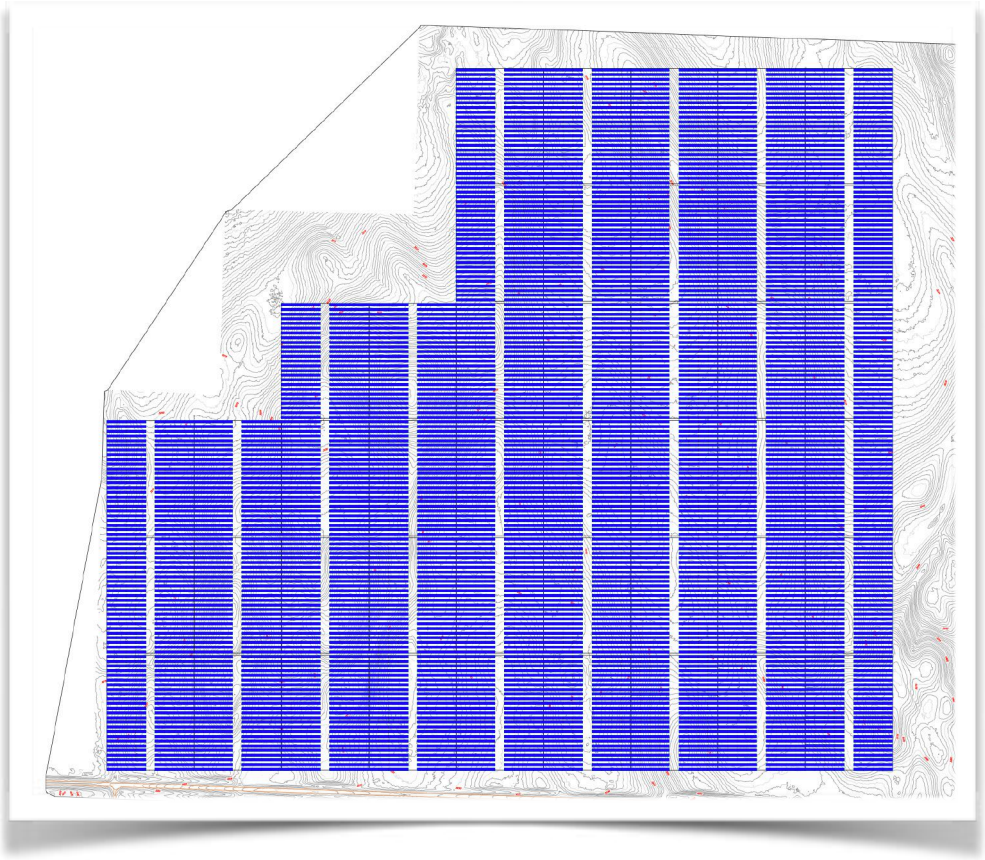
Dismantling analysis report
Solar park Lookout



Client:
Lookout Solar Park I, LLC

Report No.
K&S_Dismantling_Lookout_201900136_02

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Scope of work:
The K&S Ingenieurpartnerschaft Krug & Schram was commissioned to prepare a dismantling report.

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Revisions

No.	Changes
00	1st draft report
01	Final, implemented cost break down
02	Final
03	

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1. Executive Summary

The K&S Ingenieurpartnerschaft Krug & Schram in Munich/Germany was commissioned to prepare a dismantling cost estimate report for the solar park Lookout/USA.

The 140 MWp plant is planned to be built in 2022.

For this purpose, a cost assessment for the deconstruction of an open-space photovoltaic system in 2050 is prepared (30 years of operation of the main plant). The scope of testing includes the comparison of the costs incurred for the dismantling and the evaluation of the proceeds from the utilization of the demolition material.

If the photovoltaic ground-mounted system is dismantled in today's typical construction method at the present time, then the costs and revenues from raw material recycling would result in a cost shortfall of approx. 1,414,331 $.

