896	2,046	4,092	10,229	20,459
Solar performance factor by then	81%	86%	95%	95%	95%	95%
Average global load factor	16.5%	16.5%	16.5%	16.5%	16.5%	16.5%
Solar global capacity (GW)	218	721	1,490	2,980	7,450	14,899

Source: UBSe, MIT

Figure 25 shows the capex potential from solar PV. We estimate some c€470bn global investments over the coming 10 years, and some €2.7trn by 2050.

Figure 25: Cumulative solar PV capex from 2015E (€trn)



Source: IEA, UBSe

Land not a constraint: 0.03% of land surface on our 2050 mid case

On our analysis, one square km could fit 50-100MW of solar PV. Taking the mid-range, we see that – on our base case 2050 scenario of 10% output penetration (25% of capacity) – solar PV would occupy almost 40,000 sq km, or 0.03% of the total land surface of the globe. Even under the "Dream" scenario of half of global production from solar, the covered surface by modules would be only 0.13%.

Figure 26: Solar PV surface needs are far less demanding than perception

	Mid	High	Dream
Output penetration	10%	25%	50%
Capacity penetration	25%	61%	123%
Solar capacity 2050 (GW)	2,980	7,450	14,899
Sq km occupied by solar	39,731	99,329	198,657
Total land surface (sq km)	148,300,000	148,300,000	148,300,000
Solar land surface occupied to generate 10% of output	**0.03%**	**0.07%**	**0.13%**

Source: UBSe

Raw materials: no constraints on silicon technologies, yes on thin film

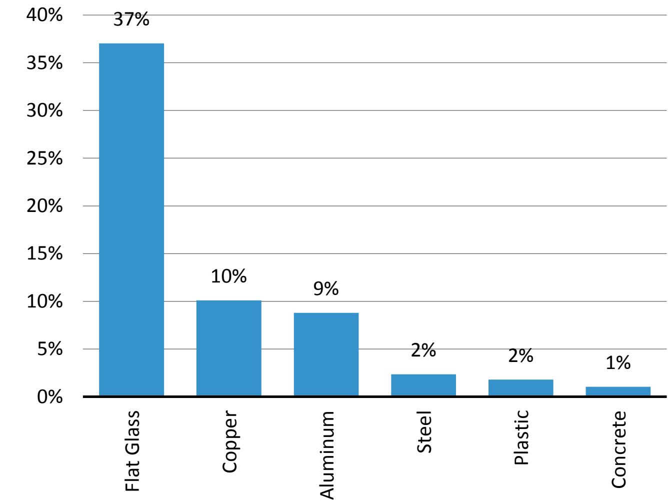
On our calculations, 1 square meter of solar would weigh some 11-12kg. Also, to develop 1MW of solar PV, some 140 tons of materials would be needed. The total weight would rise to 210 tons if we included the concrete structure on ground projects. More details are given in the appendix.

When it comes to the raw materials required to support our 2025 and 2050 scenarios, we conclude that there would be no real bottlenecks on standard silicon technologies, as these largely use glass, steel, plastic, aluminium, and copper. By 2025 the global solar industry would absorb 1-11% of the worldwide production of these materials, and the percentage would only rise to 40% for flat glass, which could be quite easily scaled up.

On critical materials though, the story would be different as – if thin film accounted for 100% of all additions to 2025 – then the global solar industry would require 40-160% of all the tellurium, gallium and indium extracted since 1900 (at "constant technology", see Figure 28).

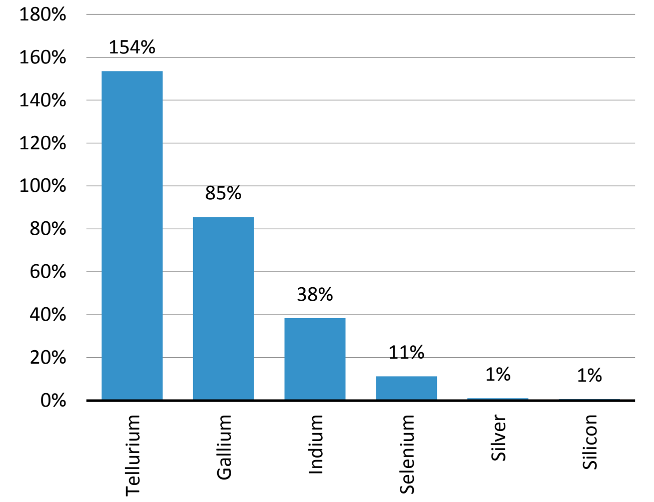
This is why we believe silicon / polysilicon technologies are likely to dominate the upcoming solar boom.

Figure 27: Materials needed to 2025E as % of annual production, if scenario achieved with silicon/polysilicon PV



Source: MIT

Figure 28: Materials needed to 2025E as % of extractions since 1900 if scenario entirely achieved with thin film

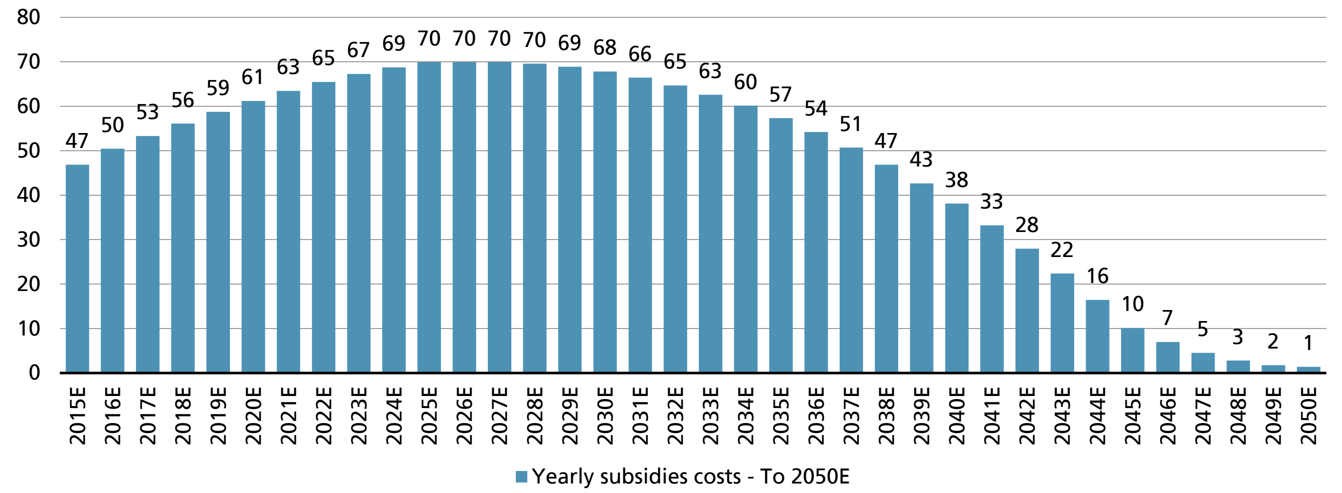


Source: MIT

Social burden: subsidies high until 2025, then quickly declining

Hereby we show the global subsidies needed to promote solar PV, at the pace we highlighted earlier (c40-60GW pa). Perhaps against "common sense", global subsidies don't appear an excessive burden: by 2025 these would merely account for 0.03% of global GDP and c1% of global tariffs, we estimate. As new facilities replace old (= expensive) ones and the need for subsidies disappears, the annual burden will largely disappear some time during 2045-50, we figure.

Figure 29: Subsidies evolution – growing to 2025E then beginning to decline as solar becomes competitive (€bn)



Source: UBSe

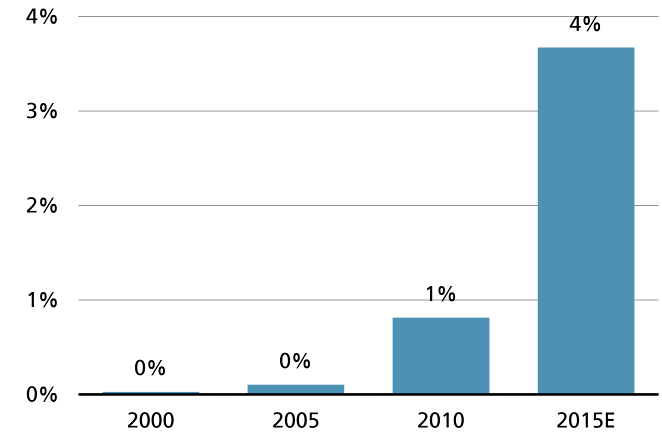
UBS 2025 scenario: solar to more than treble

During the past ten years, the global solar PV capacity has risen by over 40 times (+c200GW). During the next ten years (2015-25) we estimate this to surge by three times (+200%) to reach c720GW (+c505GW). This would require some €470bn of investments in nominal terms.

Spectacular growth over just ten years

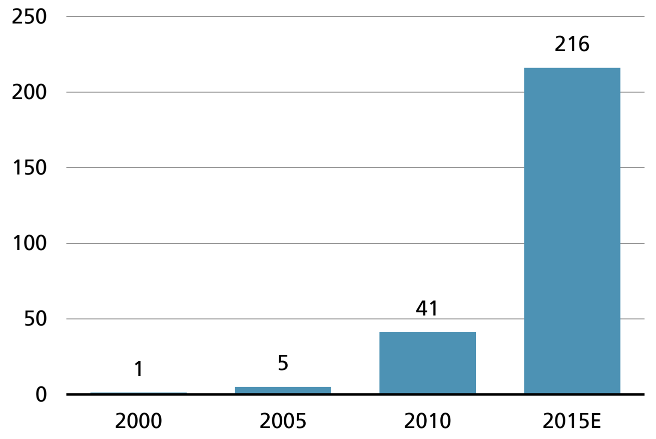
In year 2000, the global solar PV installed base was a mere 1GW, not even 0.1% of the global installed capacity. By 2010 solar was still a niche technology, given less than 1% penetration. Currently, although some 200GW of solar have been installed worldwide, the penetration (as % of capacity) is still only 4%.

Figure 30: Solar penetration as a % of capacity (global)



Source: BP, EPIA, UBSe

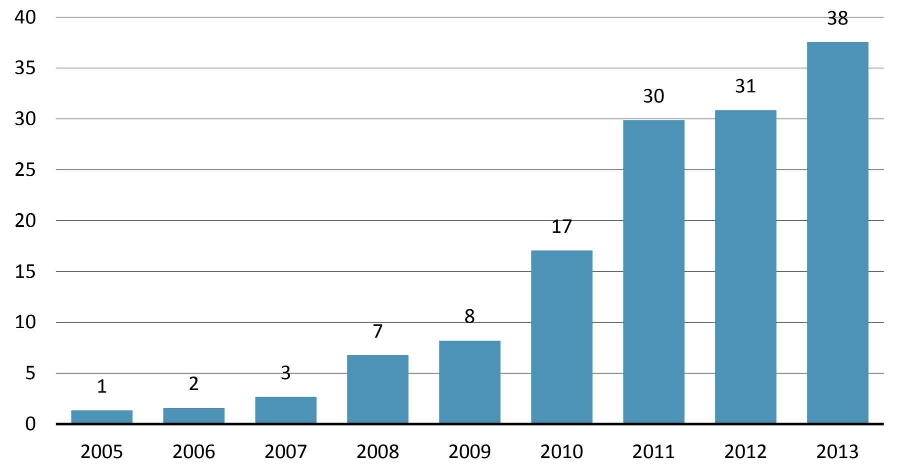
Figure 31: Global PV capacity (GW)



Source: BP, EPIA, UBSe

On a yearly basis, solar growth has been constantly accelerating since 2005, in absolute terms. Up until 2009, annual additions were well below 10GW pa. Yet by 2011, global solar growth hit 30GW and was almost 40GW by 2013.

Figure 32: Global solar additions have been consistently accelerating (GW)

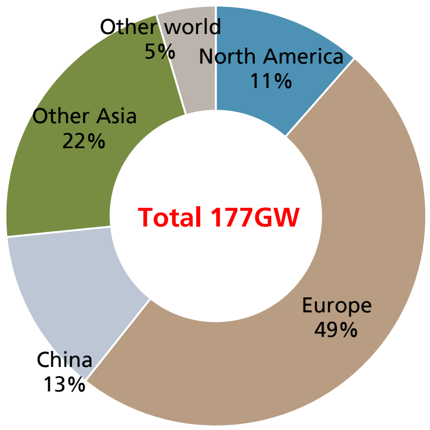


Source: BP, UBS

Europe has been the main driver for growth in 2005-15

Regionally, during 2005-15, Europe has been leading the solar boom, and currently still accounts for about half of the total installed base.

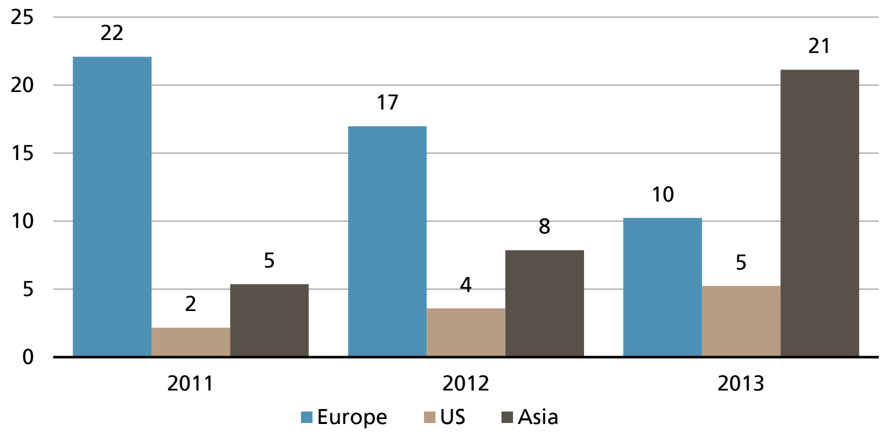
Figure 33: Split of total installed capacity as of end-2014



Source: UBSe

Yet, for the first time, in 2013 the Asian market was the largest contributor to global growth, with annual additions in excess of 20GW.

Figure 34: 2011-13 yearly additions by region (GW)

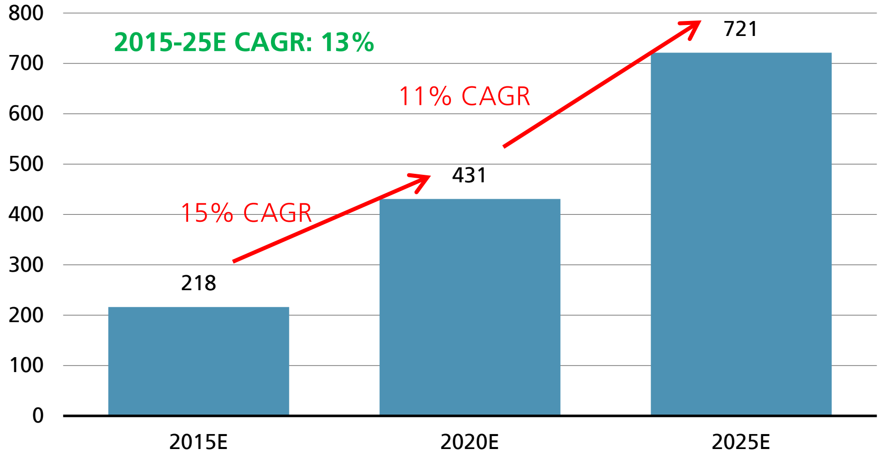


Source: UBSe

Global solar market to more than treble by 2025

Based on our assessment, government targets, and specialized consultant reports, we (conservatively) estimate that the global solar market could more than treble, and reach c720GW by 2025, vs c220GW at the end-2015.

Figure 35: Global solar capacity estimates over 2015-25E (GW)

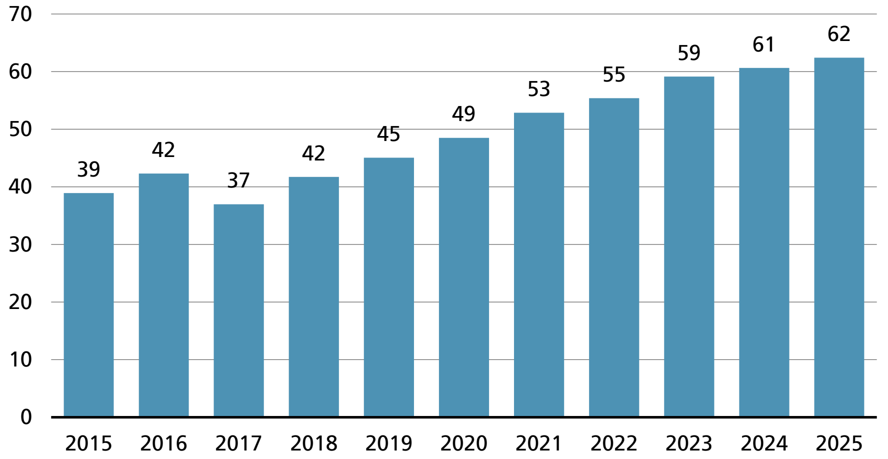


Source: UBSe

During 2015-25E, we expect c40-60GW annual additions on average. We see this mostly the result of (i) falling solar costs, (ii) the opening up of new markets, mostly Asia, Latam and Africa/Middle East, and (iii) the overall goal of several countries to lower carbon emissions and to step up energy independence.

Our growth assumptions effectively imply annual additions of c42W pa until 2020E. As of 2021, we assume accelerating growth owing to lower costs/W and hence lower needs for subsidies.

Figure 36: Global solar additions seen at 40-60GW pa during coming 10yrs (GW)



Source: UBSe

Figure 37 compares our targets with official sources, such as the European solar association (EPIA) and the US EIA. In Europe we fall in the forecast-range provided by the EPIA, whilst in the US we are much more positive than the EIA.

Figure 37: UBS targets are at the bottom end of "consensus" estimates

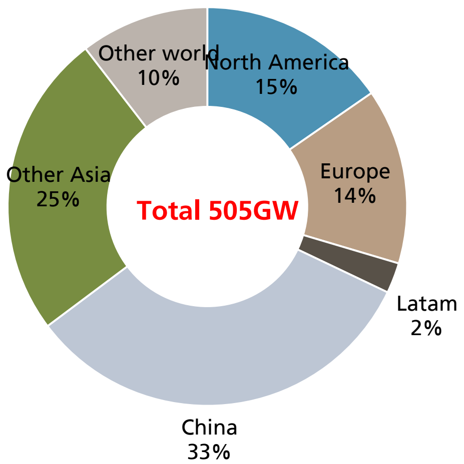
	UBS	EPIA low	EPIA high
Solar targets 2018 (Europe, GW)	112	119	156
Solar targets 2018 (Global ex-Europe, GW)	236	202	274
Solar targets 2018 (Global, GW)	342	321	430
	UBS	EPIA low	EPIA high
Solar targets 2025 (Europe, GW)	166	225	340
	UBS	EIA low	EIA high
Solar targets 2025 (US, GW)	105	84	102

Source: UBSe, EPIA, EIA

Asia to take the lion share of future additions (almost 1 in 2)

Out of the c505GW additions, we expect Asia to take the lion share (c60% o/w 30% China), followed by the US and Europe at c15% each.

