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The Total Return Hedge – An approach to overcome the limits of index hedging

1.1 Weather hedging in the energy industry

- In 'traditional' energy markets like
  - natural gas supply for heating purposes
  - power supply for air conditioning

  weather is also an important driver for profitability, however there the demand side is affected.

- In these markets weather derivatives are a standard tool for risk management, for example hedging out risk of a warm winter with put options on Heating Degree Days (Europe) or hedging out risk of a cool summer with call options on Cooling Degree Days (US).

- In both markets this business has become a billion € respectively USD business.

=> What is the reason for the success of weather derivatives in these markets ?

- Managing risk with weather derivatives allows for cash flow stabilization as it makes profits more plannable.

- In temperature the basis risk, means the difference between the unwanted deviation in income and the payout provided by a professional structured weather derivative is very small, which means the hedge works almost perfectly.

- Reason for this is that in temperature driven energy markets the correlation between temperature and energy consumption is very high and well defined by so called sigmoid functions (they literally exist for each location and consumer group and simply need to be aggregated to give a large wholeseller the basis for his hedging programme).

=> Sounds all great but now let's turn to the world of renewables and particularly wind

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1.2 Wind power generation

- Wind power generation is besides solar and hydro power generation the generation with lowest fuel cost, zero.
- In many markets its generated MWhs are heavily subsidised which make it an interesting investment opportunity (However this currently changes, at least in Germany).
- As a result traditional finance structure of wind projects is highly leveraged, often about 80% debt + 20% equity and certainly investors want to make sure that they get their money back.
- Most important influence factor for cash flow is wind speed with its well known natural volatility, however there are also parameters to be considered, like
  - grid constraints
  - planned or unplanned outages
  - administrative measures like turn-offs due to bird protection etc.
  - short term nomination requirements with penalty systems
- This creates uncertainty about cash flow from power sales and thus a very conservative evaluation approach of lenders.
- If investor’s comfort level could be increased more investments could find sponsors.
- To increase investor’s comfort level one needs to make this exposure manageable.
- Before it can be managed it must be exactly defined.

1.3 The traditional value chain of renewable generation

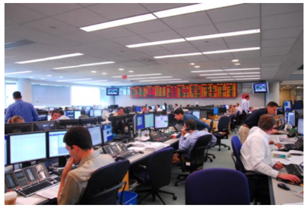
The reinsurance industry owns wind assets, has operators under contract, insures the industry against weather and all other perils and also has a deep understanding of finance.

Whilst they do not have the detailed operational knowledge of an operator they have much better know how to take and manage all the risk involved than any individual participant along the value chain of wind generation.

1. Financing

2. Construction

3. Operation



4. Power Sales

5. Debt and equity service

1.4 Actual market development and implications on financing (1)

MARKET DEVELOPMENT: EEG 2017 (onshore)

- More and more markets transfer their fixed feed-in tariffs into more market oriented models (e.g. Germany)
- From 2017 on tenders will apply for new installations (2.800 MW/a)
- With the EEG 2017 Germany establishes an annual auction system with limited maximum capacity and a system of reduced regional different subsidy factors.
- Investors need to bid for new installations with the lowest bids come first until tender is closed

Before EEG 2016 largest risk was risk of lack of wind which could at least be mitigated with index hedges. One only had to care about volume risk because the generous feed-in tariffs guaranteed a sound margin.

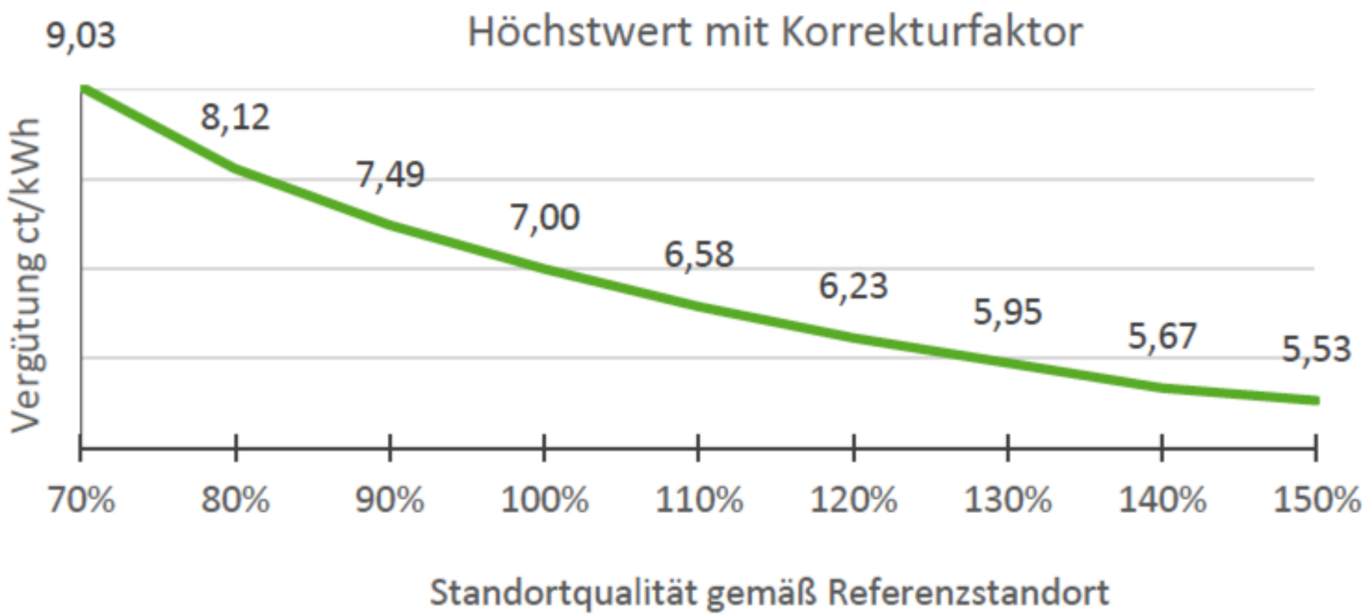
EEG 2016 introduces the 'reference location' based FIT system which finally depends on governmentally authorized wind expertises and is subject to review only every 5 years. Depending on location subsidies are cut by up to 40% (see next slide). So in the much more competitive auction environment investor's risk is increased beyond the 'normal' volume and basis risk and plannability of future cash flows becomes even more important.

Wind index hedges with a contract duration of 5 years and longer are already available, however challenge of basis risk still needs to be solved.

1.4 Actual market development and implications on financing (2)

New German Feed in Tariff System according to EEG 2017 (onshore) ‘penalizes’ high quality wind locations and fosters low quality wind locations. Idea is to reach a better regional distribution of installations and thus reduce pressure on the grids.

Gütefaktor	70 Prozent	80 Prozent	90 Prozent	100 Prozent	110 Prozent	120 Prozent	130 Prozent	140 Prozent	150 Prozent
Korrekturfaktor	1,29	1,16	1,07	1,00	0,94	0,89	0,85	0,81	0,79



1.5 Wind speed: volatility and trend: Germany

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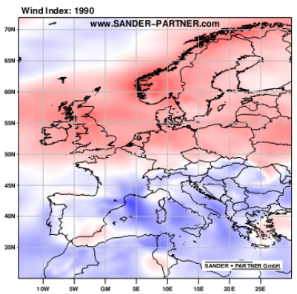
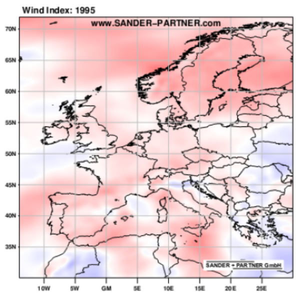
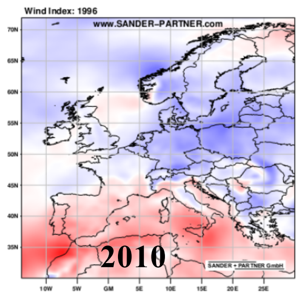
1990



