



**Tehničko-ekonomska analiza proizvodnje
„zelenog” i „plavog” amonijaka na primjeru
postrojenja za proizvodnju amonijaka
Petrokemije d.d.**



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- Base case/as it is + CCS development project
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- KBR revamp + CCS development projects
- „Green Ammonia” – mix of PV solar plant and outsourced electrical power
- „Green Ammonia” – full PV solar plant
- Conclusion



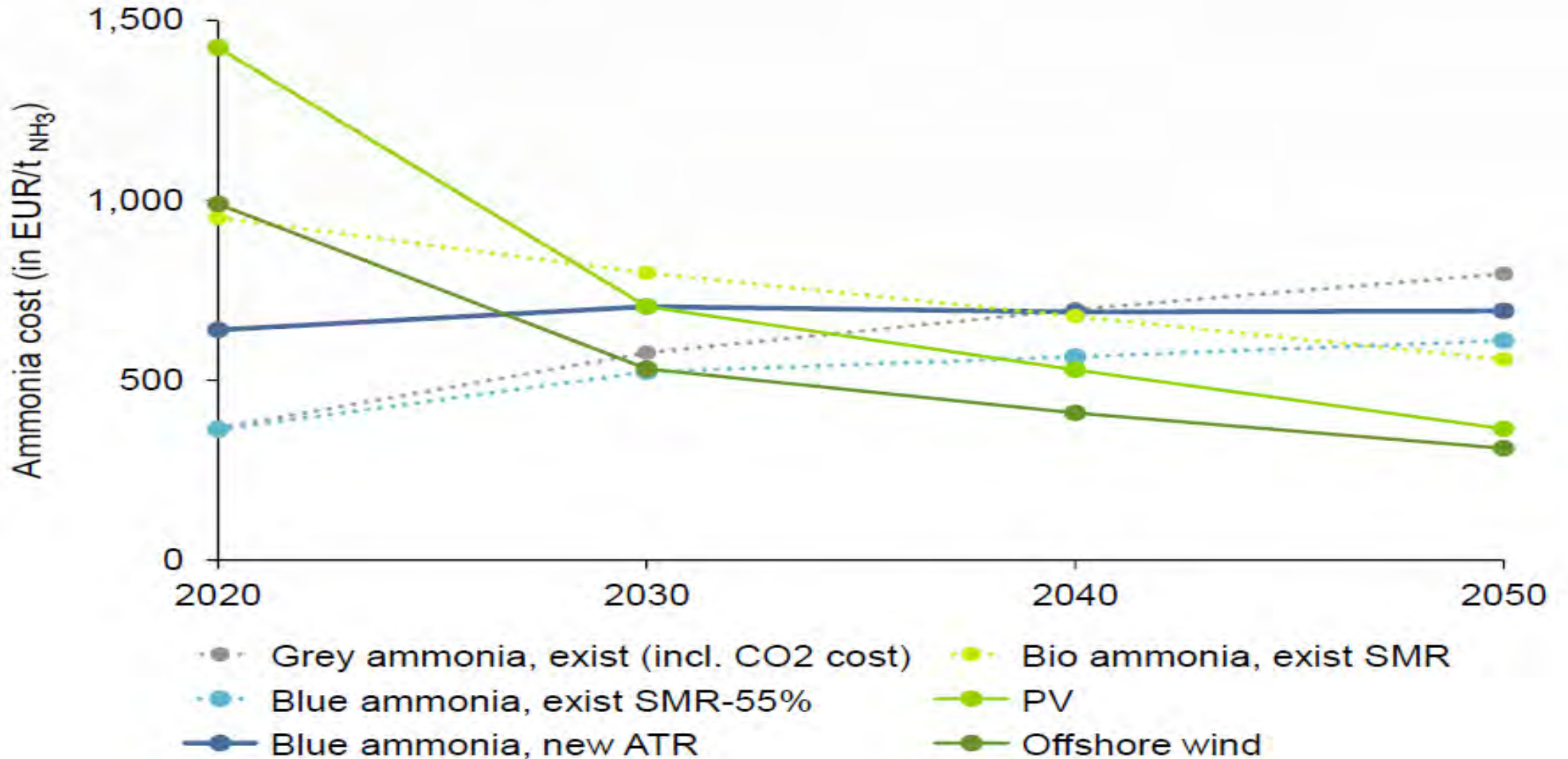
▪ Trajectories based on existing EU GHG reduction scenarios



Assuming that the European production of ammonia is 5,7% lower in 2030 (than in 2020) and remains constant afterwards.



▪ Trajectories based on existing EU GHG reduction scenarios



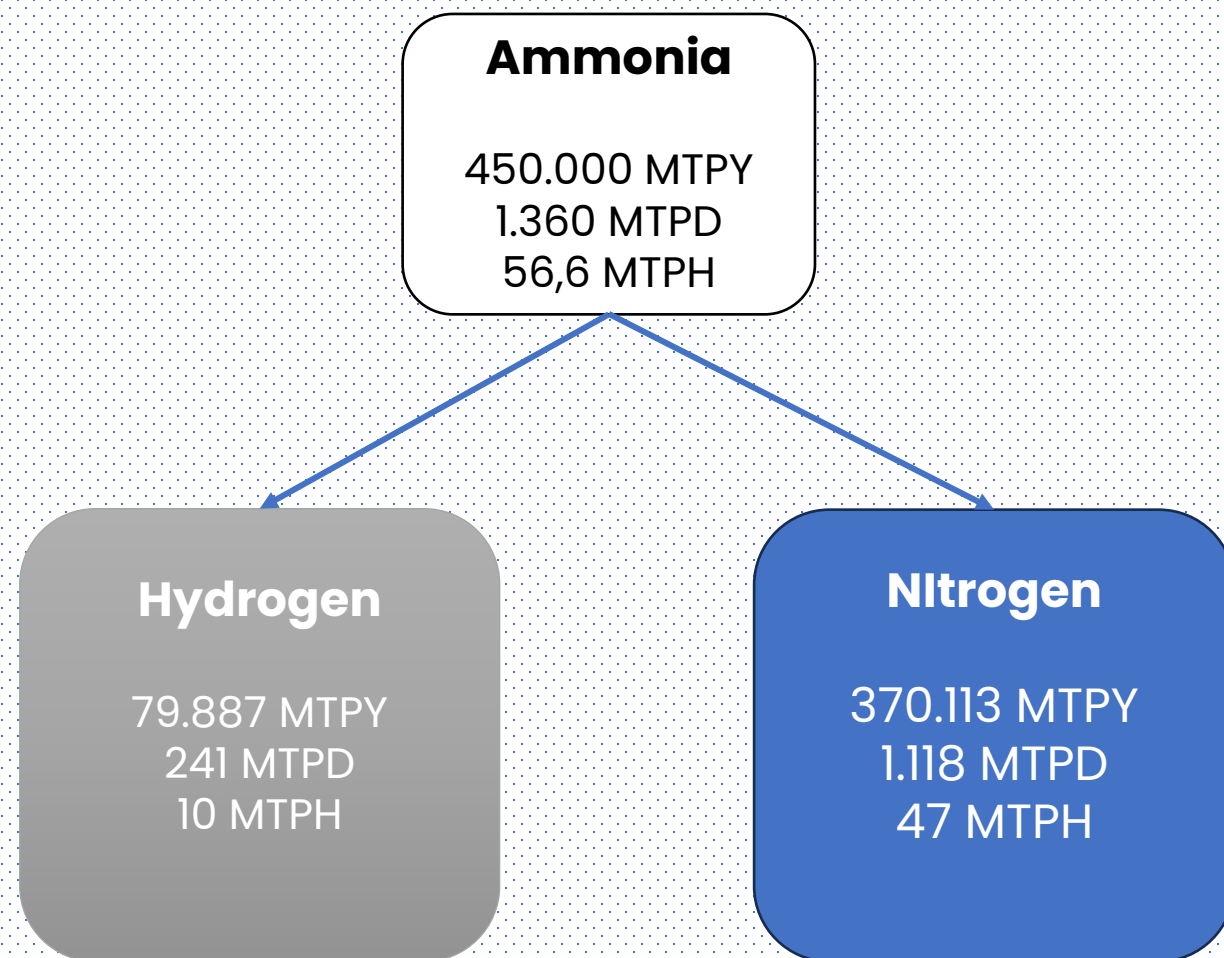


Assumptions

PRODUCTION QUANTITY

PRODUCT	MTPY
UREA	490.000
CAN	400.000
AS/ASN	100.000
NPK	100.000
TOTAL	1.090.000

Total ammonia production = 450.000 MTPY



- In the concept of green ammonia production (production of H₂ from PV solar plants and/or outsourced electrical power) there will not be possibility of CO₂ generation, which will give impossibility for UREA production
- UREA production is possible only in the case of using natural gas as raw material (base case, KBR revamp and/or CCS)
- Investment period – 15 years
- Base case prices – electrical power (75 EUR/MWh); natural gas (35 EUR/MWh); EU ETS (75 EUR/MT)



