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A market approach for valuing solar PV farm assets
Global results

April 2016

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1. Introduction

In recent years investors all over the world have paid increasing attention to the renewable energy industry.

This trend has translated into rapid renewable energy commercialisation and considerable industry expansion, of which the solar photovoltaic (PV) industry is a good example. According to Bloomberg Business, new wind and solar power accounted for about half of all new generation last year. Around 64 GW of new wind power and 57 GW of new photovoltaics was added, representing an increase of 30 % from 2014[1].

The increase in annual installed solar PV capacity may be explained by the past years' reduction in panel costs. The cost reduction is mainly due to technology improvements and the entry of low-cost production lines in China and Chinese Taipei, which now accounts for almost 70% of global PV panel production[2].

The international Energy Agency (IEA) estimates that solar PV energy's share of global energy generation will increase significantly up to 2040. Solar PV alone is expected to generate more than 10% of total energy, whereas wind energy is expected to generate 13%. This reflects an expected total capacity of solar PV assets of 1,066 GW in 2040[2].

Since the solar PV market has grown at high speed and since growth is expected to continue, we find it interesting to examine the market values of solar PV farm assets.

[1] Bloomberg Business, "As Oil Crashed,Renewables Attract Record $329 Billion, 14 January 2016"
[2] International Energy Agency, "World Energy Outlook 2015"

2. Executive summary

In the past few years focus on renewable energy has led to high growth in investments in renewable energy assets. Especially wind and solar farm assets have been exposed to great interest from investors, and markets expect high growth rates in investments in these assets in the coming decades. Due to expectations for these markets, we find it interesting to identify the structure of assets held by solar PV farm investors and to find suitable methods to value such assets.

This paper addresses how and why multiple regression analyses are a good supplement to more comprehensive cash flow models when valuing solar PV farm assets. Our analysis has been performed on the basis of transactions in the solar PV industry. Through our analyses of transactions in the solar PV industry we find that installed capacity, construction capacity and capacity in development pipeline affect the enterprise value of solar PV assets significantly.

We have performed a similar analysis of wind farm assets and we refer to "A market approach for valuing wind farm assets" for that analysis.

Since the release of the 7th edition of this analysis in April 2015, we have added transactions that are suitable for our analysis of solar PV assets. Our analysis now includes 240 solar PV farm transactions. The additional transactions in the solar analysis have enabled us to perform more comprehensive analyses of time effects on installed capacity.

In this year's edition we once more see a noticeable downward change in the preliminary installed capacity multiple. We estimate a value of EUR 2.2m per installed MW.

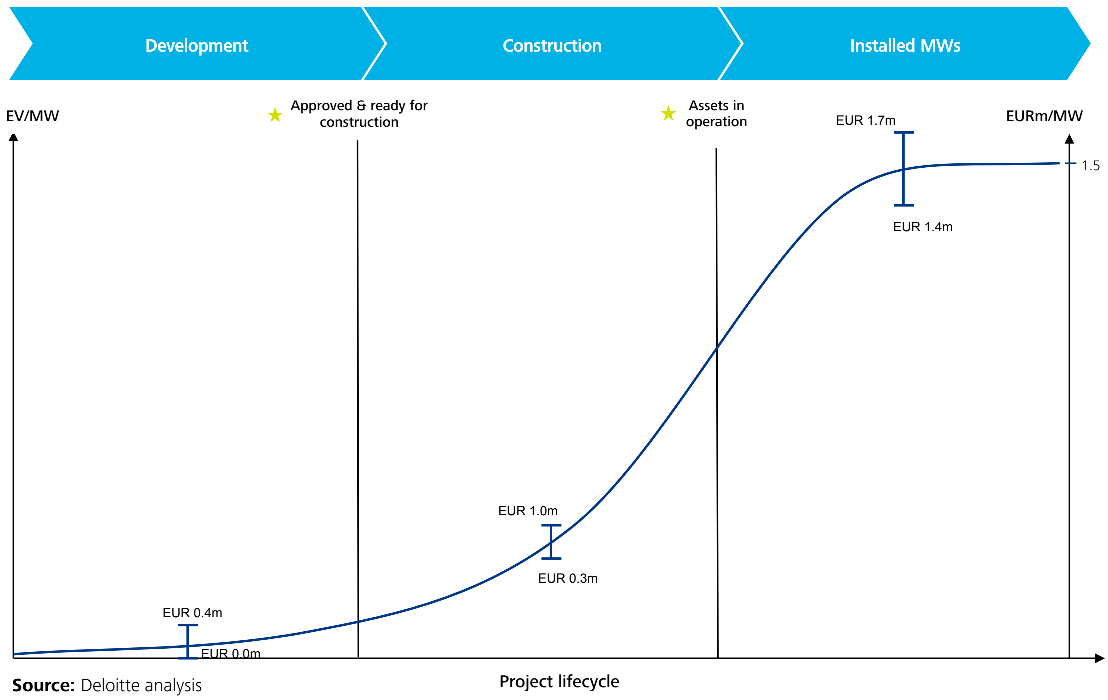
However, due to large improvements in cost-competitiveness within the last few years, a time regression on data from January 2014 until the beginning of 2016 is executed to obtain a more reliable estimate of EUR 1.5m per installed MW. The final estimates are represented in the figure below. These results are consistent with reports on declining project costs.