In 30 years, at the end of the planned operating period of the plant, there would be a cost shortfall of approx. 1,760,627 $

It is expected that the price trends for raw materials and scrap will continue to grow over the next few years. It can therefore be assumed that the balance sheet of costs and income will increasingly develop in favor of earnings.

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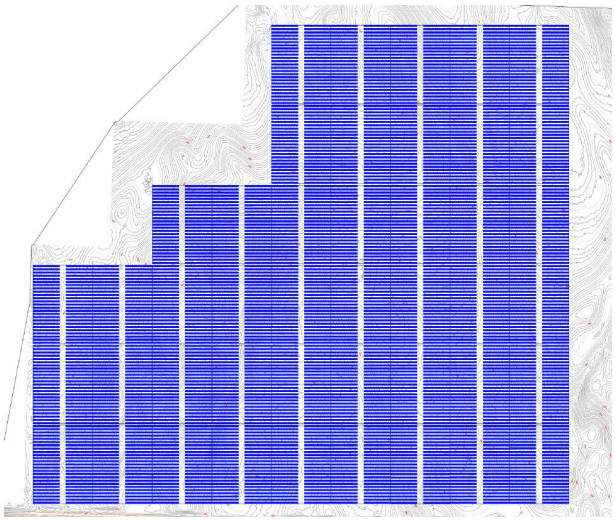
2. List of abbreviations

a	Year
AC	Alternating voltage
CE	Conformité Européenne -
DC	Direct voltage
DIN	Deutsches Institut für Normung
EN	European Standard
h	Hour
I	Electrical current
A	Ampere
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kV	Kilovolt
kVA / MVA	Kilovolt Ampere / MegaVolt Ampere
kW	Kilowatt
kWh	Kilowatt hour
kWp	Kilowatt peak
MWp	Megawatt peak
O&M	Operations and Maintenance
OHS	Occupational Health and Safety
PR	Performance Ratio
PV	Photovoltaic
TA	Technical Adviser
TC	Technical Consultant
U	Electrical voltage
V	Volt

3. Project data

Beschreibung	Werte
Location	Lookout, South Dakota, USA
Layout	
Module supplier / type	Suntech STP400S-A72/Vfh
Module power in Wp	400
No. of modules	349.920
Inverter supplier / type	SMA SC 2750-EV-US
Inverter AC power in kW	2.750
No. of inverters	48
Transformer AC power in kVA	5.500
No. of transformers	24
Total module DC power in kWp	139.968,00
Total inverter AC power in kW	132.000,00
Total transformer AC power in kVA	132.000,00
Substructure	Piles

4. Dismantling report

4.1. General comments

In ground mounted PV systems, various components are installed in larger quantities above and below ground. These include solar modules, cables, metal racks, inverters and transformer stations.

A majority of these components can be reused after demolition at the end of service life. So the interesting questions are, what will be the costs and income at the time of dismantling.

For the consideration of the dismantling costs, it is assumed that all materials used for the solar park will be removed after the end of operational life time.

The dismantling cost estimate includes the demolition of the solar modules, the dismantling of the racks, the removal of the cables above and below ground, dismantling of the fence and the paths and all transformer station buildings.

As the topic of solar park decommissioning is not yet day-to-day business for the relevant service providers, there are no concrete market experiences and figures yet. Alternatively, the costs for comparable services were used.