■ Base Case – Current Operation

CCS POTENTIAL



≈ 109,5 MTPH
≈ 1,931 MT_{CO2}/MT_{NH3}
≈ 877.752 MT/year

CO₂ Removal Unit

≈ 69,5 MTPH
≈ 1,226 MT_{CO2}/MT_{NH3}
≈ 557.112 MT_{CO2}/year

Fuel CO₂
„Grey” CO₂

TARGET FOR REDUCTION
≈ 40,0 MTPH
≈ 0,704 MT_{CO2}/MT_{NH3}
≈ 320.640 MT/year

ATM

≈ 18,5 MTPH to vent
≈ 148.296 MT/year

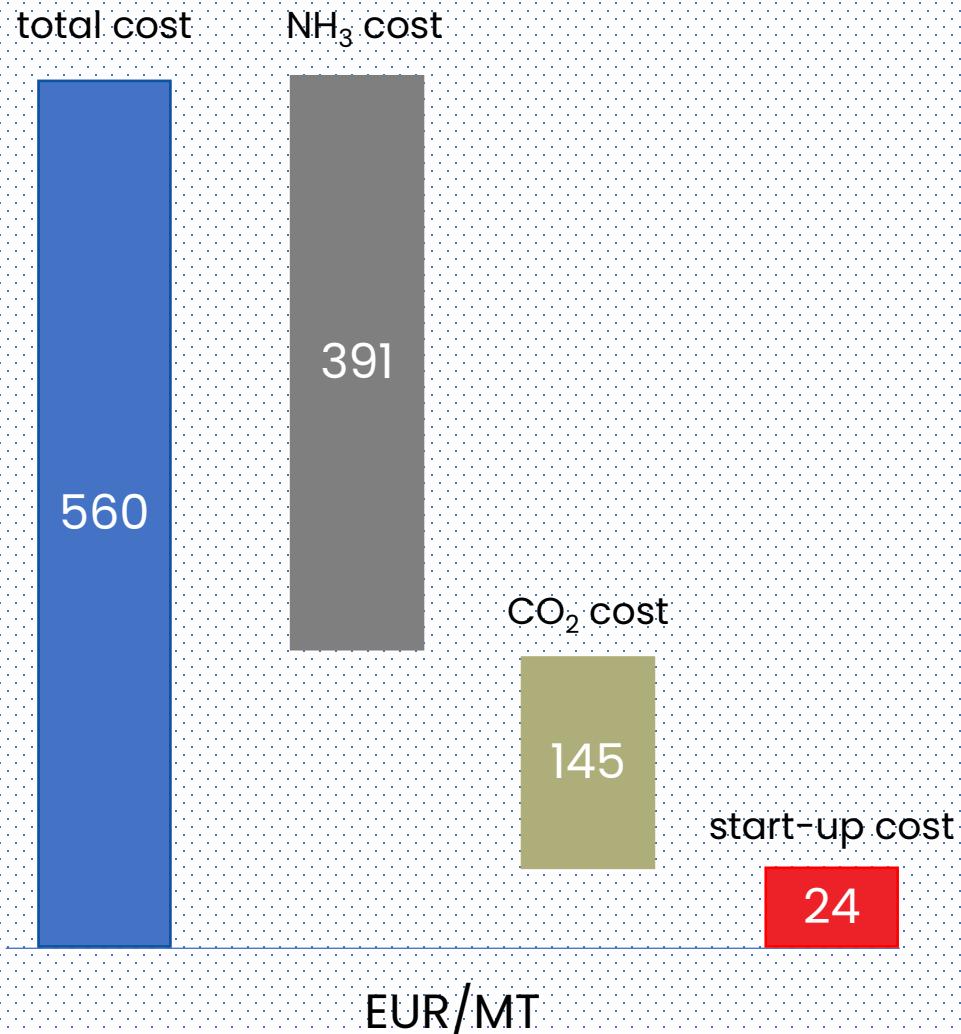
≈ 47,0 MTPH
≈ 376.752 MT/year

UREA PLANT

≈ 4,0 MTPH
≈ 32.064 MT/year

THIRD PARTY BUYER

Ammonia Cost Breakdown



Base Case/as it is



- Natural gas consumption - 10,856 MWh/MT_{NH3} at HHV
- EU ETS emission – 1,931 tCO₂e/tNH₃
- Natural gas consumption during planned start-up and shut-down – 34.000 MWh
- Total number of planned shut-downs – four (4) per year
- Without development CAPEX, only maintenance CAPEX

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)

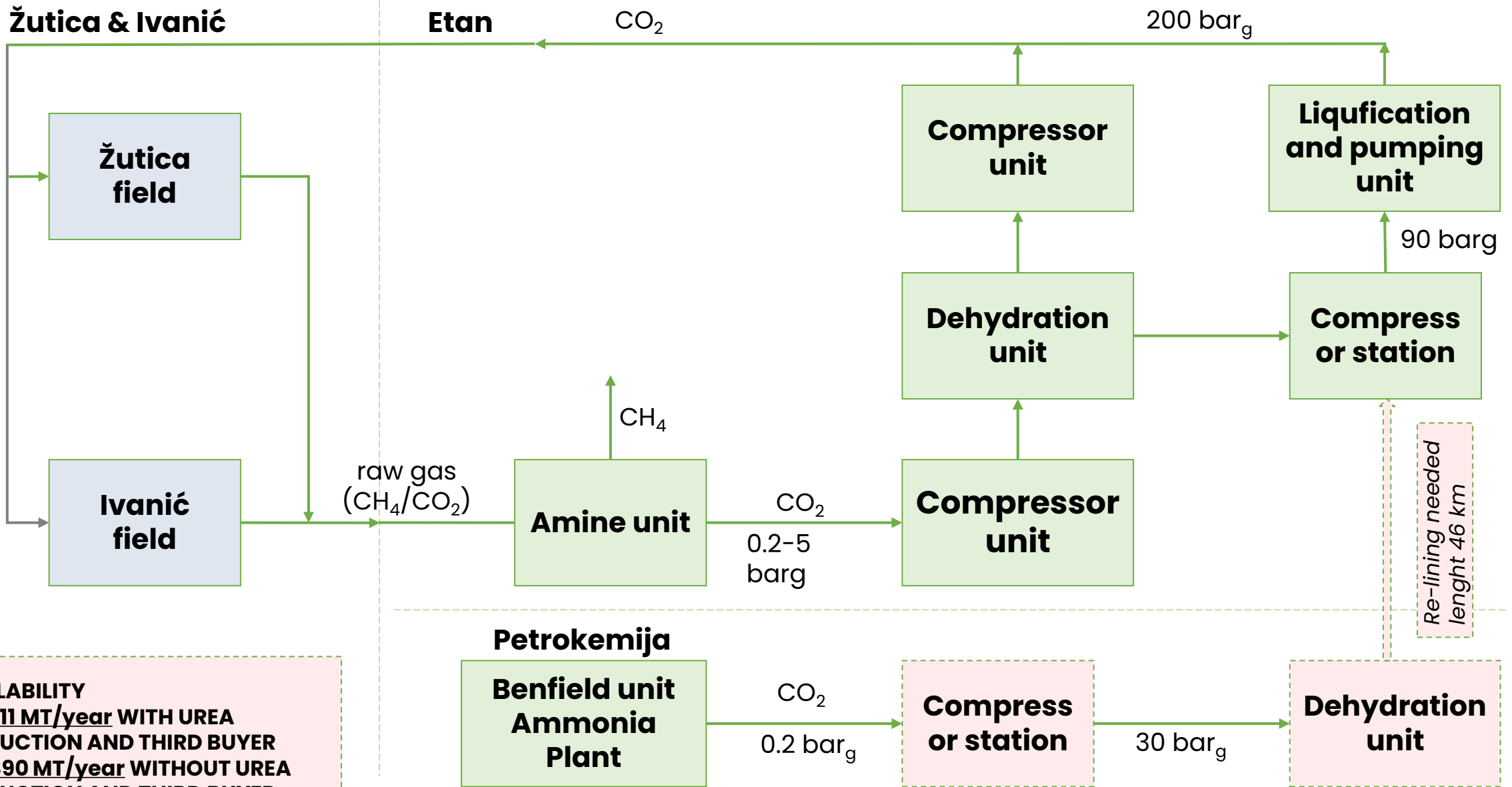


Base case/as it is (sensitivity analysis)

Ammonia price (€/MT) – Sensitivity analysis – Natural gas & CO ₂ price												
Natural gas price (€/MWh)	100	1.266	1.285	1.304	1.323	1.343	1.362	1.381	1.401	1.420	1.439	1.459
	95	1.208	1.227	1.246	1.265	1.285	1.304	1.323	1.343	1.362	1.381	1.401
	90	1.150	1.169	1.188	1.208	1.227	1.246	1.265	1.285	1.304	1.323	1.343
	85	1.092	1.111	1.131	1.150	1.169	1.189	1.208	1.227	1.246	1.266	1.285
	80	1.034	1.053	1.072	1.092	1.111	1.130	1.150	1.169	1.188	1.207	1.227
	75	976	995	1.014	1.034	1.053	1.072	1.092	1.111	1.130	1.149	1.169
	70	918	937	956	976	995	1.014	1.034	1.053	1.072	1.091	1.111
	65	860	879	898	918	937	956	976	995	1.014	1.034	1.053
	60	802	821	840	860	879	898	918	937	956	976	995
	55	744	763	782	802	821	840	860	879	898	918	937
	50	686	705	724	744	763	782	802	821	840	860	879
	45	628	647	666	686	705	724	744	763	782	802	821
	40	570	589	609	628	647	666	686	705	724	744	763
	35	512	532	551	570	589	609	628	647	667	686	705
	30	454	474	493	512	531	551	570	589	609	628	647
25	396	416	435	454	473	493	512	531	551	570	589	
20	338	358	377	396	415	435	454	473	493	512	531	
15	280	299	319	338	357	377	396	415	435	454	473	
	50	60	70	80	90	100	110	120	130	140	150	
CO ₂ price (€/t(CO ₂))												