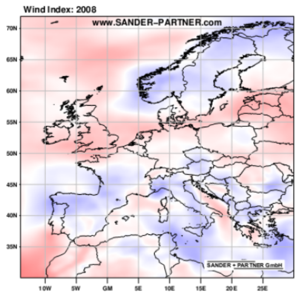
1995



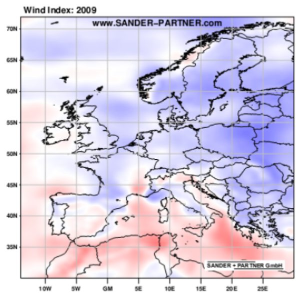
1996



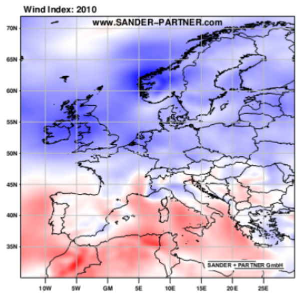
2008



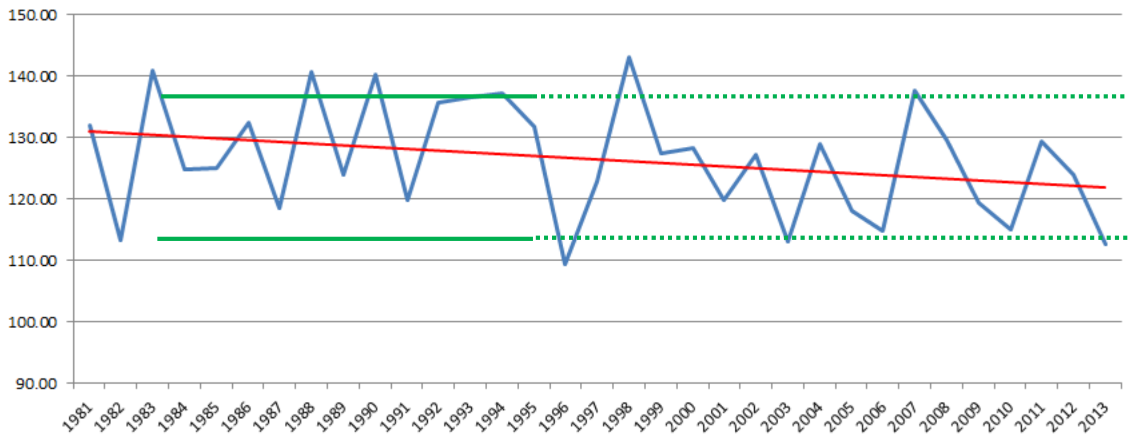
2009



2010



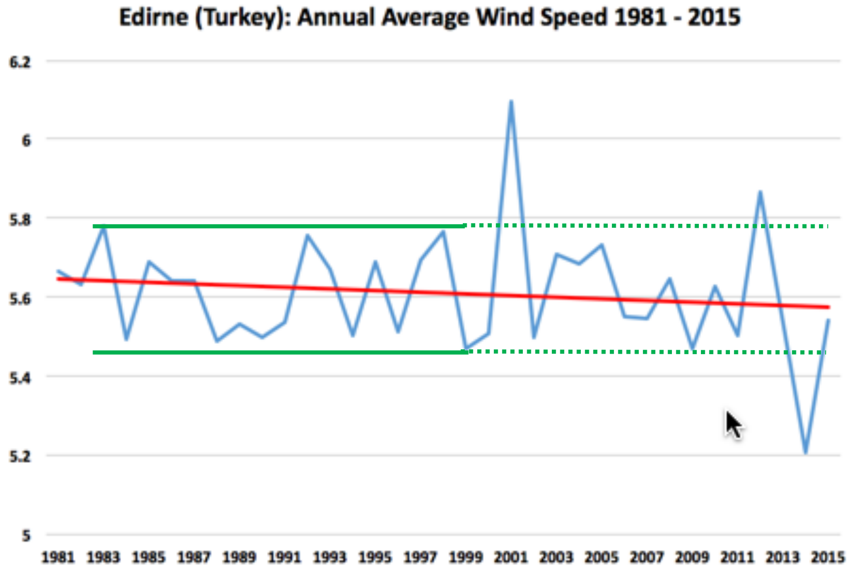
Annual production index for a location in Germany [GWh]

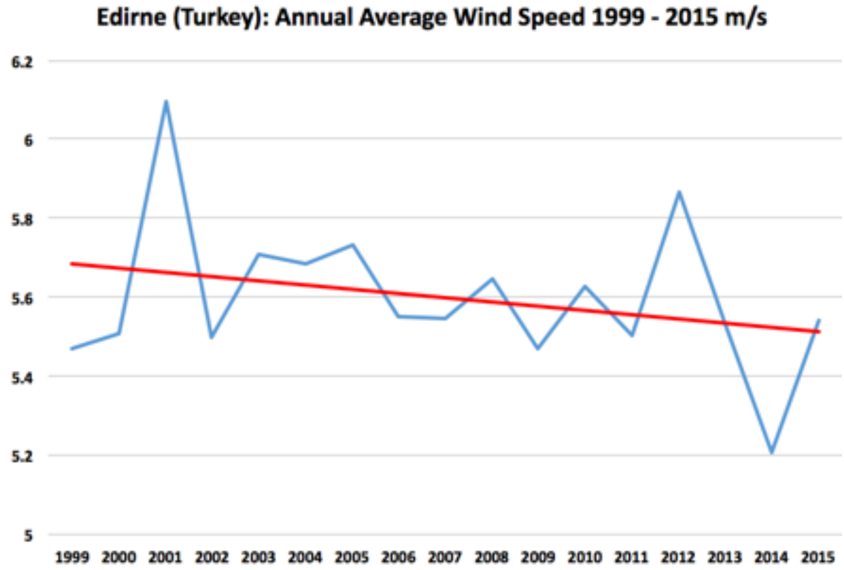


Estimated annual volatility of wind is 10 – 20%

- Investment decisions based on data until 1995 have not created the expected results.
- It looks rather that there is a trend of decreasing wind speed.
- As a result producers started to look for financial protection particularly against lack of wind (but also excess wind).
- So far only protection on basis of weather station observations or reanalysed data have been available, both leaving clients with basis risk.

1.6 Wind speed: volatility and trend: Turkey





- In other markets it looks similar, partly even higher volatility but also phenomena of general decreasing wind speed.
- As new projects are most vulnerable to cash flow variations in the first years the incorporation of wind hedges might have been proven to be a good idea.

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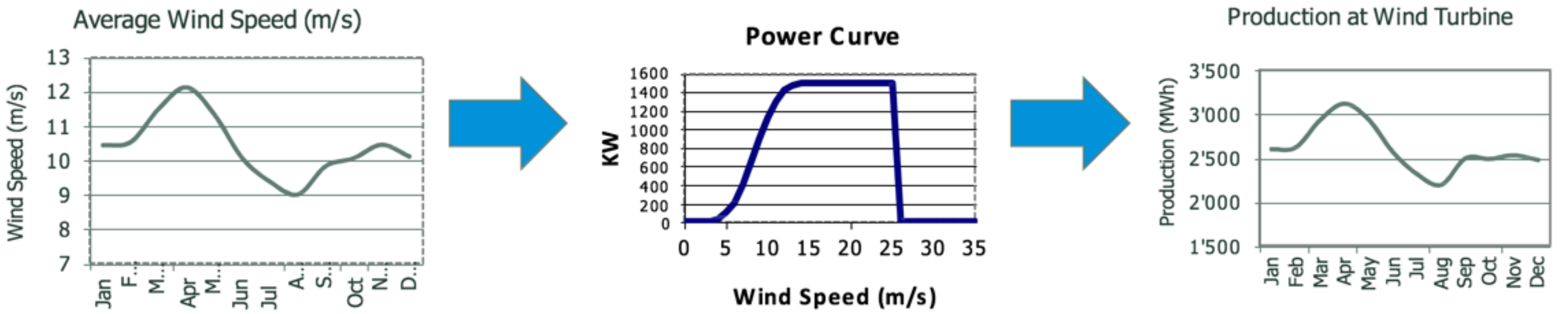
2.1 Index Hedging

Traditional risk mitigation approach are weather derivatives which are based on Wind Production Indices. A Wind Production Index is based on measured wind speed and theoretical power curve. The wind production index (WPI) created thereof is calibrated towards historical production (if available) and provides a proxy for actual production.



$$WPI = \left[\sum_{i = \text{January 1st}}^{\text{December 31st}} P(\overline{v}_i) \right] \times \text{24h} \times \text{No. of Turbines} \times \text{Efficiency Factor}$$

$P(\overline{v}_i)$ = Turbine Power Curve

$\overline{v}_i$ = Hourly Average Wind Speed (m/s)

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2.2 Index Hedging (Refinements)

First one needs to distinguish whether the wind park to be hedged is already in operation or not. The first case is the easier one, the second one is rather difficult but will become particularly relevant in Germany with the EEG 2017.