Figure 38: Split of 2015-25E expected additions, by region

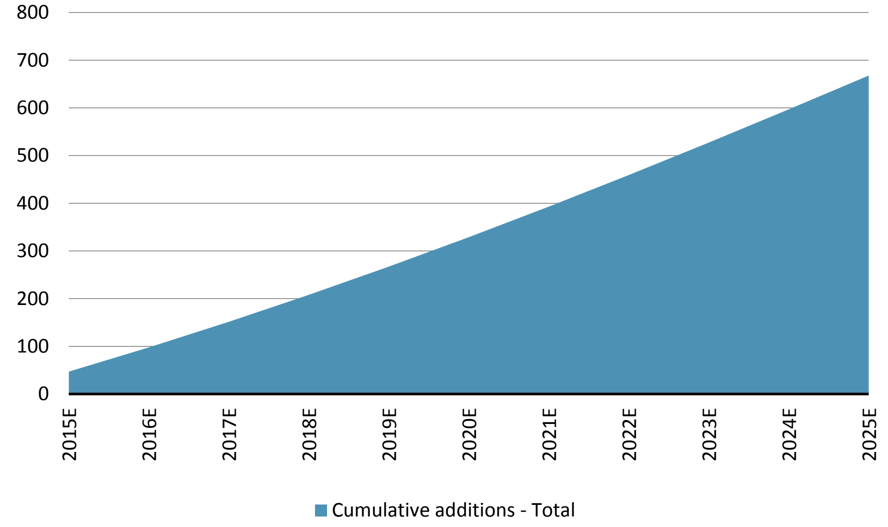


Source: UBSe

€650bn cumulative subsidies by 2025

Our analysis shows that – on a cumulative basis to 2025 – solar PV would still need some €650bn in global subsidies.

Figure 39: Cumulative solar subsidies in the world (€bn)



Source: UBSe

Although this number may appear huge, we should say that each year the world spends some €5.6trn to pay for its electricity yearly bill, or some 6% of GDP. By then we estimate annual solar subsidies at c€70bn on an annual basis. Hence, solar subsidies would appear a mere 1% of final bills.

Figure 40: Solar subsidies at just over 1% of total bills

Global consumption 2025 (TWh)	28200
Average global tariff (€/MWh)	197
Global power bill pa (€trn)	5.6
Global power bills as % of GDP	6%
Solar subsidies 2025 (€bn)	71
Solar subsidies as % of total bills	1%

Source: UBSe

Figure 41: Subsidies as % of power bills by 2025E

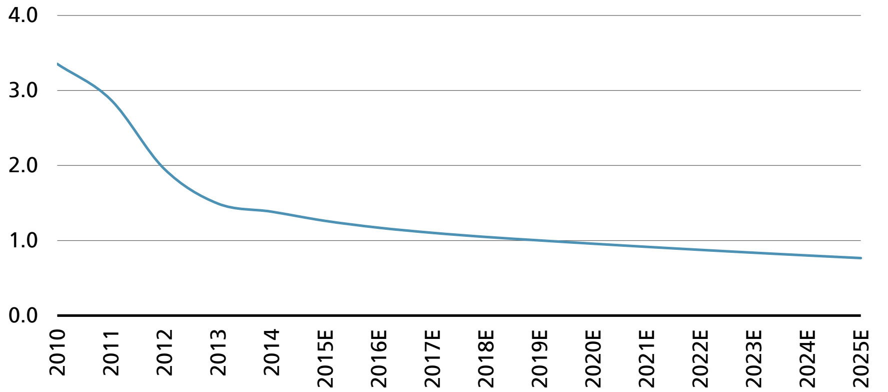
	As % of 2025E bills
Europe	2%
US	1%
Asia	2%
Others	1%

Source: UBSe

Solar PV capex potential at €470bn globally, by 2025

On our estimates, capex/W may drop by c5% pa, as seen in Figure 42, based on savings on processes, economies of scale and technological leaps (more on this later in the report).

Figure 42: Estimated solar PV capex costs over 2015-25E (€/W, utility scale)



Source: UBSe

On this basis, we estimate that the global "solar invested capital" could exceed €670bn. The 2015-25E addition would imply total investments of approximately €470bn, we calculate.

Figure 43: Global solar additions, costs per W and annual / cumulative spending: about €470bn over next 10 years

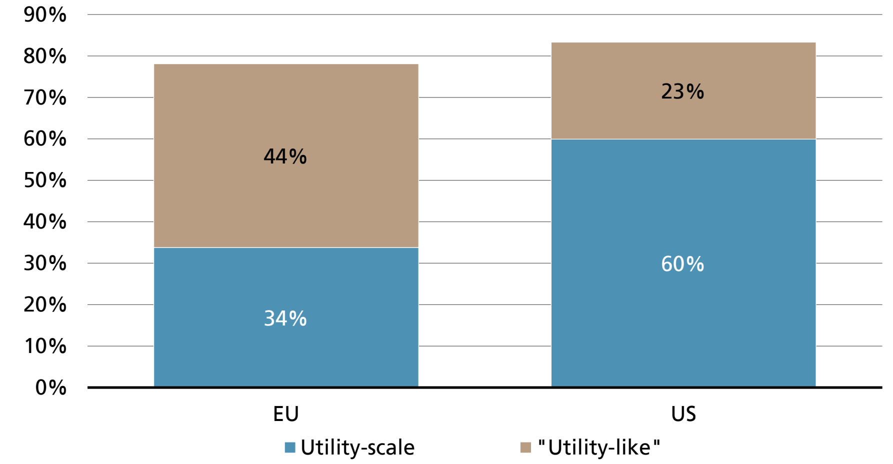
	2014E	2015E	2016E	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
Global solar additions (GW)	38	39	42	37	42	45	49	53	55	59	61	62
Capex / W (euros)	1.38	1.26	1.17	1.10	1.05	1.00	0.96	0.92	0.88	0.84	0.80	0.77
Capex spent (eur bn)	52	49	50	41	44	45	46	48	49	50	49	48
Cumulative capex 2016-25 (eur bn)			50	90	134	179	226	274	323	372	421	468

Source: UBSe, BP, EPIA, EIA

Large solar to become the new industry standard

During the past three years, some 80% of the global solar additions were either "utility-scale" (large ground installations) or "utility-like" (medium sized, developed by I&C customers). We think this trend is set to continue and believe large-solar will drive global growth, due to (i) better economics vs smaller scale, (ii) declining costs/W: we estimate that large-solar new entrant costs will broadly halve vs c€95/MWh today, and (iii) regulatory support to achieve climate targets and foster energy independence.

Figure 44: Percentage of utility-scale solar projects vs total solar built (2013)

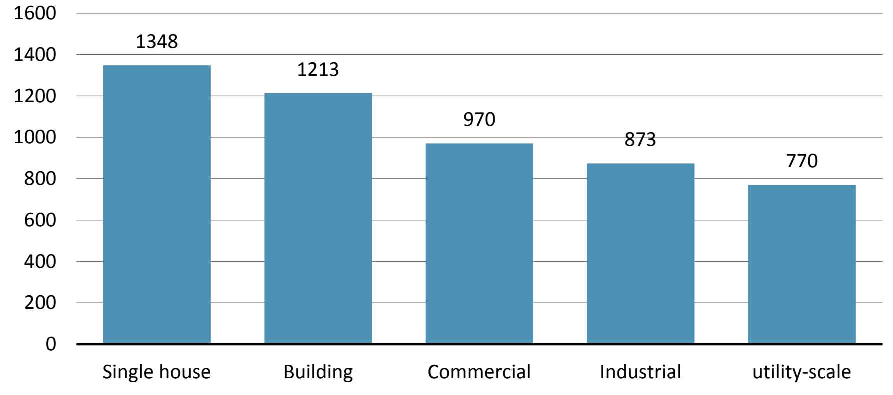


Source: EPIA, Greentech Media, UBSe – NB: "Utility-like" refers to industrial & commercial solar applications

Large solar has better economics vs smaller projects

Data by the EIA and other reputable sources show that the capex/W in large solar projects would be up to 50% cheaper than residential solar. Figure 45 shows the disparity for a pool of projects observed in Italy, as reported by a study from "Politecnico di Milano" university.

Figure 45: Capex/W in Italy by 2025E shows benefits of large projects (€/W)

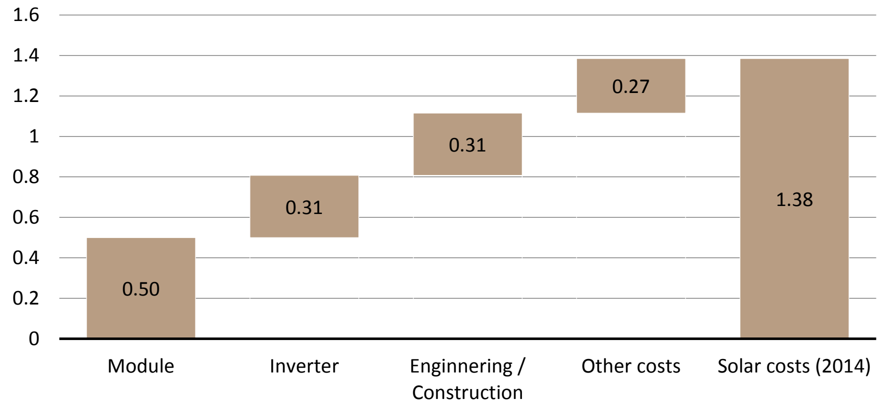


Source: Politecnico di Milano, UBS

Capex/W still set to decline: solar new entrant at €55/MWh by 2025E

The total investment in a solar park is made of four components, as seen in Figure 46.

Figure 46: Utility-scale solar PV cost per W breakdown (€/W)



Source: MIT, UBS; Note: non-module costs are referred to as Balancing of System costs (BoS)

(11) **Modules** account for 35-40% of the total cost per Watt, and is where most of the savings have been achieved so far. The main technologies utilized include crystalline silicon and to a lesser extent, thin film.

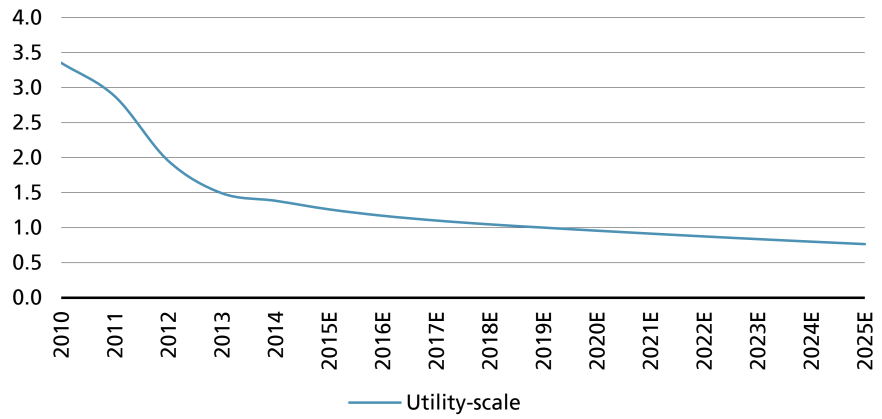
(12) **Inverters** account for c20% of the total investment. A solar inverter converts the direct current (DC) produced by a PV plant into alternating current (AC) so that it can feed a typical grid.

(13) **Engineering and Construction** costs are quite self-explanatory and account for c20%.

(14) **Other costs** include land costs and energy management costs. These account for about 20% of the overall capex requirements.

Based on official data from NREL, during 2010 and 2014 the cost per Watt (modules, inverters and other balancing of system costs) in large solar has declined by about 60%, or c15% per year. We currently assume c4.5% drop in capex/W pa through to 2025.

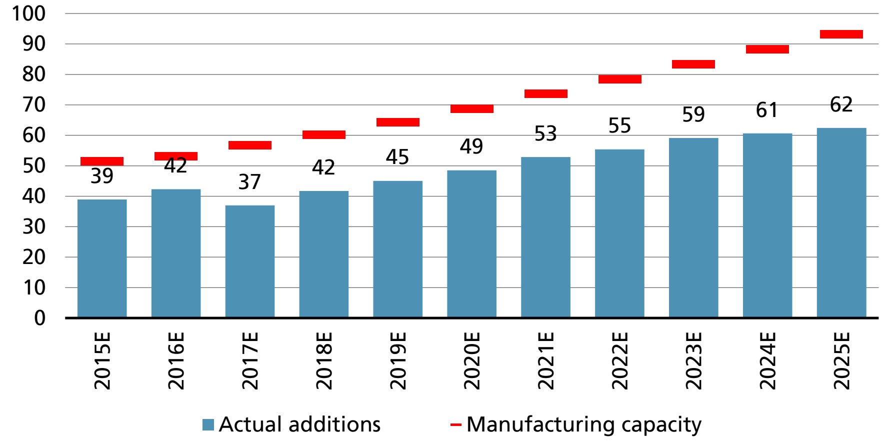
Figure 47: Utility-scale solar capex per W evolution (€/W)



Source: UBSe

As we detail later in the report, we believe that most of the savings going forward will be achieved thanks to economies of scale and improvements in processes, as opposed to better technology. Clearly, any "evolutionary jump" in the technology could lower costs even further. When it comes to supply/demand, the global solar market remains quite oversupplied. As Figure 48 shows, global suppliers would have the ability to deliver >50GW pa currently, growing to about 100GW over ten years. By contrast we expect additions at c40-60GW pa.

Figure 48: Our expected solar additions vs manufacturing capacity (GW)

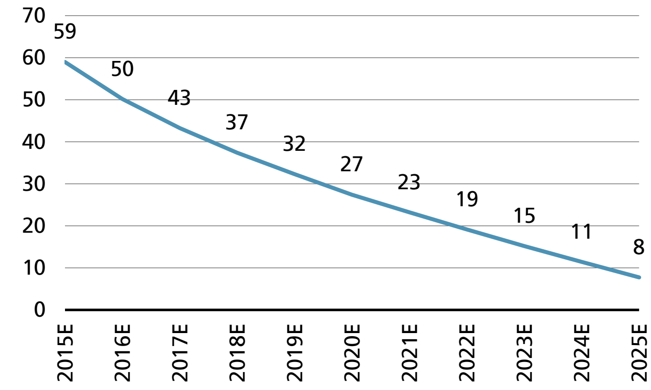


Source: UBSe; EPIA, Solarbuzz

Regulatory support is still essential

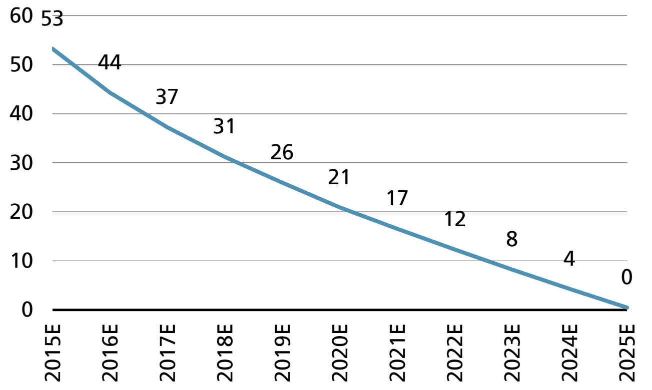
As already stated, besides a few regions with capacity factors in excess of 30%, large-scale solar will remain uncompetitive until 2020-25 in mature regions which are largely in oversupply and where wholesale prices are depressed, such as Europe. In regions where actually the installed base has to grow to meet rising demand (Asia or Latam for instance) solar could be already viable by 2018-20 as competitive vis a vis thermal new entrant costs. Either way, the regulatory support remains crucial: in the immediate future to grant subsidies, and in the medium term as solar presents obvious externalities, which include the needs to upgrade the grid, the need to have backup power (thermal or batteries) and other ancillary generation costs. Also, over the longer term (post 2020) – as solar gets cheaper – the ability to sign PPA contracts would support the take up of these facilities.

Figure 49: Solar subsidies, industrial clients (€/MWh)



Source: UBSe; Note: at 6% pre-tax ROIC

Figure 50: Solar subsidies, buildings (€/MWh)



Source: UBSe; Note: at 6% pre-tax ROIC

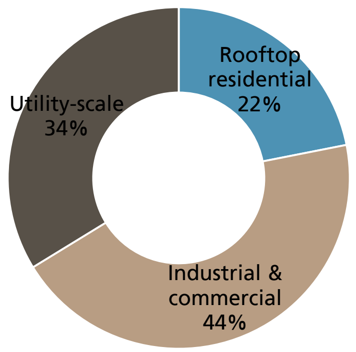
1 MW in 2 could be owned by utilities

Solar ownership is highly pulverized. Yet, Utilities could have played a prime role, as – just as a reference, during 2013 – about 80% of the projects developed in the US and Europe combined was either utility-scale or utility-like. As already seen for wind activities in the previous decade, we believe Utilities will soon begin to achieve scale in solar. We see the potential to develop almost >350GW globally to 2025, which would require some c€335bn of investments.

Utility-scale PV likely to accelerate, as seen in wind

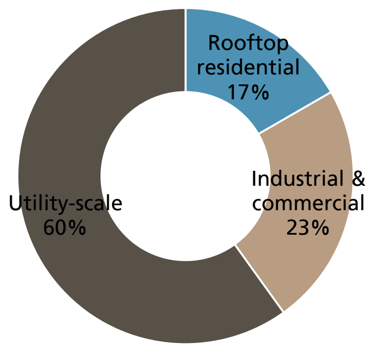
As seen in 2013, about 1/3 of EU solar additions were utility-scale, i.e. 5MW or larger. Interestingly though, the contribution of rooftop projects only accounted for about 20%. Theoretically, Utilities could therefore build either utility-scale projects, or develop solar on behalf of larger customers (shopping malls, offices, factories) and then enter LT "lease" agreements.

Figure 51: Split of EU solar additions in 2013 (tot c11GW)



Source: EPIA

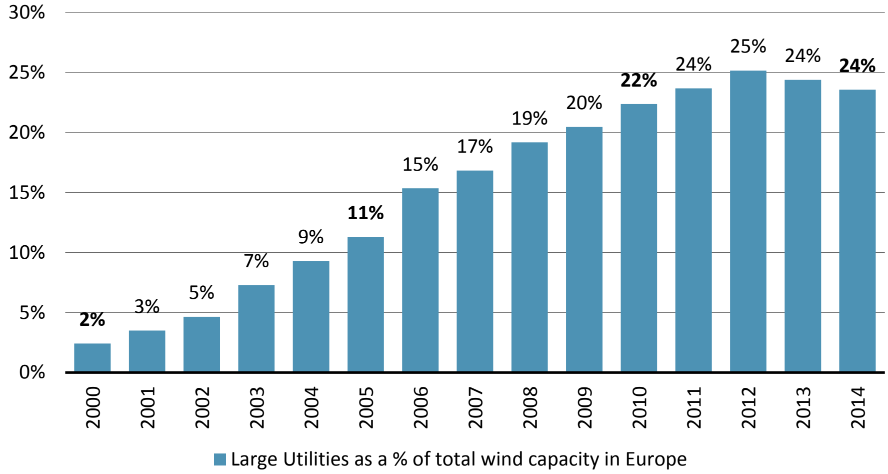
Figure 52: Split of US solar additions in 2013 (tot c5GW)



Source: Greentech Media

As already seen in wind, most mainstream utilities have been somewhat "late to the party". Company data show that in 2000, European Utilities accounted for just 2% of the EU Wind installed base; by 2005 this had grown to >10%; by 2010 it was in excess of 20% and in 2014 it was about ¼.

Figure 53: Wind owned by EU Utilities as % of total wind installed base



Source: Company data, UBSe

Vast opportunity by 2025: +360GW, or c€335bn capex

When compared to wind, solar is a much less mature technology. And its high unitary costs can be a barrier to entry for a prospect large developer. This is why we expect more and more utilities to be keen to develop solar, and then sign long-term contracts with a pool of clients. Although a similar framework only exists in the US for now, we would expect such PPA-scheme to become predominant everywhere. On this basis, the capacity that utilities may develop is about 360GW.