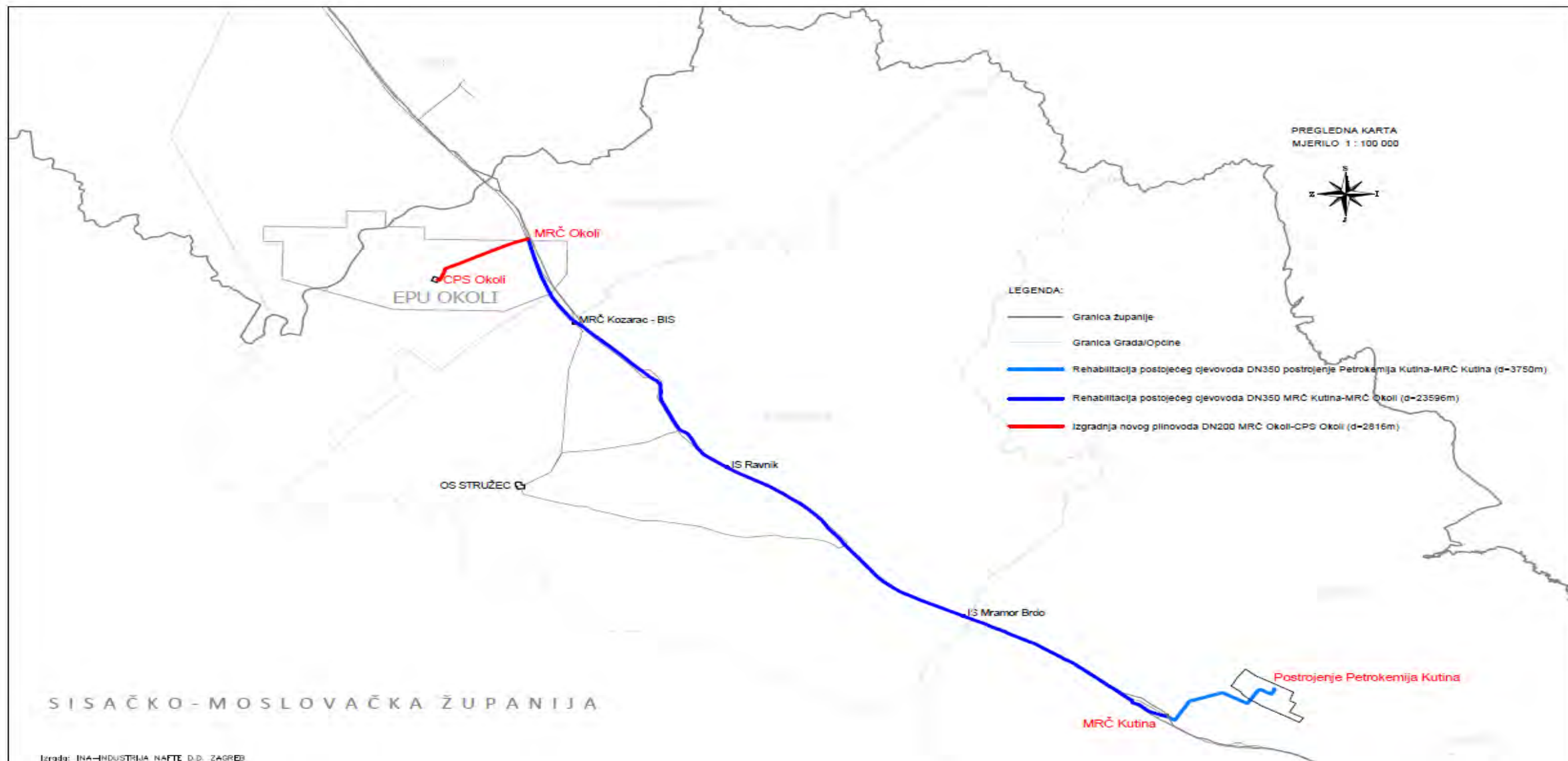


Base Case/as it is + CCS development project

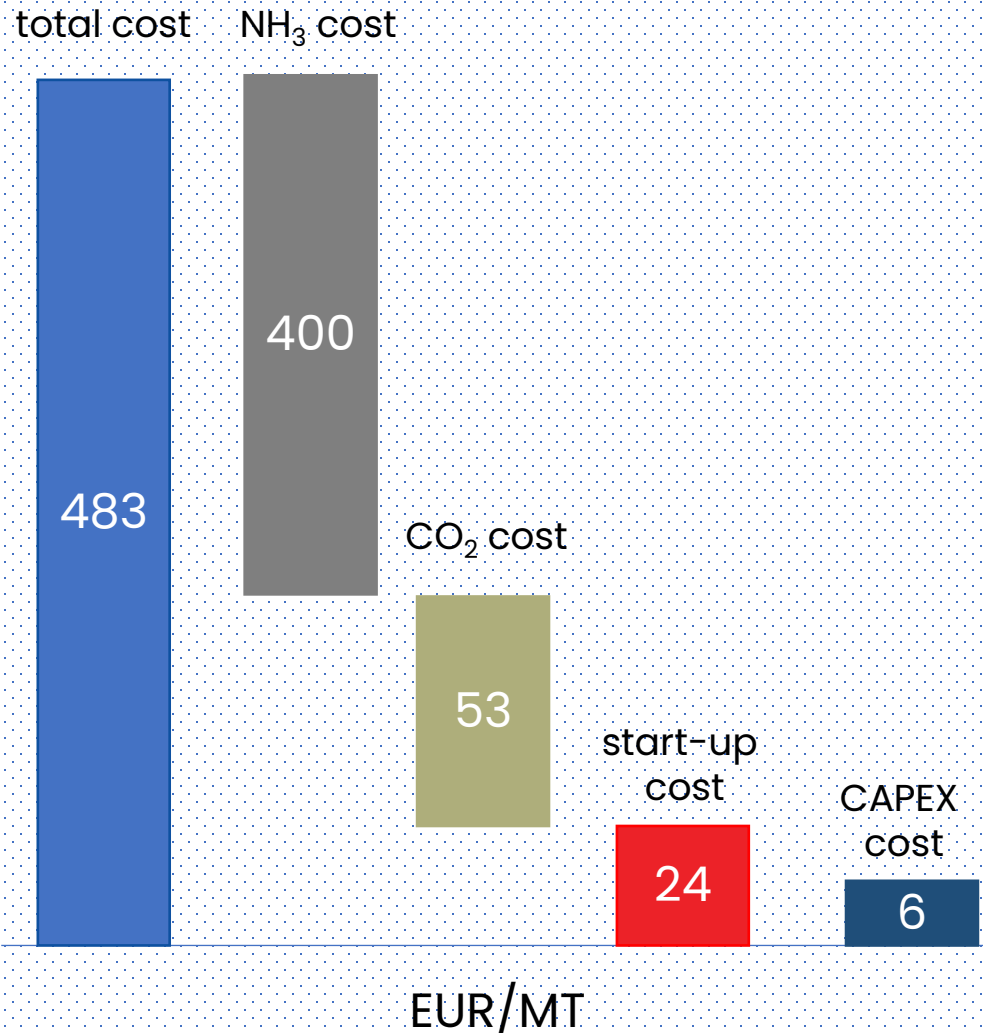




Base Case/as it is + CCS development project



Ammonia Cost Breakdown



Base Case/as it is

+

CCS development project



- Natural gas consumption - 10,856 MWh/MT_{NH₃} at HHV
- EU ETS emission – 0,710 tCO₂e/tNH₃
- Natural gas consumption during planned start-up and shut-down – 34.000 MWh
- Total number of planned shut-downs – four (4) per year
- Total CAPEX for CCS development project – 17,12 mil. EUR
- Mandatory participation of INA Plc. due to concession rights to underground storages and equipment for CO₂ liquafaction

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)



Base case/as it is + CCS development project (sensitivity analysis)

		Ammonia price (€/MT) – Sensitivity analysis – Natural gas & CO ₂ price										
Natural gas price (€/MWh)	100	1.219	1.226	1.233	1.240	1.247	1.254	1.261	1.269	1.276	1.283	1.290
	95	1.161	1.168	1.175	1.182	1.189	1.196	1.203	1.211	1.218	1.225	1.232
	90	1.103	1.110	1.117	1.124	1.131	1.138	1.146	1.153	1.160	1.167	1.174
	85	1.045	1.052	1.060	1.067	1.074	1.081	1.088	1.095	1.102	1.109	1.116
	80	987	994	1.001	1.008	1.015	1.023	1.030	1.037	1.044	1.051	1.058
	75	929	936	943	950	957	965	972	979	986	993	1.000
	70	871	878	885	892	899	907	914	921	928	935	942
	65	813	820	827	834	842	849	856	863	870	877	884
	60	755	762	769	776	784	791	798	805	812	819	826
	55	697	704	711	718	726	733	740	747	754	761	768
	50	639	646	653	661	668	675	682	689	696	703	710
	45	581	588	595	603	610	617	624	631	638	645	652
	40	523	530	537	545	552	559	566	573	580	587	594
	35	466	473	480	487	494	501	508	515	522	529	537
	30	408	415	422	429	436	443	450	457	464	471	479
	25	350	357	364	371	378	385	392	399	406	413	421
	20	292	299	306	313	320	327	334	341	348	355	363
15	234	241	248	255	262	269	276	283	290	297	305	
		50	60	70	80	90	100	110	120	130	140	150
		CO ₂ price (€/t(CO ₂))										



Base case/as it is + CCS development project (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & CO ₂												
Natural gas price (€/MWh)	100	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	95	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	90	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	85	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	80	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	75	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	70	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	65	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	60	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	55	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	50	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	45	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	40	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	35	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	30	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
	25	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54
20	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54	
15	1,79	1,45	1,22	1,06	0,93	0,83	0,75	0,68	0,63	0,58	0,54	
		50	60	70	80	90	100	110	120	130	140	150
CO ₂ price (€/t(CO ₂))												



KBR revamp development projects

FIVE PROJECTS FOR EXECUTION

1

Syngas Compressor (103-J) and its turbine (103-JT) revamp

2

Swapping lean Benfield solution pump turbines (108-JAT/JBT) for motor drives

3

Revamping of synthesis loop from wet to dry, using Syngas Dehydrator proprietary technology

4

Process Air Compressor (101-J) revamp, swapping its turbine (101-JT) for motor drive

5

Revamping CO₂ removal system with low-energy Giammarco-Vetrocoke technology

Feed & Fuel Summary

Natural Gas to Feed	22,067 GJ/MT _{NH3}
Natural Gas to Fuel	12,334 GJ/MT _{NH3}
Power Import	2,187 GJ/MT _{NH3}
HP Steam Export Credit	- 1,708 GJ/MT _{NH3}
MP Steam Export Credit	- 3,466 GJ/MT _{NH3}