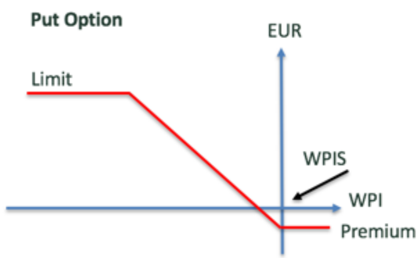
- In both cases one uses reanalysed data for turbine's exact geographical coordinates which is calibrated towards turbine axis height.
- One needs to consider wake factors from inside the park (other turbines) as well as outside (e.g. landscape specifics). They certainly also depend on prevailing wind direction.
- Finally a theoretical production curve is established which only variable is reanalysed wind speed at turbine axis height.
- For existing wind parks the theoretical production curve will be calibrated towards the historical production.

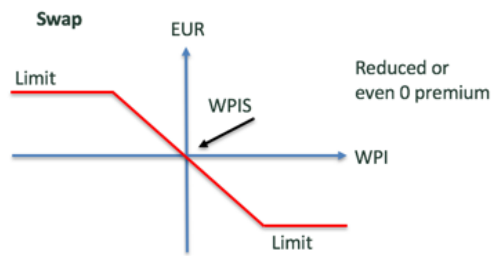
With wind parks not yet in operation it is much more difficult to build a proper index hedge.

- One needs to have trust in the wind expertise which even when elaborated for the best might prove to be wrong.
- All technical assumptions like wake factors finally etc. are only assumptions.
- The very important calibration of the theoretical (park) power curve to the observed production is not possible.
- Best approach is to compare with production data of somehow comparable parks.

3. Hedging Instruments available (1)

- The Wind Production Index (WPI) as defined on page 10 with wind speed as only variable is the ‘Underlying’ of the Hedging Instrument.
- For the WPI there is a defined strike volume expressed in [MWh] which normally is equivalent to the financially minimum required generation of the park, e.g. P(80) or P(85)
- It is important to stress that this is approach hedges the actual theoretical power generation calculated with contract formula in [MWh].
- The buyer of a wind production index put option is indemnified with positive difference between the agreed index strike level and the actual theoretical power generation calculated with observed or reanalysed wind speed.
- Alternatively operator or investor might also enter into a swap agreement which comes along with reduced premium (in extreme cases down to zero).





3. Hedging Instruments available (2)

Structure Type	**Put Option on power generation index (example)**
Underlying	Wind Production Index
Wind Park Longitude Latitude	Turkey 26° 45' 26.1" 41° 05' 12.2"
Buyer	Client
Seller	Risk Taker
Risk Period	January 1, 2017 until December 31, 2019
Turbine Type	20 x Vestas V126/3300 (3.3 MW)
Efficiency factor	0.95
Turbine axis height	127 m
Hourly Wind speed vi	Average hourly wind speed in m/s at turbine height level

Turbine Power Curve P(vi)

m/s	kW	m/s	kW
3	30	13	3'300
4	179	14	3'300
5	397	15	3'300
6	711	16	3'300
7	1'150	17	3'300
8	1'723	18	3'300
9	2'434	19	3'300
10	3'090	20	3'300
11	3'290	21	3'300
12	3'300	22	3'300

Wind Production Index WPIA

$$WPI = \left[\sum_{i = \text{January 1st}}^{\text{December 31st}} P(\overline{v}_i)\right] \times 24h \times 20 \times 0.91$$

whereby: $P(\overline{v}_i)$ = Turbine Power Curve and: $\overline{v}_i$ = Hourly Average Wind Speed (m/s)

Wind Production Index Strike WPIS	120'000	MWh
Tick Size	73	€/MWh
Payout Formula	Max[0; (WPIS - WPIA) x Tick Size]	
Payout Limit	292'000	€
Premium	[to be discussed]	
Contract Type	ISDA	

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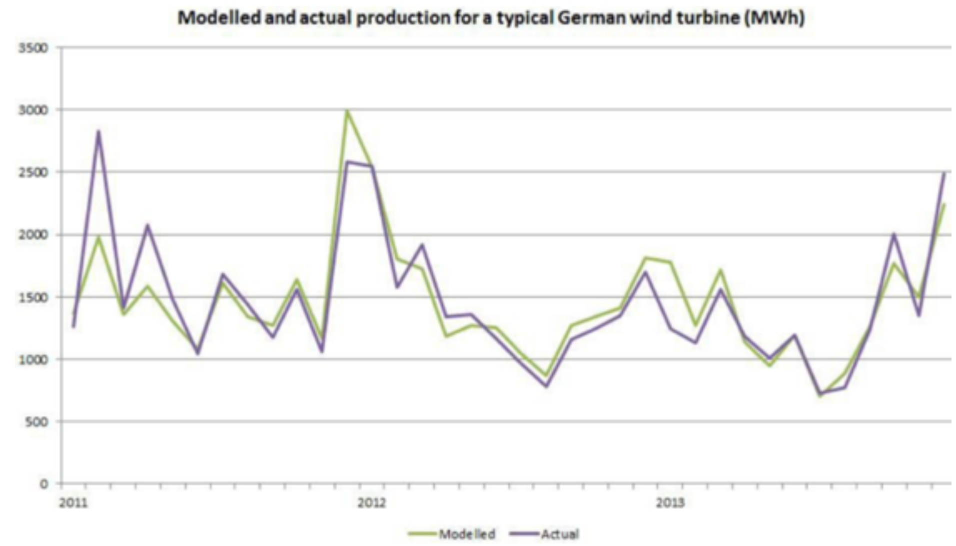
4. Limitations of index hedging

WIND PARK GENERATION

- The actual physical generation of the wind park is measured by the grid operator.
- This energy amount determines the payout for the operator or investor.



BASIS RISK

- The BASIS RISK risk is the risk that there is a difference between actual Wind Production Index and actual Wind Park Generation.
- Its root causes are manifold and its magnitude varies from wind park to wind park.
- The traditional approach is that basis risk is left completely with operator / investor.
- Investor's point of view might be that even in case one tries to mitigate the largest risk (weather) the current hedging tools do not allow basis risk removal
- As wind power index derivatives already reduce the margin whilst providing only a proxy hedge many investors shy away from using them. This is different to other areas with few or no basis risk like temperature / natural gas sales.

➢ **The fact that most risk takers in the renewables area have a very good view on most components of basis risk raises the question whether this is an efficient approach.**

5 Basis Risk – Definition and Root Causes (1)

BASIS RISK DEFINITION

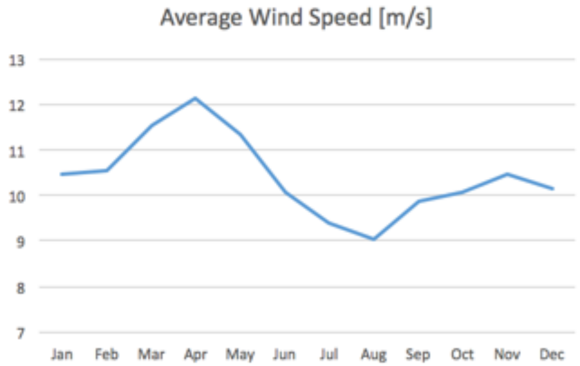
- Deviation between the value of the Wind Production Index and Actual Power Generation.