Figure 54: Utility-scale opportunity by 2025E (GW)

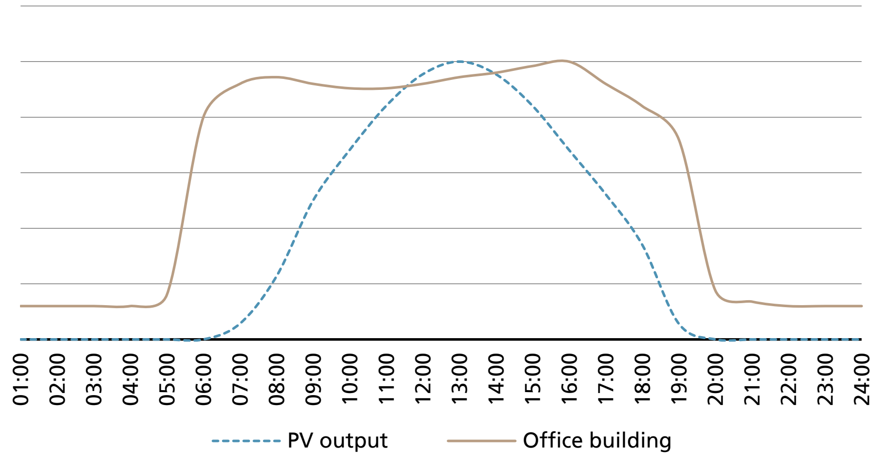
	Global additions	Utility additions opportunity		
	2015-25E	Bear	Base	Bull
North America	78	19	55	70
Europe	72	18	50	65
Latam	13	3	9	11
China	165	41	115	149
Other Asia	125	31	88	113
Other world	53	13	30	47
Utility additions opportunity (GW)	**505**	**126**	**361**	**455**
Potential capex (€bn)	**468**	**117**	**335**	**422**

Source: UBSe

Large solar ideal for I&C customers: load analysis

Contrary to the solar panels installed on rooftops by households – which in theory are primarily installed for auto-consumption – utility-scale solar parks would have to find an "end market" to sell their output. Given the consumption profile, industrial customers, shopping malls or office buildings could be ideal clients, to sign a "fixed price" agreement, such as a PPA. Figure 55 exemplifies the load profile (consumption needs) for an office building.

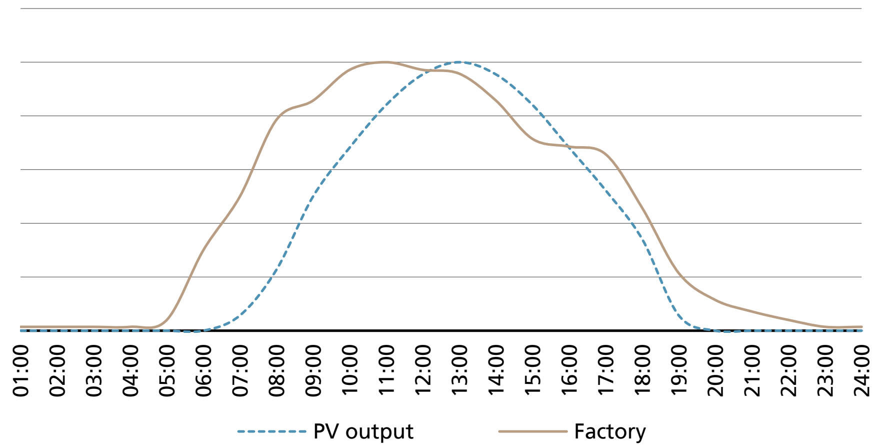
Figure 55: Load profile of an office building is decent fit with solar PV (MW)



Source: UBSe

Similarly to the previous example, the consumption pattern on a 9-5pm factory would also show a consumption profile that may fit with the supply from a solar facility.

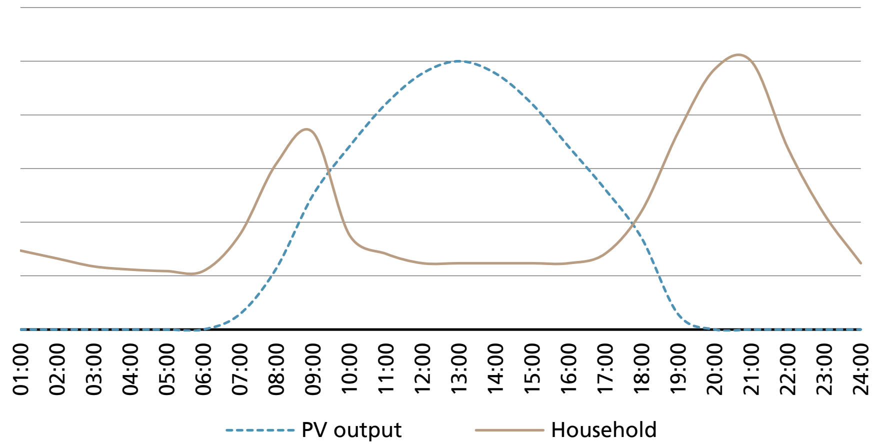
Figure 56: Load profile of a factory is perfect fit with solar output (MW)



Source: UBSe

As a reference, we also show the load mismatch between solar parks and residential consumption (Figure 57).

Figure 57: Load profile of solar PV and a typical residential consumer

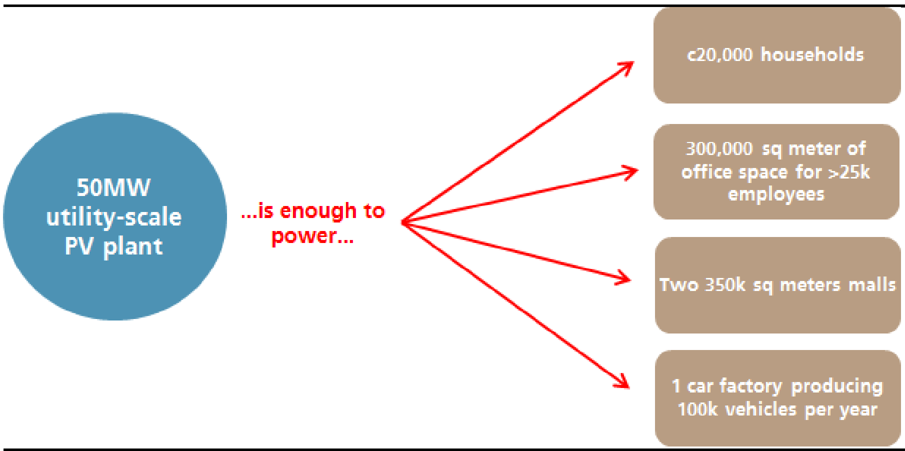


Source: UBSe

What can you power with a 50MW solar park?

As seen in the following Figure, we estimate that 50MW solar park would be needed to power 20k households, or office space for about 25k people, or two medium-sized retail shopping centres, or one car factory.

Figure 58: Illustrating the "consumption equivalent" of a 50W PV plant



Source: UBSe – NB: Assuming 15% load factor, i.e. output of 66GWh pa

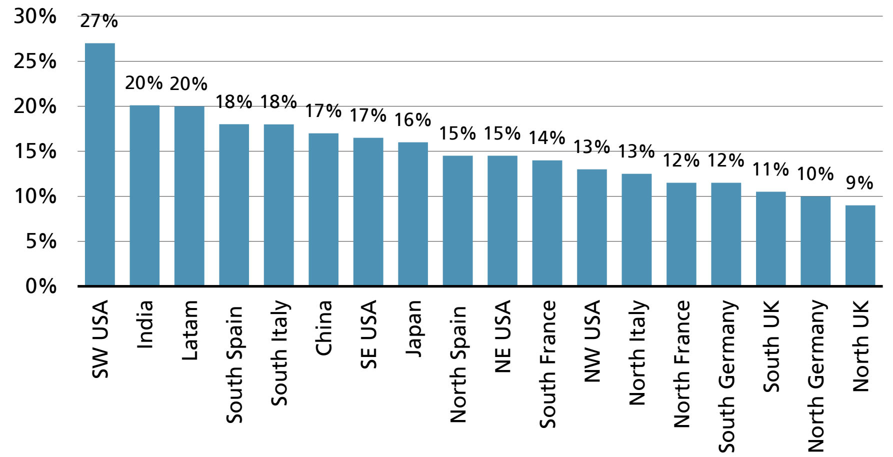
US is the ideal solar market

We believe the US market will continue to pioneer large-scale solar projects. Last year, c60% of solar additions were done by utilities (vs about 1/3 in Europe). We believe the US – especially in the South West – is the ideal market to develop utility-scale (and utility-like) solar projects, for three reasons: (1) capacity (load) factors can be two-to-three times larger than Europe. In the South West the average LF is 27%, with peaks of 32-35%; (2) regulation is supportive thanks to the ability of signing PPA-contracts, mandatory renewable targets (RPS) and investment-subsidies known as ITCs; and (3) Low density of population and vast land availability.

Capacity factors: some areas in the US are 3x Europe

Capacity factors (LF) in the South-West of the United States average 27%, vs c14% on average in Europe. As a reference, each 1pp surge in LFs would improve project-IRRs (pre-tax) by 60bps.

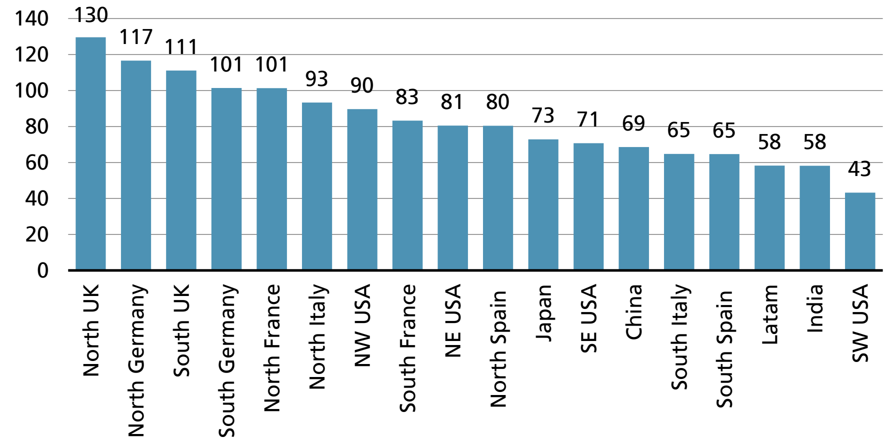
Figure 59: Solar PV load factors for key regions



Source: UBSe

The disparity in capacity factors is at the core of the divergence in new entrant solar PV prices, which – on a 2020 basis – vary from €45/MWh in the sunniest parts of the US, to €100-130/MWh in the UK and Germany.

Figure 60: 2020E new entrant costs by region (€/MWh)



Source: UBSe

Regulation: RES targets, subsidies, ability to sign PPAs

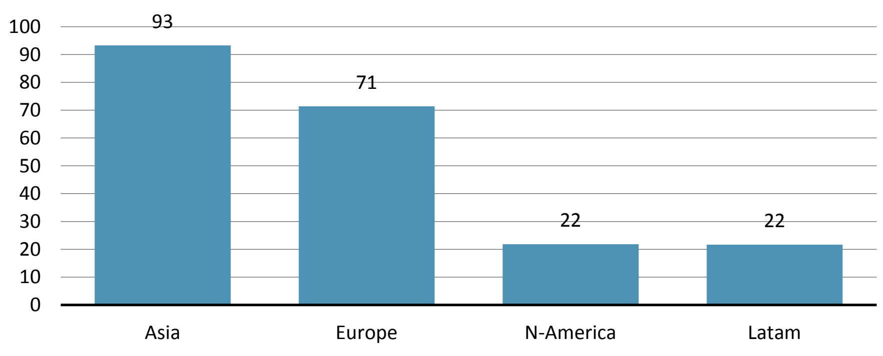
From a regulatory standpoint, we identify three conditions which, if met, are able to harbour a fast growing large-solar market.

- **Renewables (RES) targets**. The main force which propelled the developments of renewable sources (RES) in Europe – and still does – was the 2020 target of 20% of consumption from renewables. Most US states feature a similar backdrop, thanks to the RPS, which mandate a percentage of power to be supplied via renewable sources.
- **Subsidies**. Without a supportive incentive scheme (at least for about 10y) the global solar market would never reach the targets we lay out in this report. These can take the form of pre-defined tariffs, or capex incentives. Exemplifying the importance of incentives in the US, of the states with IRRs above 10%, only CA currently does not offer state-wide incentives. When the Federal ITC drops-down at the end of 2016, state-level incentives will be of even greater importance.
- **Ability to sign PPAs.** One of the key success factors in the US – where, as already said, about 80% of solar additions have been large-scale – is the ability to sign long term power purchase agreements with local utilities. This allows for a visible top line for up to 25 years. With PPAs driving growth in the utility-scale sector, many groups have entered the project-ownership level of the value chain to benefit from the consistent revenue streams.

Land availability: low density of population

Although we have proven that land will not be any impediment to a solar boom, lowly populated land availability – especially if closely located to key consumption areas – would also be a positive to gain scale, in the longer run. On our estimates, a 75MW solar park could fit in a square kilometre. As a reference, in a square kilometre, one could fit some 250MW of wind.

Figure 61: Population density (ppl/sq km)

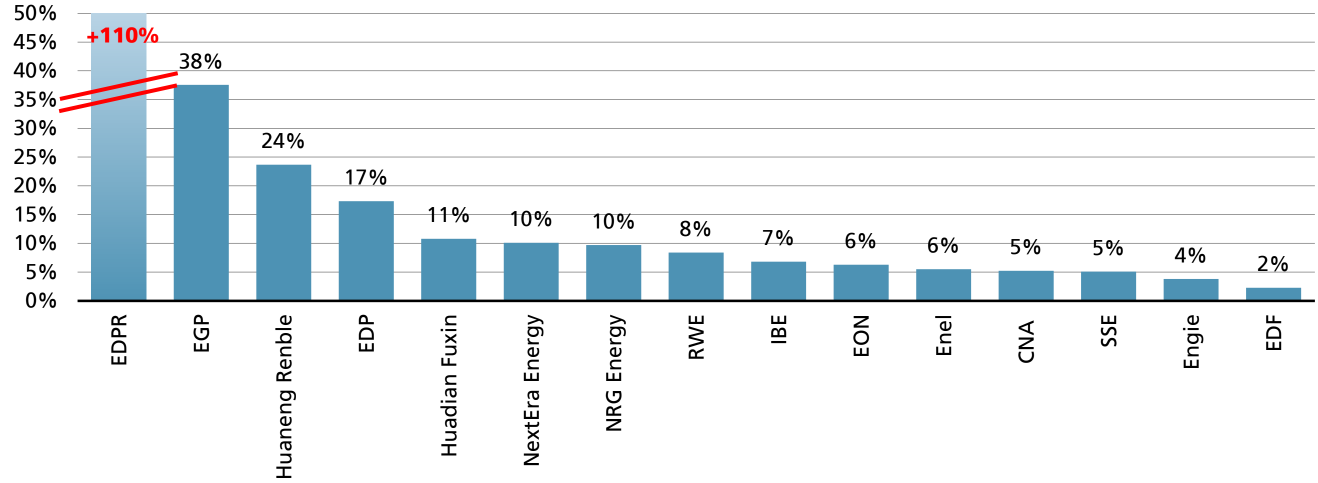


Source: World Bank, UBSe

Utilities and large solar EPS opportunity

Although we present several scenarios, our main case for 2015-25 implies c360GW large-scale solar additions. At 6% ROIC and assuming market shares of 1.5-5.0% per utility, the potential earnings uplift for utilities would be some 7%, vs 2015 levels.

Figure 62: EPS upside potential from investing in large solar (by 2025E, vs 2015E base)



Source: UBSe - Note: large-solar impact only; this is before any negative on power prices and positive from smart grids and storage

Two main business models

So far, we have seen only a handful of early movers in large solar. Currently, solar developers are following two main business models.

- **Large owners.** On one side, larger Utilities – learning from the "wind experience" – seem to purse "utility-scale" projects and offer long term PPAs to local utilities. NextEra, EDPR and Enel Green Power fall into this category.
- **Leasing companies.** On the other hand, smaller developers chase "utility-like" investments and lease solar equipment to residential, industrial and commercial clients (Solar City, SunEdison, etc).

Our methodology: The European example

To assess the potential earnings impact from the development of large solar, we carry out the following steps.

- **Analyze the global market size for solar**. As already said, we expect >505GW solar additions globally, during 2015 and 2025.
- **Assess how much large solar could be**. Of the total solar additions, more than 1 in 2, or c360GW, could be de non-residential ("large solar"). These could potentially be developed by traditional utilities.

Figure 63: Global solar additions and Large scale potential additions (GW)

	Global additions	Utility additions opportunity		
	2015-25E (GW)	Bear	1-in-2	Bull
North America	78	19	55	70
Europe	72	18	50	65
Latam	13	3	9	11
South East Asia	15	4	115	149
Other Asia	276	69	88	113
Other world	53	13	37	47
Utility additions oppty (GW)	505	126	361	455
Potential utility capex in solar (€bn)	468	117	335	422
Capex / W (€/W)	0.99	0.93	0.93	0.93

Source: UBSe

- **Identify large solar market share, using wind as case study**. We look at the market share achieved in wind by Utilities and use that as a basis to assume their market share in large solar. We assume the market shares of each company to range between 1.5-5.0%.

Figure 64: Large solar market share by company, using European wind as case study

Company	2014 wind capacity in Europe (MW)	Wind mkt Share in Europe	Solar bear	Solar base	Solar bull
RWE	2,596	2%	1.5%	3.0%	5.0%
EON	3,466	3%	1.5%	3.0%	5.0%
EDF	3,148	2%	1.5%	3.0%	5.0%
Engie	2,303	2%	1.5%	3.0%	5.0%
Enel	3,201	2%	3.0%	5.0%	7.0%
EDP	4,232	3%	3.0%	5.0%	7.0%
IBE	7,120	6%	3.0%	5.0%	7.0%
SSE	2,359	2%	0.5%	1.5%	3.0%
CNA	259	0%	0.5%	1.5%	3.0%

Source: UBSe

This would imply some 20GW large solar additions in US and Europe (by European Utilities only) over the coming 10 years.

Figure 65: Large solar potential additions by EU Utilities (GW) to 2025

Large solar built (GW)	Solar bear	Solar base	Solar bull
RWE	1.6	3.2	5.3
EON	1.6	3.2	5.3
EDF	1.6	3.2	5.3
Engie	1.6	3.2	5.3
Enel	3.2	5.3	7.5
EDP	3.2	5.3	7.5
IBE	3.2	5.3	7.5
SSE	0.5	1.6	3.2
CNA	0.5	1.6	3.2
Europe	**17**	**32**	**50**

Source: UBSe

How to estimate earnings upside

We (conservatively) assume a LT pre-tax ROIC at 6% and 70% leverage (ROE 10%). On this basis, we estimate the potential EBITDA uplift at €3.3bn, or +6% vs 2015.

Figure 66: EBITDA potential uplift from Large Solar (€bn)

	Solar bear	Solar base	Solar bull	% uplift
RWE	0.2	0.3	0.5	5%
EON	0.2	0.3	0.5	4%
EDF	0.2	0.3	0.5	2%
Engie	0.2	0.3	0.5	3%
Enel	0.3	0.5	0.8	4%
EDP	0.3	0.5	0.8	15%
IBE	0.3	0.5	0.8	7%
SSE	0.1	0.2	0.3	7%
CNA	0.1	0.2	0.3	6%
EBITDA uplift (€bn)	**2.1**	**3.3**	**5.1**	**6%**

Source: UBSe

Similarly, assuming an average cost of debt of 3% and 2/3 leverage, we work out the net income upside at 7%.

Figure 67: Net income uplift potential from Large Solar (€bn)

	Solar bear	Solar base	Solar bull	% uplift
RWE	0.0	0.1	0.2	8%
EON	0.0	0.1	0.2	6%
EDF	0.0	0.1	0.2	2%
Engie	0.0	0.1	0.2	4%
Enel	0.1	0.2	0.2	6%
EDP	0.1	0.2	0.2	17%
IBE	0.1	0.2	0.2	7%
SSE	0.0	0.0	0.1	5%
CNA	0.0	0.0	0.1	5%
Net income uplift (€bn)	**0.5**	**1.0**	**1.5**	**7%**

Source: UBSe

Expect a major pick up in smart-grids: €3trn oppty

Smart grids (SG) are the combination of "intelligent" hardware components (meters, cabins, substations, transformers, sensors, other wifi equipment) and software, which overlay the conventional grid. We believe SG serve five main purposes: (i) better integration of renewables to manage "reverse flows" and self-adjust frequency/voltage, (ii) implement demand response and peak shaving, (iii) reduce the needs for thermal capacity backup, (iv) boost energy efficiency, and (v) lower costs via real-time monitoring, anticipation and self-healing. We believe hat – as solar penetration grows – the first three reasons will increasingly gain importance. If power distribution activities were to fully turn into smart, we estimate the need for over €3trn of capex. By 2025, we estimate that investments will roughly amount to c€300bn, in today's money.