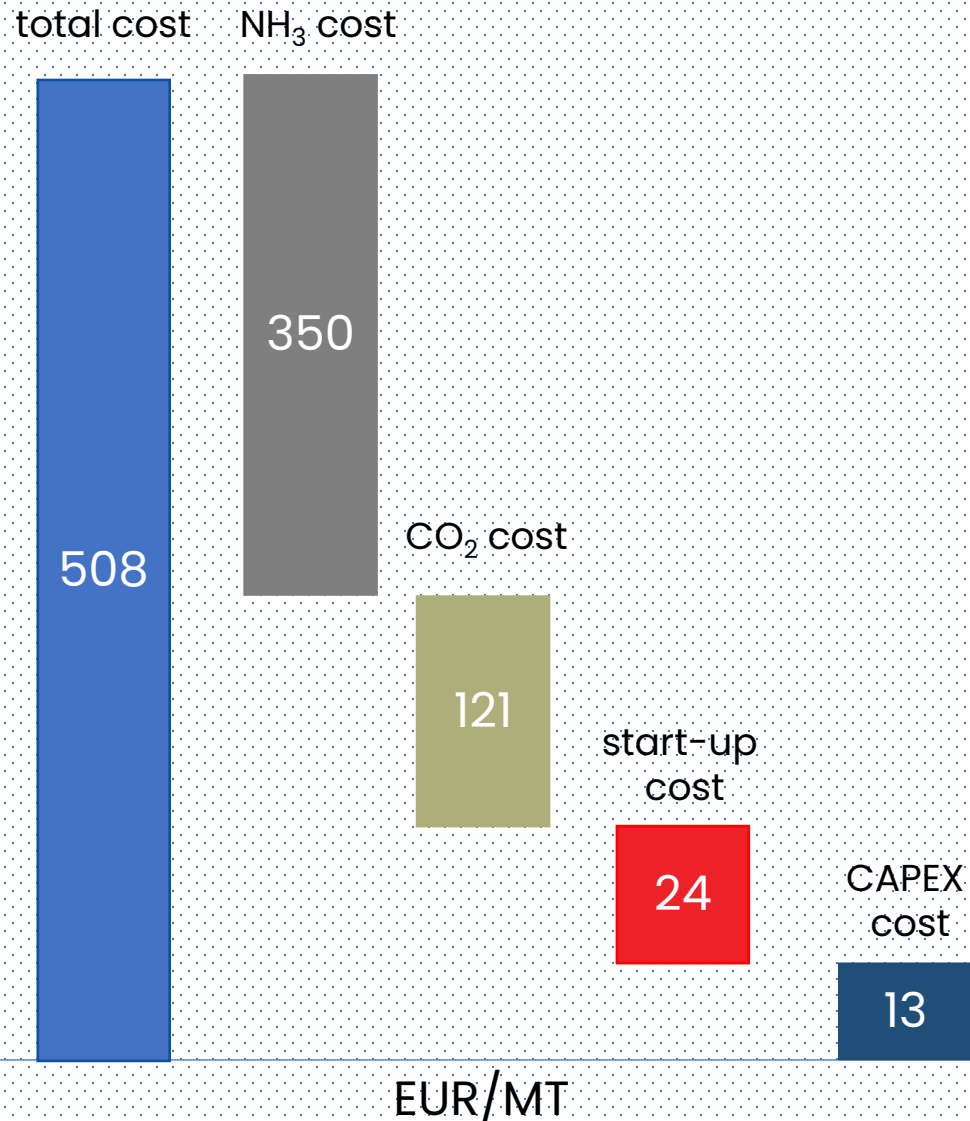
$$\Sigma = 31,413 \text{ GJ/MT}_{\text{NH}_3}$$

CO₂ Summary

Natural Gas to Feed	1,224 MT _{CO2} /MT _{NH3}
Natural Gas to Fuel	0,684 MT _{CO2} /MT _{NH3}
Power Import	0,0 MT _{CO2} /MT _{NH3}
HP Steam Export Credit	- 0,095 MT _{CO2} /MT _{NH3}
MP Steam Export Credit	- 0,192 MT _{CO2} /MT _{NH3}

$$\Sigma = 1,622 \text{ MT}_{\text{CO}_2}/\text{MT}_{\text{NH}_3}$$

Ammonia Cost Breakdown



KBR revamp development projects



- Natural gas consumption - 10,605 MWh/MT_{NH3} at HHV
- HP steam (120 bar) export – 0,997 MT/MT_{NH3}
- MP steam (40 bar) export – 0,452 MT/MT_{NH3} } NG equivalent: 1,430 MWh/MT_{NH3}
- EU ETS emission – 1,622 tCO₂e/tNH₃
- Natural gas consumption during planned start-up and shut-down – 34.000 MWh
- Total number of planned shut-downs – four (4) per year
- Five (5) development CAPEX projects
- Total CAPEX for development projects – 34,4 mil. EUR

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)



KBR revamp development plan (sensitivity analysis)

		Ammonia price (€/MT) – Sensitivity analysis – Natural gas & CO ₂ price										
Natural gas price (€/MWh)	100	1.120	1.136	1.152	1.168	1.185	1.201	1.217	1.233	1.249	1.266	1.282
	95	1.070	1.086	1.102	1.118	1.134	1.151	1.167	1.183	1.199	1.216	1.232
	90	1.019	1.036	1.052	1.068	1.084	1.100	1.117	1.133	1.149	1.165	1.182
	85	970	986	1.002	1.018	1.034	1.051	1.067	1.083	1.099	1.115	1.132
	80	919	935	951	968	984	1.000	1.016	1.032	1.049	1.065	1.081
	75	869	885	901	917	934	950	966	982	999	1.015	1.031
	70	819	835	851	867	883	900	916	932	948	965	981
	65	768	785	801	817	833	849	866	882	898	914	931
	60	718	734	751	767	783	799	816	832	848	864	880
	55	668	684	700	717	733	749	765	782	798	814	830
	50	618	634	650	666	683	699	715	731	748	764	780
	45	568	584	600	616	632	649	665	681	697	714	730
	40	517	534	550	566	582	599	615	631	647	663	680
	35	467	484	500	516	532	549	565	581	597	613	630
	30	417	433	450	466	482	498	515	531	547	563	579
	25	367	383	400	416	432	448	464	481	497	513	529
	20	317	333	349	365	382	398	414	430	447	463	479
15	267	283	299	315	331	348	364	380	396	413	429	
		50	60	70	80	90	100	110	120	130	140	150
		CO ₂ price (€/t(CO ₂))										



KBR revamp development plan (sensitivity analysis)

Ammonia price (€/MT) – Sensitivity analysis – Electricity & CO ₂ price												
CO ₂ price (€/t(CO ₂))	150	618	622	624	627	629	632	634	637	639	642	644
	140	601	606	608	611	613	616	618	621	623	626	628
	130	585	589	592	594	597	599	602	604	607	609	612
	120	569	573	576	578	581	583	586	588	591	593	596
	110	553	557	560	562	565	567	570	572	575	577	580
	100	537	541	543	546	548	551	553	556	558	561	563
	90	520	525	527	530	532	535	537	540	542	545	547
	80	504	508	511	513	516	518	521	523	526	528	531
	70	488	492	495	497	500	502	505	507	510	512	515
	60	472	476	478	481	483	486	488	491	493	496	498
50	456	460	462	465	467	470	472	475	477	480	482	
	5	30	45	60	75	90	105	120	135	150	165	
Electricity price (€/MWh)												



KBR revamp development plan (sensitivity analysis)

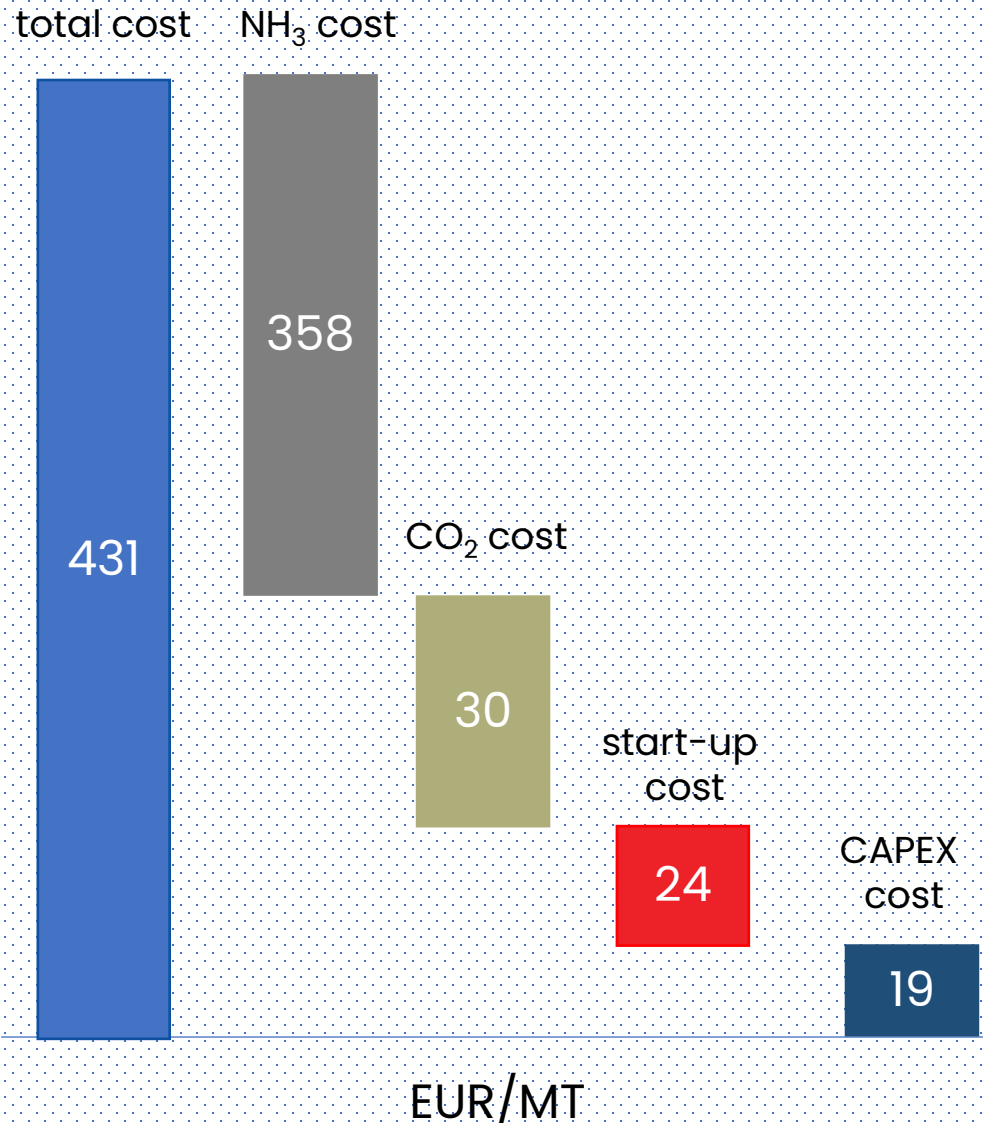
Ammonia price (€/MT) – Sensitivity analysis – Electricity & Natural gas price												
Natural gas price (€/MWh)	100	1.149	1.153	1.155	1.158	1.160	1.163	1.165	1.168	1.170	1.173	1.175
	95	1.098	1.103	1.105	1.108	1.110	1.113	1.115	1.118	1.120	1.123	1.125
	90	1.048	1.052	1.055	1.057	1.060	1.062	1.065	1.067	1.070	1.072	1.075
	85	998	1.003	1.005	1.008	1.010	1.013	1.015	1.018	1.020	1.023	1.025
	80	948	952	954	957	960	962	965	967	970	972	975
	75	898	902	904	907	909	912	914	917	919	922	924
	70	847	852	854	857	859	862	864	867	869	872	874
	65	797	801	804	806	809	811	814	806	819	821	824
	60	747	751	754	756	759	761	764	766	769	771	774
	55	697	701	704	706	709	711	714	716	719	721	724
	50	647	651	653	656	658	661	663	666	668	671	673
	45	596	601	603	606	608	611	613	616	618	621	623
	40	546	550	553	555	558	560	563	565	568	570	573
	35	496	501	503	506	508	511	513	516	518	521	523
	30	446	450	453	455	458	460	463	465	468	470	473
	25	396	400	403	405	408	410	413	415	418	420	423
	20	346	350	352	355	357	360	362	365	367	370	372
15	295	300	302	305	307	310	312	315	317	320	322	
	5	30	45	60	75	90	105	120	135	150	165	
	Electricity price (€/MWh)											



