

PREFERENTIAL TREATMENT IN RENEWABLE ENERGY AUCTIONS

An analysis of the reference yield model & German wind auctions

Prokop Čech

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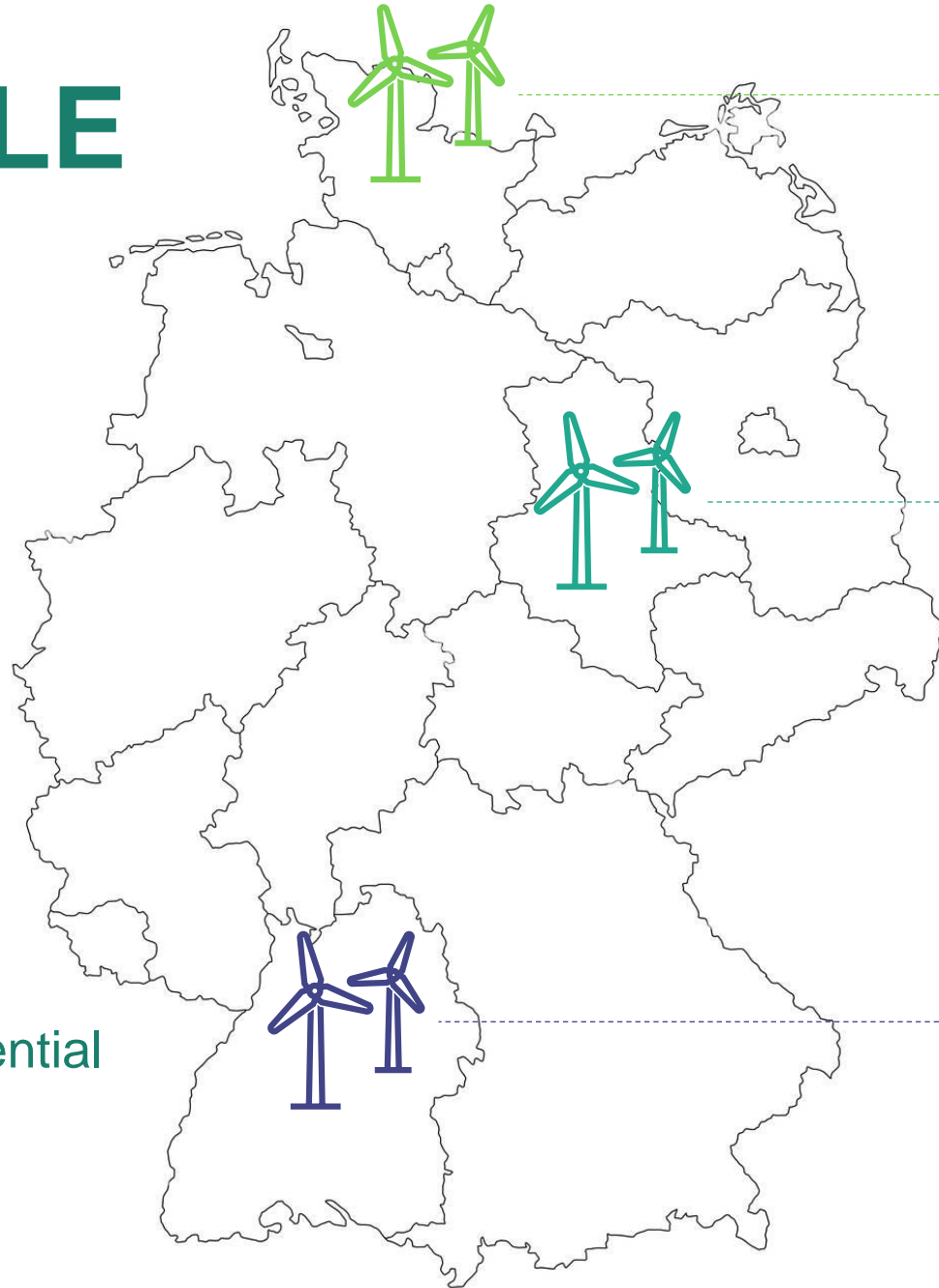
This research was funded from internal grant (SGS) of the Jan Evangelista Purkyně University, project number: UJEP-SGS-2021-45-001-2, name of the project: Preferenční zacházení s projekty v aukcích obnovitelných zdrojů.