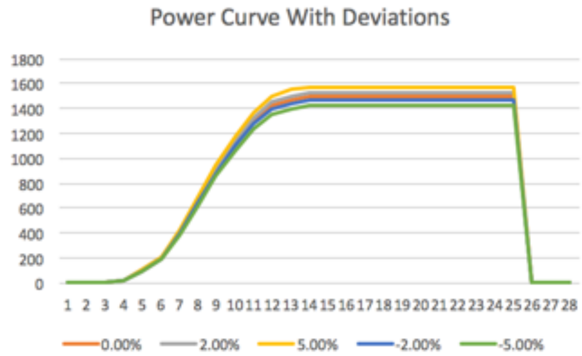
TURBINE AVAILABILITIES

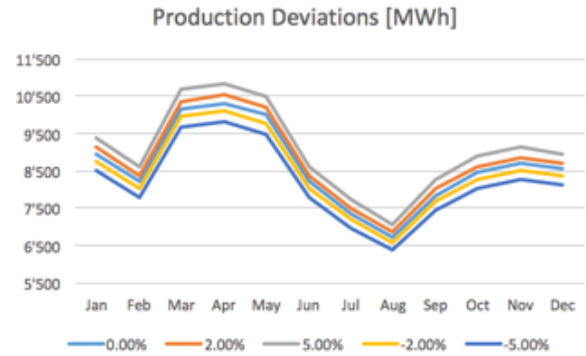
- A wind turbine has in every time unit two possible technical availability conditions, it's either available or unavailable to produce power. The availability status is measured on a continuous basis by the Condition Monitoring System inside the turbine which is turbine manufacturer's property (see also separate page about Availabilities)

POWER CURVE

- There are variations even in same turbine type
- Depend on turbine's production tolerances







Turbine	1.5	MW
Installations	10	Turbines
FIT	89	€/MWh

Variation in Power Curve	0.00%	2.00%	5.00%	-2.00%	-5.00%
Annual Generation [MWh]	103'446	105'515	108'618	101'377	98'273
Difference [MWh]	0	2'069	5'172	-2'069	-5'172
Difference [€]	0	184'133	460'333	-184'133	-460'333

5 Basis Risk – Root Causes (2)

WIND DIRECTION AND TURBULENCES

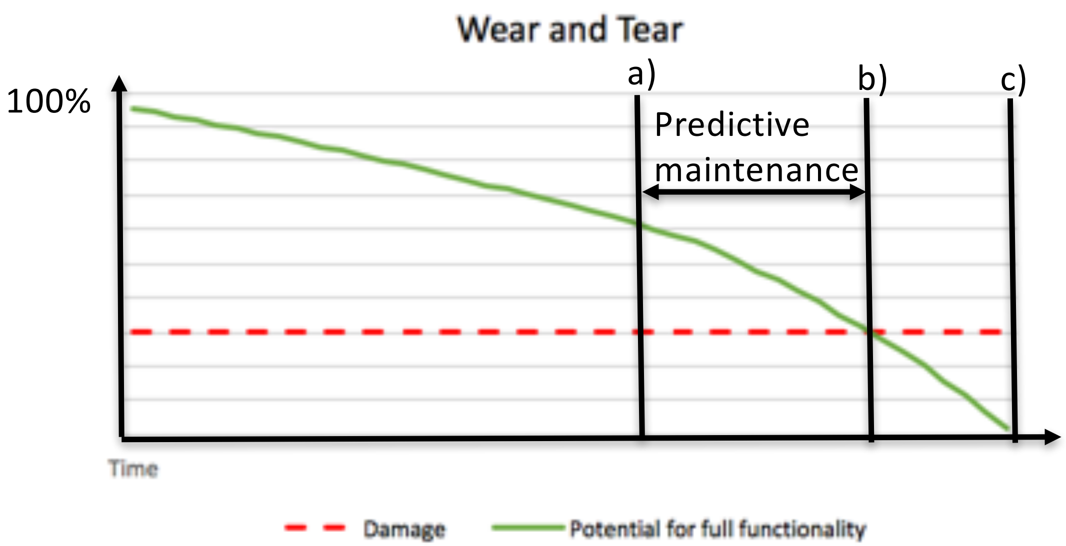
- Traditional weather derivatives refer to wind speed only
- Wind direction counts for 40% of a wind farm's output
- Turbines have flexibility regarding wind direction but it's difficult to predict and park is designed for major wind direction

SHADING EFFECTS

- Are known from the park design and should be considered in the Wind Production Index

WEAR AND TEAR

- Function of turbine's age and maintenance, has strong influence on technical availability



a) Periodical maintenance
b) Condition related maintenance
c) Outage (and possible consequent damages)

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5 Basis Risk – Root Causes and Conclusion (3)

ADMINISTRATIVE CUT OFFS

- Grid Constraints
- Bird Protection measures

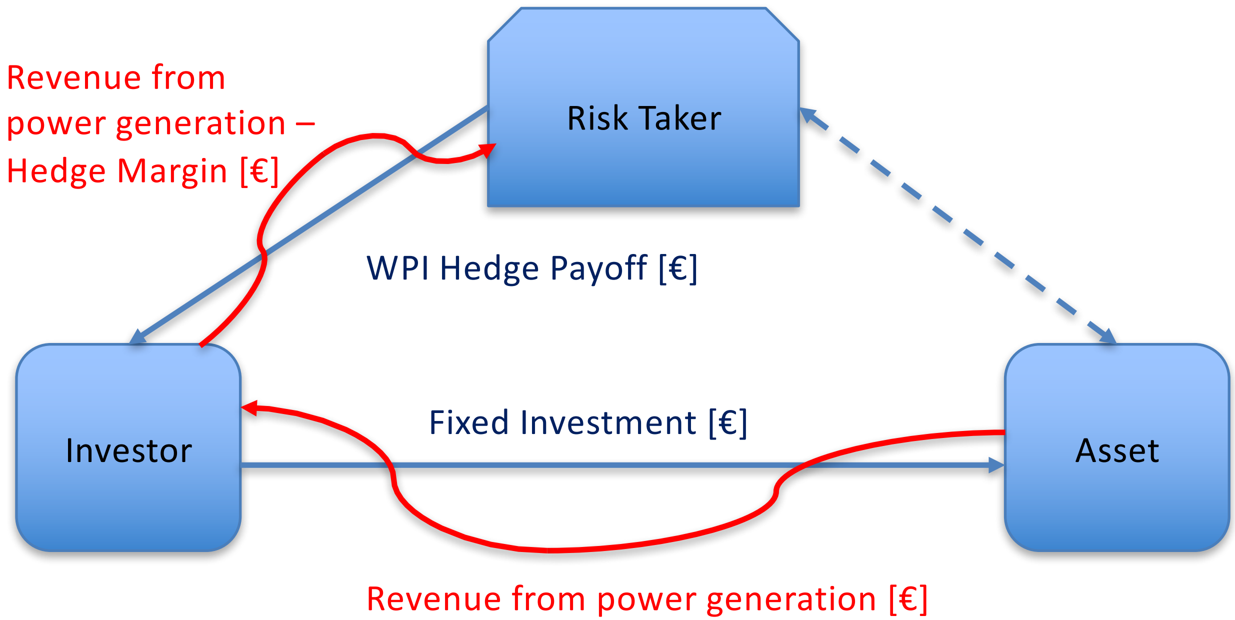
MARKET PRICE CONSIDERATIONS

- Negative Power Prices and other cut-off incentives

CONCLUSION

- Basis risk obviously has a couple of dimensions, for its understanding and possible coverage one needs to look at the world of availabilities as well as turbine's Condition Monitoring System (SCADA data)
  - ➢ A turbine is only able to produce if it's technically available
  - ➢ If it is not available for whatever reason ever it can't produce
  - ➢ However even if it is available it might not necessarily produce at all or what it would be expected to at a given power curve
  - ➢ Reasons for this being manifold, e.g. weather, technical or economic considerations
- For a risk taker becoming comfortable with a total return hedge one would need to be able to quantify this whole complex and put a value to it

6.1 Approach to an 'ideal' solution: The total return hedge



THE APPROACH

- The final aim would be a 'Total Return Hedge' which would guarantee for a defined period a minimum (fixed) cash flow for a given investment
- Given the nature of the business on the one side there will always remain some necessary caveats on side of risk taker
- In addition there are particularly technical details in which risk taker relies on third parties' knowledge
- On the other side investor needs to make sure that risk taker understands the industries' best practices, e.g. that there are situations where it makes sense to switch off turbines although they would be available
- So let's look what would need to be hedged and how one could close the gap