KBR revamp development plan (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & CO ₂												
Natural gas price (€/MWh)	100	1,20	1,17	1,15	1,13	1,11	1,09	1,07	1,05	1,04	1,02	1,00
	95	1,26	1,23	1,21	1,19	1,16	1,14	1,12	1,10	1,08	1,06	1,05
	90	1,33	1,30	1,27	1,25	1,22	1,20	1,18	1,15	1,13	1,11	1,09
	85	1,40	1,37	1,34	1,31	1,29	1,26	1,23	1,21	1,19	1,16	1,14
	80	1,49	1,45	1,42	1,39	1,36	1,33	1,30	1,27	1,25	1,22	1,20
	75	1,59	1,55	1,51	1,47	1,44	1,41	1,37	1,34	1,32	1,29	1,26
	70	1,70	1,65	1,61	1,57	1,53	1,49	1,46	1,42	1,39	1,36	1,33
	65	1,82	1,77	1,72	1,67	1,63	1,59	1,55	1,51	1,47	1,44	1,41
	60	1,97	1,91	1,85	1,80	1,75	1,70	1,65	1,61	1,57	1,53	1,49
	55	2,14	2,07	2,00	1,94	1,88	1,83	1,77	1,72	1,68	1,63	1,59
	50	2,35	2,26	2,18	2,11	2,04	1,97	1,91	1,85	1,80	1,75	1,70
	45	2,60	2,50	2,40	2,31	2,23	2,15	2,07	2,01	1,94	1,88	1,83
	40	2,91	2,78	2,66	2,55	2,45	2,35	2,27	2,19	2,11	2,04	1,98
	35	3,31	3,14	2,99	2,85	2,72	2,61	2,50	2,40	2,31	2,23	2,15
	30	3,83	3,60	3,40	3,22	3,06	2,92	2,79	2,66	2,55	2,45	2,36
25	4,54	4,23	3,95	3,72	3,50	3,31	3,14	2,99	2,85	2,73	2,61	
20	5,58	5,11	4,72	4,38	4,09	3,83	3,61	3,41	3,23	3,07	2,92	
15	7,23	6,47	5,85	5,34	4,91	4,55	4,24	3,96	3,72	3,51	3,32	
		50	60	70	80	90	100	110	120	130	140	150
		CO ₂ price (€/t(CO ₂))										

Ammonia Cost Breakdown



KBR revamp + CCS development projects



- Natural gas consumption – 10,605 MWh/MT_{NH3} at HHV
- HP steam (120 bar) export – 0,997 MT/MT_{NH3}
- MP steam (40 bar) export – 0,452 MT/MT_{NH3} } NG equivalent: 1,430 MWh/MT_{NH3}
- EU ETS emission – 0,40 tCO₂e/tNH₃
- Natural gas consumption during planned start-up and shut-down – 34.000 MWh
- Total number of planned shut-downs – four (4) per year
- Five (5) development CAPEX projects + CCS project
- Total CAPEX for development projects – 51,5 mil. EUR

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)



KBR revamp + CCS development projects (sensitivity analysis)

Ammonia price (€/MT) – Sensitivity analysis – Natural gas & CO ₂ price												
Natural gas price (€/MWh)	100	1.073	1.077	1.081	1.085	1.089	1.093	1.097	1.101	1.105	1.109	1.113
	95	1.023	1.027	1.031	1.035	1.039	1.043	1.047	1.051	1.055	1.059	1.063
	90	973	977	981	985	989	993	997	1.001	1.005	1.009	1.013
	85	923	927	931	935	939	943	947	951	955	959	963
	80	872	876	880	884	888	892	896	900	904	908	912
	75	822	826	830	834	838	842	846	850	854	858	862
	70	772	776	780	784	788	792	796	800	804	808	812
	65	722	726	730	734	738	742	746	750	754	758	762
	60	672	676	680	684	688	692	696	700	704	708	712
	55	621	625	629	633	637	641	645	649	653	657	661
	50	571	575	579	583	587	591	595	599	603	607	611
	45	521	525	529	533	537	541	545	549	553	557	561
	40	471	475	479	483	487	491	495	499	503	507	511
	35	421	425	429	433	437	441	445	449	453	457	461
	30	371	375	379	383	387	391	395	399	403	407	411
	25	321	325	329	333	337	341	345	349	353	357	361
20	270	274	278	282	286	290	294	298	302	306	310	
15	220	224	228	232	236	240	244	248	252	256	260	
		50	60	70	80	90	100	110	120	130	140	150
CO ₂ price (€/t(CO ₂))												



KBR revamp + CCS development projects (sensitivity analysis)

Ammonia price (€/MT) – Sensitivity analysis – Electricity & CO ₂ price												
CO ₂ price (€/t(CO ₂))	150	441	448	452	456	461	465	469	473	477	481	486
	140	437	444	448	452	457	461	465	469	473	477	482
	130	433	440	444	448	453	457	461	465	469	473	478
	120	429	436	440	444	449	453	457	461	465	469	474
	110	425	432	436	440	445	449	453	457	461	465	470
	100	421	428	432	436	441	445	449	453	457	461	466
	90	417	424	428	432	437	441	445	449	453	457	462
	80	413	420	424	428	433	437	441	445	449	453	458
	70	409	416	420	424	429	433	437	441	445	449	454
	60	405	412	416	420	425	429	433	437	441	445	450
50	401	408	412	416	421	425	429	433	437	441	446	
	5	30	45	60	75	90	105	120	135	150	165	
Electricity price (€/MWh)												



KBR revamp + CCS development projects (sensitivity analysis)

Ammonia price (€/MT) – Sensitivity analysis – Electricity & Natural gas price												
Natural gas price (€/MWh)	100	1.064	1.071	1.075	1.079	1.083	1.087	1.091	1.096	1.100	1.104	1.108
	95	1.014	1.020	1.025	1.029	1.033	1.037	1.041	1.045	1.050	1.054	1.058
	90	963	970	974	979	983	987	991	995	999	1.004	1.008
	85	914	920	925	929	933	937	941	945	950	954	958
	80	863	870	874	878	882	887	891	895	899	903	907
	75	813	820	824	828	832	836	840	845	849	853	857
	70	763	770	774	778	782	786	790	794	799	803	807
	65	712	719	724	728	732	736	740	734	748	753	757
	60	662	669	673	677	682	686	690	694	698	702	706
	55	612	619	623	627	631	636	640	644	648	652	656
	50	562	569	573	577	581	585	590	594	598	602	606
	45	512	519	523	527	531	535	539	543	548	552	556
	40	461	468	473	477	481	485	489	493	497	502	506
	35	412	418	423	427	431	435	439	443	448	452	456
	30	361	368	372	377	381	385	389	393	397	401	406
	25	311	318	322	326	331	335	339	343	347	351	355
	20	261	268	272	276	280	284	289	293	297	301	305
15	211	218	222	226	230	234	238	242	247	251	255	
	5	30	45	60	75	90	105	120	135	150	165	
Electricity price (€/MWh)												