RENEWABLE ENERGY AUCTIONS



WIND

- Production potential
- Other costs

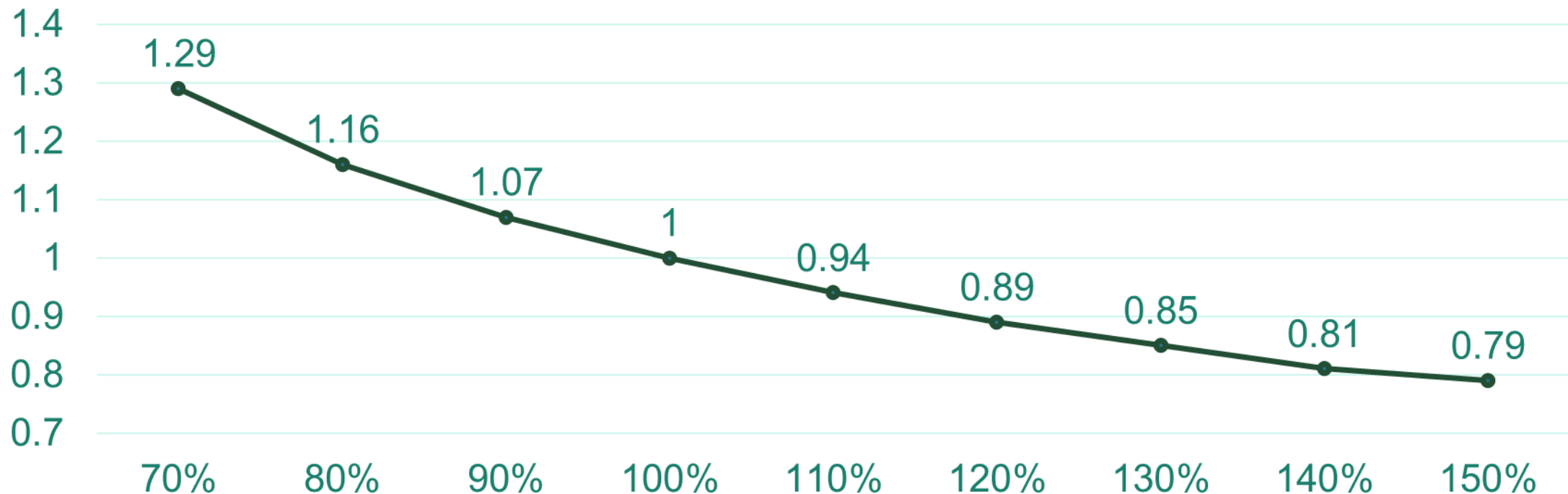


LCOE: 35 – 55 EUR/MWh

LCOE: 50 – 70 EUR/MWh

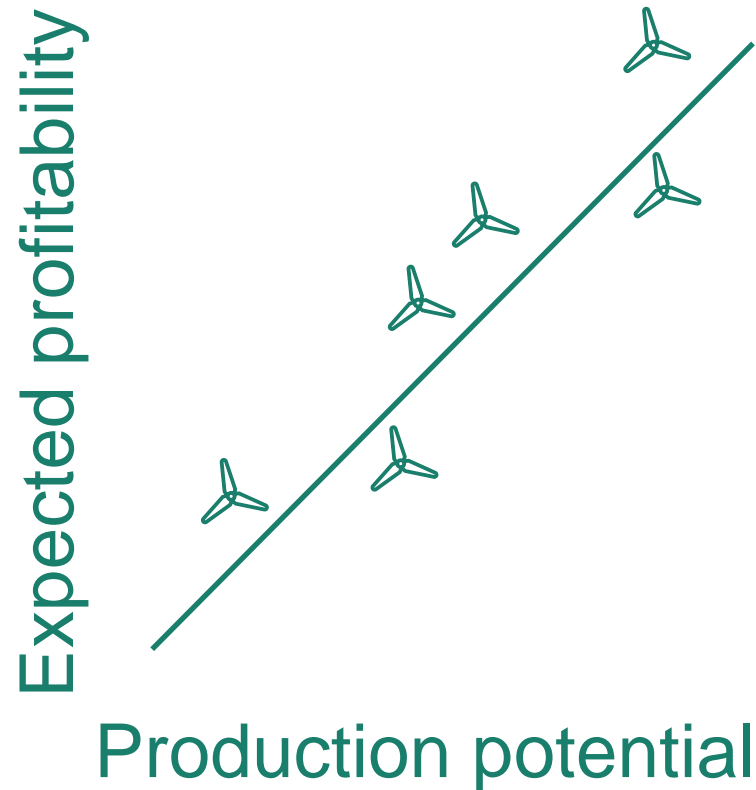
LCOE: 65 – 85 EUR/MWh

REFERENCE YIELD MODEL



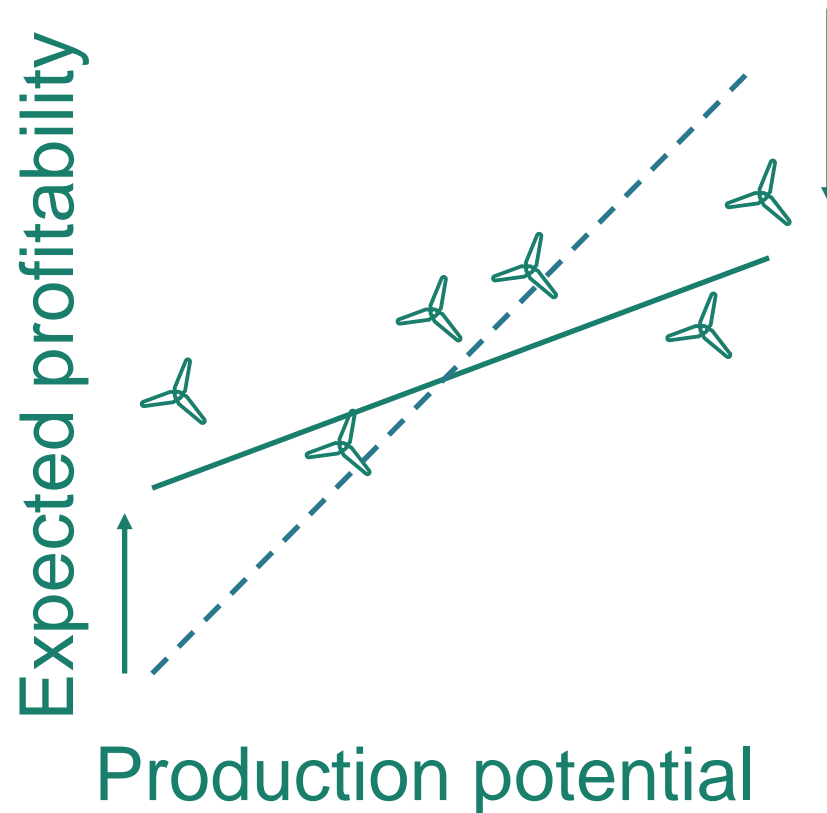
The reference yield model compensates differences only from production potential.

EFFECT OF THE RYM



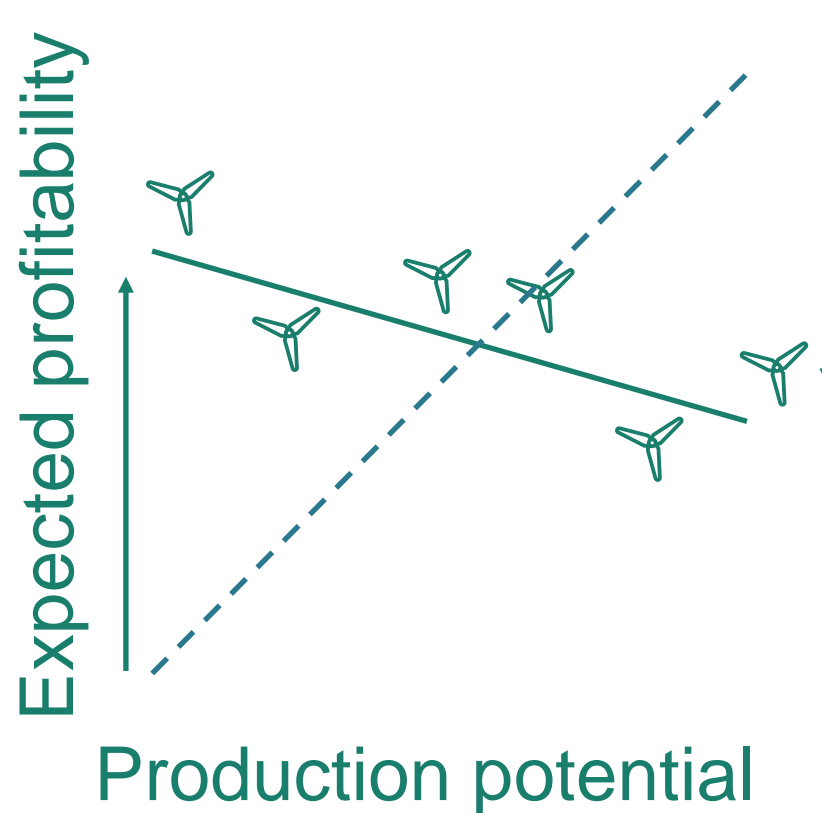
Higher production potential leads typically to higher expected profitability.

EFFECT OF THE RYM



Reference yield model reduce differences in profitability between projects.

EFFECT OF THE RYM



The effect of the reference yield model depends on the level of compensation of the differences.

RESEARCH QUESTION

The background of the slide is a photograph of a rural landscape. In the foreground, there is a grassy field with several large, cylindrical hay bales scattered across it. In the middle ground, a line of trees separates the field from a hillside. On the hillside, several white wind turbines are visible, spaced out across the slope. The sky is overcast with soft, grey clouds. The overall tone of the image is muted and natural.

„Does the reference yield model increase or decrease the cost efficiency of renewable energy auctions and what are the main drivers for the effect?“

THEORY

- Building on top of auction theory
- Price preference policy - McAfee & McMillan 1989
 - But renewable energy auctions not studied

ASSUMPTIONS

1

Independent private values

2

Revenue equivalence

3

One project per bidder

THE MODEL

INPUTS

- Production potential
- Other cost
- RYM set up
- Supply
- Demand

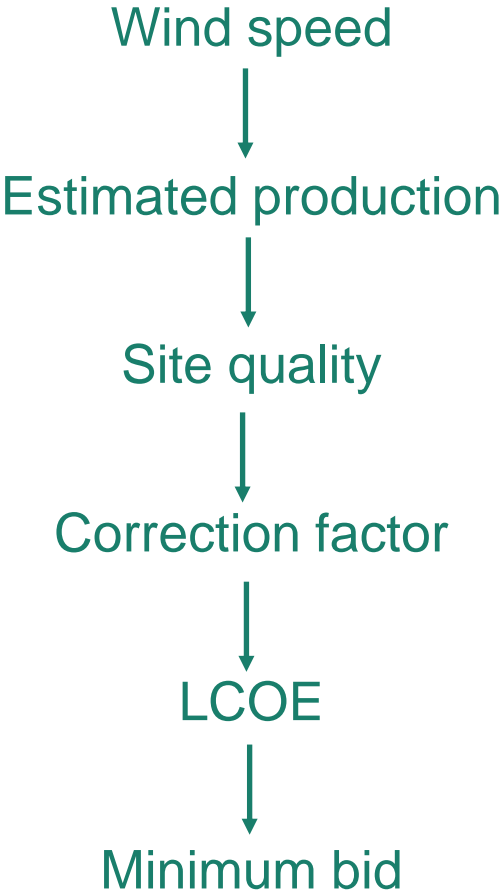
SIMULATION

- **Monte Carlo** simulation; repeated random sampling from probability density function of production potential and other costs provides
- Custom python code