Besides a more efficient manufacturing industry, we believe that this decline is caused by tighter government subsidy policies in the European countries and lower return requirement driven by the low interest rate in Europe.

We have tested for geographical differences in prices of solar PV assets. We conclude that installed capacity in Europe and North America trades at a premium compared to the global estimate, while installed capacity in Asia trades at a significant discount.

We also find that variations exist among the European countries. We find that installed capacity the UK, France and Germany trades at a discount compared to the global multiple, while Italy trades at premium.

For transaction details and details on the geographical analysis we refer to "A market approach for valuing solar PV farm assets – geographical analysis and transaction details" and the order form on page 18.



Source: Deloitte analysis

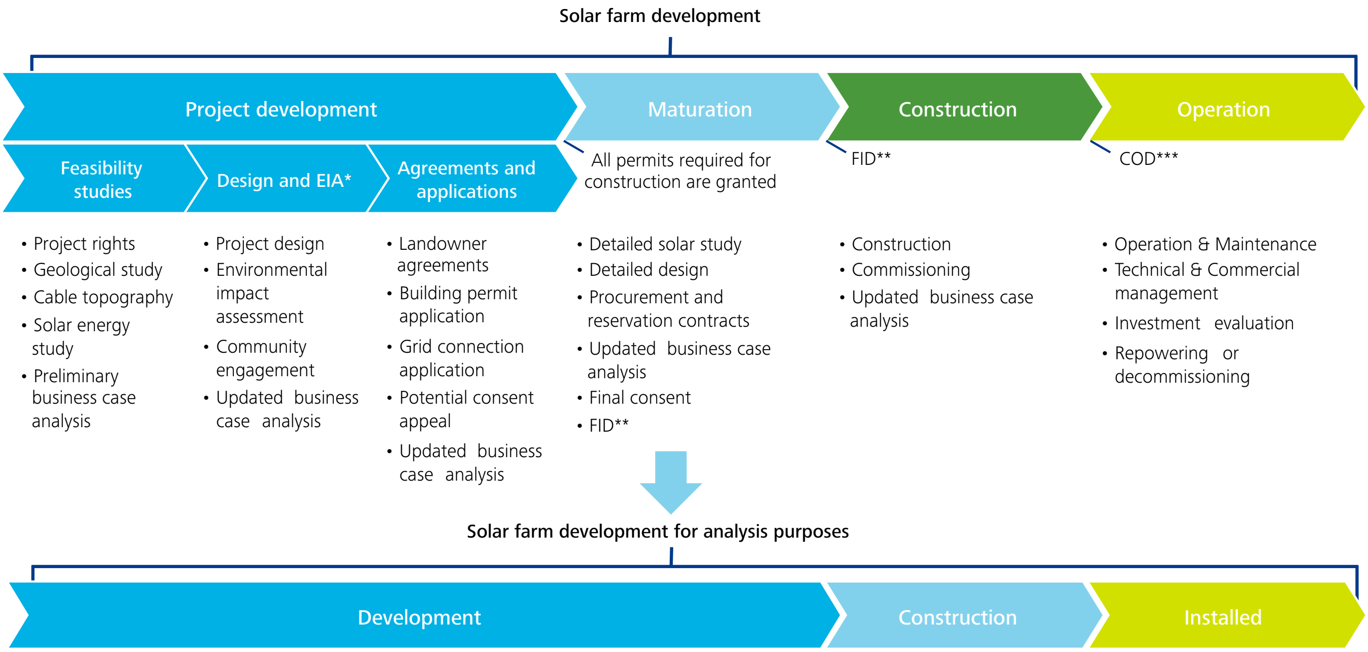
3. Methodology

Introduction

This paper addresses how multiple regression analysis of transaction multiples can be used as a benchmarking tool to support a more comprehensive valuation based on a cash flow model. We present the technical considerations underlying the analysis followed by practical examples that illustrate how the results can be applied from a valuation perspective.