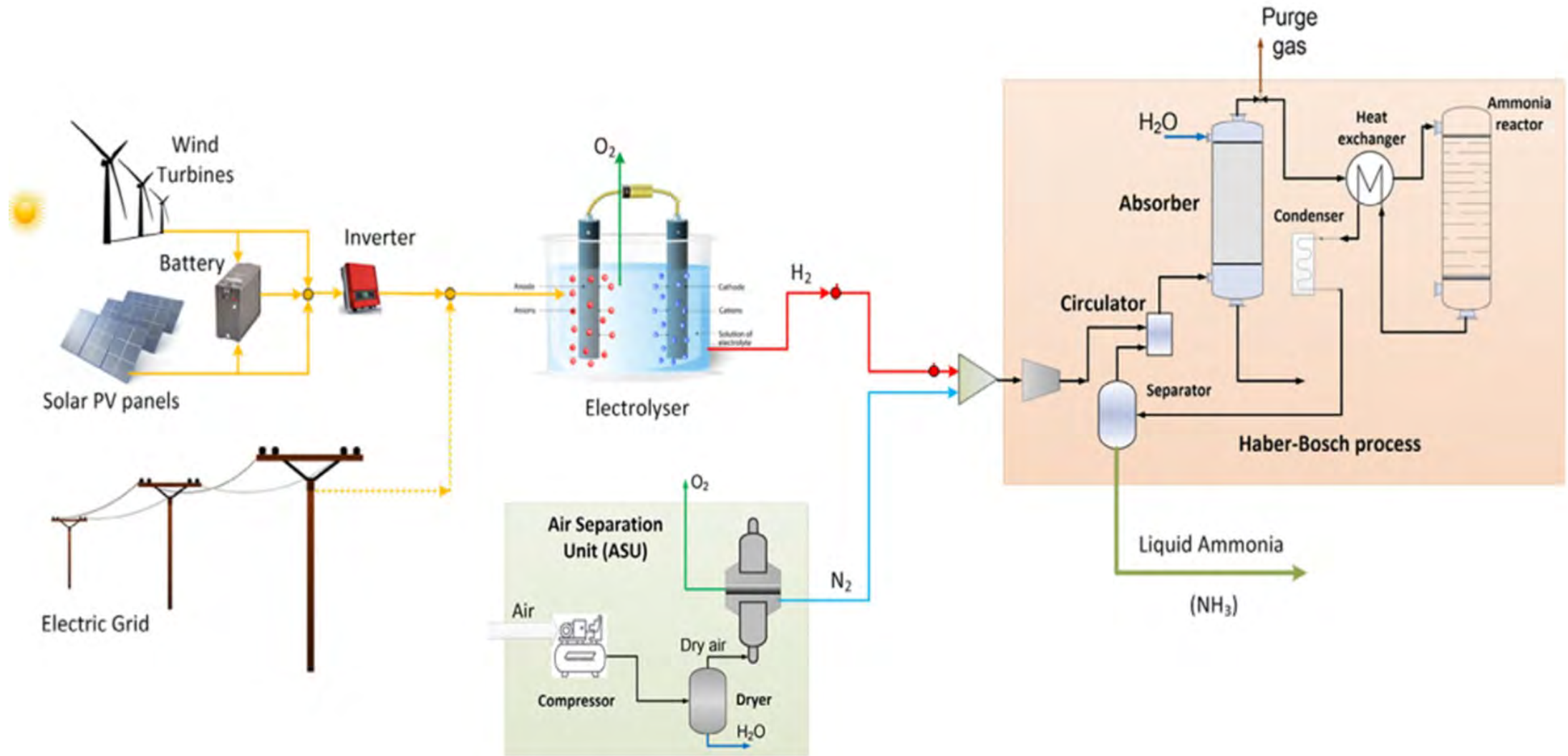


KBR revamp + CCS development projects (sensitivity analysis)

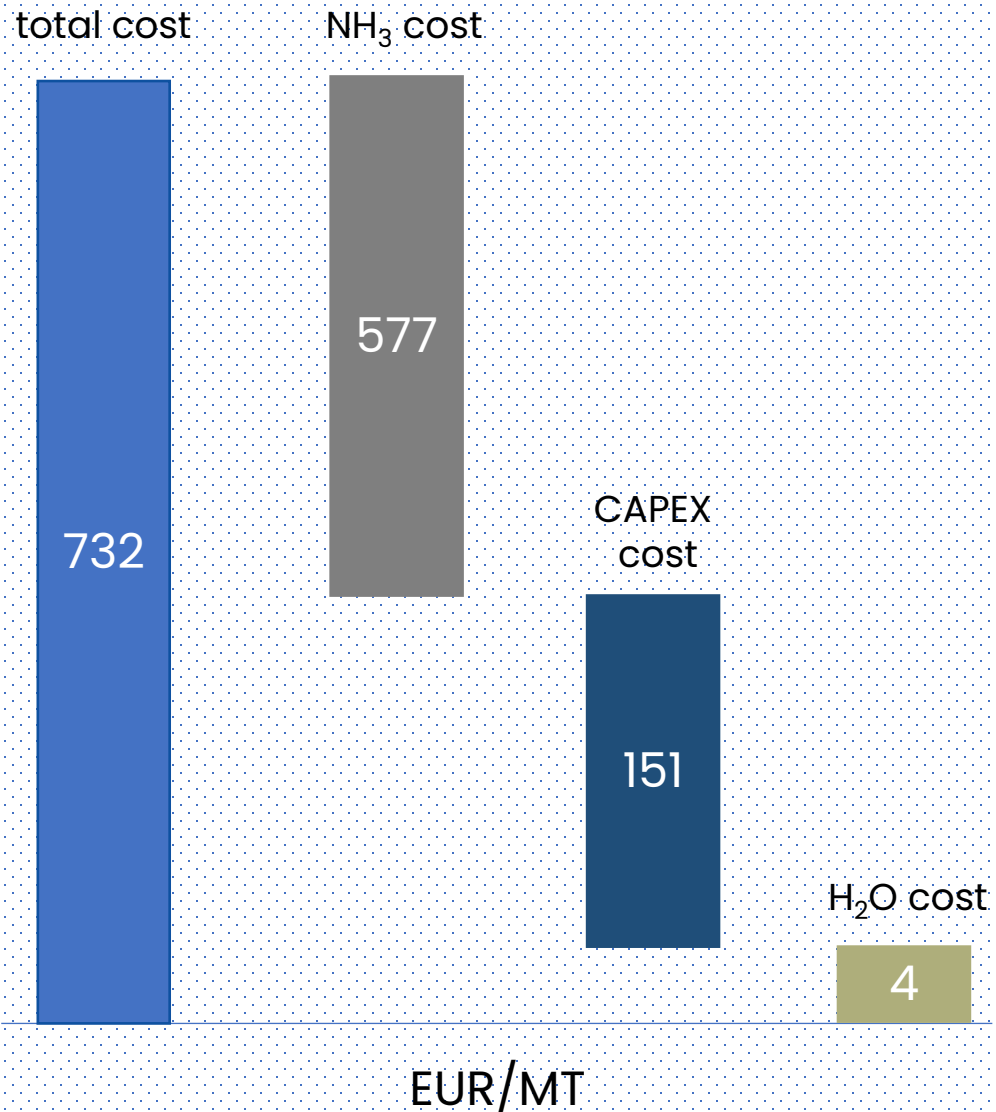
Payback period (year) – Sensitivity analysis – Natural gas & CO ₂												
Natural gas price (€/MWh)	100	1,34	1,25	1,17	1,10	1,04	0,99	0,94	0,89	0,85	0,81	0,78
	95	1,40	1,30	1,21	1,14	1,07	1,01	0,96	0,91	0,87	0,83	0,80
	90	1,45	1,35	1,25	1,17	1,10	1,04	0,99	0,94	0,89	0,85	0,81
	85	1,51	1,40	1,30	1,21	1,14	1,07	1,01	0,96	0,91	0,87	0,83
	80	1,58	1,45	1,35	1,26	1,18	1,11	1,04	0,99	0,94	0,89	0,85
	75	1,65	1,51	1,40	1,30	1,21	1,14	1,07	1,02	0,96	0,91	0,87
	70	1,72	1,58	1,45	1,35	1,26	1,18	1,11	1,04	0,99	0,94	0,89
	65	1,81	1,65	1,51	1,40	1,30	1,22	1,14	1,07	1,02	0,96	0,92
	60	1,90	1,73	1,58	1,46	1,35	1,26	1,18	1,11	1,05	0,99	0,94
	55	2,01	1,81	1,65	1,52	1,40	1,30	1,22	1,14	1,08	1,02	0,96
	50	2,13	1,91	1,73	1,58	1,46	1,35	1,26	1,18	1,11	1,05	0,99
	45	2,26	2,01	1,81	1,65	1,52	1,40	1,30	1,22	1,14	1,08	1,02
	40	2,41	2,13	1,91	1,73	1,58	1,46	1,35	1,26	1,18	1,11	1,05
	35	2,58	2,26	2,01	1,82	1,66	1,52	1,40	1,31	1,22	1,14	1,08
	30	2,77	2,41	2,13	1,91	1,73	1,59	1,46	1,35	1,26	1,18	1,11
	25	3,00	2,58	2,26	2,02	1,82	1,66	1,52	1,41	1,31	1,22	1,15
20	3,27	2,78	2,41	2,14	1,92	1,74	1,59	1,46	1,35	1,26	1,18	
15	3,59	3,00	2,58	2,27	2,02	1,82	1,66	1,52	1,41	1,31	1,22	
		50	60	70	80	90	100	110	120	130	140	150
		CO ₂ price (€/t(CO ₂))										



„Green Ammonia” – mix of PV solar plant and outsourced electrical power - concept