OUTPUTS

- **Subsidy** awarded for projects
- **Profit** achieved by projects
- **Electricity** production of selected projects

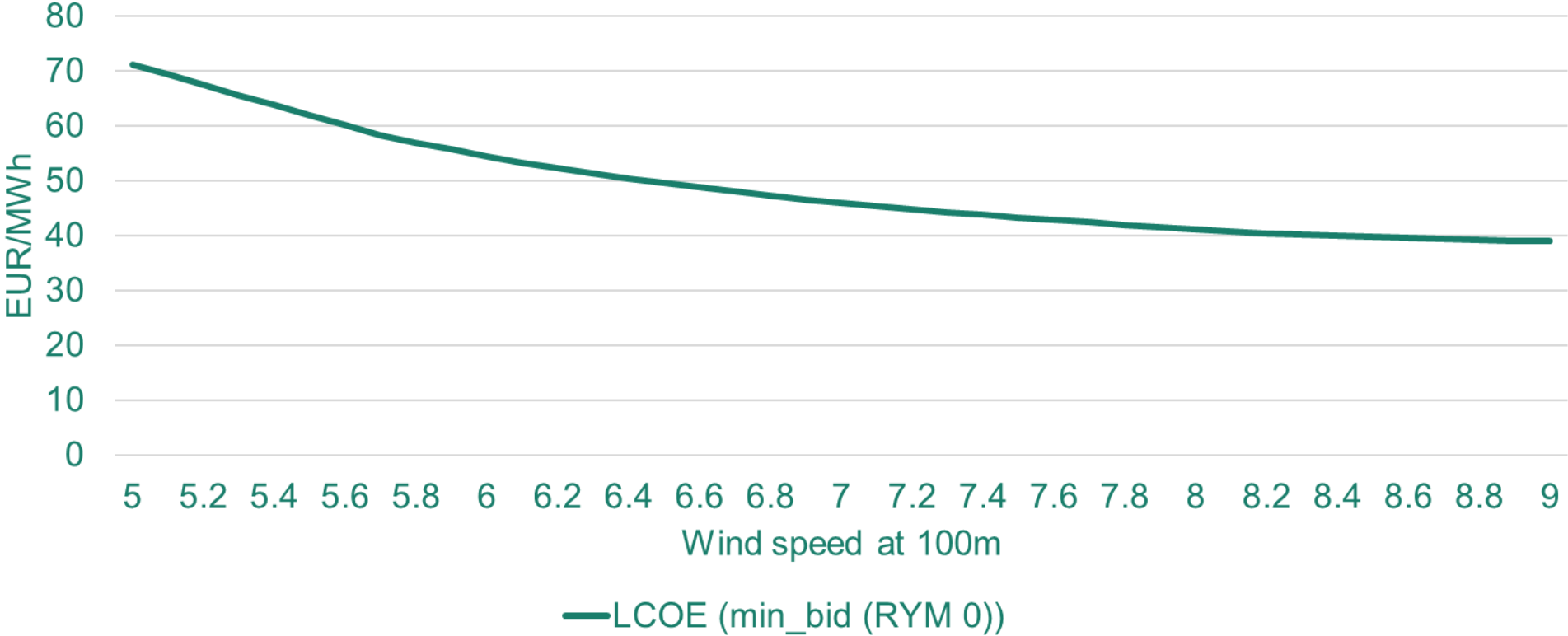
EXAMPLE



WS 100m	Estimated production per MW	Capacity factor	Site quality	Correction factor (RYM)	Ext. Correction	LCOE (production)	Min bid RYM 0	Min bid RYM 0.5	Min bid RYM 1	Min bid RYM 1.5
5.0	1 548 008	17.7%	0.60	1.290	1.423	71.17	71.17	62.15	55.17	49.59
5.1	1 620 660	18.5%	0.63	1.290	1.387	69.34	69.34	60.56	53.76	48.32
5.2	1 693 612	19.3%	0.65	1.290	1.350	67.51	67.51	58.96	52.34	47.05
5.3	1 766 750	20.2%	0.68	1.290	1.314	65.68	65.68	57.36	50.91	45.77
5.4	1 839 965	21.0%	0.71	1.277	1.277	63.84	63.84	56.08	50.00	45.11
5.5	1 913 153	21.8%	0.74	1.240	1.240	62.01	62.01	55.36	50.00	45.59
5.6	1 986 219	22.7%	0.77	1.203	1.203	60.17	60.17	54.62	50.00	46.10
5.7	2 059 071	23.5%	0.79	1.167	1.167	58.35	58.35	53.85	50.00	46.66
5.8	2 131 627	24.3%	0.82	1.140	1.140	56.98	56.98	53.26	50.00	47.11
5.9	2 203 807	25.2%	0.85	1.115	1.115	55.73	55.73	52.71	50.00	47.56
6.0	2 275 540	26.0%	0.88	1.090	1.090	54.48	54.48	52.14	50.00	48.03
6.1	2 346 760	26.8%	0.91	1.066	1.066	53.30	53.30	51.60	50.00	48.50
6.2	2 417 406	27.6%	0.93	1.047	1.047	52.35	52.35	51.15	50.00	48.90
6.3	2 487 422	28.4%	0.96	1.028	1.028	51.40	51.40	50.69	50.00	49.33
6.4	2 556 759	29.2%	0.99	1.009	1.009	50.46	50.46	50.23	50.00	49.77
6.5	2 625 370	30.0%	1.01	0.992	0.992	49.60	49.60	49.80	50.00	50.20
6.6	2 693 214	30.7%	1.04	0.976	0.976	48.82	48.82	49.40	50.00	50.61
6.7	2 760 254	31.5%	1.07	0.961	0.961	48.04	48.04	49.00	50.00	51.04
6.8	2 826 458	32.3%	1.09	0.946	0.946	47.28	47.28	48.60	50.00	51.48
6.9	2 891 794	33.0%	1.12	0.932	0.932	46.60	46.60	48.24	50.00	51.89
7.0	2 956 236	33.7%	1.14	0.920	0.920	45.98	45.98	47.90	50.00	52.29
7.1	3 019 760	34.5%	1.17	0.907	0.907	45.36	45.36	47.57	50.00	52.69
7.2	3 082 346	35.2%	1.19	0.895	0.895	44.76	44.76	47.24	50.00	53.11
7.3	3 143 974	35.9%	1.21	0.885	0.885	44.23	44.23	46.94	50.00	53.49
7.4	3 204 627	36.6%	1.24	0.875	0.875	43.76	43.76	46.67	50.00	53.84
7.5	3 264 291	37.3%	1.26	0.866	0.866	43.30	43.30	46.41	50.00	54.19
7.6	3 322 953	37.9%	1.28	0.857	0.857	42.85	42.85	46.15	50.00	54.55
7.7	3 380 599	38.6%	1.30	0.848	0.848	42.41	42.41	45.89	50.00	54.92
7.8	3 437 221	39.2%	1.33	0.839	0.839	41.97	41.97	45.63	50.00	55.29
7.9	3 492 808	39.9%	1.35	0.831	0.831	41.54	41.54	45.38	50.00	55.67
8.0	3 547 353	40.5%	1.37	0.822	0.822	41.12	41.12	45.13	50.00	56.05
8.1	3 600 847	41.1%	1.39	0.814	0.814	40.71	40.71	44.88	50.00	56.44
8.2	3 653 284	41.7%	1.41	0.808	0.808	40.40	40.40	44.69	50.00	56.74
8.3	3 704 659	42.3%	1.43	0.804	0.804	40.20	40.20	44.57	50.00	56.94
8.4	3 754 965	42.9%	1.45	0.800	0.800	40.01	40.01	44.45	50.00	57.13
8.5	3 804 199	43.4%	1.47	0.796	0.796	39.82	39.82	44.33	50.00	57.33
8.6	3 852 355	44.0%	1.49	0.793	0.793	39.63	39.63	44.22	50.00	57.52
8.7	3 899 431	44.5%	1.50	0.790	0.789	39.45	39.45	44.08	49.94	57.59
8.8	3 945 422	45.0%	1.52	0.790	0.785	39.27	39.27	43.88	49.71	57.33
8.9	3 990 327	45.6%	1.54	0.790	0.782	39.10	39.10	43.69	49.49	57.08
9.0	4 034 143	46.1%	1.56	0.790	0.779	38.93	38.93	43.50	49.28	56.83