Why more solar will support the need for SG

Historically, power used to flow unilaterally from larger plants, through the high-voltage (transmission) grid, down to the medium/low voltage grid (distribution), to be delivered to the final customer. The surge in distributed generation and the rising penetration of solar have turned some consumers into power generators, creating the figure of "prosumers".

To avoid disruptions and blackouts, power has to flow within the grid at constant frequency / voltage. Historically this was guaranteed by thermal plants which could vary fairly quickly the kinetic energy of their generation units. Yet, the intermittency brought by renewables sources (amongst which solar) has added a layer of complexity in managing electricity flows. To practically understand this, it is enough to think of a summer-sunny day with maximum solar production, which suddenly turns cloudy and then releases a quick shower, to then return very bright. These situations create stress to the grid, and will do so increasingly given the rising solar penetration. Hence, as solar penetration grows and as solar customers / prosumers grow, the need to actively manage flows will also increase. This will require a different grid, which features a higher degree of technological components and software.

What is a smart grid?

Smart grids (SG) are the combination of "intelligent" hardware components (meters, cabins, substations, transformers, sensors, other wifi equipment) and software, which overlay the conventional grid. The key elements of a smart grid include

- **Smart meters** to allow for real-time reading in the usage of power from consumers. In the future, this element will be key to implement demand response/energy efficiency measures.
- **Upgraded primary and secondary cabins/substations** to help maintain network parameters (voltage, frequency) within acceptable ranges throughout the grid, regardless of the volumes produced from renewables.
- **Sensors**, to be deployed throughout the grid and to gather real-time information
- **Wi-Fi connections** to allow real-time data gathering from the grid and from final consumers

- **New software** to manage the grid to aggregate and interpret the data acquired, and to provide real time information to consumers, to modulate consumption accordingly.

- **Devices installed in houses**. These include displays that show real time electricity costs and increase customer awareness. It could also include energy boxes which manage domestic appliances and optimize consumption profiles. Additional items may include preparatory work to connect electric vehicles for instance.

The cost to benefit analysis of a smart grid is largely positive…

We believe SG serve five main purposes: (i) better integration of renewables to manage "reverse flows" and self-adjust frequency/voltage, (ii) implement demand response and peak shaving, (iii) reduce the needs for thermal capacity backup, (iv) boost energy efficiency, and (v) lower costs via real-time monitoring, anticipation and self-healing.

From a benefit perspective, we believe that SG will mostly: lower network losses & thefts, allow consumers to change behaviours and thus consume less, and imply lower opex as well as maintenance costs. Figure 68 summarizes the benefits we see for Europe.

Figure 68: Benefits of Smart Grids outweigh costs by almost 20%, as seen by our analysis per customer for Europe

	€/customer	Comment
Extra costs on consumers pa from SG	98	6% ROIC, 2% Opex, 35y useful life
Savings per customer pa from SG	116	
Lower losses and thefts	*22*	2% savings for the system from lower losses & thefts
Lower consumption	*54*	5% drop in due to change in habits
Peak shifting / shaving	*10*	10% shift/shaving in peak
Lower thermal capacity needed	*4*	17% of thermal may close due to SG or 22GW
Less CO2 emissions	*13*	150mt saved at €25/t
Lower opex and maint-capex	*14*	25% savings vs standard grids

Source: UBSe

These savings are equivalent to €116/customer per year and assume full penetration of SGs. If we scaled this up to US and Asia, we would estimate global annual savings of c€300bn per year.

Figure 69: Savings from SG for three main regions at almost €300bn pa

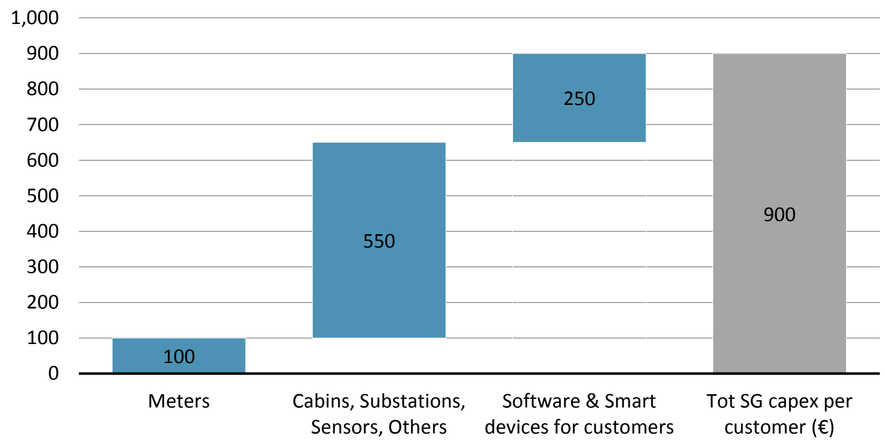
	EU	US	Asia
Customers (m)	293	228	1,938
Savings pa (€bn)	34	26	225

Source: UBSe

Total capex opportunity of €3trn (c€300bn to 2025E)

On our estimates, a golden plated smart grid system would cost some €900/customer, in today's money. About 10% of this would be for the meters, whilst some €250/customer could be the cost for softwares and smart devices to install in the customer's property. The rest – some 60% of the total – would relate to upgrading cabins, substations, sensors and other devices.

Figure 70: Smart Grid cost per customer at c€900



Source: UBSe

For the global system, capex to turn power distribution networks into intelligent would amount to €3trn. Assuming a 5-25% advancement stage by 2025, we estimate an investment potential of c€300bn by then.

Figure 71: Smart Grids global capex potential at €3trn

(2025)	H'holds (bn)	Max SG capex (€bn)	Share by 2025	10y capex (€bn)
Asia	1.9	1,744	10%	174
Africa	0.5	411	1%	4
Europe	0.3	264	20%	53
Russia and Ex-USSR	0.1	113	1%	1
North America	0.2	206	15%	31
South America	0.2	165	1%	2
Oceania	0.1	120	10%	12
Middle East	0.1	109	1%	1
World	3.5	3132		278
Total Smart Grid capex pool (€trn)		3.1		0.3

Source: UBSe

Energy storage to go hand in hand with solar PV…

The surge in intermittent supplies and the mismatch that is frequently typical between hours of renewables production and hours of consumption[3] has led to the need to invest in new solutions to store power. Energy storage could indeed, bridge the temporal and geographical gap between power supply and demand, in a decarbonised, renewable-intensive world. Although we will address this topic in a much wider and deeper effort, for now we will just share some high level conclusions and key calculations.

In a "solar world", storage would have three main applications

We highlight three main applications for power storage that would be consistent with a world characterized by high solar penetration.

- **Network support,** which we split into stabilization and de-bottlenecking. *Stabilization* takes different forms. Frequency regulation refers to the balancing of continuously shifting supply and demand. *De-bottlenecking*; storage devices can be placed in congested network areas and support the system, as well as delay investments in T&D.

- **Seasonality management,** which relates to volume-storage and pricing arbitrage. *Storage* is the ability to store power for hours, days or weeks and reutilize it at a later date. *Arbitrage* is the process that allows storing power during off peak times and reselling it during peak hours.

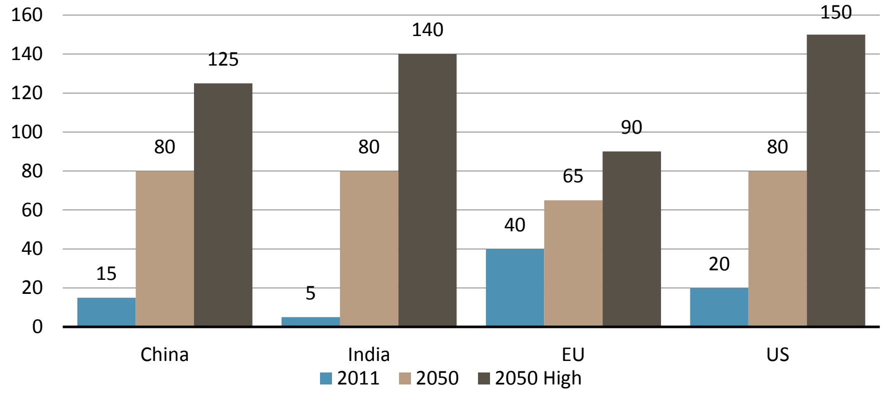
- **Demand shifting and Peak shaving** allows to shift demand to smooth the integration of intermittent, renewable sources. Peak shaving refers to the reduction of load (demand) during peak times.

Storage market could grow by 4-5x and imply up to $750bn capex (IEA)

Although there are different energy storage devices, for electricity the largest source of storage is from pumping hydro plants. In the future though, batteries should be playing an increasingly important role. Based on data provided by the IEA, in 2011 the global battery installed base in China, India, the EU and US amounted to about 80GW. IEA projections suggest that, by 2050 this could rise to 300-500GW.

[3] For instance, wind largely produces in spring and autumn and load factors higher at night, normally. Residential solar produces during the week when most people are not in their homes

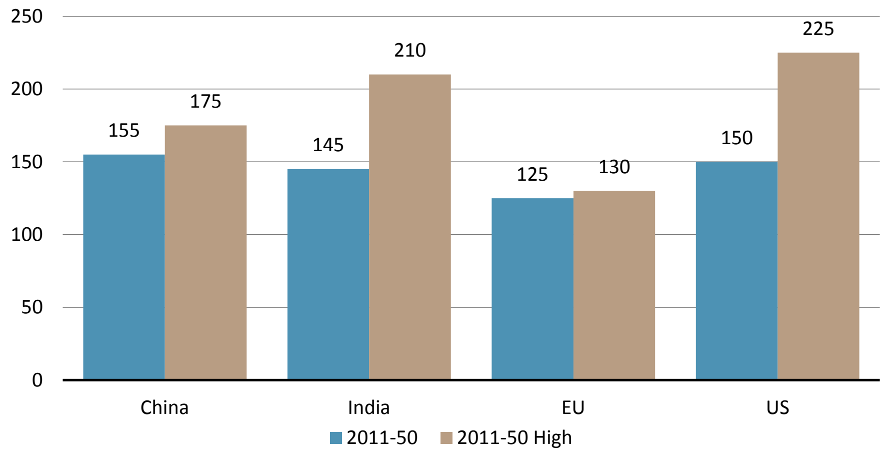
Figure 72: IEA electricity storage scenarios to 2050 (GW)



Source: IEA

Based on these two scenarios by 2050, the IEA presents capex projections of $600-750bn, as seen in this Figure

Figure 73: IEA capex projections to 2050 ($bn)



Source: IEA

On our assessment the capex estimates by the IEA are very optimistic. We do envisage a much steeper decline in the cost of batteries. This would imply a much, much lower capex number. As a reference the power wall battery by Tesla has an all-in cost of c$700/kWh. This would imply total capex of c$300bn (potentially much lower as we also expect the cost of batteries to keep declining).

Costs remain high – policy needed to foster the development

Currently battery costs remain high and require subsidies, to attract investors. From a residential perspective, we estimate that a typical storage system – which comprises a battery, inverters, a monitoring system, energy management system, taxes and installation) could cost €10-15k for a typical house. Of this, just 50-60% relates to the battery cost. Projections by industry experts which we have consulted suggest that, in Germany alone, battery systems could grow from less than 10k today, to about 100k within three years.

Figure 74: Germany – penetration of residential storage systems

Germany	
Number of storage devices by families now	<10k
Number of storage devices by families within 3y	c100k

Source: UBSe, GLG

Yet, costs remain very high as already anticipated. The typical size of a household battery system is 2-10kWh. The cost breakdown is indicated in Figure 75.

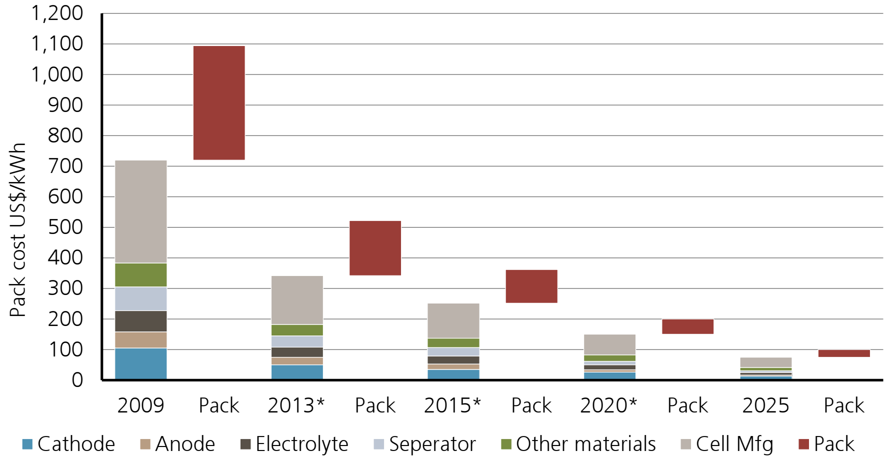
Figure 75: Battery system costs for typical household (€)

Typical residential storage size	2-10kWh
Battery cost	500-700/kWh
Other costs (inverters, monitoring, installation, etc)	400-600/kWh

Source: UBSe, GLG

We estimate that the Lithium battery pack cost will drop very substantially compared to current prices: We see battery costs moving down from $360/kWh today to $100/kWh within 10 years. Umicore and Tesla have indicated that the science needed to significantly reduce battery costs has already been discovered, with Industrialisation being the final barrier. Towards this end, the mass adoption of battery storage technologies for use in electric vehicles would be the catalyst in driving the costs down. Risks in the market lie mainly with material suppliers rather than consumers and will be driven by the impact of lower cost technologies to suppliers.

Figure 76: Battery cost should decrease by c75% over the next 10 years



Source: Tesla, Umicore, industry estimates, UBSe – Note: Excludes BoS costs

Batteries to become essential but will not take customers off the grid

On our analysis, a typical family consumes 4.5MWh per year, or 12kWh per day, on average. Potentially, a 3kW solar PV system could produce 3.7MWh pa. This coupled with a 3kWh battery would potentially provide almost full coverage.

Yet, a residential customer would largely produce when not at home. Also, the battery couldn't fully absorb the power produced during peak times (e.g. summer). Lastly, batteries wouldn't be sufficient to deal with the yearly seasonality (winter vs summer). In other words a retail customer may well be "long solar" in summer months, but fall short in winter months. Hence, remaining attached to the grid would still be a requirement.

Figure 77: Solar PV + Battery wouldn't still be enough to get customers off grid

Family annual consumption	MWh	4.5
Daily avg consumption	kWh	12
Solar PV system	kW	3
Solar PV output per year	MWh	3.7
Solar PV output avg per day	kWh	10
Potential self-consumption	–	*82%*
Actual usage of power produced	–	*50-65%*
Battery	kWh	3.0
Potential coverage		*103%*
Actual coverage adj for technical limitations		*70-85%*

Source: UBSe

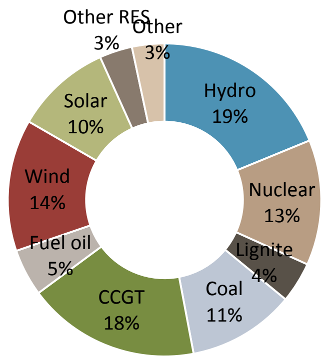
Generation mix to deeply transform

As case study, we present how we believe the European generation mix will evolve by 2025 and 2050. Essentially, we see a rising dominance of renewables and gas in the mix, which will jointly account for more than half of the 2025 installed base and for c60% by 2050 (UBSe). By then, solar could be about 30% of the installed base or c10% of EU output.

The mix will be more skewed towards gas and renewables

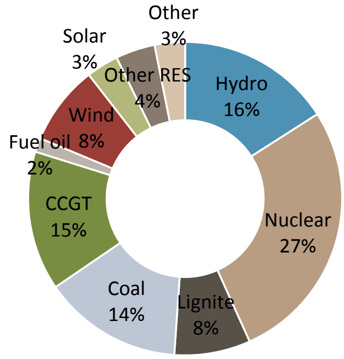
Currently, the renewables (RES) installed base in Europe is less than 30%, and is largely dominated by wind and solar. Yet, from a production basis, RES output only accounts for less than 15%.

Figure 78: Capacity mix Europe (2015E, c900GW)



Source: UBSe

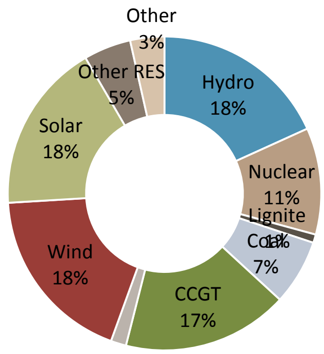
Figure 79: Output mix Europe (2015E, c3000TWh)



Source: UBSe

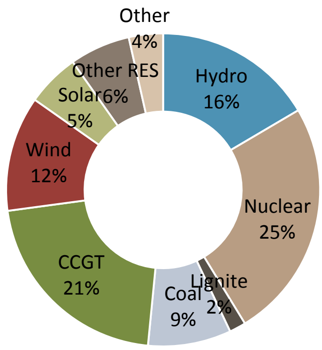
Within 10 years, we believe the RES installed base will surge to about 40%, though their contribution in the production mix will still be some 20%. Our underlying assumption is that rising carbon and German nuclear closures will shrink the weight of these technologies in the mix.

Figure 80: Capacity mix Europe (2025E, c900GW)



Source: UBSe

Figure 81: Output mix Europe (2025E, c3000TWh)

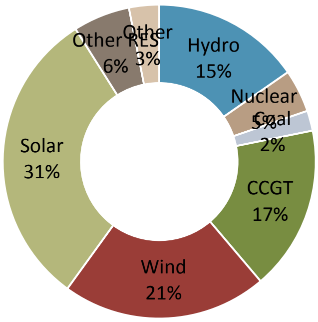


Source: UBSe

By 2050 then, we would expect another major change – besides the large growth in RES (especially solar) we would envisage the vast disappearance of coal and the

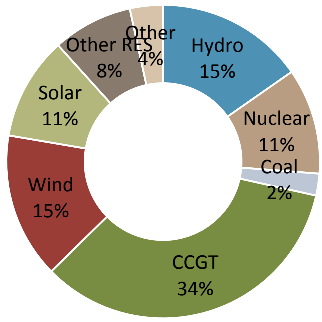
major reduction in nuclear. By then, RES could account for c60% of the installed base, and about 1/3 of the output.

Figure 82: Capacity mix Europe (2050E, c900GW)



Source: UBSe

Figure 83: Output mix Europe (2050E, c3000TWh)



Source: UBSe

Further pressure on power prices: Italy case study

As unequivocally observed in Europe, rising solar penetration will have detrimental effects on merchant power prices. Yet, this will manifest very differently on a regional basis.