From our point of view, one of the main challenges is the determination of the market value of solar assets in different stages of the solar PV farm lifecycle. We define this lifecycle as illustrated in the figure below.

Project lifecycle of solar PV farm assets



Note: * Environment Impact Assessment, ** Final Investment Decision, *** Commissioning Date
Source: Deloitte analysis

We recognise that transaction prices depend on other factors than capacity, such as local weather conditions, operating efficiency, power price agreements, local tax rules, subsidies and financing – most of which are country dependent. Therefore we also test for geographical effects and refer to "A market approach for valuing solar PV farm assets – geographical analysis and transaction details" and the order form on page 18 for that analysis.

Since wind and solar farm assets have different characteristics, and since offshore wind farm assets differ from onshore wind farm assets, we perform three separate analyses in two separate papers – one paper with analyses solely based on transactions in the wind farm industry and one paper solely based on transactions in the solar PV farm industry (this paper). The wind analysis is divided into an onshore and an offshore analysis. The approach yields "clean" multiple estimates for the different stages of the project, and it indirectly implies that in our analyses we assume that there is no interaction effect between holding a portfolio containing more than one kind of these assets. The multiple regression analysis is a market-based valuation approach as it is based on data from historical transactions.

In the analyses we disaggregate transactions into the different project stages as illustrated in the figure above. This disaggregation makes it possible to apply the multiple regression approach and also gives us the possibility of assigning separate multiples to each stage of the project. The reason for applying the multiple regression approach is that it allows us to estimate EV/MW multiples for the capacity in each stage of the project lifecycle.

The quality of a multiple regression analysis is critically dependent on the quality of the underlying dataset. Therefore the data collection process becomes important to ensure sufficient and reliable data. It is our experience that collection of data is one of the main challenges when using statistical analysis. The accessibility of EV and the total capacity of target's assets divided into the different project stages have been the primary criteria for including transactions in our analyses.

Below we give a more thorough introduction to the multiple regression analyses and present the underlying technical considerations of the analysis that we have performed. To exemplify the analyses performed, we use a fictive company named Renewable Energy Company (REC) throughout the paper to illustrate how a multiple regression can be applied for valuation purposes. REC has solar PV farm assets in different lifecycle stages as illustrated in the table below.

In the following section 4 we present the findings of the global regression analysis, followed by practical examples that illustrate how the results can be applied from a valuation perspective.

Renewable Energy Company (REC)

MWs	Development	Maturation	Construction	Installed
Solar PV farms	200	100	50	25
Total	**200**	**100**	**50**	**25**

Source: Deloitte analysis

Identification of data and choice of method

Our analysis of the value of solar PV farm assets is based on transactions over the past ten years to secure a sufficient dataset. We have identified 240 transactions, which we find suitable for our multiple regression analysis of the solar PV farm industry.

The major challenge in the process of collecting data has been the lack of information on transactions. It has not been possible to find enough transactions in which capacity in the project development stage and maturing capacity are reported separately. Therefore we treat capacity in these two stages as one explanatory variable, which we name non-installed capacity.

Our analyses derive from the following regression model (1). Based on this model, we find that installed capacity, construction capacity and development capacity affect the EV of solar PV farm assets significantly.

$$(1)\ EV = \alpha + \beta_1 \cdot MW_{installed} + \beta_2 \cdot MW_{construction} + \beta_3 \cdot MW_{development}$$

4. Solar PV farm transaction analysis

Our analysis consists of two preliminary analyses and a more detailed time analysis leading to our final estimate of the capacity multiples of solar farms.

Based on model (1), the preliminary EV/MW multiple estimates for installed, construction and development capacity are EUR 2.2m, EUR 0.1m and EUR 0.1m. The analysis has a coefficient of determination of 0.87, which means that 87 % of the variation in transaction prices can be explained by model (1).