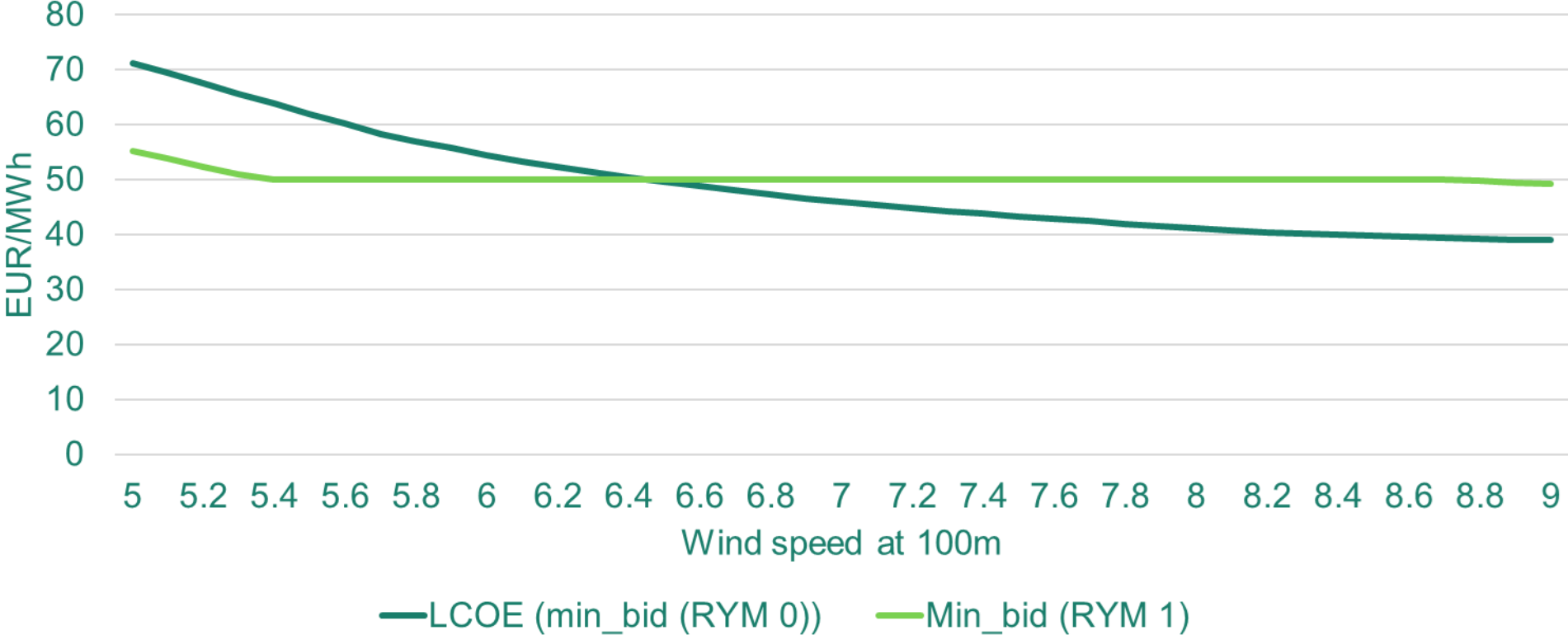
EXAMPLE

Minimum bid based on wind speed and reference yield model



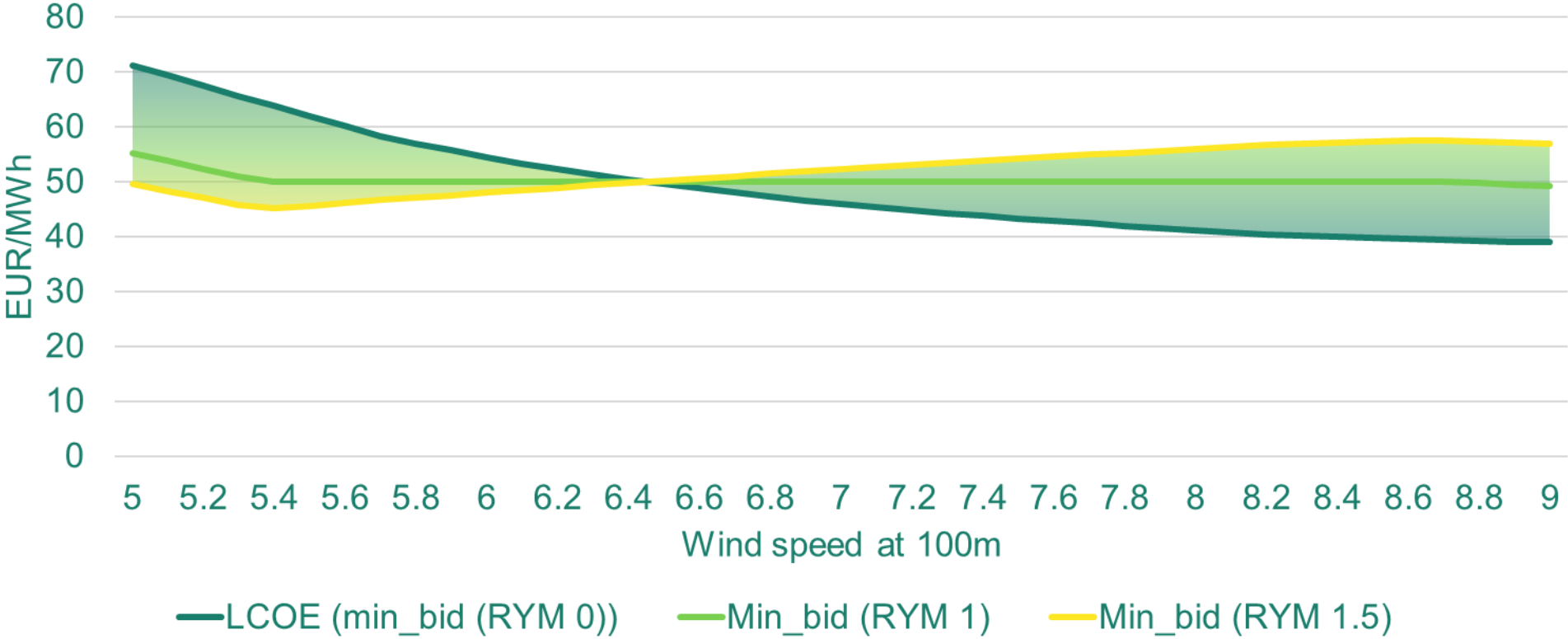
EXAMPLE

Minimum bid based on wind speed and reference yield model



EXAMPLE

Minimum bid based on wind speed and reference yield model

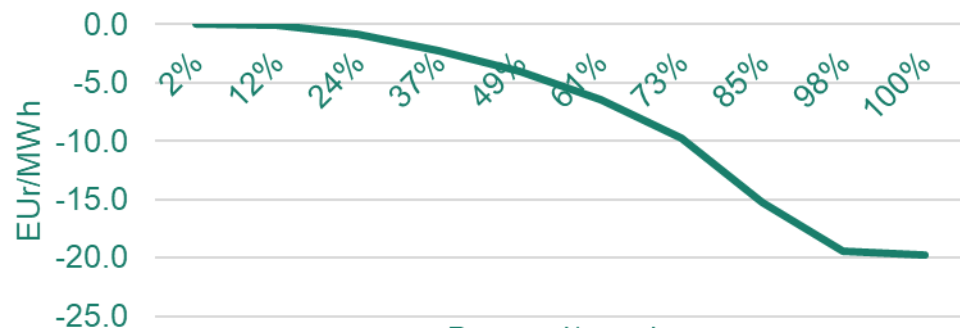


RESULTS

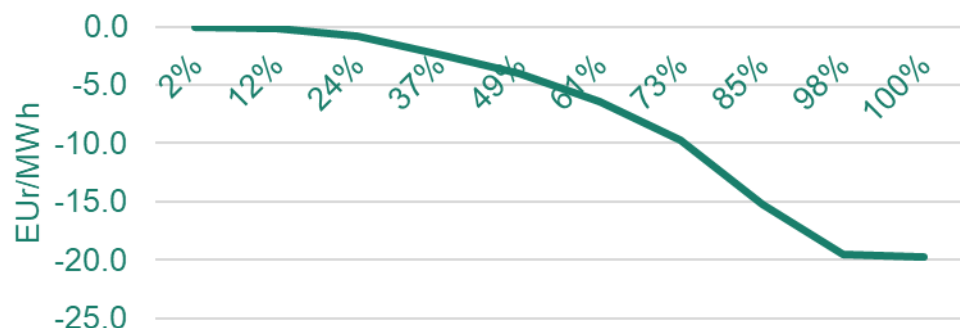


SIMPLE CASE

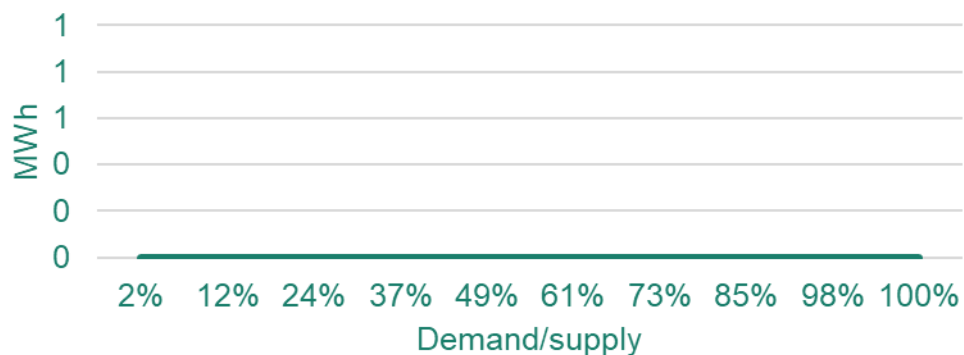
Subsidy



Profit



Electricity



Subsidy EUR per MWh

		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		38.9	39.6	40.7	42.9	45.4	48.8	53.3	60.2	69.3	71.2