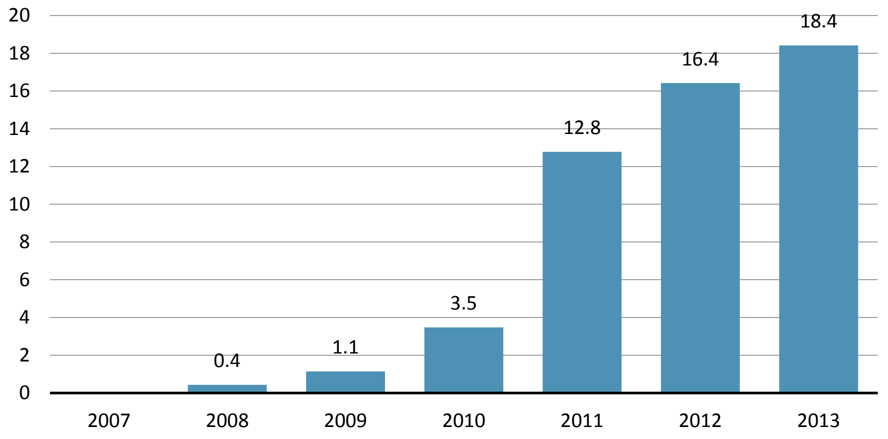
- **Europe**: we estimate that countries where solar has reached 10% or more of output during summer months (Italy, Germany), have already suffered a negative impact on power prices of some €3-4/MWh. By 2025 we see some additional €3-4/MWh downside risk. Yet, we should stress that – as explained in recent reports – half of the EU thermal fleet is already FCF-negative. Our solar outlook will surely add to the problem. Yet, we believe the ultimate solution will entail major closures (c25-30GW across Europe) and the introduction of availability-subsidies for thermal. Hence, we believe the main impact from rising solar will be on fixed-cost technologies such as nuclear (to a lesser degree as time goes by, owing to closures) and hydro. We estimate c€8bn downside risk for Europe as a whole.
- **US**: some 40% of this region is remunerated under regulated rates. Yet, in the remaining 60% we believe solar will have disruptive effects. Using Europe as example, we estimate $10/MWh downside risk to merchant prices.
- **Asia**: although this will be the fastest growing solar market globally, and will become the largest by 2016, the repercussions on power prices should be contained as most plants are remunerated on regulated contracts, and as volumes in the region keep growing. Thus, solar may steal market share from thermal but won't have much impact on the absolute TWh currently generated by thermal plants. We see a similar dynamic in Latam.

Ultimately, the rising penetration of RES is likely to lead to rethinking the whole philosophy of merchant markets. In our view, thermal activities should be increasingly remunerated for their availability. This will either imply rising revenues from ancillary services / capacity markets, or a come-back to regulated returns. We show Italy as a case study to demonstrate how solar can disrupt merchant markets. During 2010 and 2014 Italian (achieved) spark spreads have more than halved even though solar was still less than 10% of total production. Based on our 2025 scenario – solar to double vs 2014 – baseload prices could drop by a further >€3/MWh, assuming constant commodities in nominal terms. Yet, daily peak prices during March and August could fall by as much as €12/MWh. For the overall Italian merchant generation business this would imply a risk of €0.8bn, or c5% of system revenues.

Italian solar: a typical booming example

In about five years, the Italian solar PV installed base went from zero to 18GW, or c15% of the total installed base

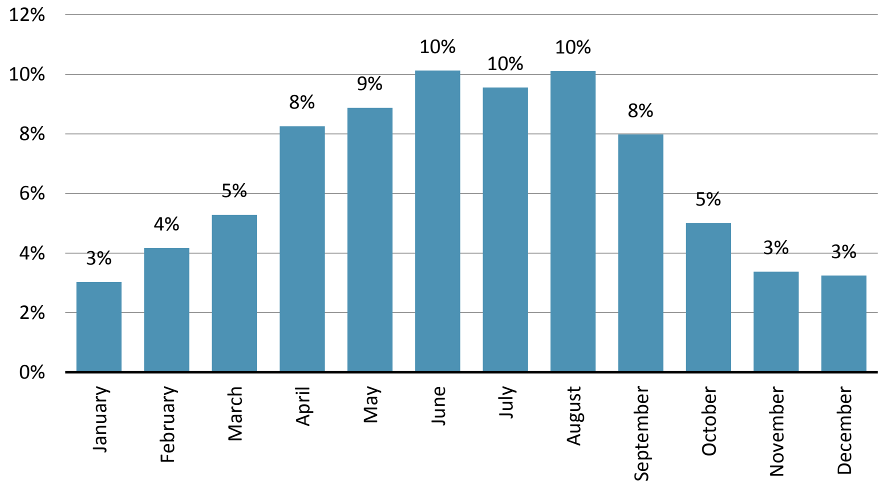
Figure 84: Italian solar PV capacity evolution; 16% penetration in just 5y (GW)



Source: GSE, UBS

On an output basis, solar would still account for c8%, as seen on Figure 85. Actually solar would hit 10% only in summer months.

Figure 85: Solar output penetration on a monthly basis (2014)

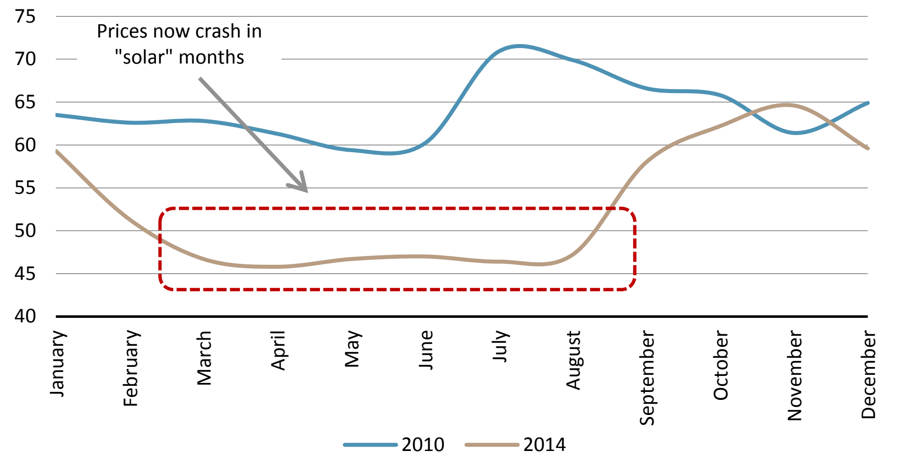


Source: GSE, UBS

Disproportionate impact on thermal profitability and peak prices

Yet, the disruption to the system has been staggering. Figure 86 compares 2010 and 2014 spot prices on a monthly basis and visually highlights the "solar valley" created by solar PV during summer months.

Figure 86: Italy – solar led to the crash in summer prices (€/MWh)



Source: GME, UBS

Our hourly analysis shows that the price actually achieved by CCGTs has considerably dropped. As a result, achieved spark spreads (ie gas plants' unitary gross margins) have more than halved.

Figure 87: Italy – solar led to 60% drop in achieved spark spreads

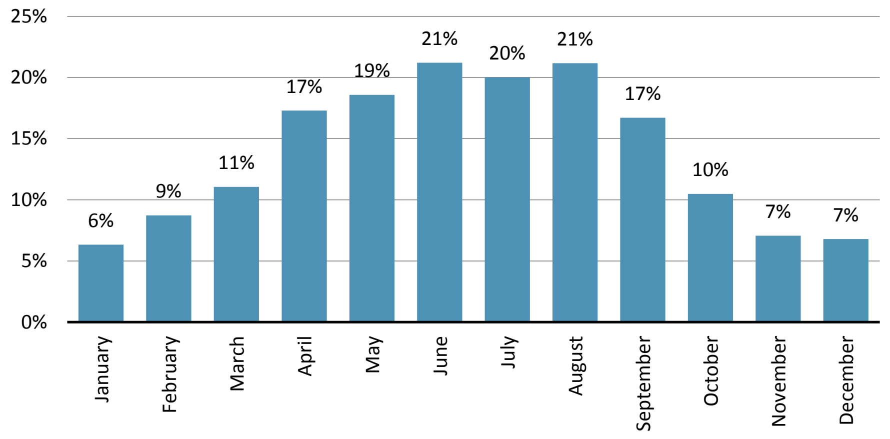
	2010	2014
Baseload (e/MWh)	64.3	52.0
CCGT marginality (%)	56%	50%
CCGT marginality (hrs)	4940	4364
Achieved price (e/MWh)	76.2	63.9
Achieved spark spread (e/MWh)	19.2	7.3
CCGT vols (TWh)	153	95
Solar vols (TWh)	2	23
Total Output (TWh)	291	272
Solar as % of total	1%	8%
Solar GW	3.5	19.6
Total GW	110	126
Solar as % of total	3%	16%

Source: UBSe

Outlook shows further downside but thermal subsidized by then

By 2025, we do envisage the Italian solar PV installed base to double to 36GW, vs 2014 levels. By then solar PV would be c20% of the summer months' output.

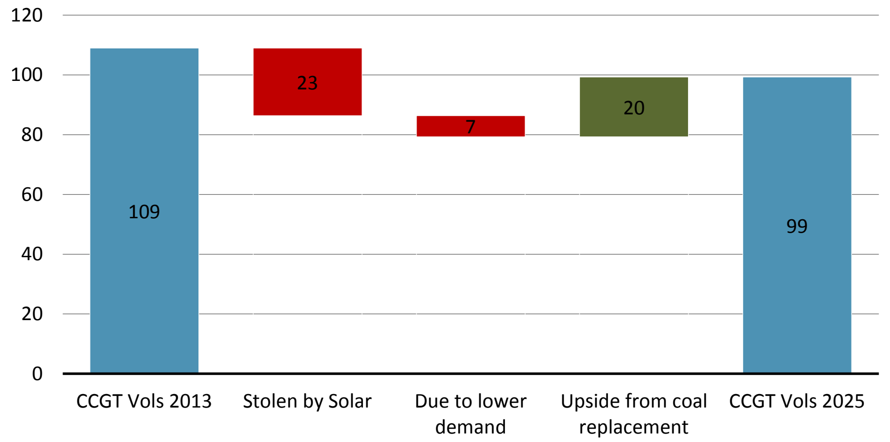
Figure 88: Italy – solar at 20% of output during summer months (2025E)



Source: UBSe

This would put pressure on CCGT-volumes, although the expected reduction in volumes from coal (technical availability and rising carbon) would allow to partly offset it.

Figure 89: CCGT vols unchanged as solar offset by coal replacement (TWh)



Source: UBSe

As explained in our recent report "*Thermal profits have already halved: half of fleet is already FCF negative*" (April 21), we believe profits for thermal activities have already bottomed as half of thermal plants in EU generate negative cash flows. This would suggest further closures and / or some compensation to remunerate thermal backup capabilities.

Hence, if solar were to become 20% of summer months production the downside risk would be relevant but it would be no Armageddon. We estimate that the profitability of CCGTs would be severely hit.

Figure 90: Italy – 5% downside risk to generation revenues from solar PV

CCGT vols lost during summer daytime (TWh)	-23
Peak prices 2014 (e/MWh)	71
Off peak prices 2014 (e/MWh)	54
Peak - Off peak gap in 2014 (e/MWh)	11.7
CCGT Loss	-265
Downside to baseload from larger hrs where prices are zero (e/MWh)	3.3
Downside risk on non-RES technologies	-556
Downside risk to the system by 2025 (em)	-821

Source: UBSe

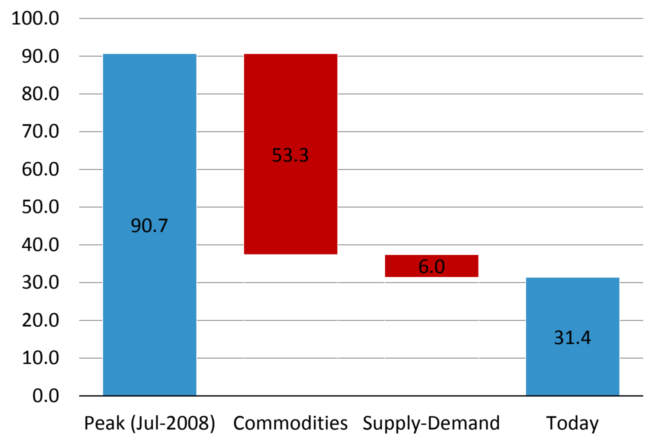
Once again we should stress that this is done before accounting that – on these numbers – most gas plants would not be profitable and would therefore require a larger share of availability-subsidies to remain operational.

Europe: RES have been a negative but not as much as common belief

As repeatedly stated, solar is a disruptive technology. Yet, to prove that its impact has been somehow overstated, we have estimated the downside risk in German and Italian power prices since the summer-2008 peaks. We explain this via two components: (1) commodities, as we estimate the drop in coal, CO2 and gas prices since mid-2008; (2) supply-demand, which encompasses a rising penetration of renewables (solar, but also wind) and the decline in demand. All in all, we show that, since 2008, the downside risk from commodities explains 85-90% of the decline in power prices. In other words, solar and wind additions, as well as contraction in demand had a negative impact of €6-10/MWh in these regions.

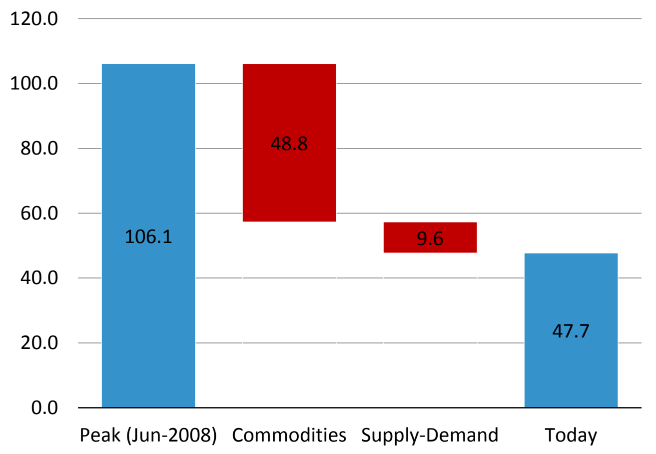
Clearly, this is still highly negative as baseload thermal spreads in these countries have been "wiped away". This means that gross margins from coal and gas have fallen close to zero. Yet, this is far smaller than perception would suggest.

Figure 91: Italy – decline in power prices mostly explained by drop in commodities (€/MWh)



Source: UBSe, Bloomberg

Figure 92: Germany – decline in power prices mostly explained by drop in commodities (€/MWh)



Source: UBSe, Bloomberg

EU thermal profits have already largely bottomed

We estimate that – by 2017 – half of the European thermal fleet will be free-cash-flow negative (figure 93). Based on our 2015-17E assumptions of (i) cumulative demand drop of -1.5% (c7GW), and (ii) cumulative renewable additions equivalent to 3% of the installed base (c50GW), we estimate that, to keep stable profits, power generators would have to close c10GW of thermal capacity pa (c4% of the EU thermal fleet). Interestingly, this process is already in motion: during 2013-14, coal/gas closures exceeded 25GW pa.

Figure 93: EBITDA per MW of thermal plants across Europe (2017E, €)

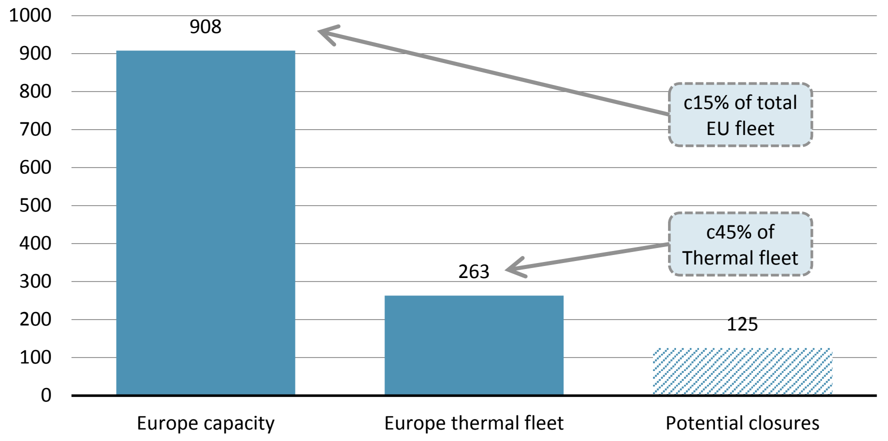
Adj EBITDA / MW (2017E)	Spain	Italy	Germany	France	Belgium	UK	Nordic
CCGT	22,523	32,054	-11,596	-15,850	7,599	6,757	-22,664
Old Coal	-2,084	80	-14,783	-22,133	-1,776	-19,387	-22,838
New Coal (efficiency >40%)	nm	95,309	72,897	23,212	140,073	nm	nm

Source: UBS

Lack of action by policymakers would therefore trigger a wave of closures (or at least, of closure requests); we estimate 125GW, or one coal/gas plant out of two (figure 94). This would theoretically lead to major savings for utilities and a spike in power prices. As a result the EPS of the integrated names would rise by about one-third.

However, from a security-of-supply perspective, we calculate that only c20% of the FCF-negative plants would be allowed to shut and hence lead to cost savings. The rest should receive some form of incentive (strategic reserve, capacity payment, ancillary services) and remain available to guarantee security of supply. This would ultimately upgrade the EPS of integrated utilities by 5%, on our assessment.

Figure 94: European capacity and 125GW of potential closures (GW)

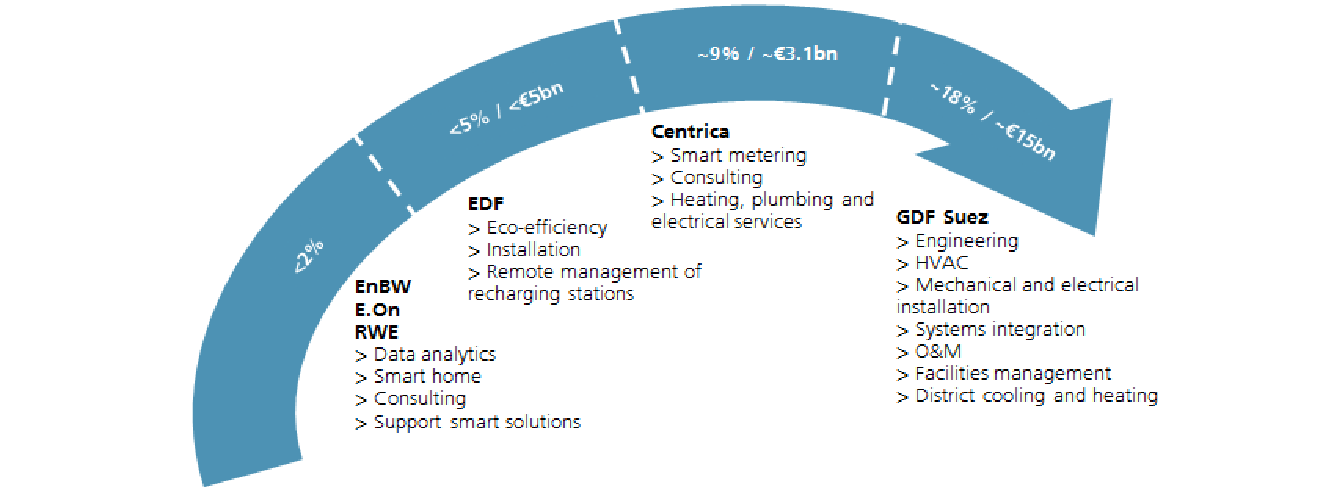


Source: UBSe; Note: Thermal fleet only refers to "coal and CCGT" to the extent of this report

Energy svc to benefit from solar PV boom

Energy services are a fast growing activity for utilities. Developing solar PV on behalf of customers (similar to the business models of Solar City and Sun Edison) could strengthen the relationship between utilities and their customers. Leasing solar could open up the door for further services. Although these activities are typically "low margin" (5-7% EBITDA margin), it would still be a positive to the industry. For Europe we forecast a negligible c€500m EBITDA upside, whilst the global potential EBITDA uplift could be about €3bn, or +1%.