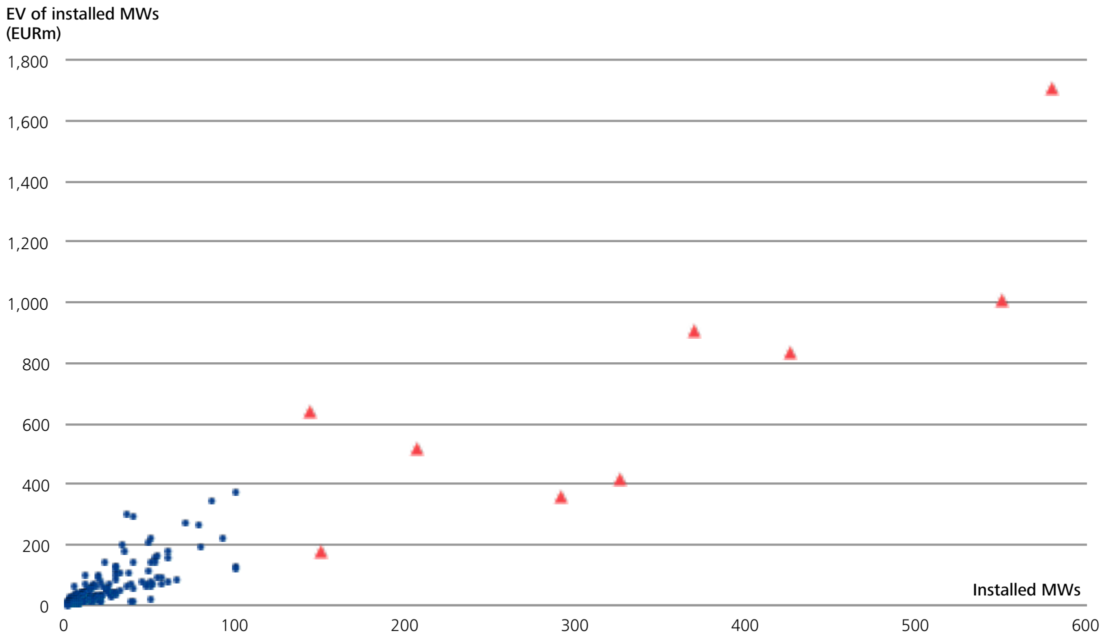
Regression and valuation of solar PV farms

EURm	Development	Construction	Installed
EV/MW coefficient[1]	**0.1x**	**0.1x**	**2.2x**
Significance (p-value)	0.0	0.0	0.0
Upper 95%	0.2x	0.2x	2.3x
Lower 95%	0.1x	0.0x	2.1x

[1] Transactions (n): 240, R-square: 0.87
Source: Deloitte analysis

When looking closer at the data and the results, we realise that model (1) may be distorted. In the figure below, the solar PV farm transactions used for the analyses are illustrated based on installed capacity and enterprise value of installed capacity. Note how nine transactions (the red data points) separate themselves from the rest of the dataset by having a very large installed capacity. Besides representing very large installed capacities, the nine solar PV farms have been traded at very different installed capacity multiples of EUR 1.2-4.5m/MW. This variation may be caused by geographical and technological effects as well as size effects. Given the limited number of these very large solar PV farms, we have not been able to perform statistical analyses of them. Therefore we consider these transactions to be outliers.

Size effect on installed MWs



Note: EV installed MWs are calculated as the transaction price less MW construction and MW development pipeline multiplied by their estimated multiples. This can lead to negative EVs, which are economically unreasonable, but are accepted in the model. Expressed as a formula this becomes: $EV\_inst.cap. = EV - \beta_2 \cdot MW_{construction} - \beta_3 \cdot MW_{development}$

Source: Deloitte analysis

Given the construction of the multiple regression analysis, the outliers may control a major part of the results when included in the analysis, and the nine outliers are therefore disregarded in our further analyses. The exclusion of the nine outliers results in a different and higher estimate of EUR 2.4m/MW for the installed capacity multiple. This indicates that some of the outliers were under-priced due to non-observable externalities. The analysis has a coefficient of determination of 0.71, which means that 71% of the variation in transaction prices can be explained by model (1) when adjusting for the nine outliers.