0.5		38.9	39.6	40.3	41.8	43.5	45.6	48.2	51.8	58.3	60.0
0.99		38.9	39.5	39.9	40.5	41.4	42.4	43.6	44.9	49.9	51.4
1.01		38.9	45.0	49.9	50.4	49.6	48.1	47.0	45.9	49.6	51.1
1.5		63.8	63.0	63.0	61.3	59.2	57.3	55.7	53.8	51.9	51.5

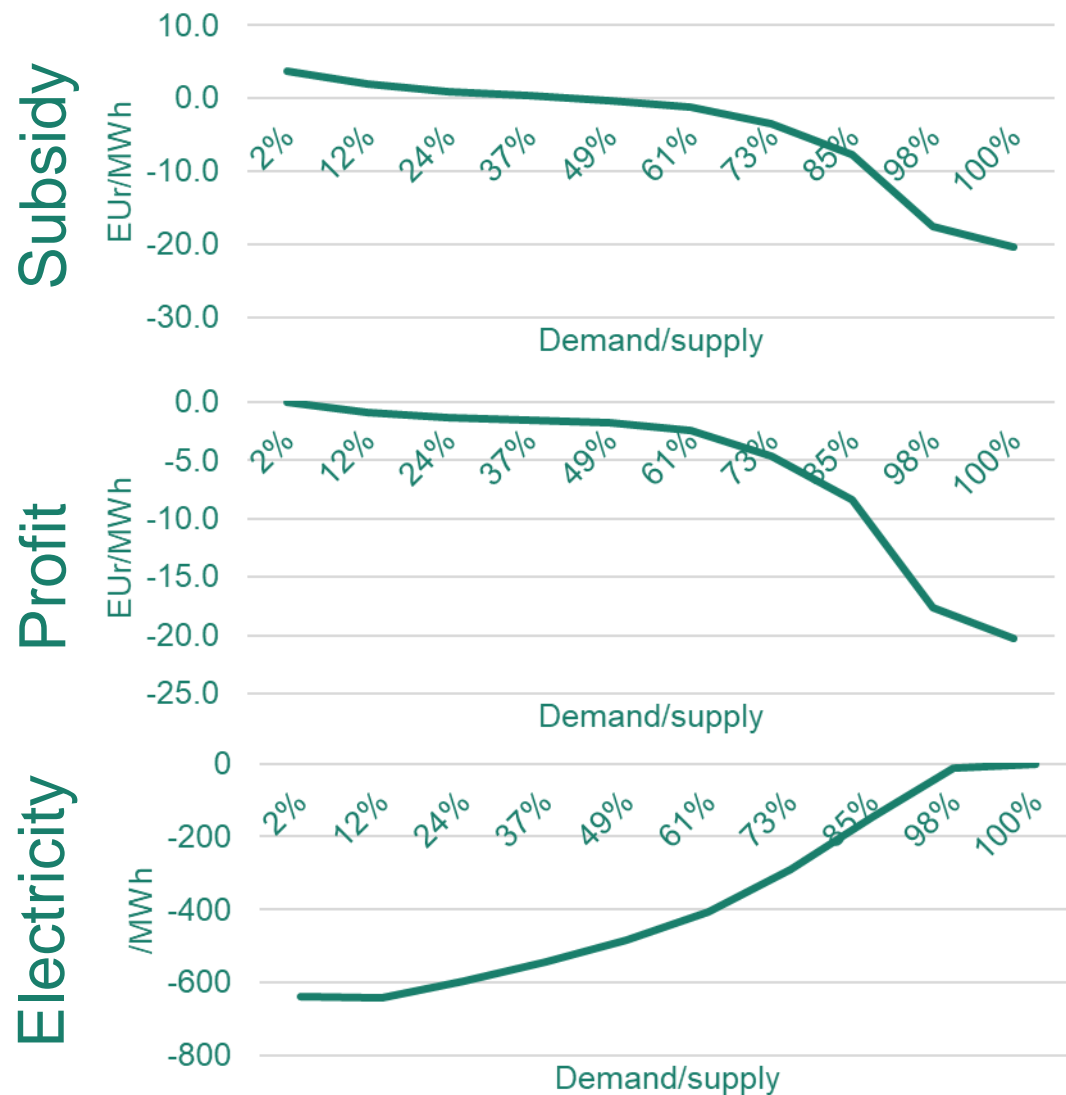
Surplus EUR per MWh

		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		0.0	0.4	1.0	2.4	4.1	6.5	9.9	15.4	23.0	24.5
0.5		0.0	0.3	0.6	1.3	2.2	3.3	4.8	7.0	12.0	13.3
0.99		0.0	0.3	0.1	0.1	0.1	0.1	0.1	0.2	3.5	4.8
1.01		0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	3.2	4.5
1.5		0.0	1.1	2.1	2.7	4.0	4.7	5.4	5.4	5.0	4.9