Ammonia Cost Breakdown



„Green Ammonia” – mix of PV solar plant and outsourced electrical power

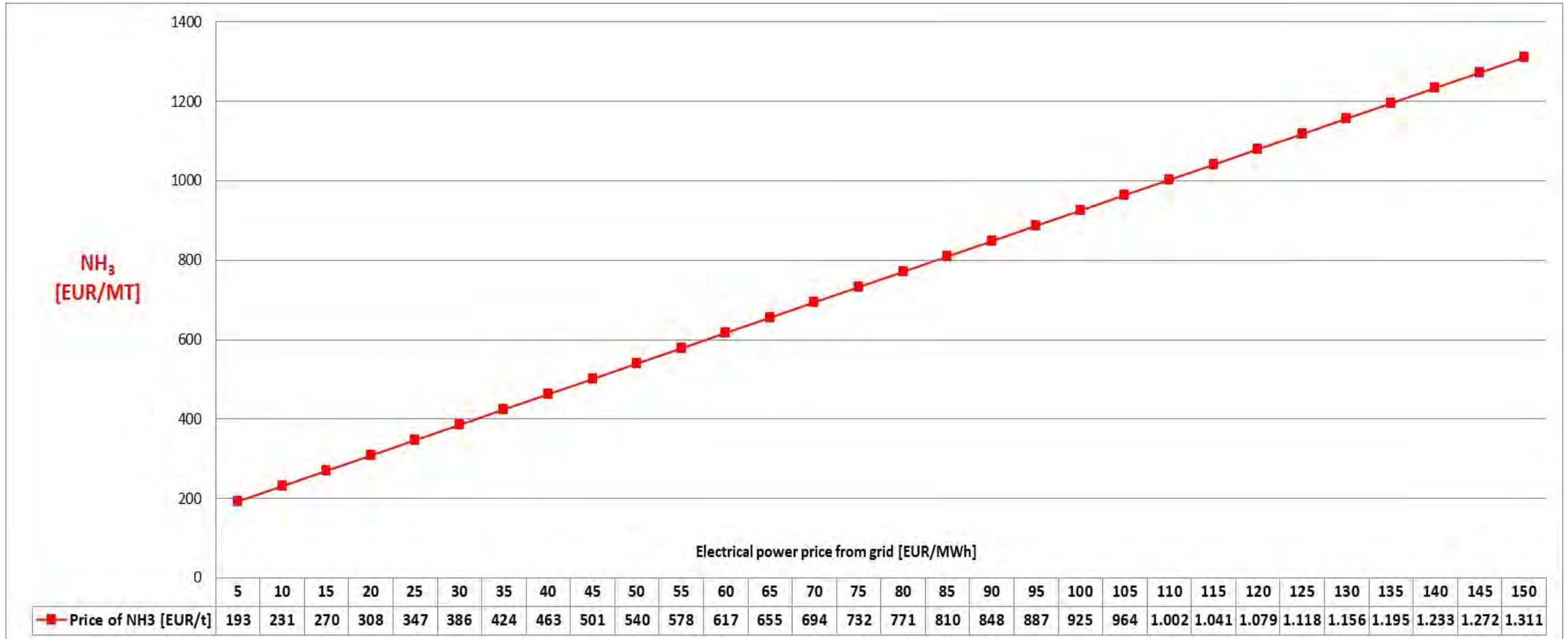


- PV farm – 215 MW (976 MWh/day) – 430 ha surface
- Average sunny hours during the year – 1.500 hours (4,54 hours/day)
- Electrical power from grid – 4.232 MWh/day
- Total consumption of electrical power – 5.208 MWh/day
- Water electrolyser – 220 MW
- Electrical power consumption in water electrolyser – 4,45 kWh/Nm³H₂
- Total CAPEX for development projects – 409,25 mil. EUR (water electrolysis – 198 mil. EUR; ASU – 7 mil. EUR; PV farm – 204,25 mil. EUR)

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)



„Green Ammonia” – mix of PV solar plant and outsourced electrical power (ammonia price vs. electrical power price)





„Green Ammonia” – mix of PV solar plant and outsourced electrical power (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & electricity price

Natural gas price (€/MWh)	100	1,90	2,26	2,56	2,94	3,46	4,21	5,37	7,40	11,90	30,47	-
	95	1,99	2,39	2,72	3,17	3,78	4,68	6,16	9,00	16,67	113,74	-
	90	2,09	2,54	2,91	3,43	4,15	5,28	7,23	11,48	27,82	-	-
	85	2,20	2,70	3,13	3,73	4,62	6,04	8,75	15,85	83,88	-	-
	80	2,32	2,89	3,39	4,10	5,19	7,07	11,08	25,59	-	-	-
	75	2,45	3,10	3,69	4,55	5,93	8,52	15,10	66,44	-	-	-
	70	2,61	3,35	4,05	5,11	6,92	10,71	23,69	-	-	-	-
	65	2,78	3,65	4,49	5,82	8,30	14,42	55,01	-	-	-	-
	60	2,98	4,00	5,03	6,77	10,36	22,06	-	-	-	-	-
	55	3,21	4,42	5,72	8,09	13,79	46,93	-	-	-	-	-
	50	3,48	4,95	6,63	10,03	20,63	-	-	-	-	-	-
	45	3,80	5,62	7,89	13,22	40,92	-	-	-	-	-	-
	40	4,18	6,49	9,73	19,38	2447,58	-	-	-	-	-	-
	35	4,65	7,70	12,70	36,28	-	-	-	-	-	-	-
	30	5,23	9,44	18,27	282,67	-	-	-	-	-	-	-
	25	5,98	12,21	32,58	-	-	-	-	-	-	-	-
	20	6,98	17,28	150,00	-	-	-	-	-	-	-	-
15	8,39	29,56	-	-	-	-	-	-	-	-	-	
		5	30	45	60	75	90	105	120	135	150	165
		Electricity price (€/MWh)										

CAPEX IS GOING IN MINUS – NO ROI



„Green Ammonia” – mix of PV solar plant and outsourced electrical power (sensitivity analysis)

Payback period (year) – Sensitivity analysis – CO ₂ & electricity price												
CO ₂ price (€/t(CO ₂))	150	3,58	5,15	7,00	10,91	24,70	-	-	-	-	-	-
	140	3,69	5,39	7,45	12,03	31,31	-	-	-	-	-	-
	130	3,81	5,65	7,95	13,41	42,74	-	-	-	-	-	-
	120	3,94	5,94	8,53	15,14	67,35	-	-	-	-	-	-
	110	4,08	6,26	9,20	17,40	158,77	-	-	-	-	-	-
	100	4,23	6,61	9,99	20,43	-	-	-	-	-	-	-
	90	4,38	7,00	10,92	24,76	-	-	-	-	-	-	-
	80	4,56	7,45	12,04	31,41	-	-	-	-	-	-	-
	70	4,74	7,96	13,43	42,93	-	-	-	-	-	-	-
	60	4,94	8,54	15,17	67,82	-	-	-	-	-	-	-
	50	5,16	9,21	17,43	161,39	-	-	-	-	-	-	-
	5	30	45	60	75	90	105	120	135	150	165	
Electricity price (€/MWh)												

CAPEX IS GOING IN MINUS – NO ROI



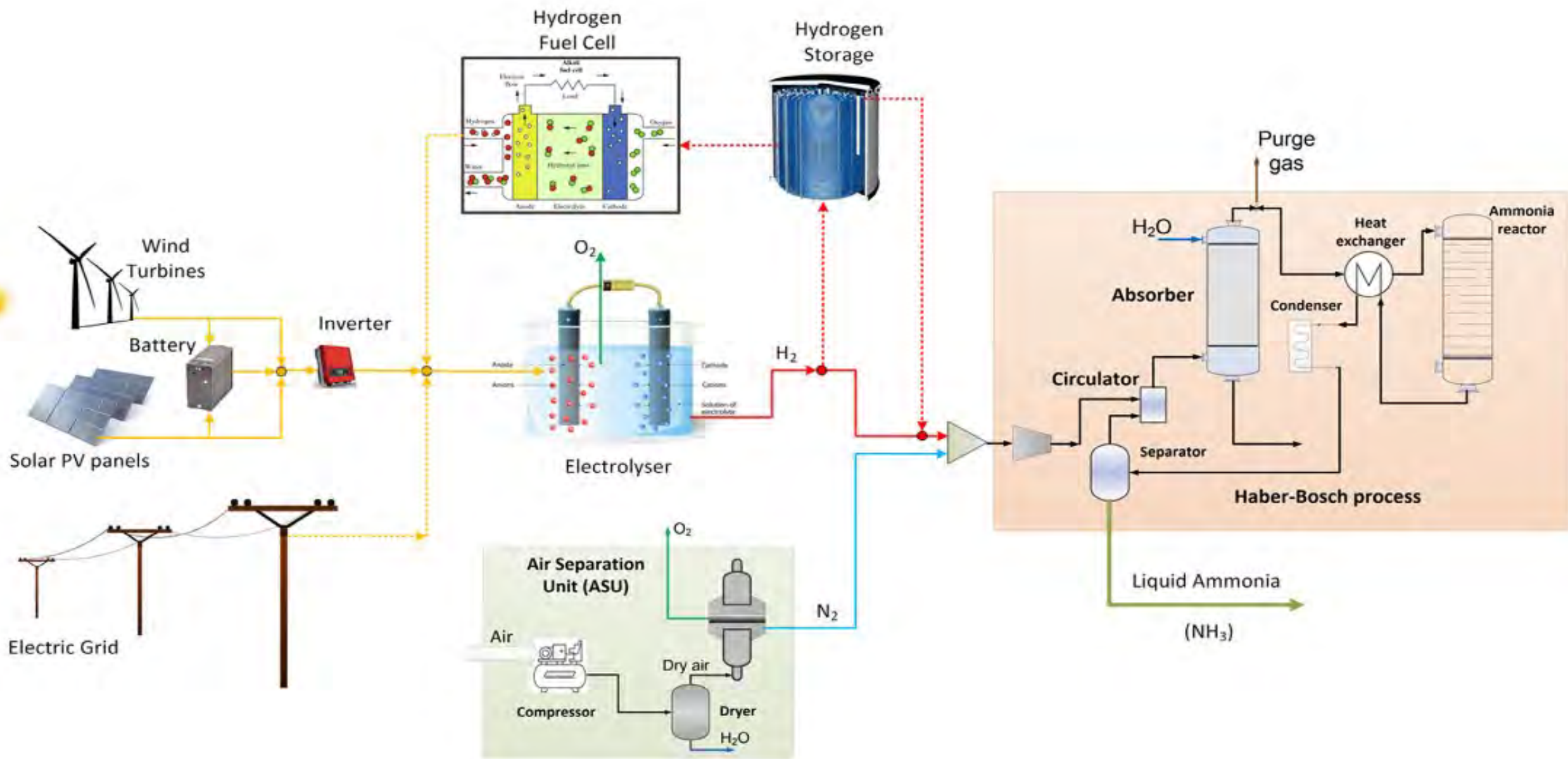
„Green Ammonia” – mix of PV solar plant and outsourced electrical power (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & CO ₂												
Natural gas price (€/MWh)	100	3,74	3,62	3,52	3,41	3,32	3,22	3,14	3,06	2,98	2,90	2,83
	95	4,11	3,97	3,84	3,72	3,60	3,50	3,39	3,30	3,21	3,12	3,04
	90	4,56	4,39	4,23	4,08	3,94	3,82	3,70	3,58	3,48	3,38	3,28
	85	5,12	4,91	4,71	4,53	4,36	4,20	4,06	3,92	3,79	3,67	3,56
	80	5,84	5,56	5,31	5,08	4,87	4,67	4,49	4,33	4,17	4,03	3,89
	75	6,79	6,42	6,09	5,78	5,51	5,26	5,04	4,83	4,64	4,46	4,30
	70	8,12	7,59	7,13	6,72	6,35	6,03	5,73	5,46	5,22	5,00	4,79
	65	10,08	9,28	8,60	8,01	7,50	7,05	6,65	6,29	5,97	5,68	5,42
	60	13,31	11,95	10,84	9,92	9,15	8,48	7,91	7,41	6,97	6,58	6,23
	55	19,56	16,76	14,66	13,03	11,72	10,65	9,76	9,01	8,37	7,81	7,32
	50	36,91	28,05	22,63	18,96	16,32	14,32	12,76	11,50	10,47	9,61	8,88
	45	326,06	86,09	49,59	34,83	26,84	21,83	18,40	15,90	14,00	12,50	11,29
	40	-	-	-	213,55	75,58	45,92	32,97	25,72	21,09	17,87	15,50
	35	-	-	-	-	-	-	158,77	67,35	42,74	31,31	24,70
	30	-	-	-	-	-	-	-	-	-	126,35	60,74
25	-	-	-	-	-	-	-	-	-	-	-	
20	-	-	-	-	-	-	-	-	-	-	-	
15	-	-	-	-	-	-	-	-	-	-	-	
	50	60	70	80	90	100	110	120	130	140	150	
	CO ₂ price (€/t(CO ₂))											