Modified regression adjusted for outliers

EURm	Development	Construction	Installed
EV/MW coefficient[1]	**0.1x**	**0.1x**	**2.4x**
Significance (p-value)	0.0	0.0	0.0
Upper 95%	0.2x	0.2x	2.6x
Lower 95%	0.1x	0.1x	2.2x

[1] Transactions (n): 231, R-square: 0.71
Source: Deloitte analysis

Note that the estimates represent the overall capacity multiples across the entire dataset, which includes ten years of transactions. However, in the past years, reports on the solar PV industry show that construction costs related to solar PV farm assets have been declining. This means that the overall capacity multiples estimated above are likely to be upward biased when looking at current multiple levels.

We therefore find it interesting to investigate a potential time pattern in transaction multiples of installed capacity, since we expect transaction multiples to have found a lower level as the development of the market has pushed down development and construction costs.

Fortunately, the size of the dataset has enabled such analyses, resulting in our final and most reliable estimate of the current installed capacity multiple of solar PV farms. More specifically, we have analysed whether transaction prices on installed capacity have changed over time. Limited data of construction and non-installed capacity transactions complicates a time analysis of these stages. In addition it seems reasonable to perform this analysis of installed capacity only, since the improvements in cost-competitiveness within solar PV energy is mainly effective in the installed capacity stage.

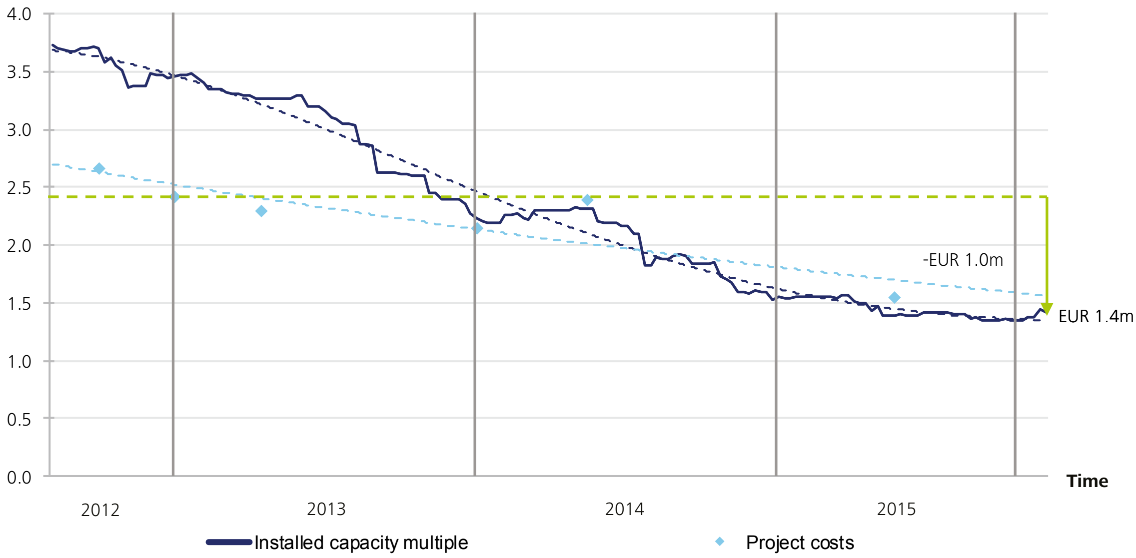
To investigate a potential time effect and to estimate the current installed capacity multiple, we have applied a rolling regression analysis. This method uses the latest 60 transactions on forward running dates by constantly substituting the oldest transaction with a newer transaction. By running 172 regressions, each with 60 transactions, we create a picture of how the installed capacity multiple has developed since 2011. We find that the current multiple for installed capacity is approx. EUR 1.0m lower than the modified regression multiple of EUR 2.4m. This highlights the importance of taking into account the time effect when estimating solar PV valuation multiples. Again, in this analysis, we have excluded the outliers from the sample in order to preserve higher consistency in the rolling regression analysis.

The figure below illustrates our findings. The values on the time axis represent the announcement date of the latest of the 60 transactions included in the relevant capacity multiple. Consequently the first point on the dark blue line represents the multiple based on 60 transactions with the most recent one occurring in February 2012.

The dark blue line illustrates a downward trend in EV per MW installed capacity. This trend is similar to the one we have been seeing in project costs (light blue line). Note that project costs and transaction prices seem to be almost at the same level in 2015, while intuitively transaction prices should include a developer premium and therefore be higher than project costs. We consider the current multiple estimate of EUR 1.4m as being associated with large uncertainty while the overall picture of a decreasing trend in the installed capacity multiple is still somewhat evident.