Produced electricity per MW

		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		4 034	3 944	3 824	3 695	3 557	3 411	3 257	3 096	2 930	2 896
0.5		4 034	3 944	3 824	3 695	3 557	3 411	3 257	3 096	2 930	2 896
0.99		4 034	3 944	3 824	3 695	3 557	3 411	3 257	3 096	2 930	2 896
1.01		4 034	3 145	2 638	2 588	2 647	2 772	2 873	2 984	2 930	2 896
1.5		1 840	1 913	1 949	2 056	2 232	2 402	2 565	2 728	2 871	2 896

OTHER COSTS



Subsidy EUR per MWh

		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		33.1	36.9	40.5	43.4	46.1	49.4	54.0	60.4	72.7	77.2
0.5		33.2	36.7	40.0	42.7	45.1	47.6	50.2	53.9	61.8	65.3
0.99		36.8	38.8	41.4	43.7	45.8	48.2	50.5	52.6	55.2	56.9
1.01		38.0	39.1	41.6	43.8	45.9	48.3	50.6	52.7	55.1	56.7
1.5		50.8	50.7	49.9	49.8	50.6	52.3	54.0	55.8	58.7	59.7

Surplus EUR per MWh

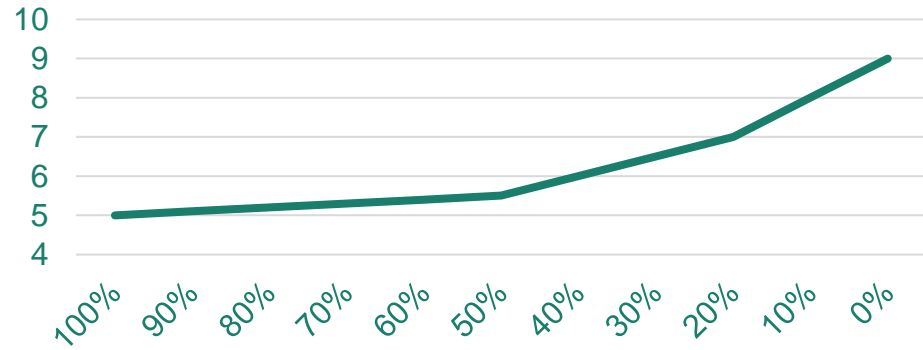
		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		0.0	1.8	3.4	4.7	6.0	7.8	11.1	15.9	26.5	30.5
0.5		0.0	1.5	2.8	3.9	4.9	6.0	7.3	9.5	15.6	18.6
0.99		0.0	0.9	2.1	3.2	4.2	5.3	6.5	7.6	8.9	10.2
1.01		0.0	0.9	2.1	3.2	4.2	5.4	6.5	7.6	8.8	10.0
1.5		0.0	2.3	3.5	4.2	5.1	6.2	7.4	9.1	12.0	13.0

Produced electricity per MW

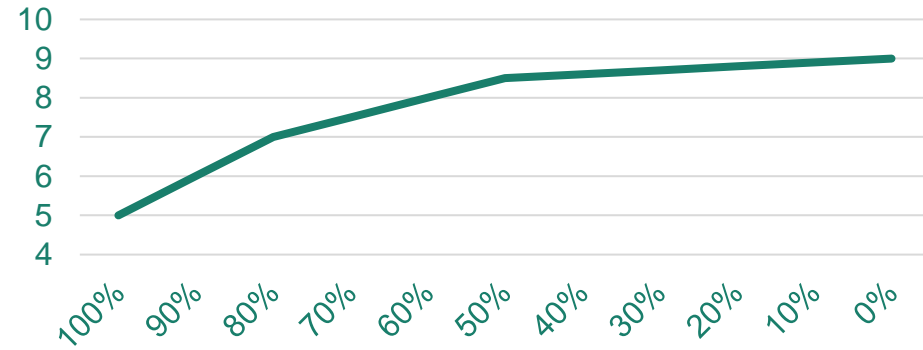
		Demand/supply (selected projects)									
		2%	12%	24%	37%	49%	61%	73%	85%	98%	100%
RYM		1	5	10	15	20	25	30	35	40	41
0		3 818	3 672	3 569	3 494	3 433	3 342	3 222	3 077	2 927	2 896
0.5		3 746	3 557	3 411	3 312	3 250	3 194	3 142	3 052	2 926	2 896
0.99		3 179	3 031	2 974	2 952	2 949	2 935	2 930	2 930	2 916	2 896
1.01		3 047	2 993	2 951	2 937	2 936	2 924	2 920	2 922	2 912	2 896
1.5		1 972	2 182	2 385	2 524	2 609	2 654	2 705	2 779	2 874	2 896