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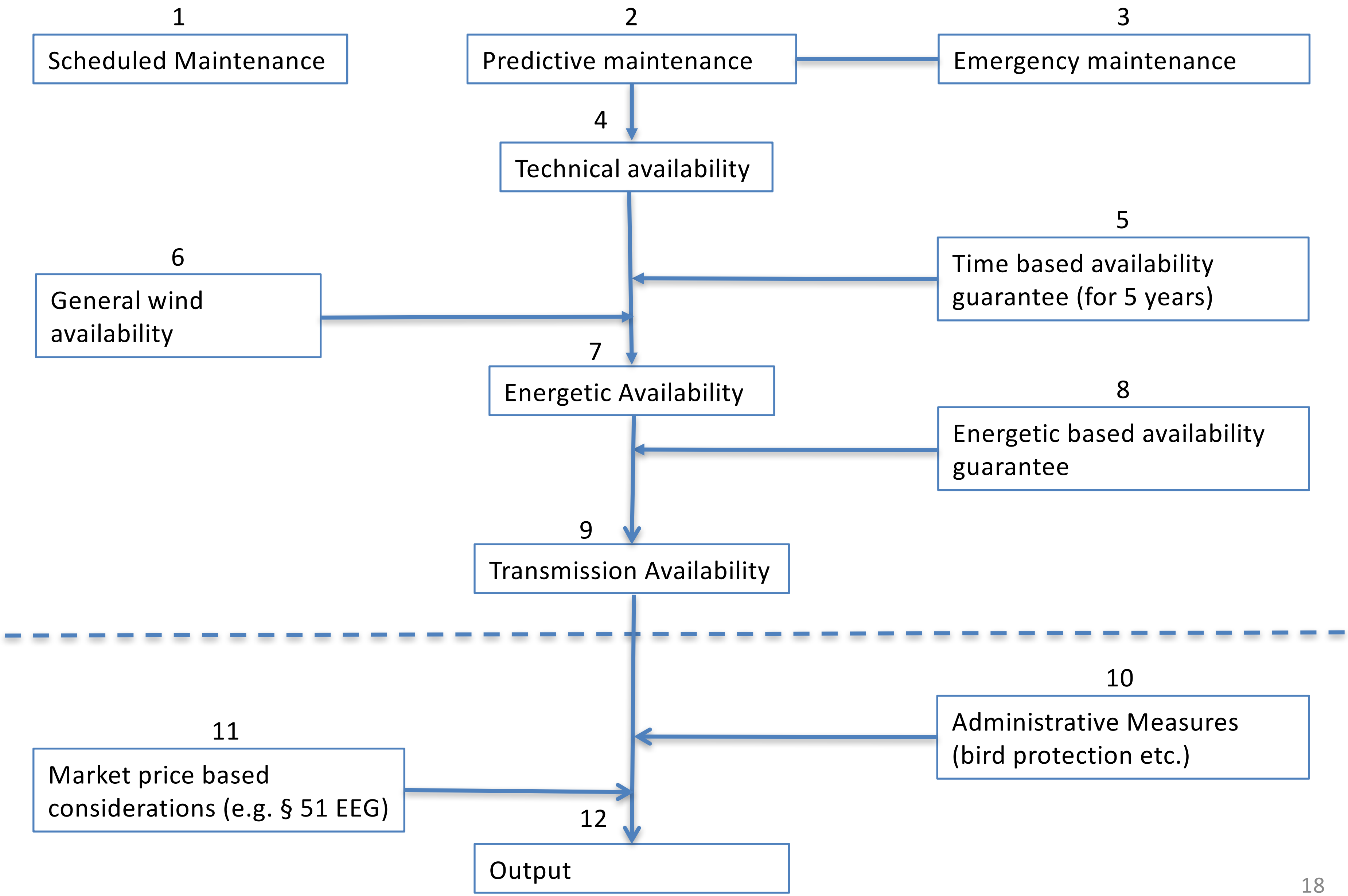
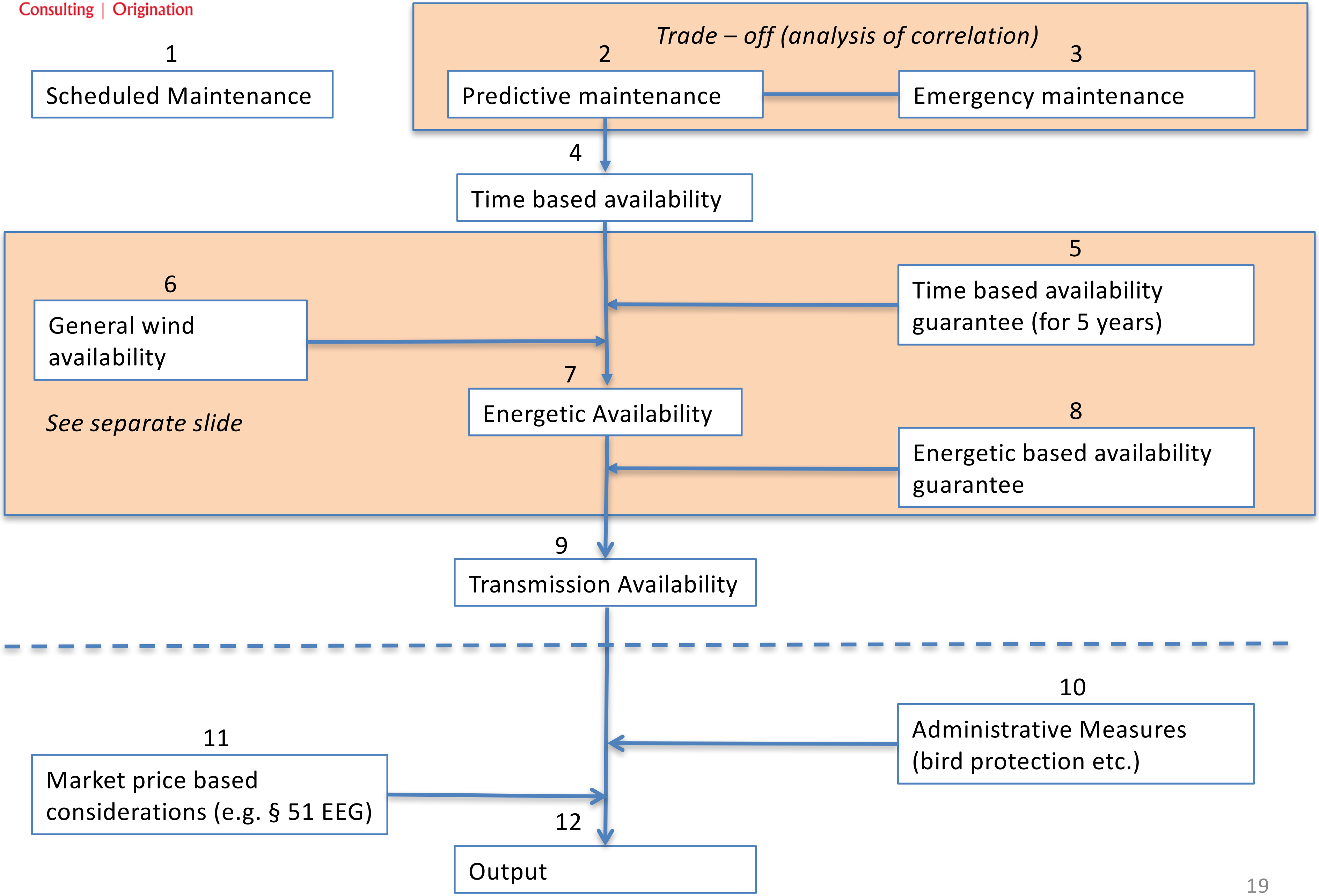
6.2 The World of Availabilities (1)



6.2 The World of Availabilities (2)



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6.3.1 Pricing Approach for the Risk Factors – Availabilities (1)

AVAILABILITY OF WIND

- Usual pricing approach with reanalysed data.

TIME BASED AVAILABILITY

- Percentage of period in which a turbine is technically able to generate power. In a year with 365 days 100% correspond to 8,760 hours.