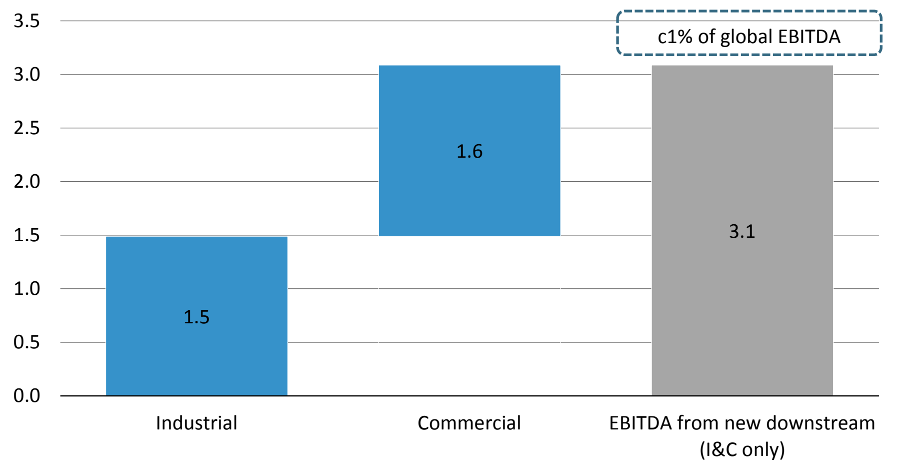
Figure 95: Overview of the business services landscape in Europe



Source: Centrica, UBSe

On our estimates these additional services could range from energy management, to energy efficiency, to data analytics, to home services, to facilities management, to heating and cooling. The following figure shows our conservative EBITDA upside assessment.

Figure 96: Global utilities EBITDA uplift from service cross-selling (€m, 2025E)



Source: UBSe

As shown by figure 96, we estimate that, on our 2025 scenario, the yearly EBITDA pool for the global sector would rise by >€3bn, or c1%.

Basis for our computations

To estimate such upside we first need to identify how many GW of solar utilities could add for I&C customers. We show this granularly for Europe. Out of the >70GW additions, we estimate that about 30% will be "utility-like", in other words, on rooftops of industrial and commercial customers.

Figure 97: EU potential utility-like solar additions for I&C customers

	GW
EU solar additions 2015-25	72
of which, done by Utilities	56
o/w Utility-scale	19
o/w Utility-like (I&C)	25
o/w Commercial	15
o/w Industrial	10

Source: UBSe

For European commercial clients, we estimate the square metres covered by solar PV of 74 square kilometres. Assuming standard revenues per sqm from facility management activities, we work out potential revenue pool >€3bn. At a 7% EBITDA margin, this would imply just over €200m upside for Europe.

Figure 98: EBITDA from new downstream for EU commercial "solar" clients

Commercial EBITDA upside by 2025E (EU)	
Commercial additions by Utils (GW)	15
Output at 15% LF (TWh)	19
Commercial consumption/sqm (kWh)	265
Sqm covered by Solar PV (millions)	74
Revs per sqm from Facility Mgmt (€)	43.4
New downstream revs for commercial (€m)	3,192
EBITDA at 7% margin (€m)	223

Source: UBSe

For industrial clients, we believe most of the "new downstream" profits would come from energy efficiency services. In other words, utilities could approach an industrial client that has just entered a lease agreement on solar and, in addition, could offer to upgrade their equipment and processes, to save on power consumption. Anecdotal evidence shows savings of 20-40% on this basis. We assume 30% savings, a 50/50 profit sharing with the utility and 50% margin to account for overhead costs. This implies an EBITDA upside for Europe of >€200m.

Figure 99: EBITDA from new downstream for EU industrial "solar" clients

Industrials EBITDA upside by 2025E	
Industrial additions by Utils (GW)	10
Output at 15% LF (TWh)	13
Solar coverage of industrial consumption	65%
Tot consumption by these customers (TWh)	20
Average bill (€/MWh)	160
Consumption savings from e-efficiency	30%
Money saved (€m)	959
Savings kept by Utilities (€m)	480
Savings kept by Utilities post overheads (€m)	240

Source: UBSe

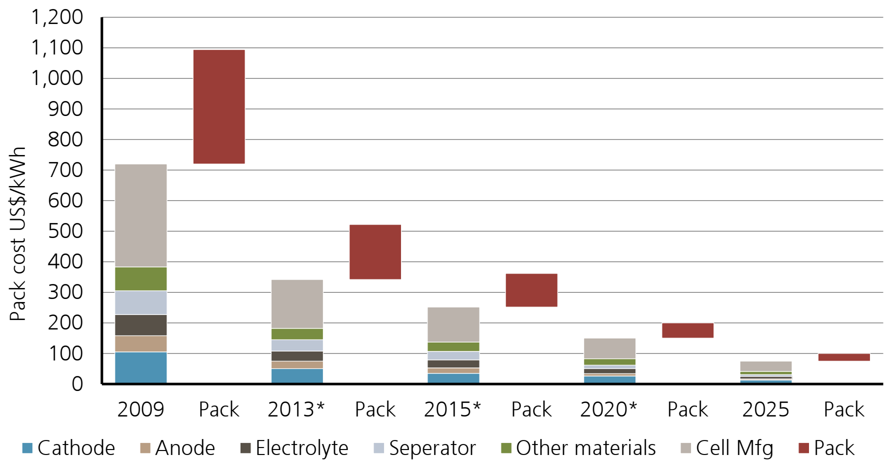
Solar boom impact on other industries

This section is dedicated to providing out of the box implications from a solar boom scenario. We will address beneficiaries from rising demand of chemical components, beneficiaries from rising demand for other raw materials such as silicon, aluminium, silver, or copper, downside risk for the manufacturers of traditional plants. Lastly, we discuss the second order of magnitude repercussions on related industries such as chemicals, autos or capital goods.

Chemicals

Battery Materials technology and advancement will continue to play a significant role in reducing the cost of energy storage. The materials science options continue to remain significant and offer potential for cost improvement over several decades to come. Both the technology opportunities but also the disruptive market outcomes of cheap energy storage are already impacting corporate strategies of some chemical companies. There are two outcome areas for chemicals (1) Value capture through volume growth & R&D (2) Strategy adjustment leading to corporate action and refocus

Figure 100: Battery cost should decrease by c75% over the next 10 years



Source: Tesla, Umicore, industry estimates, UBSe

(1) Value capture through volume growth and R&D

Typically the chemical industry has captured about 40% of the installed cost of a battery but this includes a significant amount of material and in particular metal pass through. But based on the optimistic EIA estimates of a global battery market of US$ 600-750bn by 2050 implies that on a 40% assumption this could be a US$240-300bn market for the chemicals industry from a US$20bn estimated market today

The state of play table below probably best reflects the first movers in chemicals and provides some indication of winners and losers. We would highlight Umicore, Johnson Matthey, BASF, Hitachi Chemical and LG Chemical as having a significant first mover advantage

Figure 101: Global Chemical State of Play in Battery Materials

Stock	Market Cap	Comments	Cell Assembley	Cathode	Anode	Separators	Electrolytic Solutions	Battery recycling
LG Chemical (051910 KS)	US$15.7bn	A leading assembler of batteries and through the LG group providing a wide range of components for use in Lithium Ion Battery Packs	Top 3 supplier in total batteries					
Umicore (UMI BB)	US$5.7bn	Key developer of cathode materials with particular focus on NMC, NCA, LFP technologies. Pioneering technology to recover		Leading supplier of lithium ion battery cathodes				Pilot facility in operation for metal recovery from NMC
Hitachi Chemical (4217 JT)	US$4.29bn	Graphite anode material technology and sales leader			No1 Producer			
Mitsubishi Chemical (4188 JT)	US$6.7bn	Only supplier to provide the combined platform of technologies - anodes, cathodes, electrolytes and separators		NMC Cathode producer	Second largest Producer Globally of	SEPALANT ® - Poly propylene based	No.2 producer globally	
Asahi Kasei (3407 JT)	US$12.81bn	Inventor of the Lithium Ion Battery technology in the 1980's				No1 separator producer glohally.		
Toray (3402 JT)	US$13.78bn	A Leader in separator technologies				No.2 separator producer glohally		
Ube Industries (4208 JT)	US$1.9bn					Top 10 producer globally UPORE ®	No.1 producer globally Purelyte ®	
Tokuyama (4043 JT)	US$0.8bn						Top 10 producer	
Arkema (AKE FP)	US$5.7bn					PVDF technology		
Solvay (SOLB BB)	US$12bn					Top 10 producer globally Utilises Monofluoro ethylene		
BASF SE (BAS GR)	US$90bn	Targets €0.5bn of sales in battery materials by 2020 and EBIT breaking even from 2020. The business will be an ongoing €60-80m burden for the catalyst business line until 2020 Plans to become the world's leading system supplier of functional materials						
Johnson Matthey (JMAT LN)	US$11bn	Acquired lithium ion battery manufacturing assets from A123 and Axeon, Acquired Clariant's Lithium Ion Phosphate business		Leading supplier of LFP cathodes and				

Key	
(darkest red)	>15% of revenues
(dark red)	10-15% of revenues
(red)	5-10% of revenues
(light red)	0-5% of revenues
(pink)	R&D interest only

Source: UBS

(2) Strategy Adjustment leading to corporate action and refocus

An energy revolution due to low storage costs will be disruptive for the chemical industry on a number of levels. End markets such as automotive will transform dramatically. About 10-15% of global chemicals are consumed in transportation markets and changes in engine technology or requirements for energy efficiencies will require a refocus from materials and automotive catalyst producers. BASF, Solvay, Victrex, EMS-Chemie, DuPont, Umicore, Johnson Matthey, LG Chemical are examples of companies where they are already adjusting R&D and capex to reflect a changing automotive outlook. Raw material supply and how chemical companies think about the energy balance will change. A gradual shift to electrification may radically change the supply structure of oil derived raw materials such as naphtha

which will increase the focus of chemical companies to build alternative chemical production technologies where Johnson Matthey, Clariant, Dow, Air Liquide and BASF are leaders in Natural Gas Liquid (NGL) and coal to chemical production technologies and Novozymes, DuPont, BASF and DSM are pioneers of biological chemical production.

We see increased momentum for M&A for companies wanting a strategic position in battery or new production technologies: Umicore, Johnson Matthey, DSM and Clariant possibly could be considered – Novozymes shareholder structure makes it largely un-acquirable.

Potential upside for Chemical companies: Wacker Chemie (Buy, €142)

We reiterate our Buy rating on Wacker Chemie and publish a standalone note today, in conjunction with this report. Wacker Chemie commands a (steadily rising) 23% share in installed capacity for polysilicon (poly-Si). Poly-Si based material is included in 90% of global modules deployed for photovoltaics installation, and this share keeps rising as the technology keeps displacing thin-film manufacturing technology (which accounted for 20% ten years ago, now down to 10% and relentlessly declining).

Not only does Wacker command a co-No 1 position from a size perspective, it is both low cost and high quality producer. It is one of the rare producers of purity grade "12N" material (1 part phosphorous/boron/aluminium impurity per trillion area surface- an impurity grade equivalent to one eurocent coin on 2000 football pitches). This implies a higher KW output per wafer area, ie higher cell efficiency for a module producer, allowing for premium pricing. As module prices have fallen, balance of system costs will be the marginal driver to move total costs of installations for PV to grid parity. As such, Wacker's pitch for business becomes more compelling over time vis-à-vis low quality competitors.

This has led to a market position of 'first right of refusal' and Wacker secures almost 100% of business in the form of take/pay contractual arrangements which include penalty clauses, with little direct (but some indirect) exposure to (highly volatile) poly-Si spot market pricing.

The analysis presented in this report implies that Wacker can now sustain both this pole position (premium margins, superior risk management) as well as fast growth for longer, and well into the next decade: if total PV installations grow from 217GW in 15E to 760GW in 2025E, if one then assumes that silicon based material reaches a penetration level of 95% (vs 90% today) and if all poly-Si material had Wacker grade, we would need c340kT highest-purity poly-Si material by 2025. Total nameplate capacity today, across all grades (1N-12N) amount to c215kT.

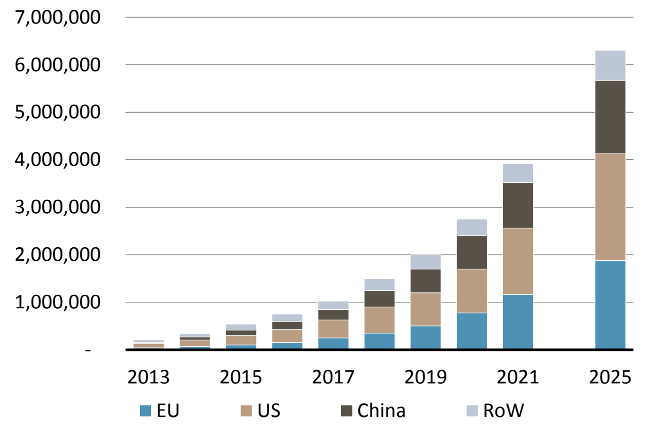
For sure the industry can install an incremental 125kT between here and 2025. But hardly in this highest grade material. Nor can the existing facilities producing lower quality material be easily upgraded easily to 12N grade. Both of which is required to meet the demand.

We conclude that Wacker's c74kT in poly-Si capacity (2016E, including new Tennessee facility starting up in H2 2015) will remain low on the global cost/efficiency curve and will be the first supplier which will be attracted by the demand. This implies double digit volume growth until 2020, and high single digit through to 2025, through a mix of market growth in PV, penetration gains of Si-material and share gains within the poly-Si supplier landscape

Autos

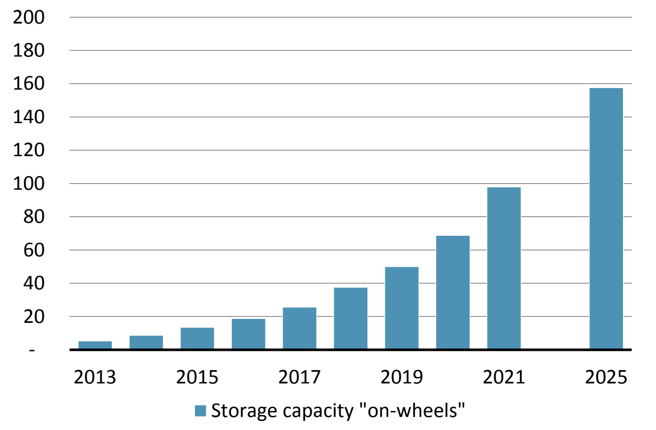
We believe that electric vehicles will be part of a future decentralised electricity system. Even assuming that the auto industry can continue to deliver efficiency gains in line with past achievement, meeting the various CO2 targets set around the world will require electrification of traditional internal combustion engines (ICE) and a degree of penetration of battery operated vehicles, even in an environment of lower oil prices. Adjusted for various super-credits we forecast market penetration of 2.6% globally by 2020, or 2.75m electric (BEV) and plug-in hybrids (PHEV) vehicles sold that year, up from less than 350k units sold in 2014, c.40% CAGR. We focus on these configurations due to their meaningful storage capacity vs series hybrids or other configurations. We expect Europe will lead the way, with penetration approaching 4.5% by 2010 vs less than 1% today. Assuming average battery capacity of 40Kwh for BEVs and 10Kwh for PHEVs, this suggests total global storage capacity of 68.7Gwh.

Figure 102: Global sales of BEV and PHEVs – units by region



Source: Global EV outlook, UBS estimates

Figure 103: Global est. of "on-wheel" power storage (GWh)



Source: UBS estimates

Progress in automotive battery technology is a key factor in reducing the cost of battery and therefore contributing to lower costs for stationary storage. OEMs and suppliers continue to make advances in energy density and management to improve autonomy and reduce "range anxiety" to a stage where purchase incentives will no longer be required and EVs will reach total cost parity with ICE vehicles. From a current estimated cost of $350 per Kwh in automobile applications, a level consistent with the recently announced price of the Tesla stationary battery, we believe cost per Kwh can decline to c$200 by 2020. Based on the current pricing structure of EVs and electricity costs, and excluding the potential benefit of self-generation, we believe true cost parity with ICE for most users can be achieved with a $70-150 reduction per Kwh. Renault-Nissan, BMW, GM and Tesla remain at the forefront of technological developments and market acceptance, with the latter also promoting stationary storage applications.

Capital goods

It is likely that the electrical equipment companies will benefit from the trends described in this report and we look forward to returning to this topic, and the electricals, in more detail at a later date. Siemens, ABB and Schneider Electric, supply all or most of the electrical equipment used to enable solar PV power generation and should therefore benefit from the investments described in this report. ABB for example acquired PowerOne, a leading solar inverter manufacturer, for circa USD 750m enterprise value in 2013. The business has struggled financially since the time of acquisition but it should be a key beneficiary when solar investments take off. ABB, Siemens and Schneider Electric offer electricity distribution products and solutions (medium voltage, transporting electricity from, say, the city limit into the building) and should benefit as the smart grid is rolled out. ABB generates circa 40% of revenues from power transmission and distribution, Siemens 15% and Schneider Electric 21%.

Appendix…

Global Utilities sector view and valuation

We remain constructive on the industry, thanks to potential capex acceleration in renewables and networks and mid-single digit EPS/DPS growth to 2020E. Yields in Europe and Latam continue to stand out vs the other regions.

- **Europe** – the European Utilities sector is full of contradictions. On one side we see companies still capped by balance sheet constraints (Germany for instance) and lacking a global growth platform. On the other side, we also see attractive business models, which feature large exposure to visible, growth-areas such as power distribution and renewables, and which are also diversified in several regions. Here is where we believe most of the value lies, and consider Enel, Iberdrola, SSE, EDP and SEV as best expressions. We also like pure renewable plays such as EDPR and EGP. All in all, Utilities trade at a vast discount to the market (c15.5x PE), whilst offering solid and growing dividends (8 in 10 are rock solid) of c4.7% and positive optionality from the ongoing renewables / networks / storage / new downstream revolution.

- **US** – We continue to see renewable penetration as an ongoing inevitability in the US, as both wind and solar continue to gain market share. We see the market as entering a 'third' phase of adoption, towards one geared towards compliance with forthcoming 111(d) carbon regulations, set to be finalized by the EPA later this month. In the interim, particularly 2015, we are in the midst of the latest surge in renewable contracting given robust federal tax credits from the Production Tax Credit (PTC) and Investment Tax Credit (ITC). This has effectively made renewables near 'economic' for utilities to procure in their own right – and they have been – vigorously. Among the developers we prefer the two heavy-weights SUNE and NEE. We also see EIX as benefitting from this thesis through increased infrastructure investment.

- **Asia** – Renewable energy investments in Asia are likely to accelerate under supportive regulatory regimes and subsidy programs along with strong government renewable capacity addition targets. Governments across Asia are recognising the need to reduce pollution and develop alternative sources of energy. We like Chinese renewable companies such as Huadian Fuxin and Huaneng Renewable as grid curtailment eases and we believe the renewable policy environment in China will remain supportive. These companies are increasingly focused on developing solar farms throughout the country. We also like Indian Power companies due to improving plant availability as fuel supplies improve. We prefer Indian power companies with large free cash flow growth and ROE expansion such as JSW Energy. We also like KEPCO due to improving generation mix and undemanding valuations. Electric utilities and IPPs across Asia are trading at premium (15x) to the market (13x) on a 2015E PE basis. However, value can be found in coal-based IPPs listed in Hong Kong and India (10x 2015E PE).