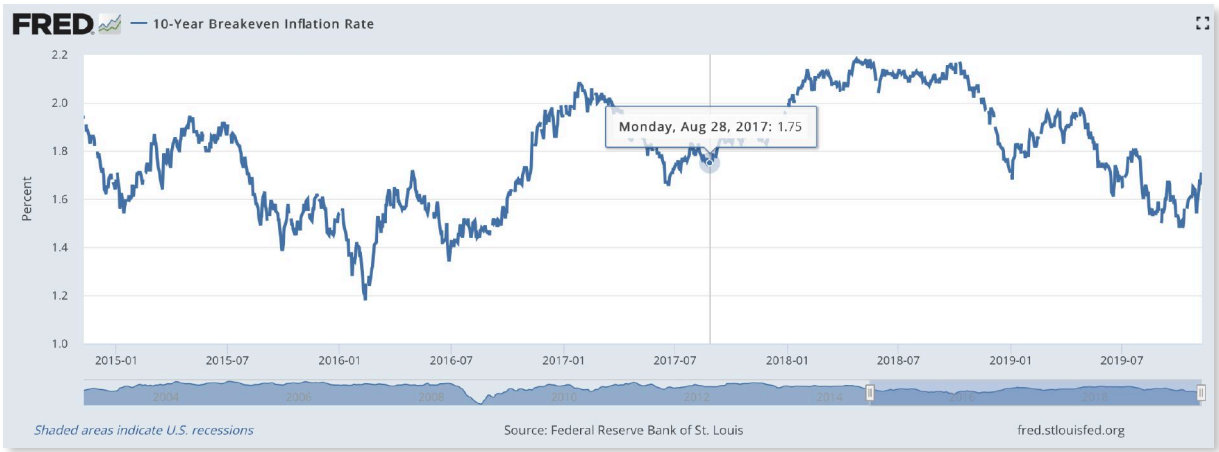
Almost all materials to be recovered represent valuable raw materials in terms of recycling. Raw material cost development can only be predicted very vaguely over the next decades. With overall rising prices, the price development in the past has been subject to very large fluctuations.

4.2. Inflation

Some of the data used are not adjusted for inflation. These still have to be charged with an inflation correction.

For the US market, the inflation figure is as follows:

Trend **Inflation** 2014-2018 (Source: https://fred.stlouisfed.org/series/T10YIE)



This results in a mean inflation value of **1.6 %**. In the further considerations this is used for the historical as well as for the future values.

4.3. Cost and income determination

All of the following considerations and assumptions apply to large multi-megawatt class ground-mounted systems.

Looking at the costs of dismantling a PV system results in both fixed (equipment costs) and variable costs (working time); on the other hand, only variable returns can be expected from recycling from the park decommissioning. The variable costs and revenues (specific to asset performance) typically develop non-linearly with increasing park size. Basically, the larger the solar park, the smaller the specific cost of dismantling and the higher the specific yield.

For the values in this report a conservative approach was chosen. The costs were assumed based on a current robust offer for today's solar park size and projected for the expected value in 30 years (2050) with an inflation index. When accepting the costs, it was assumed that the total park would be dismantled at once.

Consideration of the costs

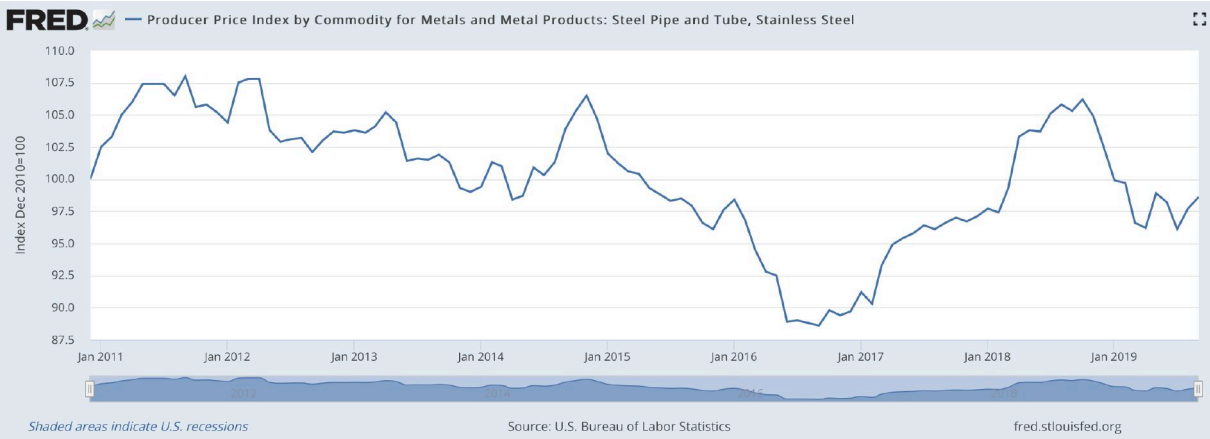
In the construction business, performance prices have remained relatively stable in recent years. This applies to new construction as well as to demolition. The reason for this is the increasing substitution of manpower by machines. Rising labor costs were compensated. The cost of constructing solar parks is now similar. For the dismantling of solar parks in the future, therefore, the same developments are assumed. This dismantling report therefore assumes that the cost of benefits calculated for today will remain stable over the long term. Only an inflation-related inflation rate of **1.6 %** per annum is estimated.