AVAILABILITY GUARANTEE

- Is normally issued for 5 or more years after installation but refers to TIME BASED AVAILABILITY. However relevant for client is ENERGETIC AVAILABILITY. Both Siemens and Vestas say they offer yield based guarantees but it sounds vague and details are not disclosed.

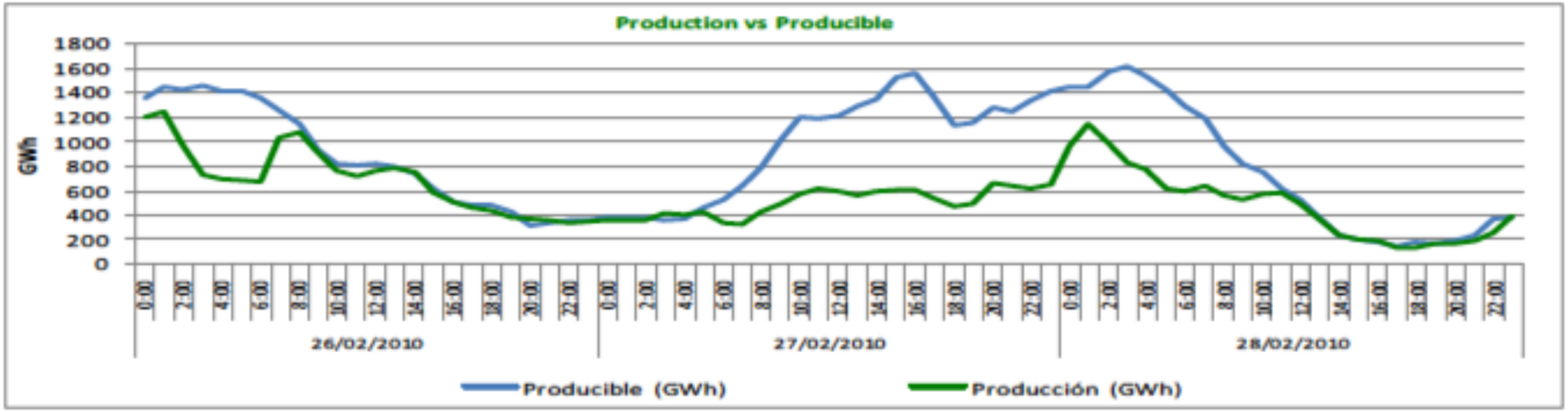
TECHNICAL AVAILABILITY OF TURBINE

- Identify status codes / availability groups which are still under (technical) warranty.
- Choose the remaining acceptable ones, exclude others from coverage.
- If no more warranty in place choose all acceptable ones and exclude others from coverage.
- Historical calculation of turbine's availability (use data from same turbines installed elsewhere if park is new).
- Considering aging process of turbine.

6.3.1 Pricing Approach for the Risk Factors – Availabilities (2)

ENERGETIC AVAILABILITY

- Relationship between actual realized power generation and theoretical possible power generation at prevailing wind conditions. This means that technical non-availability at low wind speed has no or only small influence on energetic availability whilst at high wind speed the influence is larger. Energetic availability is a an economic much better indicator than time based availability.
- Simultaneous analysis and future simulation of AVAILABILITY OF WIND and TECHNICAL AVAILABILITY OF TURBINE.



MAINTENANCE

- Consider maintenance plan in technical availability calculation.
- Production put needs to include operator's obligation for a reasonable maintenance policy according to industry standards ('condition related maintenance').
- Industries best practice needs to be considered.

Source: Iberdrola, EWEA 2013

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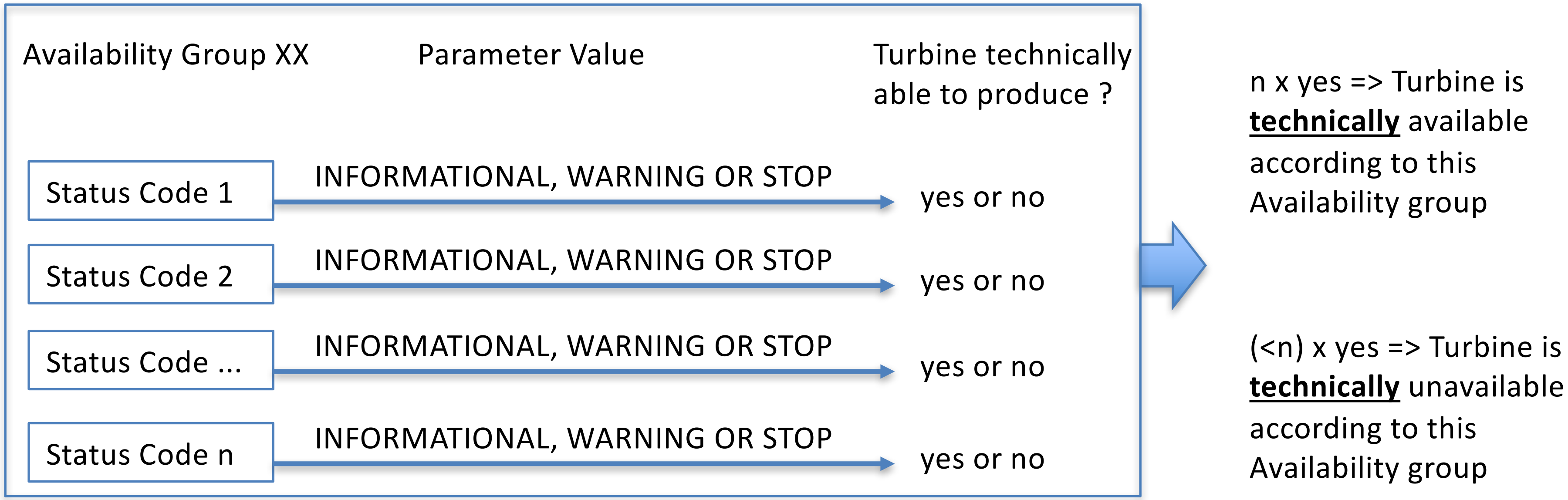
6.3.1 Pricing Approach for the Risk Factors – Availabilities (3)



- Availabilities are determined by availability groups which themselves consist of an array of status codes.
- For each turbine this array of status codes is continuously monitored. Each status code has assigned possible parameter values (e.g. INFORMATIONAL, WARNING OR STOP) which are linked to certain conditions or tresholds.

6.3.1 Pricing Approach for the Risk Factors – Availabilities (4)

Availability for each turbine is continuously measured at the end of the risk period one gets a table of the monthly availability of each turbine:

Datum	Windpark N.N.															
	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646
	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)	Verfügbarkeit (%)
Jan 13	79.18	98.83	96.97	99.76	93.65	100	99.76	99.13	98.76	99.47	100	98.73	99.57	99.58	100	87.07
Feb 13	0	99.23	99.02	99.84	95.14	100	100	98.05	100	93.07	99.92	95.67	99.72	92.75	92.41	100
Mrz 13	43.92	94.78	100	85.1	98.53	99.86	100	97.19	100	97.74	100	99.08	99.94	97.26	94.48	100
Apr 13	99.69	99.27	100	98.89	98.74	100	100	92.36	99.33	99.94	100	99.81	99.48	97.7	99.59	99.65
Mai 13	98.9	90.86	99.81	98.2	95.53	98.27	100	95.24	97.94	99.88	99.83	99.59	93.85	99.55	95.19	99.47
Jun 13	96.18	99.51	100	99.23	97.45	100	100	100	97.26	100	97.32	100	98.82	99.31	99.8	99.84
Jul 13	100	97.69	100	100	67.75	94.24	93.01	99.92	99.85	100	90.37	99.21	99.72	100	100	100
Aug 13	100	93.39	99.88	100	96.3	99.97	100	99.85	98.14	99.74	70.17	94.15	99.93	99.93	91.66	100
Sep 13	97.61	93.77	99.99	91.54	99.69	99.02	97.32	95.2	91.55	98.81	99.77	90.22	86.56	100	97.76	99.91
Okt 13	100	93.7	93.5	86.25	90.03	98.02	96.12	98.74	97.81	99.98	100	99.96	99.34	100	98.15	99.39
Nov 13	92.01	98.78	97.86	91.27	94.48	99.3	99.91	99.64	99.61	100	97.78	81.48	89.64	100	99.95	99.93
Dez 13	98.26	84.74	93.15	96.82	98.82	99.54	99.79	99.51	95.65	96.22	99.88	98.66	98.77	99.88	92.07	99.86