Figure 104: Global comp sheet valuation

Utilities sub-sector valuations												
Sub-sectors	**P/E**				**EV/EBITDA**				**Dividend Yield**			
	2015E	**2016E**	**2017E**	**2018E**	**2015E**	**2016E**	**2017E**	**2018E**	**2015E**	**2016E**	**2017E**	**2018E**
Generation	16.6x	16.8x	14.6x	13.3x	9.7x	9.2x	8.3x	7.8x	3.3%	3.2%	3.6%	3.8%
Integrated	15.7x	15.7x	15.0x	14.2x	8.7x	8.4x	8.3x	7.9x	4.1%	4.1%	4.4%	4.5%
Integrated Regulated	15.2x	14.7x	14.1x	13.5x	9.0x	8.6x	7.9x	7.6x	4.0%	4.1%	4.3%	4.4%
T&D	28.6x	22.9x	19.9x	18.2x	12.3x	11.2x	10.4x	10.0x	4.3%	4.7%	5.0%	5.4%
Water	20.2x	16.9x	14.0x	12.7x	10.0x	9.0x	8.1x	7.5x	3.1%	3.4%	4.1%	4.7%
Sector	**20.7x**	**18.4x**	**16.7x**	**15.5x**	**10.1x**	**9.5x**	**9.0x**	**8.5x**	**4.1%**	**4.2%**	**4.6%**	**4.8%**

Regional utilities valuations												
Regions	**P/E**				**EV/EBITDA**				**Dividend Yield**			
	2015E	**2016E**	**2017E**	**2018E**	**2015E**	**2016E**	**2017E**	**2018E**	**2015E**	**2016E**	**2017E**	**2018E**
N America	25.2x	21.0x	18.6x	16.7x	10.9x	10.0x	9.4x	8.8x	4.2%	4.5%	4.8%	5.1%
Europe	16.3x	16.6x	15.8x	15.0x	8.7x	8.8x	8.7x	8.4x	4.6%	4.4%	4.7%	4.9%
Asia	16.0x	15.2x	13.9x	13.6x	10.1x	9.4x	8.6x	8.2x	3.0%	3.1%	3.3%	3.5%
Australia / NZ	25.2x	23.5x	20.8x	19.5x	13.3x	10.6x	9.7x	9.4x	5.0%	4.9%	5.7%	6.1%
LatAm	18.1x	12.3x	9.9x	9.1x	9.2x	7.5x	6.6x	6.2x	4.9%	6.4%	7.5%	8.1%
Sector	**20.7x**	**18.4x**	**16.7x**	**15.5x**	**10.1x**	**9.5x**	**9.0x**	**8.5x**	**4.1%**	**4.2%**	**4.6%**	**4.8%**

Source: UBSe- Note: Priced as of 1 June 2015

Payback period by customer type ex-subsidies

Figure 105 details a study made by Politecnico di Milano University, on Southern Italy. This shows a payback period (assuming variable system costs: T&D, renewable incentives) of 5-8 years depending on the customer, based on their cost projections, which may prove somehow too prudent.

Figure 105: Solar economics and payback by customer type (2025E)

	Single house	Building	Commercial	Industrial
Size (kW)	2	20	200	400
Load Factor	15.0%	15.0%	15.0%	15.0%
Efficiency	85%	85%	85%	85%
Output (MWh)	2.2	22.3	223.4	446.8
Own consumption	55%	55%	55%	55%
Capex / W (eur)	1.35	1.21	0.97	0.87
Capex (eur)	2,695	24,255	194,040	349,272
Solar Opex pa (eur)	81	728	4,851	6,985
Annual bill (eur)	1,005	10,052	91,383	162,458
Gross savings if sys costs variable	553	5,529	50,261	89,352
Net savings if sys costs variable	337	3,588	35,708	64,903
Payback	8	7	5	5
Gross savings if sys costs fixed	307	3,071	30,715	53,611
Net savings if sys costs fixed	92	1,131	16,162	29,162
Payback	29	21	12	12

Source: UBSe, Politecnico di Milano

Comparison amongst new entrant costs

Although the best way to compare costs would be on LCOE – these observe the cost of a technology over its lifetime, and divide such costs by the total output produced – many governments still run their energy policy based on new entrant comparisons. Figure 106 compares the competitiveness of solar in 2015-25E against conventional technologies and wind. Solar clearly remains less competitive, although the gap is quickly closing and the outcome largely depends on the capacity factors.

Figure 106: Solar new entrant vs conventional technologies and wind (€/MWh)

New entrant (e/MWh)	2015E	2020E	2025E
Solar at 11.0% LF	146.0	106.0	84.5
Solar at 16.5% LF	97.0	70.7	56.3
Nuclear	91.6	98.5	113.6
Coal at 50% LF	75.6	87.3	102.6
Wind at 23% LF	73.0	74.8	78.7
CCGT at 50% LF	60.2	69.5	81.1
Wind at 28% LF	60.0	61.5	64.7
Solar at 27.0% LF	59.3	43.2	34.4

Source: UBSe

What really drives solar costs

Solar costs are typically divided into two major categories: the module, which accounts for about 1/3 of the total capex/W and balancing of system costs (BoS).

- **Modules.** The cost of modules is split amongst the module itself, raw materials (polysilicon), the cell and the wafer.
- **Balancing of Systems.** BoS include the cost of the inverter (the largest BoS component), engineering and construction works, installation costs, other electrical hardware, costs related to grid connections, and others.

Since 2010, costs per Watt have fallen by 60%, mostly due to better processes, economies of scale and cheaper raw material. At the same time –as explained earlier – the global solar manufacturers could deliver >50GW pa at present, which is some 25% above the annual needs of c40GW, at the current run rate.

Figure 107: Solar costs per W have been steadily falling – Outlook suggests more to go (€/W)

	2010	2011	2012	2013	2014	Historical driver
Polysilicon	*0.19*	*0.16*	*0.12*	*0.11*	*0.10*	Raw materials
Ingot & wafer	*0.22*	*0.19*	*0.16*	*0.13*	*0.12*	Processes / Scale
Cell	*0.20*	*0.17*	*0.14*	*0.12*	*0.11*	Processes / Scale
Module	*0.34*	*0.28*	*0.22*	*0.19*	*0.17*	Processes / Scale
Tot Module	0.96	0.79	0.64	0.56	0.50	–
Balancing of System costs	2.49	2.17	1.37	0.99	0.88	Processes / Scale
Solar capex / Wp (€)	**3.45**	**2.96**	**2.02**	**1.55**	**1.38**	–
Evolution 2010-14					*-60%*	
% cost from Modules	*28%*	*27%*	*32%*	*36%*	*36%*	
% cost from Bos	*72%*	*73%*	*68%*	*64%*	*64%*	

Outlook

Modules: crystalline silicon savings from processes and scale. R&D in thin film could creat major leap on savings

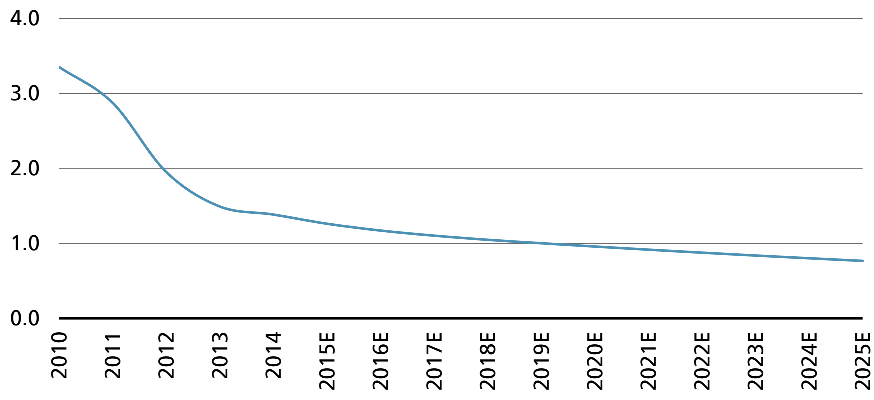
BoS: Most balancing of system costs are scalable; thus BoS for large scale solar are much cheaper than residential PV. Overall residential solar is c70-80% more expensive than large solar

Note: manufacturers could supply c60GW pa, or c50% above the current additions-run-rate pa

Source: UBSe

Going forward, most industry studies suggest further potential for savings in processes. Also, increasing the size of utility-scale projects would clearly lead to cheaper unitary costs. Going forward, we assume c5% decline pa.

Figure 108: Estimated solar PV capex costs over 2015-25E (€/W, utility scale)



Source: UBSe

Focus on solar PV technologies

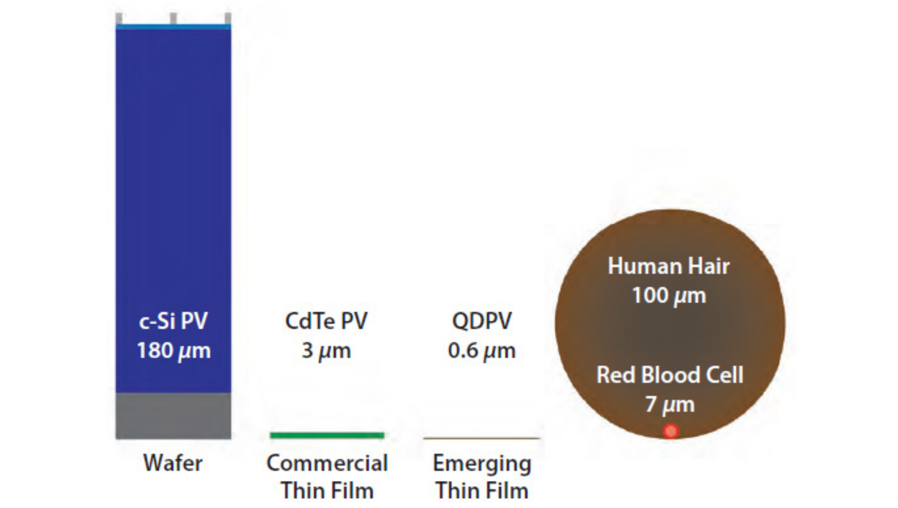
A typical solar module (typically 1.0 x 1.5m surface, c20kg weight) is made of 60 to 100 solar cells (15cm square each) along with other various materials (glass sheet for protection, steel frame…). A solar cell is made of a wafer (thin slice of silicon) or a layer of specific semi-conductors, which are the key to the photovoltaic chemical reaction, along with other chemicals and materials. The solar PV module value chain could be summarised as follows:

Wafer/Thin-film ➔ Cell (typically 4-5 watts capacity) ➔ Module (typically 260-320 watts capacity) ➔ Photovoltaic system

The module is the key part of any solar system, where the PV reaction happens, but it needs to be combined with an inverter (to convert DC power into AC), as well as some installation works (including a concrete and steel base on which the system is mounted) and various electrical equipment (wiring, AC control panel…). Additionally, this can be coupled with an electricity storage system.

Current technology options

Figure 109: Solar cell thickness by technology classification



Source: MIT

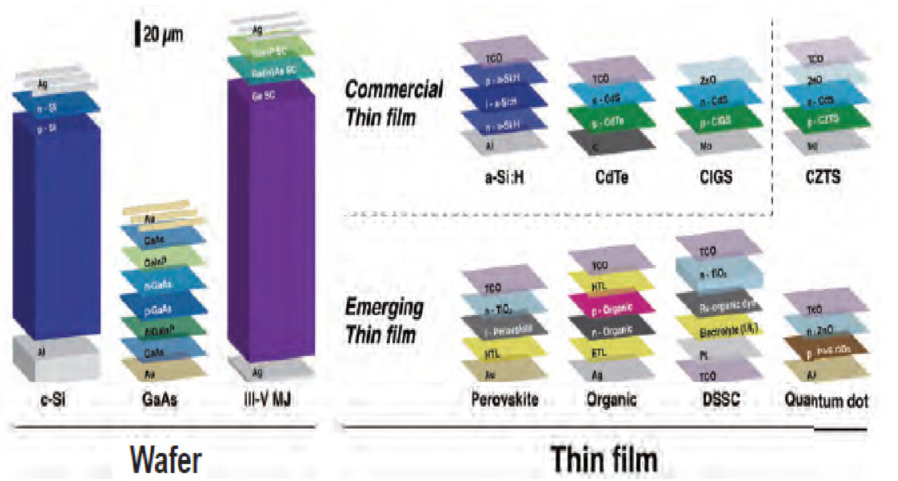
Wafer-based (c-Si): This designates the technology that relies on slices of silicon ('wafer') as the key to the PV reaction. The wafer is typically about 150-180 μm (microns) thick, and can be based on two different standards, i.e. poly or mono-silicon. This is the standard technology at present, and represents 90% of the existing PV market.

- **Poly-Silicon (mc-Si)**: Efficiency typically in the 12-15% range – This form dominates the wafer-based market, with a 60% share (55% share in total PV market).
- **Mono-Silicon (sc-Si)**: Typically 20-30% higher cost when compared to poly, but also higher efficiency (typically 15-17% or more)

Thin film: Completely different from silicon-based PV (and much more recent), this relies on an extremely thin (1-3 μm) layer of semi-conductor materials instead of a silicon wafer. When compared to crystalline, thin film typically has a lower cost but also a lower efficiency (10-12%). Another key difference is that, due to its very thin structure, thin film modules can be manufactured as "flexible sheets" that

allow a better integration into any building's structural designs and much lower weight. Additionally, it relies on 'critical' materials (such as Tellurium and Gallium) much more than silicon-based technologies. This represents about 10% of the market at present.

Figure 110: Current solar PV device structures



Source: MIT

Outlook on PV technology

As said, crystalline (i.e. silicon-based) solutions are dominant on the market right now. Based on current assessment of technological prospects, most industry stakeholders (companies, consultants, government agencies) expect wafer-based (and within that, polysilicon), to remain the main option going forward, for at least the next decade. Current innovation opportunities include increasing commercial module efficiencies, reducing manufacturing complexity and costs, reducing the amount of silicon used per watt, and reducing reliance on silver for contact metallization. The MIT estimates that c-Si will remain the leading deployed PV technology in the near future, and present c-Si technologies could achieve terawatt-scale deployment by 2050 without major technological advances.

However, given that thin film is much less mature, expectations both in terms of cost reductions and efficiency improvements are still significant. Depending on technological progress, this could become the most competitive option, medium term. Current innovation opportunities in thin-film technology include improving module efficiency, improving reliability by introducing more robust materials and cell architectures, and decreasing reliance on rare elements by developing new materials with similar ease of processing.

The US is the "ideal" solar market despite ITC drop

We do note that when the ITC steps down to 10% in 2017 for commercially-owned projects (from 30%), utility-scale systems should begin to take a smaller share of the US market, and retail PV should grow at a faster rate. While we feel as though the ITC step-down in 2017 will create a pull-in in 2016 and a drop-off in 2017, determining the LT impacts of the drop is less concrete.

Longer-term implications of the drop depend on the costs continuing to come down, as well as the increase of state-level incentives. Completely eliminating the ITC could be a net-positive for the industry, as installation/ equipment costs will be forced to decrease, and drop in-line with the most competitive markets (i.e. Germany & other European markets). This side of the debate feels as though the ITC incentives are baked into the costs structures, so the drop will be absorbed and costs will continue to decrease. On the other side of the debate, individuals cite the lack of growth in markets where incentives have been removed. Once again, Germany is the main example here, as it once was the leader in PV installations but has fallen behind markets with more competitive rebates and incentives.

Regarding the risk of displacing thousands of jobs via the ITC drop, we feel as though states will be incentivized to develop in-state rebates in order to attract and retain PV-related labour. We believe states will pick up where the ITC leaves off, but that this could fragment the industry even more than it already is in the US with only a handful of states having thriving PV markets.

Closely tied to the ITC debate is the US-China trade case generated by SolarWorld. The feeling that a lessened or eliminated tariff on Chinese/Taiwanese modules would be in the best interest of the US PV market is nearly unanimous, and we see a major issue arising if both the ITC is eliminated and tariff is up-held long term, as costs will not be able to decrease enough to continue spurring growth. Ultimately, it is clear that this more of a SolarWorld vs. low cost module supplier battle, as low cost manufacturers will continue to expand production to countries outside of the tariff, and tariffs will need to continue to play catch-up.

As we have heard from many industry experts, consolidation is expected to increase in the distributed gen development and installation sector. Companies with large C&I and residential portfolios are very attractive to larger players. As the industry has shifted toward a YieldCo model, ownership of projects is desirable, with the larger portfolios generating the most revenue.

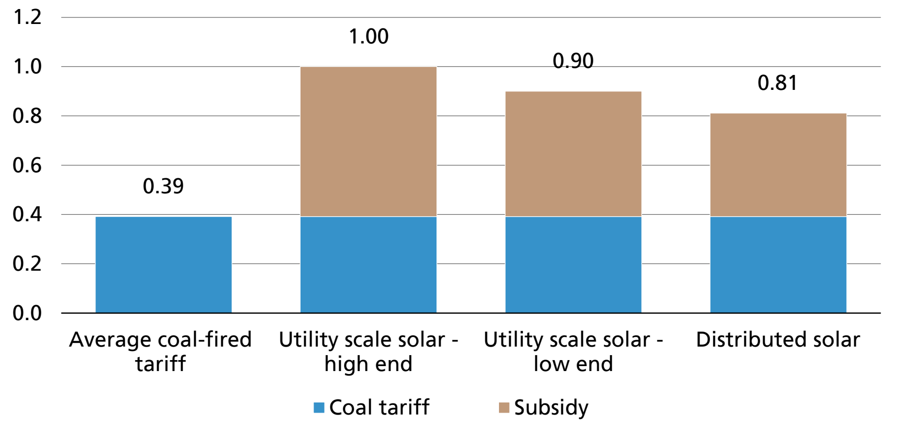
While many desirable C&I accounts (Whole Foods, Home Depot, Trader Joes etc.) are highly competitive between C&I developers seeking customers with national portfolios, we flag that less than 1% of the C&I market have adopted solar, and the sector has huge potential. Financing structures must change in the space, as the cost of capital in C&I is more expensive than residential due to the lack of standardized credit ratings and doesn’t have the scale of utility projects to compensate for the high costs. We expect community solar/ virtual net metering to take-off in the next ~5 years, and that could be a major catalyst for future growth in the space.

Focus on China

Specifics on China – From Asian team

China's government has played a pivotal role in developing the wind-power industry. The introduction of the Renewable Energy Law in 2006 and the accompanying regulations provided a legal framework and policy direction for the development of the industry. Under the Renewable Energy Law and associated regulations, solar-farm operators are entitled to special feed-in tariffs. The grid companies are required to provide grid connections and to take all the electricity that solar farms generate.

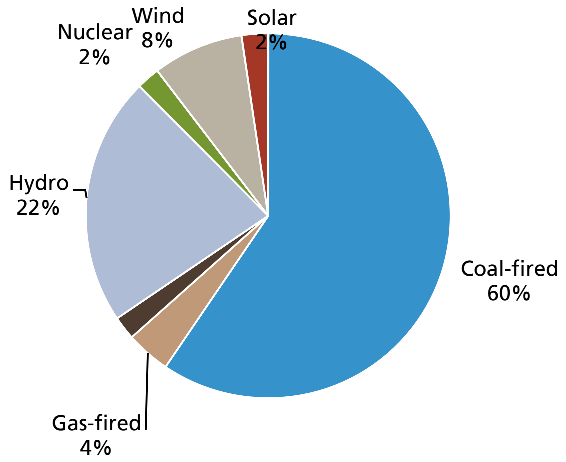
Figure 111: Chinese solar feed-in-tariffs (RMB/kWh)



Source: UBSe

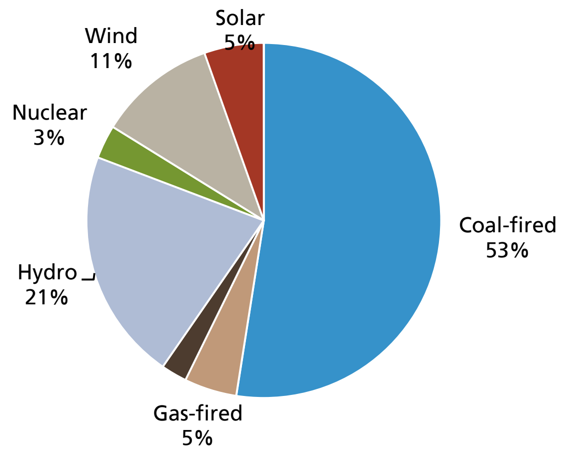
Utility-scale ground solar generators are paid an on-grid tariff between Rmb0.90/kWh to Rmb1/kWh. As for distributed solar, an extra Rmb0.42/kWh premium is paid over the local coal-fired on-gird tariff for power sold back to the grid. The premium is paid out of the Renewable Energy Fund, which is funded by a renewable energy surcharge on end-users' power bills. Returns are supported further by favourable tax policies, such as a full tax holiday for the first three years and a 50% rebate for the next, as well as VAT rebates for equipment and a return of half of the VAT collected on revenue.