TYPIFIED DISTRIBUTIONS

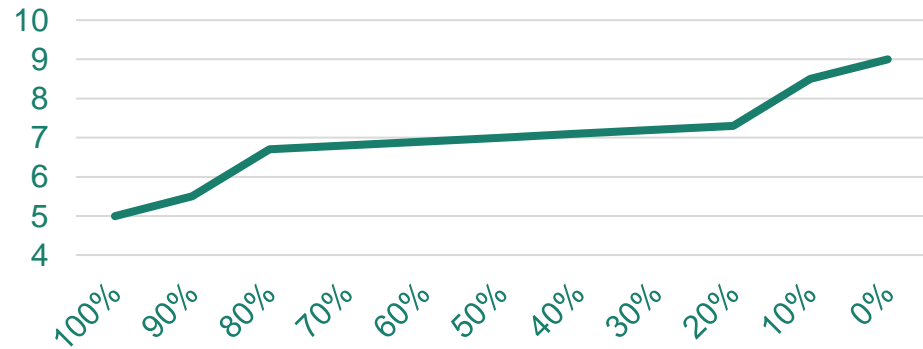
Lots of bad projects



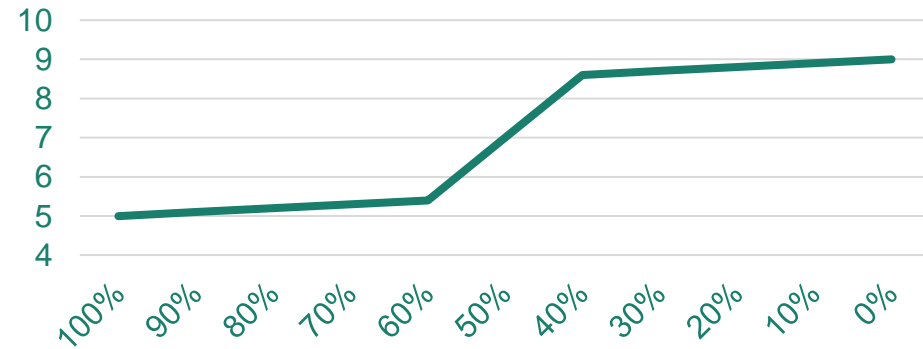
Lots of good projects



Lots of medium projects

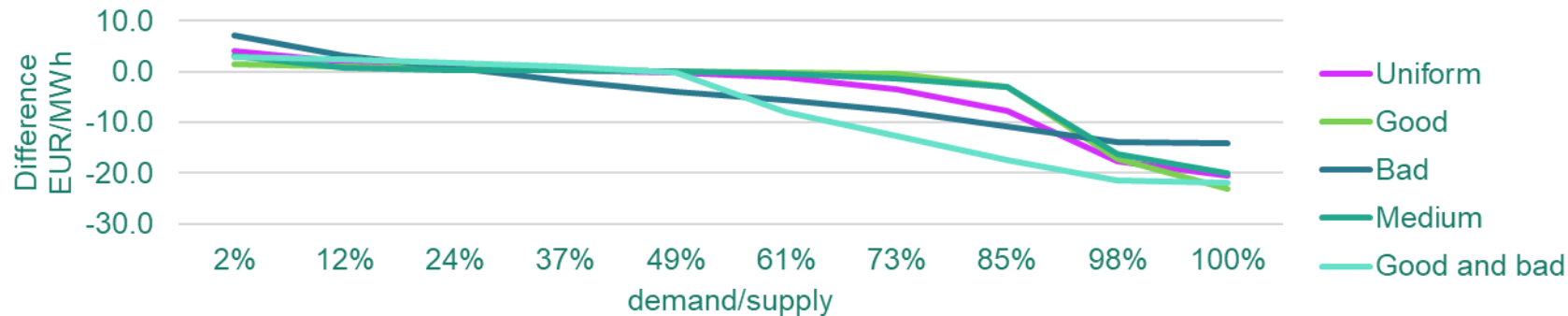


Lots of good and bad projects

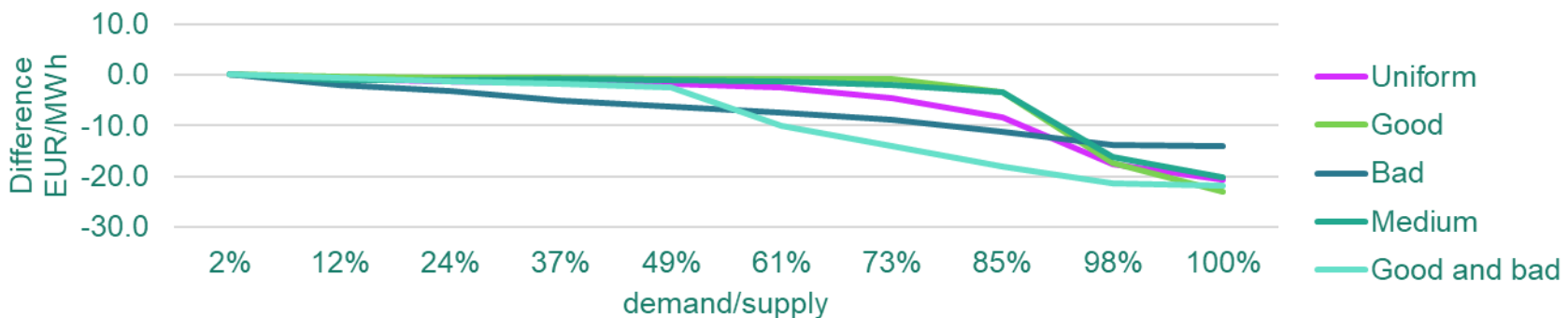


TYPIFIED DISTRIBUTIONS

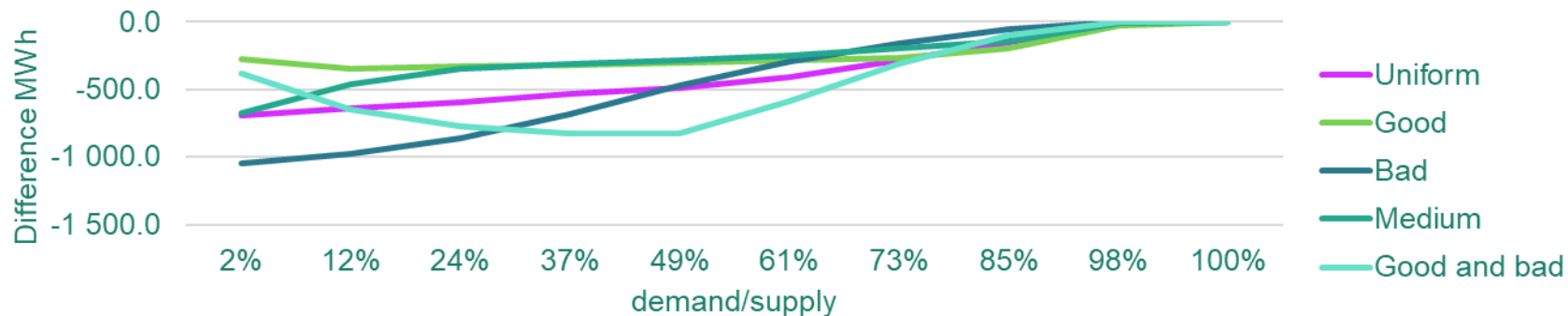
Subsidy



Profit



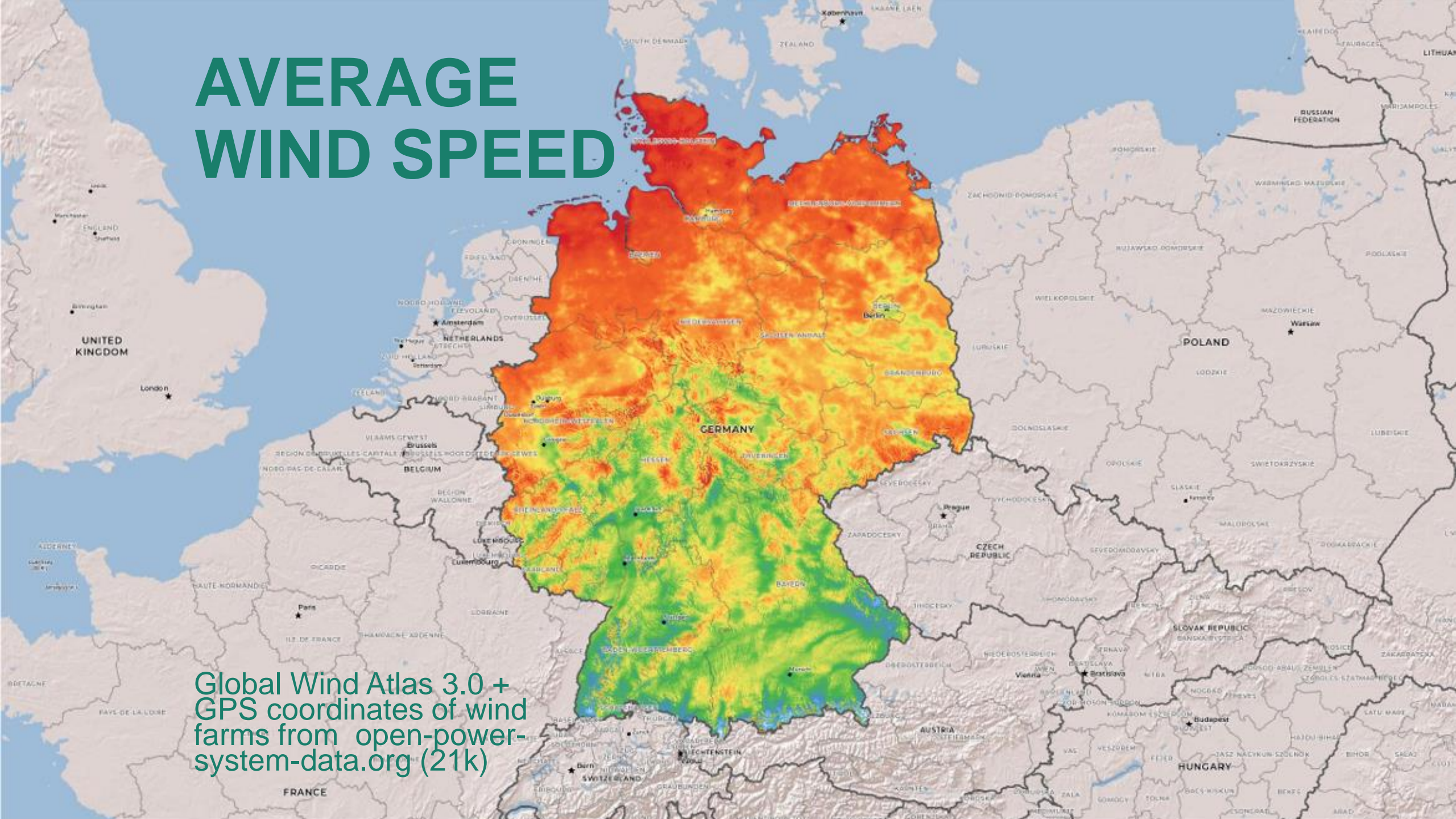
Electricity



GERMAN WIND AUCTIONS



AVERAGE WIND SPEED

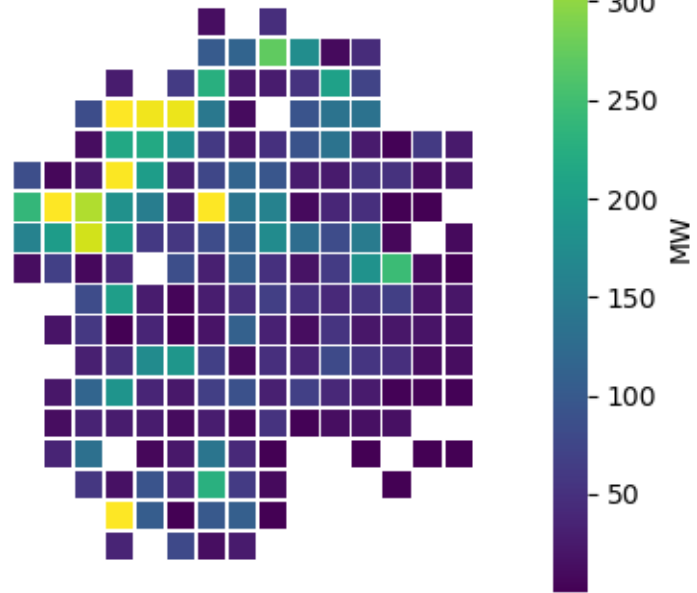


Global Wind Atlas 3.0 +
GPS coordinates of wind
farms from open-power-system-data.org (21k)

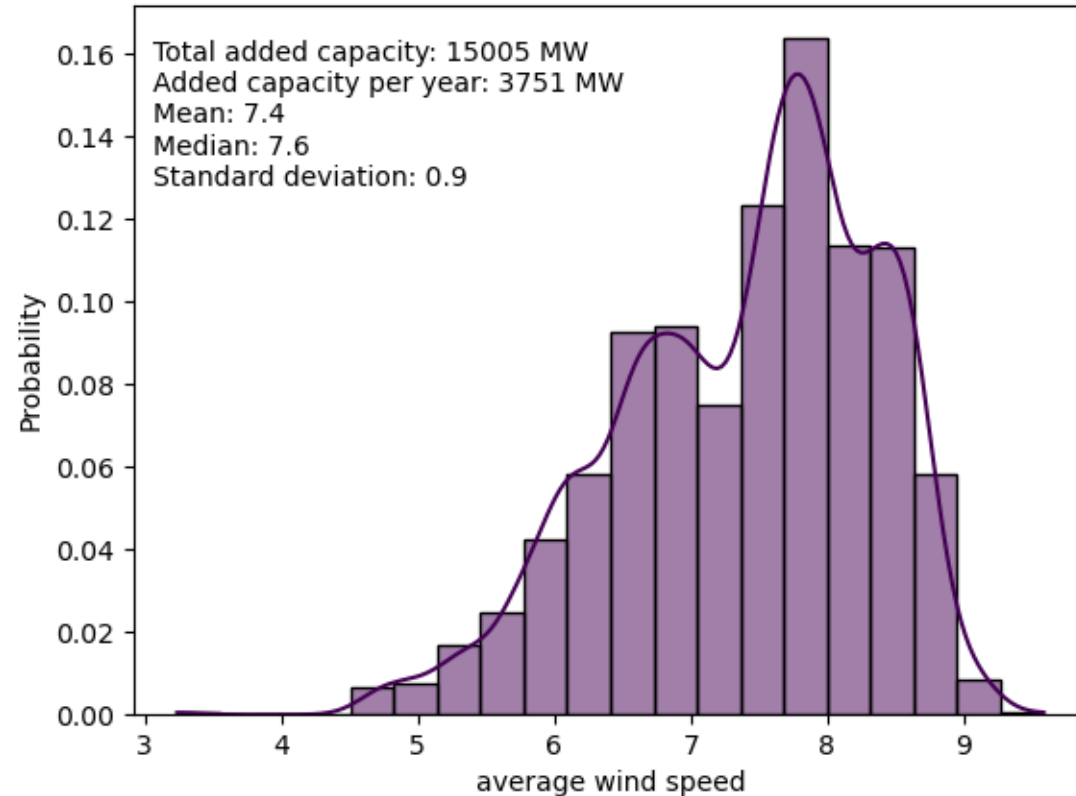
WIND SPEED DISTRIBUTION

Period7: 2015 - 2018

Total added capacity: 15005 MW
Added capacity per year: 3751 MW



Period7: 2015 - 2018



DEMAND & SUPPLY

German auctions - supply/demand



RESULTS

Date	Demand/supply	Difference - subsidy (EUR/MWh)	Difference - surplus (EUR/MWh)	MW Selected	Produced el per MW	Total subsidy difference/year	Total surplus difference/year
2017_05	37.4%	0.3	-0.9	807	3 187	732 117	-2 342 135
2017_08	34.2%	0.4	-0.9	1 021	3 191	1 206 771	-2 936 512
2017_11	38.6%	0.2	-0.9	1 011	3 186	746 317	-2 943 479
2018_02	70.8%	-0.3	-0.9	709	3 173	-578 997	-2 066 097
2018_05	110.9%	-22.1	-22.1	604	3 161	-42 241 985	-42 241 985
2018_08	94.6%	-8.6	-8.8	666	3 170	-18 097 809	-18 622 302
2018_10	172.6%	-22.1	-22.1	363	3 161	-25 395 254	-25 395 254
2019_02	140.2%	-0.7	-1.3	476	3 171	-1 095 262	-1 967 747