By adding availabilities over the turbines one gets the parks total monthly availability during the risk period (measured in hours or percentage):

Jahr 2013	verfügbare Zeit [h]	Bereitschaftszeit		planmäßige Stillstandszeit [h]	ungeplante Stillstandszeit [h]
		Insgesamt [h]	davon Netzfehler [h]		
Jan	11455:28	59:35	4:27	15:27	373:30
Feb	9677:59	140:28	126:14	25:09	908:24
März	11154:55	13:06	11:14	50:33	685:26
April	11070:38	163:35	161:12	178:02	107:45
Mai	11510:24	8:38	0:00	103:10	281:48
Juni	11113:40	72:38	65:44	223:39	110:03
Juli	11207:25	23:40	0:00	239:36	433:19
Aug	10698:46	607:14	594:26	174:49	423:11
Sep	10232:26	774:04	770:38	72:07	441:22
Okt	11386:03	26:26	0:00	138:47	368:43
Nov	11002:42	8:05	0:00	88:51	420:23
Dez	11405:33	11:41	0:00	126:47	359:59
Trend	**94.1 %**	**1.4 %**	**1.2 %**	**1.0 %**	**3.5 %**

6.4 Example for Status Codes (1): Siemens SWT-2.3-101

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Reason for grouping Status Codes in Availability Groups becomes obvious here:

Turbine Type	Status	Code	Comment
Turbine type: Siemens SWT-2.3-101	Warning	0	System faultless
Turbine type: Siemens SWT-2.3-101	Stop	1001	Manual stop
Turbine type: Siemens SWT-2.3-101	Stop	1005	Availability - low wind
Turbine type: Siemens SWT-2.3-101	Stop	1007	Remote stop - Owner
Turbine type: Siemens SWT-2.3-101	Warning	1022	Local, scheduled service work
Turbine type: Siemens SWT-2.3-101	Warning	1023	Local, ad-hoc / repair work
Turbine type: Siemens SWT-2.3-101	Warning	1024	Local, customer / guest visit
Turbine type: Siemens SWT-2.3-101	Stop	1115	Strong Twr. Vib. (SS stopped
Turbine type: Siemens SWT-2.3-101	Stop	7102	Hyd oil temperature error
Turbine type: Siemens SWT-2.3-101	Stop	7106	Pitch pump. time too long,stop
Turbine type: Siemens SWT-2.3-101	Warning	7110	Hyd. oil temp. sensor error
Turbine type: Siemens SWT-2.3-101	Stop	7111	Hyd. for crane/cover activated
Turbine type: Siemens SWT-2.3-101	Stop	8000	Windspeed too high to operate
Turbine type: Siemens SWT-2.3-101	Warning	8108	FT1 Sonic wind sensor error
Turbine type: Siemens SWT-2.3-101	Warning	8114	FT1 Configuration error
Turbine type: Siemens SWT-2.3-101	Stop	8131	Pri.Windspeed < expect, Icing
Turbine type: Siemens SWT-2.3-101	Stop	8135	Pri.Windspeed Range err, Icing
Turbine type: Siemens SWT-2.3-101	Stop	8136	Sec.Windspeed < expect, Icing
Turbine type: Siemens SWT-2.3-101	Stop	8155	Pri.Windspeed Range error
Turbine type: Siemens SWT-2.3-101	Warning	8163	Pri FT sensor turbulence error
Turbine type: Siemens SWT-2.3-101	Warning	8184	Many Anemometer activations
Turbine type: Siemens SWT-2.3-101	Warning	8185	Many Wind Vane activations
Turbine type: Siemens SWT-2.3-101	Warning	8187	Primary wind vane failure
Turbine type: Siemens SWT-2.3-101	Warning	8230	Ice detection: Low torque
Turbine type: Siemens SWT-2.3-101	Stop	8234	Ice detection: No cut in
Turbine type: Siemens SWT-2.3-101	Stop	8801	Blade de-icing active (stop)
Turbine type: Siemens SWT-2.3-101	Stop	8802	Blade de-icing active (idle)
Turbine type: Siemens SWT-2.3-101	Informational	9995	Data communication unavailable: Turbine - ParkPC (Modem)
Turbine type: Siemens SWT-2.3-101	Informational	9996	Data communication unavailable: Turbine - ParkPC
Turbine type: Siemens SWT-2.3-101	Informational	9997	Data communication unavailable: Turbine - Breeze

→ System faultless, Status Warning, Turbine Available (=1)

→ Low wind speed, Status Stop, Turbine Available (=1)

→ High wind speed, Status Stop, Turbine Available (=1)

→ Blade de-icing, Status Stop, Turbine Unvailable (=0)

→ Data communication unavailable, Status Informational, Turbine Available (there is even literature available about this status code) (= unknown)

6.4 Example for Status Codes (2): Example Vestas V90 2 MW

There are also different Status Parameters for identical Status Codes so all very generator specific (e.g. Status Code 0 INFORMATIONAL VERSUS WARNING)

Turbine Type	Status	Code	Comment
Turbine type: Vestas V90 2MW	Informational	0	Turbine OK
Turbine type: Vestas V90 2MW	Stop	30	Internal sublogic error
Turbine type: Vestas V90 2MW	Stop	76	PitchC pos:Â° vel:Â°/s
Turbine type: Vestas V90 2MW	Stop	79	Max. Yaw error: Â°
Turbine type: Vestas V90 2MW	Stop	79	Max. Yaw error: 239.1Â°
Turbine type: Vestas V90 2MW	Stop	79	Max. Yaw error: 238.8Â°
Turbine type: Vestas V90 2MW	Stop	83	B Ctrl:34.59V P.Vel:0Â°/s
Turbine type: Vestas V90 2MW	Stop	83	B Ctrl:35.31V P.Vel:0Â°/s
Turbine type: Vestas V90 2MW	Stop	83	B Ctrl:34.14V P.Vel:0.1Â°/s
Turbine type: Vestas V90 2MW	Stop	84	C Ctrl:V P.Vel:Â°/s
Turbine type: Vestas V90 2MW	Stop	102	Emergency circuit open
Turbine type: Vestas V90 2MW	Stop	144	High windspeed: m/s
Turbine type: Vestas V90 2MW	Stop	144	High windspeed: 25 m/s
Turbine type: Vestas V90 2MW	Stop	144	High windspeed: 25.1 m/s
Turbine type: Vestas V90 2MW	Stop	144	High windspeed: 25.2 m/s
Turbine type: Vestas V90 2MW	Stop	144	High windspeed: 25.1 m/s
Turbine type: Vestas V90 2MW	Stop	151	High temp. Gen bearing 2:177Â°C
Turbine type: Vestas V90 2MW	Stop	176	Error on all wind sensors
Turbine type: Vestas V90 2MW	Warning	178	Def. fuse,lightn. prot.(F9-11)
Turbine type: Vestas V90 2MW	Stop	182	Feedback = 0, yawing CCW 0
Turbine type: Vestas V90 2MW	Stop	187	Q8 open, US12 UL12
Turbine type: Vestas V90 2MW	Stop	189	Feedback = 1, Brake
Turbine type: Vestas V90 2MW	Stop	3621	Converter Disconnected In Prod
Turbine type: Vestas V90 2MW	Warning	3624	Tower nat frequency test not done
Turbine type: Vestas V90 2MW	Stop	3630	PrevCabTwCode: CabTwCode:
Turbine type: Vestas V90 2MW	Stop	3633	Yaw System Stopped
Turbine type: Vestas V90 2MW	Stop	3656	Conv Charge Failed
Turbine type: Vestas V90 2MW	Informational	4185	Unknown status code
Turbine type: Vestas V90 2MW	Stop	4917	RotorTachSpdSigErr.400,15
Turbine type: Vestas V90 2MW	Stop	4917	RotorTachSpdSigErr.400,12
Turbine type: Vestas V90 2MW	Informational	9997	Data communication unavailable: Turbine - Breeze

Turbine OK, Status Informational, Turbine Available (=1)

High wind speed (with Speed), Status Stop, Turbine Available (=1)

Converter disconnected in production, Status Stop, Turbine Unvailable (=0)

Data communication unavailable, Status Informational, Turbine Available (there is even literature available about this status code) (= unknown)

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6.5 What should be in and what should be out of scope ? (1)

Influence area	Risk Factor	Coverage	Approach
Outside operator	Availability of wind	In scope	f(wind speed)
Outside operator	Technical availability of turbine	In scope	f(outage)
Outside operator	Energetic availability of turbine	In scope	f(wind speed, technical availability)
Outside operator	Deviations of wind expertise and actuals	In scope	f(wind speed, long term)
Partly with operator	Maintenance	Might be partly in scope	f(warranty, trade off wear & tear vs. technical availability)
Outside operator	Power Curve Deviations	Out of scope	Turbine manufacturer
Outside operator	Administrative measures	Out of scope	n.a.