Figure 112: China 2015E capacity mix



Source: UBSe

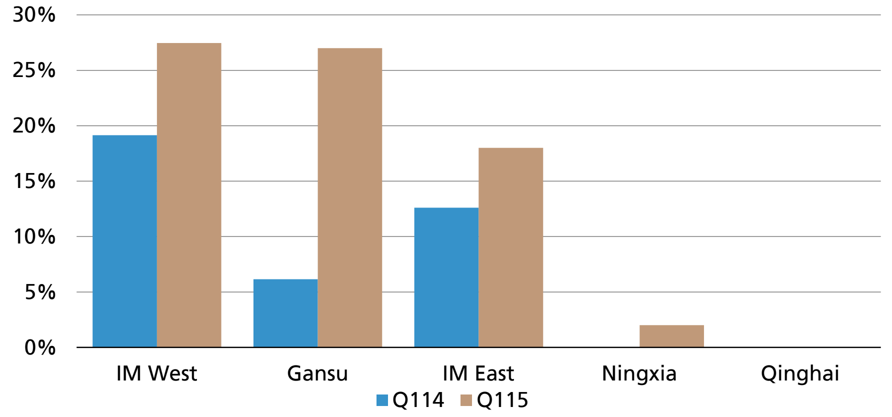
Figure 113: China 2020E capacity mix



Source: UBSe

However, solar power in China, especially large utility scale solar could face potential curtailment issues, similar to those experiences by wind-farms operators by where the local power grid infrastructure is unable to cope with the large about of capacity additions. Majority of the Provinces that receive high solar irradiation, such as Gansu, Qinghai, Inner Mongolia and Ningxia are sparsely populated and it may be difficult the power generated to consume locally; hence power is most likely to be sent to coastal areas. Although China is building ultra-high voltage transmission lines to ease grid congestion by sending power to the coast, we believe the risk would be the pace of transmission line construction could not keep up with the pace of solar farm construction.

Figure 114: Share of power generated but not send to the grid (curtailed)



Source: UBSe

We are comfortable with our Asian solar forecasts

For China we are on target to achieve the government target of 100GW by 2020 of solar power. Policy is very supportive here given the high solar tariff and it's compulsory for the grid to purchase the power generated by solar plants. Risk to the target would be a shift in policy and severe grid curtailment (as highlighted previously).

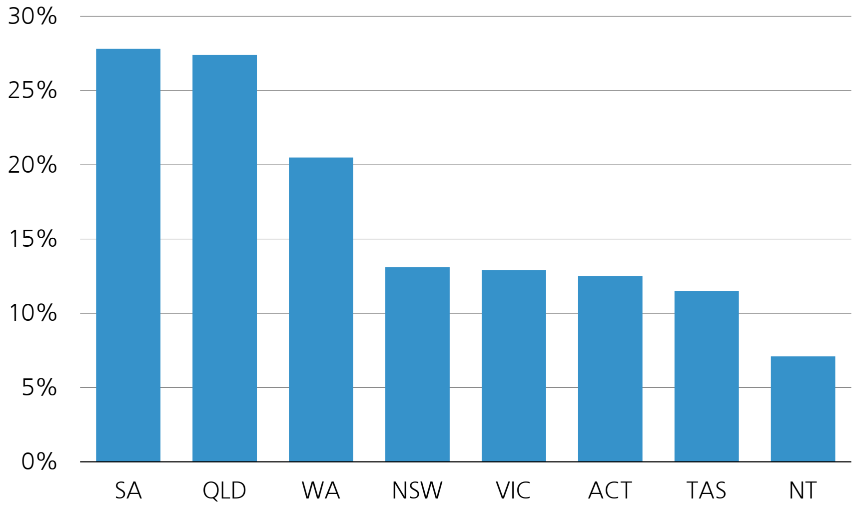
For India, we are below the government target of 100GW by 2020. Our Indian utilities analysts think it around 14-15GW by 2020 is more achievable. The main issue preventing rapid solar capacity additions is the cost of purchasing power from solar plants. The local electricity boards, which are in deep losses wants to minimize power purchase from solar plants due to the high purchase cost. Despite the government setting a renewable purchase obligation for these local electricity boards, they often fail to meet the target (to avoid further losses). As for distributed solar, affordability is an issue. It will also be difficult for India's power grid to cope with a large amount of solar capacity additions give significant capex will be required even to improve the reliability of the current network up to suitable standards.

For Japan, government is targeting c.50-65GW by 2020, our forecast sits in the middle of that range. Certainly it is possible for Japan to add more (dependent on the possibility of restarting nuclear power plants). We want to be a bit more conservative given the mature nature of Japan's power market.

Focus on Australia

Australia has 4.2GW of solar PV installed of which around 4 GW is rooftop solar designed for consumption behind the grid. Australia has the world's highest residential rooftop penetration rate by some distance with 1.35m household small business installations. Three States in Australia have over 20% of houses with solar on the roof and the national average is 17%. Annual installations for residential rooftop solar still appear to be running at around 600 MW per year.

Figure 115: % of dwellings with a PV system by state



Source: Australian PV Institute

The 4 GW of solar compares with median midday power demand of about 30 GW. So we see the stand impact of solar having a significant impact on midday pricing.

The main subsidy available in Australia today is effectively a capital subsidy equal to about 30% of the installed cost for systems less than 100 KW. The subsidy is effectively recovered from tariffs charged by retailers. The subsidy cost will decline when installations decline.

The market in Australia is shifting from residential to business and is also expected to shift towards utility scale. Subsidies for utility scale solar come in the form of Renewable Energy Certificates with a market price. Retailers must procure enough certificates to satisfy an annual target that increases from about 15 TWh today to about 33 TWh in 2020. There is a "penalty" price equal to A$95. Utility scale solar is still more expensive than wind in Australia but in regions where the wind resource is less (QLD) we expect to see an increase in utility solar projects.

For solar to go on to become the main electricity source in Australia in the longer term it is essential that economic storage solutions become available.

Australia now is becoming one of the key global testbeds for domestic lithium ion storage because of high peak tariffs ~$0.50 KWh, low export to the grid price ~$0.06 KWh and the high installation base. Two years ago storage was being talked about; today the products are on the market albeit not economic.

Australia's two largest electricity retailers have both significantly increased their offerings in the PV space and one has publicly announced a household storage product expected to be on the market in the next quarter.

As part of the ongoing conversation of adapting Australia's electricity value chain to new technology we are seeing intensive discussion of grid pricing. Traditionally done on the basis of "postage stamp" tariffs which were based 90% on consumption, the new proposals involve higher connection fees and fees based on maximum monthly instantaneous demand. Associated with this we expect to see increasingly rapid take up of time of use metering which will shift the electricity business into one where the data collected has its own value.

Our expectations are for solar PV installations in total of about 0.8 GW this year (similar to last year) helped by about 200 MW of utility scale. In 2016 we expect only about 0.5 GW before stepping back towards 1 GW per year in the 2017 to 2020 period.

Evidence of large solar projects already happened

Figure 116: Large solar projects already happened

Project name	Company	Location	Capacity	COD	Currency	Expected LF	Capex	Capex	PPA	PPA length
			MW	mmm/yy		%	LOCm	LOC/W	LOC/MWh	years
Cestas PV plant	Neoen	SW France	300	Oct/15	EUR	13.9%	360	1.20	105	20
German 1st PV auction	Multiple projects	Germany	157		EUR				92	
Desert Sunlight	NextEra	SW USA	550	May/15	USD	22.0%	1,622	2.95		
McCoy	NextEra	SW USA	250	2016	USD					
2 West Texas plants	SunEdison	SE USA	150		USD				50	25
Macho spring project	SunEdison	SW USA	50	May/14	USD		75	1.50	58	25
Pampa Norte	EGP	Chile	79		USD	28.9%	128	1.62		
Carrera Pinto	EGP	Chile	97	H2-2016	USD	30.6%	180	1.86		

Source: Company data, UBSe

Regulatory snapshot of main markets

Figure 117: Key metrics for key country in terms of global PV deployment

Country	Regime	Average LF	2014 solar capacity	Capacity penetration
Germany	- FiT for distributed - Auctions for large-scale	11%	39,858	21%
Italy	- FiT for distributed - Auctions for large-scale	15%	20,420	16%
Spain	- FiT for distributed - Pool + capacity component for large-scale	16%	6,988	7%
France	- FiT for distributed + tax credit - Auctions for large-scale	13%	5,292	4%
UK	- FiT for distributed + tax breaks for businesses - Auctions for large-scale	10%	2,106	2%
US	- FiT for distributed + tax credit - Bilateral PPAs for large-scale, with ITC	16%	20,332	1%
China	FiT with tax credits for both distributed and large-scale	17%	22,581	2%
Chile	- Bilateral PPAs for large-scale	21%	N/A	N/A
Brazil	- Centralised tender and PPAs for large-scale	19%	N/A	N/A
Mexico	- Bilateral PPAs for large-scale	19%	N/A	N/A

Source: UBSe

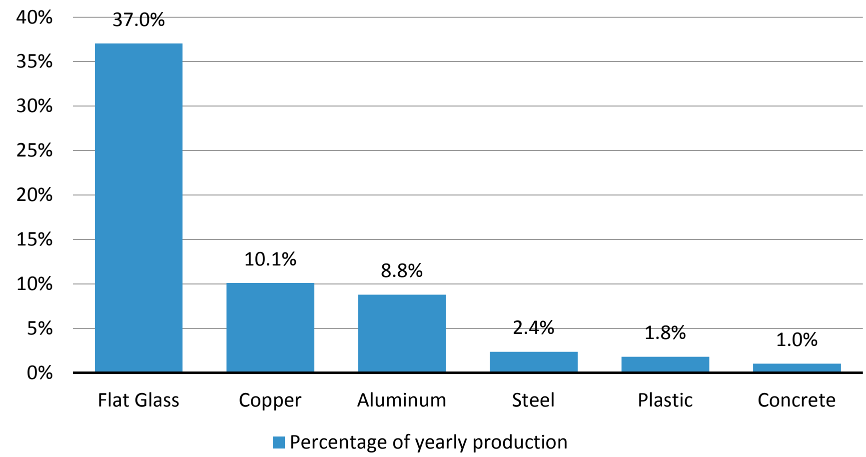
Raw materials show no constraints (full analysis)

The materials used to construct PV sites could impose limits in the development of solar electricity, so it is necessary to focus on any constraints related to the material scarcity and the availability of sufficient material quantities in timely fashion. Specifically, there is the widespread belief that rare earths could impose obstacles in the development of solar electricity. Our analysis shows that overall there are no significant material scarcity constraints regarding our estimate of 505 GW of PV sites by 2025. Even if it is very possible that solar electricity based on 'critical materials' would face very serious challenges, the overwhelming majority of solar modules currently in use and in production are based on Silicon and Silver in order to transform light to electricity. Thus, the relative scarcity of rare earths seems to play only very limited role in the development of PV sites in the medium term. Figure 120 presents the estimated commodity materials for 1MW of installed capacity using modules based on silicon.

In general we need two kinds of materials to construct a PV site: commodity materials and critical materials. The first category includes materials that are used in a variety of applications and are not associated with the production of solar electricity: coper, aluminium, flat glass, plastic, steel and concrete. The second category includes materials that are very closely related to PV (critical materials): Silicon, Silver, Tellurium, Gallium, Indium and Selenium. A further acceleration of PV construction may be influenced by a supply shortage in the above materials.

Figure 118 presents the quantities of necessary commodity materials for the 505 GW expansion forecasted in our scenario as a percentage of their current yearly production.

Figure 118: Commodity materials required to reach 2025 estimate.

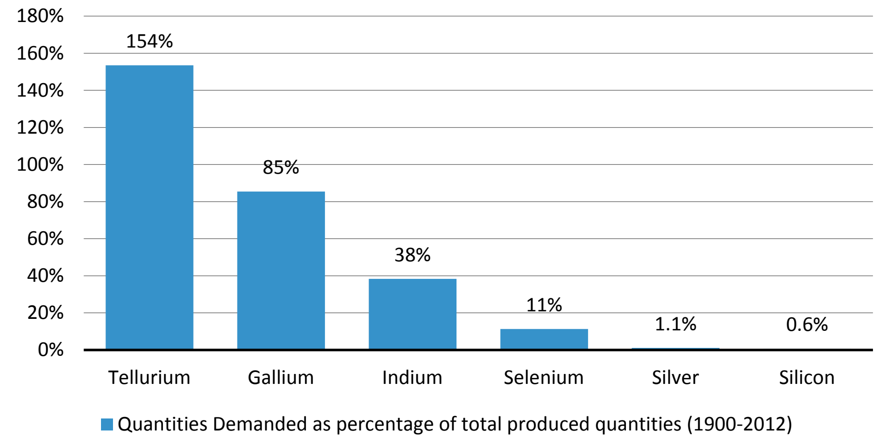


Source: MIT, UBSe

Overall, with the exception of flat glass, the required quantities are fairly small at the range of 1-10% of yearly production, so we expect no particular difficulties in satisfying demand. Moreover, even if the demand for flat glass will be high and could have an impact on flat glass prices, the availability of glass in reasonable prices will not be a constraint for the development of PV sites. The raw materials for glass are widely available, the production technology is mature and widely available, and also there is idle capacity because of the recession and the subsequent decline in construction activities.

The situation is different regarding the critical materials. Four out of six materials are very difficult to obtain, there are not easily substituted and they are mainly produced as a by-product of other metallurgical procedures. Figure 119 presents the necessary quantities for our scenario as percentage of the total quantities extracted from 1900 until 2012.

Figure 119: Critical materials required to reach 2025 estimate



Source: MIT, UBSe

The percentages for Silicon and Silver are 0.6% and 1.1% of the total extracted quantities from 1900 to 2012, so we don't expect any bottlenecks in the technologies based on these two materials. The situation is very different for the first four critical materials. For example, if all the modules in our scenario use Tellurium based technology, the amount of Tellurium required would be more than 1.5 times the amount already produced from 1900 to 2012. This could mean serious problems, but given that around 90% of solar modules use Silicon and Silver based technologies, we don't expect the scarcity of critical materials to impose serious challenges to the expansion of PV sites in the short and medium term. A more important problem could arise from the availability and price of silver, but the solar panels industry is trying to decrease the use of Silver with success.

Figure 120: Commodity materials for 1MW (tons)

Commodities	
Copper	4
Aluminium	8
Glass	44
Plastic	10
Steel	70
Concrete	72

Source: MIT, UBSe

New entrant cost sensitivity to LF and capex

Figure 121: New entrant cost (€/MWh) sensitivity to load factors (X) and capex / W (€, Y)

	10%	12%	14%	16%	18%	20%	22%	24%	26%	28%	30%
0.50	66.2	55.1	47.3	41.3	36.8	33.1	30.1	27.6	25.4	23.6	22.1
0.60	79.4	66.2	56.7	49.6	44.1	39.7	36.1	33.1	30.5	28.4	26.5
0.70	92.6	77.2	66.2	57.9	51.5	46.3	42.1	38.6	35.6	33.1	30.9
0.80	105.8	88.2	75.6	66.2	58.8	52.9	48.1	44.1	40.7	37.8	35.3
0.90	119.1	99.2	85.1	74.4	66.2	59.5	54.1	49.6	45.8	42.5	39.7
1.00	132.3	110.3	94.5	82.7	73.5	66.2	60.1	55.1	50.9	47.3	44.1
1.10	145.5	121.3	104.0	91.0	80.9	72.8	66.2	60.6	56.0	52.0	48.5
1.20	158.8	132.3	113.4	99.2	88.2	79.4	72.2	66.2	61.1	56.7	52.9
1.30	172.0	143.3	122.9	107.5	95.6	86.0	78.2	71.7	66.2	61.4	57.3
1.40	185.2	154.4	132.3	115.8	102.9	92.6	84.2	77.2	71.2	66.2	61.7
1.50	198.5	165.4	141.8	124.0	110.3	99.2	90.2	82.7	76.3	70.9	66.2
1.60	211.7	176.4	151.2	132.3	117.6	105.8	96.2	88.2	81.4	75.6	70.6
1.70	224.9	187.4	160.7	140.6	125.0	112.5	102.2	93.7	86.5	80.3	75.0
1.80	238.2	198.5	170.1	148.8	132.3	119.1	108.3	99.2	91.6	85.1	79.4
1.90	251.4	209.5	179.6	157.1	139.7	125.7	114.3	104.7	96.7	89.8	83.8
2.00	264.6	220.5	189.0	165.4	147.0	132.3	120.3	110.3	101.8	94.5	88.2

Source: UBSe

Figure 122: Other assumptions used in the sensitivity

Asset life (years)	25
Performance	81%
Cell decay pa	0.35%
ROIC (pre-tax)	6.0%
Opex as % of capex	2.0%

Source: UBSe

Regional solar forecast

Figure 123: Regional solar forecast – Installed capacity (GW)

	2015E	2016E	2017E	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
North America	28	37	41	47	55	63	72	80	88	97	105
Europe	94	100	106	112	118	124	131	139	148	157	166
Latam	0	1	2	3	4	5	7	8	10	11	13
Asia	84	109	133	158	185	214	244	276	309	342	374
Other	10	12	14	17	21	25	30	36	43	52	62
Total	**216**	**258**	**295**	**337**	**382**	**431**	**484**	**539**	**598**	**659**	**721**

Source: UBSe

Statement of Risk

Utilities are driven by commodities, power prices, M&A, regulatory intervention and interest rates.

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EDF	EDF.PA	Neutral	N/A	€22.46	02 Jun 2015
Edison International[2, 4, 6, 16]	EIX.N	Buy	N/A	US$59.54	02 Jun 2015
EDP Renovaveis[5]	EDPR.LS	Neutral	N/A	€6.52	02 Jun 2015
Enel[2, 4]	ENEI.MI	Buy	N/A	€4.40	02 Jun 2015
Enel Green Power SpA	EGPW.MI	Buy	N/A	€1.76	02 Jun 2015
Energias de Portugal[4, 5]	EDP.LS	Buy	N/A	€3.56	02 Jun 2015
Fortum[5]	FUM1V.HE	Sell	N/A	€17.34	02 Jun 2015
Huadian Fuxin Energy Corporation[2, 4]	0816.HK	Buy	N/A	HK$4.06	03 Jun 2015
Huaneng Renewable Corporation	0958.HK	Buy	N/A	HK$3.46	03 Jun 2015
Iberdrola[4, 5]	IBE.MC	Buy	N/A	€6.26	02 Jun 2015
JSW Energy	JSWE.BO	Buy	N/A	Rs102.95	03 Jun 2015
KEPCO[16]	015760.KS	Buy	N/A	Won45,300	03 Jun 2015
LIGHT	LIGT3.SA	Neutral	N/A	R$17.14	02 Jun 2015
NextEra Energy[2, 4, 6, 16]	NEE.N	Buy	N/A	US$102.22	02 Jun 2015
Red Electrica de España[13]	REE.MC	Buy	N/A	€76.73	02 Jun 2015
RWE[2, 4, 5, 13]	RWEG.DE	Neutral	N/A	€21.12	02 Jun 2015
SSE PLC	SSE.L	Buy	N/A	1,639p	02 Jun 2015
Suez Environnement	SEVI.PA	Buy	N/A	€17.44	02 Jun 2015
SunEdison Inc.[13, 16]	SUNE.N	Buy	N/A	US$30.47	02 Jun 2015
Wacker Chemie	WCHG.DE	Buy	N/A	€100.50	02 Jun 2015

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