Consideration of the income

When decommissioning a solar park, large quantities of pure raw materials are produced. Both metals and gravel / concrete already have a high resale value as a raw material from recycling.

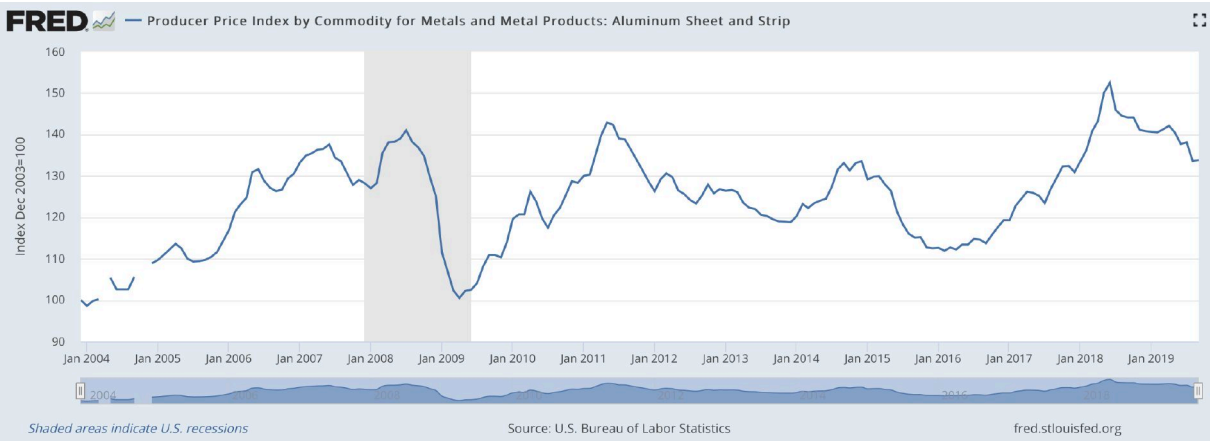
However, a forecast on the scrap value at the time of dismantling after about 30 years is only possible with great uncertainty. The price development on the commodity exchanges has shown strong fluctuations in the past. Overall, however, the trend is pointing upwards. The following charts are intended to illustrate only volatility and trends in price performance. The scrap prices that are relevant for the determination of the value fluctuate daily and between different sources very strongly, but show comparable trends.

Trend **steel index** 2010-2018 (Source: https://fred.stlouisfed.org/series/WPU10170674)