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6.5 What should be in and what should be out of scope ? (2)

Siemens SWT-2.3-101

- Availabilities (defined by availability groups and their status codes) finally define whether a turbine is **technically available for production** or not, independently whether it produces or not (for whatever reason).

- All reasons beyond the physical borders of the turbine (even storms, administrative measures or operator's measures like security tests) do not affect the technical availability of the turbine (although they certainly affect operator's profit).

Status Code No.	Status Code Trigger Definition	Available (allows technically for production)	Remark	Explanation	Warranty Cover	Insurability	Type
1005	Wind Speed < 5 m/s	1	Availability - low wind	Wind speed below cut-in wind speed	no	yes (weather derivative)	weather
8000	Wind Speed > 25 m/s	1	Windspeed to high to operate	Wind speed above shut down speed	no	yes (weather derivative)	weather
8234	Ice detection: No cut in	1	Allows for production but not prudent	Blades have ice cover and need to be de-icesd before	no	no	maintenance
3104	Hub: Blade B valve error	0	Valve is critical part	needs to be fixed before resuming production	maybe	possibly (insurance)	outage
9303	Brake pressure too low	0	Brake is critical part	needs to be fixed before resuming production	maybe	possibly (insurance)	outage
1024	Local, customer / guest visit	1	Economic decision	Guest security considerations	no	no	economic
1008	Remote stop - Siemens	0	Turbine manufacturer decision	Safety consideration	maybe	no	outage
3130	Pitch Lubrication	0	Part of maintenance programme		maybe	no	maintenance

- Due to the different technologies of different turbine one needs to define for each turbine type which status codes are covered or not. Particularly in the area of predictive maintenance this requires very specific know how. Complexity is added by phenomena like power curve deviations within the same turbine type.

6.6 Conclusion re insurability

- A total return hedge might be very desirable for the renewables industry, however a parametric style production hedge at whatever level is quite a challenge for the risk takers of this world.

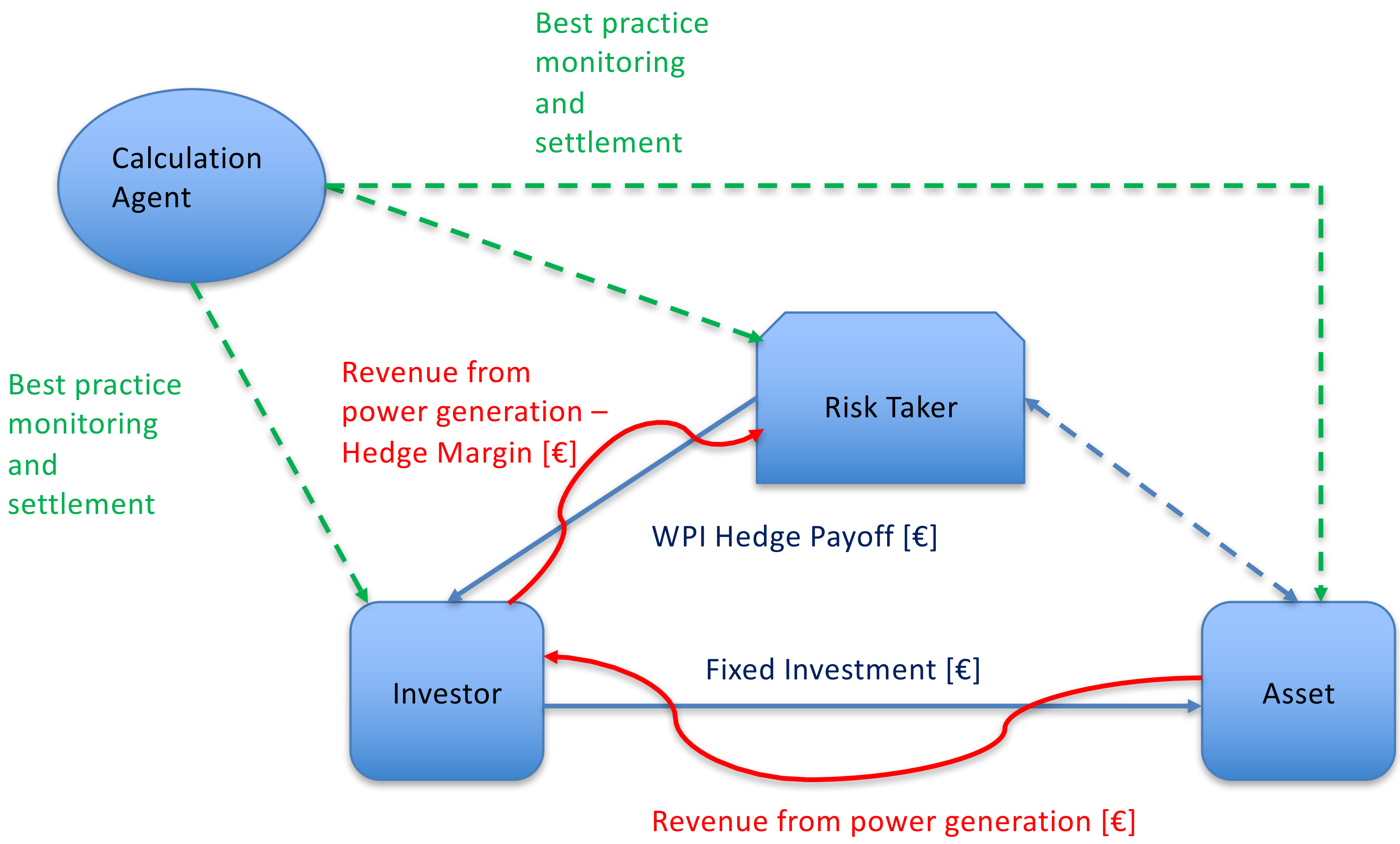
- Reason not only that particularly in the area 'available but not producing for any reason' there are lots of combinations which might need to be excluded in a traditional insurance approach but should not be excluded if considering best industry experience (particularly in the area maintenance).

- Although they own assets the know how about best industry practice is not necessarily with the risk takers of this world as they outsource their asset operations to third parties.

- So an ideal solution would be a business set-up in which a third independent party is involved which

  - makes sure that risk taker understand what they insure and receive the necessary information including data to make them comfortable with taking the risk.
  - monitors that investor conducts 'best market practices' when operating his plants.
  - acts as independent calculation agent / claims settlement manager for the settlement process.

6.7 Approach to an ‘idea solution’ with a Calculation Agent



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6.8 Product Development: Munich Reinsurance Group is looking for a pilot client to set up the product

1. Ideally a brownfield project with sufficient historical data available (including original wind expertise).

2. Openess in the structuring process would be necessary.

3. Calculation agent would be involved in the structuring process from the beginning (idea would be an operator who manages about 250 MW within Europe).

4. Incentive for pilot client would be not only getting a new kind of cash flow protection but also at the utmost competitive risk transfer price.

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6.9 Data to be provided by client (as a starting point)

1. Technical details of wind park
2. Wind expertise
3. Historical production if available
4. Array of availability groups, status codes and availabilities including their history
5. Risk engineering report if available
6. Information about coverages (warranties, insurances) still in place (to be filtered with the status codes)
7. Maintenance Plan

On request a non disclosure agreement will be signed.

Energy Risk Solutions
Your competent partner for optimizing the weather and energy exposure in your portfolio

Thank you !

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