Time effect on installed capacity multiple

EV/Installed MW



Source: Deloitte Analysis, Clean Energy Pipeline and IEA

To obtain a more precise estimate of the multiples, considering the time effect on the installed capacity multiple, we have estimated the regression using only data from January 2014 until the beginning of 2016.

This provides us with a final estimate for installed, construction and development capacity of EUR 1.5m, EUR 0.7m and EUR 0.1m, respectively.

Modified regression adjusted for outliers (2014-2016)

EURm	Development	Construction	Installed
EV/MW coefficient[1]	**0.1x**	**0.7x**	**1.5x**
Significance (p-value)	0.1	0.0	0.0
Upper 95%	0.4x	1.0x	1.8x
Lower 95%	0.0x	0.3x	1.3x

[1] Transactions (n): 98, R-square: 0.65
Source: Deloitte analysis

A multiple regression analysis is subject to uncertainty, just like any other valuation method. One advantage of statistical models compared with other models is that the uncertainty is easier to quantify. The uncertainty can be expressed by the statistical term "standard error". The standard error is calculated for each EV/MW multiple and can be used to determine a lower and upper boundary, i.e. a value interval at a certain confidence level. Our analysis is based on a 95% confidence level. This can be interpreted as the EV/MW multiple estimate being within this interval with 95% confidence.

The lower boundaries for the EV/MW multiples on solar PV farm assets are EUR 1.3m, EUR 0.3m and EUR 0.0m for installed, construction and development capacity while the upper boundaries for the EV/MW multiples are EUR 1.8m, EUR 1.0m and EUR 0.4m for installed, construction and development capacity.

We apply the lower and upper boundaries in the valuation of REC's solar PV assets to determine a lower and an upper value. The table below illustrate the uncertainty of REC's capacities in different stages of development. Based on these upper and lower boundaries, our analysis indicates that the value of REC's solar PV assets lies within the interval of approx. EUR 50-200m with 95% certainty.