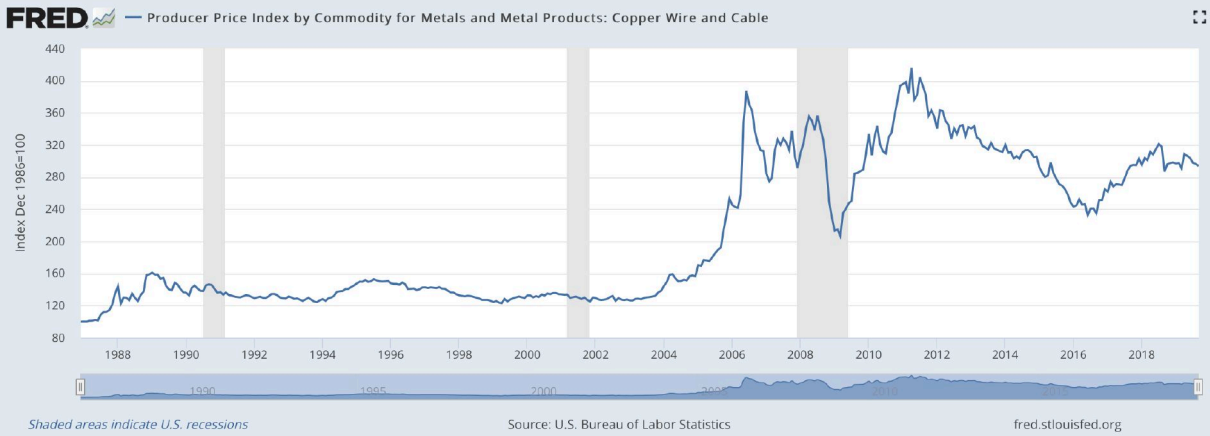
As the steel price fluctuation in the past 8 years was so high, there is no trend to be identified in either direction. Hence we would not use any index increase or decrease value, respectively.

Trend **aluminum index** 2004-2018 (Source: https://fred.stlouisfed.org/series/WPU10250105)



Based on the index stated above, the index for aluminium is considered to be around + 1,8 %. As a conservative approach, the further price increase for copper is assumed to be 1.5 % plus 1.6 % per annum inflation.

Trend **copper price** 1988-2018 (Source: https://fred.stlouisfed.org/series/WPU10260314)



The development for the copper values shows an inflation-related increase over the last 30 years by about 4.0 %. As a conservative approach, the further price increase for copper is assumed to be 3.5 % plus 1.6 % per annum inflation.

Due to the global economic development, it can currently be assumed that these trends will continue in the future. When dismantling a solar farm, copper accumulates in large quantities in the cables and is not as pure as, for example, the frame material.

For the values in the form of aluminum and steel bound in the racks, the current scrapping value of 1 tonne of the single-grade substances was assumed as the assumption.

Changes due to any missing variety purity or quantity decreases are not taken into account here and are likely to cancel out. For the future value analysis, we assume a constant trend in the price development of commodities according to the illustrated 3 year trends of the past.

Recyclables prices and trends

Today's prices for the raw materials from the solar park are given in the table below:

Scrap price		Steel	Aluminium	Copper cable	Electro
Source	lb/ton	$/t	$/t	$/t	$/t
http://de.buying-up.com/index.php?cc=USA	2204,62	40	440	3618	
https://iscrapapp.com/prices/		Steel	Aluminium	Copper cable	Electro
$/lb			0,23	0,48	0,05
$/t		**85**	**507,1**	**1058,2**	**110,2**

Price table of materials (decimal comma separated)

Parallel to the detailed research, established and experienced project developers were asked about the demolition of solar parks after the end of their useful life of typically 30 years.

For the most part, the statements were that costs and revenues will be offset against each other. The general tenor was that the costs for the dismantling would be compensated by the utilization of the deconstruction material and thus more likely to be due to revenues than with costs. This statement can only be made if the price indexation for the scrap prices corresponds to the raw material prices of recent years.

As a conservative approach, the price indexation of commodity prices has been more weighted towards the lower index value.

In addition, the inflation indexation of 1.6 % will be applied to all prices and costs.

List of costs

The following list of cost are based on experience of existing cost offers on single mechanical and electrical demolition works at PV power plants above 100 MWp.

The single values depend on the fact that the disassembly and transport is not under restrictions of special care to reuse any of the parts.

Once a reuse of the parts is under consideration, there is an extra value behind and this can then be compensating extra disassembly cost if arising.