2019_05	220.4%	-22.1	-22.1	270	3 161	-18 861 849	-18 861 849
2019_08	271.7%	-22.1	-22.1	208	3 161	-14 557 522	-14 557 522
2019_09	266.2%	-22.1	-22.1	179	3 161	-12 544 500	-12 544 500
2019_10	330.8%	-22.1	-22.1	204	3 161	-14 268 749	-14 268 749
2019_12	72.9%	-22.1	-22.1	509	3 161	-35 592 511	-35 592 511
2020_02	170.9%	-22.1	-22.1	523	3 161	-36 572 102	-36 572 102
2020_03	154.8%	-22.1	-22.1	151	3 161	-10 551 057	-10 551 057
2020_06	176.5%	-22.1	-22.1	464	3 161	-32 442 577	-32 442 577
2020_07	144.0%	-22.1	-22.1	191	3 161	-13 358 379	-13 358 379
2020_09	118.2%	-22.1	-22.1	285	3 161	-19 920 451	-19 920 451
2020_10	107.4%	-22.1	-22.1	659	3 161	-46 053 370	-46 053 370
2020_12	55.8%	-0.2	-0.9	400	3 172	-274 421	-1 147 240
2021_02	208.7%	-22.1	-22.1	691	3 161	-48 346 774	-48 346 774
2021_05	107.0%	-22.1	-22.1	1 110	3 161	-77 639 417	-77 639 417
2021_09	81.8%	-1.4	-1.9	1 494	3 171	-6 573 973	-9 100 311

Subsidy difference per MWh: +0,4 to -22,1 EUR

Subsidy difference per year: - 472m EUR

Surplus difference per year: - 489m EUR

RESULTS

1

RYM can significantly reduce the subsidy awarded but depends on the level of compensation.

2

Profit of projects can be significantly decreased by the RYM.

3

Other costs decrease the efficiency of the RYM.

4

Main driver is the demand supply ratio.

5

Shape of the production potential distribution also matters.

6

Since past German auctions were largely undersubscribed, the effect of the RYM was significant.

THANK YOU