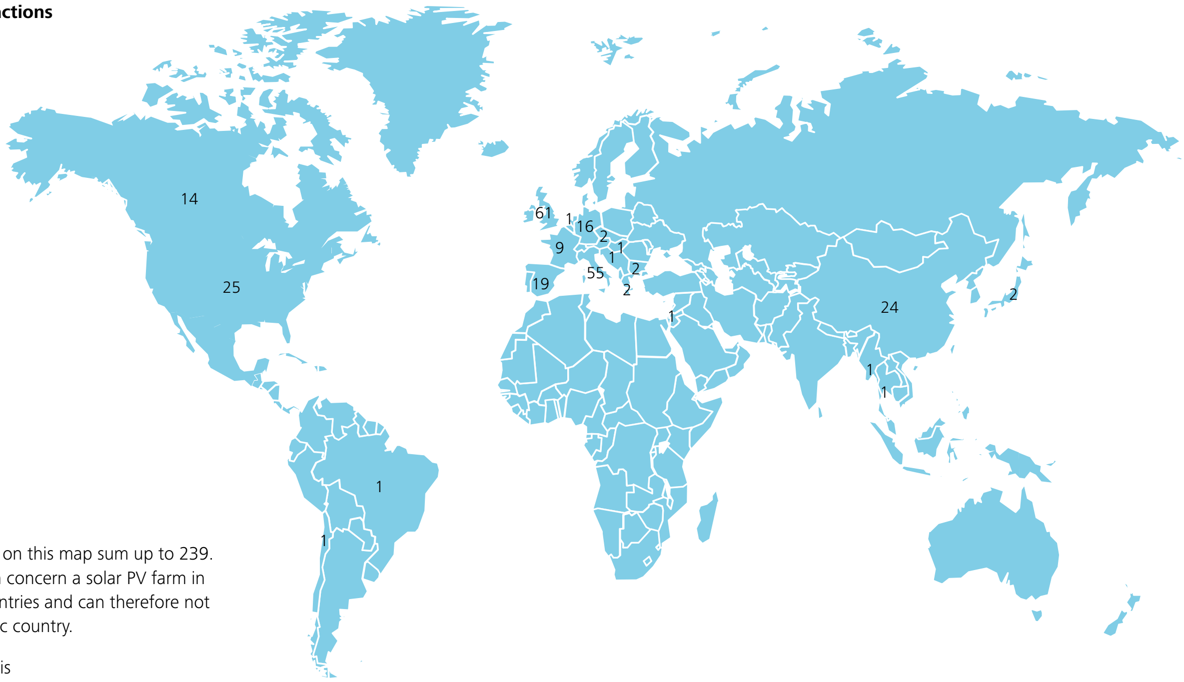
Solar PV farm valuation uncertainty

EURm	Development	Construction	Installed
Upper EV/MW multiple	**0.4x**	**1.0x**	**1.8x**
REC solar MWs	300	50	25
REC solar EVs	109	49	44
REC solar upper EV			**202**
Lower EV/MW multiple	**0.0x**	**0.3x**	**1.3x**
REC solar MWs	300	50	25
REC solar EVs	0	16	32
REC solar lower EV			**48**

Source: Deloitte analysis

Appendix A:
Summary of transactions in the solar PV farm industry

Solar PV farm transactions



Note: The transactions on this map sum up to 239. The missing transaction concern a solar PV farm in different European countries and can therefore not be assigned to a specific country.

Source: Deloitte analysis

		EV in EURm			Installed MW		Construction		Development	
	Obs.	Min.	Max.	Average	Total	Average	Total	Average	Total	Average
Overall	**240**	**0**	**1,710**	**79**	**6,939**	**29**	**2,378**	**10**	**9,037**	**38**
Geography										
Europe	171	-	641	51	2,977	13	218	1	3,073	94
Non-Europe	69	0	1,710	115	3,962	53	2,161	12	5,964	57
North America	39	1	1,710	185	2,489	60	1,909	39	4,811	97
France	9	10	140	54	195	22	18	2	-	-
UK	61	1	143	30	1,002	16	91	1	92	2
Germany	16	2	160	32	234	15	-	-	9	1
Italy	55	0	641	76	1,157	21	33	1	168	3
Year										
2006	1	25	25	25	6	6	-	-	-	-
2007	2	14	70	42	13	6	-	-	-	-
2008	4	12	307	107	69	17	82	21	350	88
2009	10	4	318	103	164	16	1,862	186	1850	185
2010	17	2	320	115	334	20	1,898	112	5,451	341
2011	23	0	910	132	839	36	209	9	66	3
2012	29	1	1,710	138	1,155	40	1,267	44	25	1
2013	53	0	211	31	719	14	60	1	578	11
2014	51	0	140	26	699	14	406	8	487	10
2015	52	1	1,012	107	2,470	48	1,223	24	230	5
2016	5	38	833	268	557	111	106	21	-	-

Source: Deloitte analysis

Appendix B: Regression output – solar PV farm analysis

Summary output

Regression statistics	
R-square	0.87
DF	237
Observations	240

	Coefficients	Standard error	t Stat	p-value	Lower 95%	Upper 95%
Intercept	-	-	-	-	-	-
Installed	2.221	0.057	38.894	0.000	2.109	2.333
Construction	0.137	0.057	2.383	0.009	0.024	0.250
Development	0.142	0.019	7.378	0.000	0.104	0.180

Source: Deloitte analysis

Appendix C:
Regression output adjusted for outliers – solar PV farm analysis

Summary output

Regression statistics	
R-square	0.71
DF	228
Observations	231

	Coefficients	Standard error	t Stat	p-value	Lower 95%	Upper 95%
Intercept	-	-	-	-	-	-
Installed	2.411	0.118	20.444	0.000	2.179	2.642
Construction	0.137	0.041	3.359	0.000	0.057	0.217
Development	0.140	0.014	10.264	0.000	0.114	0.167

Source: Deloitte analysis

Appendix D:
Regression output adjusted for outliers (2014-2016) - solar PV farm analysis

Summary output

Regression statistics	
R-square	0.65
DF	95.00
Observations	98.00

	Coefficients	Standard error	t Stat	p-value	Lower 95%	Upper 95%
Intercept	-	-	-	-	-	-
Installed	1.515	0.124	12.239	0.000	1.272	1.758
Construction	0.655	0.170	3.861	0.000	0.323	0.988
Development	0.147	0.110	1.338	0.092	(0.068)	0.362

Source: Deloitte analysis

Order form for geographical analysis and transaction details

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