Removal cost	Cost per Unit in $	Units	Total Cost in $
Removal panels	1 $	349.920	349.920 $
Removal combi-ner Box	10 $	864	8.640 $
Removal inverter/ transformer stati-on	2.000 $	48	96.000 $
Removing DC ca-bles	0,1 $	1.728.00	172.800 $
Removing under-graoud AC cables	0,5 $	188.960	94.480 $
De-assamble table	100 $	4.320	432.000 $
Pullout piles	12 $	60.480	725.760 $
Roads site resto-ration	300.000 $	1	300.000 $
Summ			**2.179.600 $**

Removal cost estimations (decimal comma separated)

Comparison of revenues

The following material count results for the present solar park design:

Inverter	No.	Steel	Electro
Pcs.	48	22	4,3
Weight[t] Electro		**1.056,0**	**206,4**

String combiner	Pcs	Weight	Sum
Pcs.	864	33	28,512
Weight [t]			**28,512**

Modules	Inverter	Power [Wp]	MWp
Pcs.	349.920	400	**140,0**
Weight [kg]/Pcs	**23,2**		
Total weight [t]	**8.118**		

Counting	Material	Length [m] / pcs. / Unit	Spec. weight [kg/km] o. [kg/Stk.]	Weight total [t] cooper	Weight total [t] aluminium	Weight total [t] steel
String cable PV1-F	Copper	1.728.000	80,0	138,2	-	-
NA2XY 1x300mm²	ALU	120.960	1.250,0	-	151,2	-
NA2XS(F)2Y 3x1x150mm²	Alu	40.000	1.950,0	-	78,0	-
Round wire [Eart-hing] V4A, 8mm	Steel	28.000	400,0	-	-	11,2
Tables	Steel	4.320	950.000,0	-	-	4.104,0
Tables total steel	Steel	10	40.000,0	-	-	400,0
Mesh [m]	Steel	6.300	1.900,0	-	-	12,0
Piles I [Stk.]	Steel	2.520	10,0	-	-	25,2
Corner piles [Stk.]	Steel	70	12,0	-	-	0,8
Gates [Stk.]	Steel	4	250,0	-	-	1,0
Sum				**138,2**	**229,2**	**4.554,2**

Material counting tables (decimal comma separated)

The following table is based on the above material counts and offers from companies specialized in earthmoving and demolition.

Remark: As the central inverter station of SMA is a steel based solution, no concrete demolition is to be considered. Further on, we have considered, that from the total weight of the stations, 22 tonnes will be counted as steel, and 4,3 tonnes as electro scrap.

Installed material	Weight [t]	Spec. revenue (Scrap price) [$/t]	Revenue/ Cost 2019	Revenue/ cost per Megawatt 2020	Index	Inflation	Revenue/ cost per Megawatt 2050	Revenue/ cost / Kilowatt 2020
Steel	4.554,2	85,0	387.107,85 $	2.765,69 $	0,0 %	1,6 %	4.452,61 $	2,77 $
Aluminium	229,2	507,1	116.218,75 $	830,32 $	1,5 %	1,6 %	2.074,95 $	0,83 $
Copper	138,2	1.058,2	146.288 $	1.045,15 $	3,5 %	1,6 %	4.647,95 $	1,05 $
Modules	8.118,1	0,0	0 $	0 $		1,6 %	0 $	0 $
Inverter electro	206,4	110,2	22.751,68 $	162,55 $	0,0 %	1,6 %	261,7 $	0,16 $
Inverter steel	1.056	85,0	89.760 $	641,29 $	0,0 %	1,6 %	1.032,44 $	0,64 $
String combiner electro	28,512	110,2	3.142,91 $	22,45 $	0,0 %	1,6 %	36,15 $	0,02 $
Total revenue			**765.269,18 $**	5.467,46 $			**12.505,79 $**	5,47 $
Cost								
Construction measures			-2.179.600 $	-15.572,13 $	0,0 %	1,6 %	-25.070,29 $	-15,57 $
Total cost			**-2.179.600 $**	**-15.572,13 $**			**-25.070,29 $**	-15,57 $
Total value / Megawatt				**-10.105 $**			**-12.564 $**	
Total value				**-1.414.331 $**			**-1.758.627 $**	

Result of cost and revenue (decimal comma separated)

For module it is considered to have the modules delivered under the PV-cycle conditions (http://www.pvcycle.org/usa/) with the signed contract to have the modules recycled after life time.

5. Annex - Data sheets