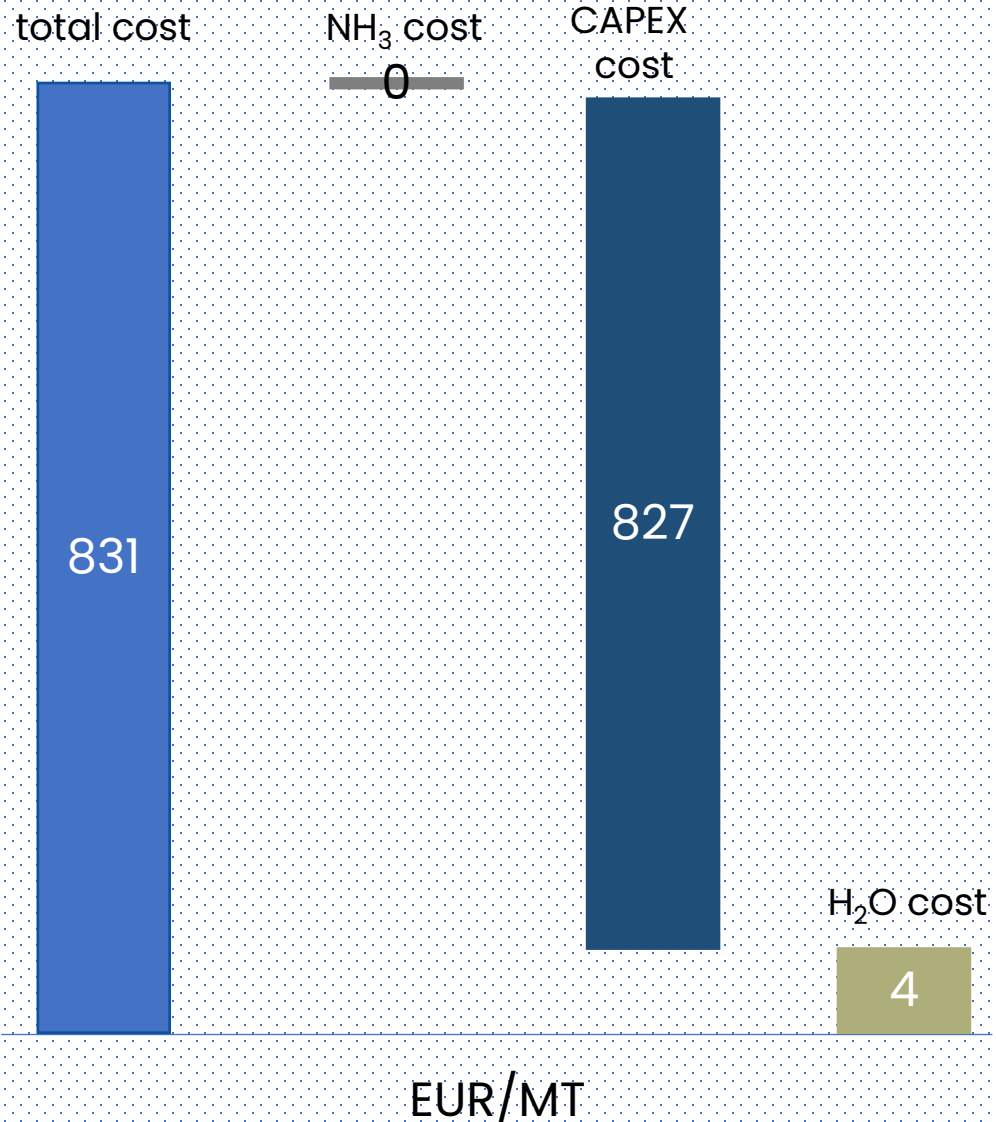
CAPEX IS GOING IN MINUS – NO ROI



„Green Ammonia” – full PV solar plant concept



Ammonia Cost Breakdown



„Green Ammonia” – full PV solar plant



- PV farm – 1.130 MW – 2.260 ha surface
- Average sunny hours during the year – 1.500 hours (4,54 hours/day)
- Battery capacity – 236 MW
- Water electrolyser – 1.100 MW
- H₂ storage – 100 t
- Electrical power consumption in water electrolyser – 4,45 kWh/Nm³H₂
- Total CAPEX for development projects – 2.247 mil. EUR (water electrolysis – 990 mil. EUR; ASU – 7 mil. EUR; PV farm – 1.073 mil. EUR; battery capacity – 141,60 mil. EUR; H₂ storage – 35 mil. EUR)

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)



„Green Ammonia” – full PV solar plant (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & electricity price												
Natural gas price (€/MWh)	100	10,08	10,08	10,07	10,07	10,07	10,07	10,07	10,07	10,06	10,06	10,06
	95	10,55	10,54	10,54	10,54	10,54	10,53	10,53	10,53	10,53	10,53	10,52
	90	11,06	11,05	11,05	11,05	11,04	11,04	11,04	11,04	11,04	11,03	11,03
	85	11,62	11,61	11,61	11,61	11,61	11,60	11,60	11,60	11,60	11,59	11,59
	80	12,24	12,23	12,23	12,23	12,23	12,22	12,22	12,22	12,22	12,21	12,21
	75	12,93	12,93	12,92	12,92	12,92	12,92	12,91	12,91	12,91	12,90	12,90
	70	13,71	13,70	13,70	13,70	13,69	13,69	13,69	13,68	13,68	13,68	13,67
	65	14,58	14,58	14,57	14,57	14,56	14,56	14,56	14,55	14,55	14,55	14,54
	60	15,58	15,57	15,57	15,56	15,56	15,55	15,55	15,54	15,54	15,53	15,53
	55	16,72	16,71	16,70	16,70	16,69	16,69	16,68	16,68	16,67	16,67	16,66
	50	18,04	18,03	18,02	18,01	18,01	18,00	18,00	17,99	17,98	17,98	17,97
	45	19,58	19,57	19,56	19,56	19,55	19,54	19,54	19,53	19,52	19,51	19,51
	40	21,42	21,40	21,39	21,39	21,38	21,37	21,36	21,35	21,34	21,34	21,33
	35	23,63	23,61	23,60	23,59	23,58	23,57	23,56	23,55	23,54	23,53	23,52
	30	26,36	26,34	26,32	26,31	26,30	26,29	26,27	26,26	26,25	26,24	26,22
25	29,79	29,77	29,75	29,74	29,72	29,70	29,69	29,67	29,66	29,64	29,62	
20	34,26	34,23	34,20	34,18	34,16	34,14	34,12	34,10	34,08	34,06	34,04	
15	40,30	40,26	40,23	40,20	40,17	40,14	40,11	40,08	40,05	40,02	39,99	
		5	30	45	60	75	90	105	120	135	150	165
		Electricity price (€/MWh)										



„Green Ammonia” – full PV solar plant (sensitivity analysis)

Payback period (year) – Sensitivity analysis – CO ₂ & electricity price												
CO ₂ price (€/t(CO ₂))	150	18,52	18,51	18,50	18,50	18,49	18,49	18,48	18,47	18,47	18,46	18,45
	140	19,07	19,06	19,05	19,05	19,04	19,03	19,03	19,02	19,01	19,01	19,00
	130	19,65	19,64	19,64	19,63	19,62	19,61	19,61	19,60	19,59	19,59	19,58
	120	20,27	20,26	20,26	20,25	20,24	20,23	20,23	20,22	20,21	20,20	20,20
	110	20,94	20,92	20,91	20,91	20,90	20,89	20,88	20,87	20,87	20,86	20,85
	100	21,64	21,63	21,62	21,61	21,60	21,59	21,58	21,58	21,57	21,56	21,55
	90	22,40	22,38	22,37	22,36	22,35	22,34	22,34	22,33	22,32	22,31	22,30
	80	23,20	23,19	23,18	23,17	23,16	23,15	23,14	23,13	23,12	23,11	23,10
	70	24,07	24,06	24,05	24,04	24,03	24,02	24,00	23,99	23,98	23,97	23,96
	60	25,01	24,99	24,98	24,97	24,96	24,95	24,94	24,93	24,91	24,90	24,89
	50	26,03	26,00	25,99	25,98	25,97	25,96	25,94	25,93	25,92	25,91	25,89
	5	30	45	60	75	90	105	120	135	150	165	
Electricity price (€/MWh)												



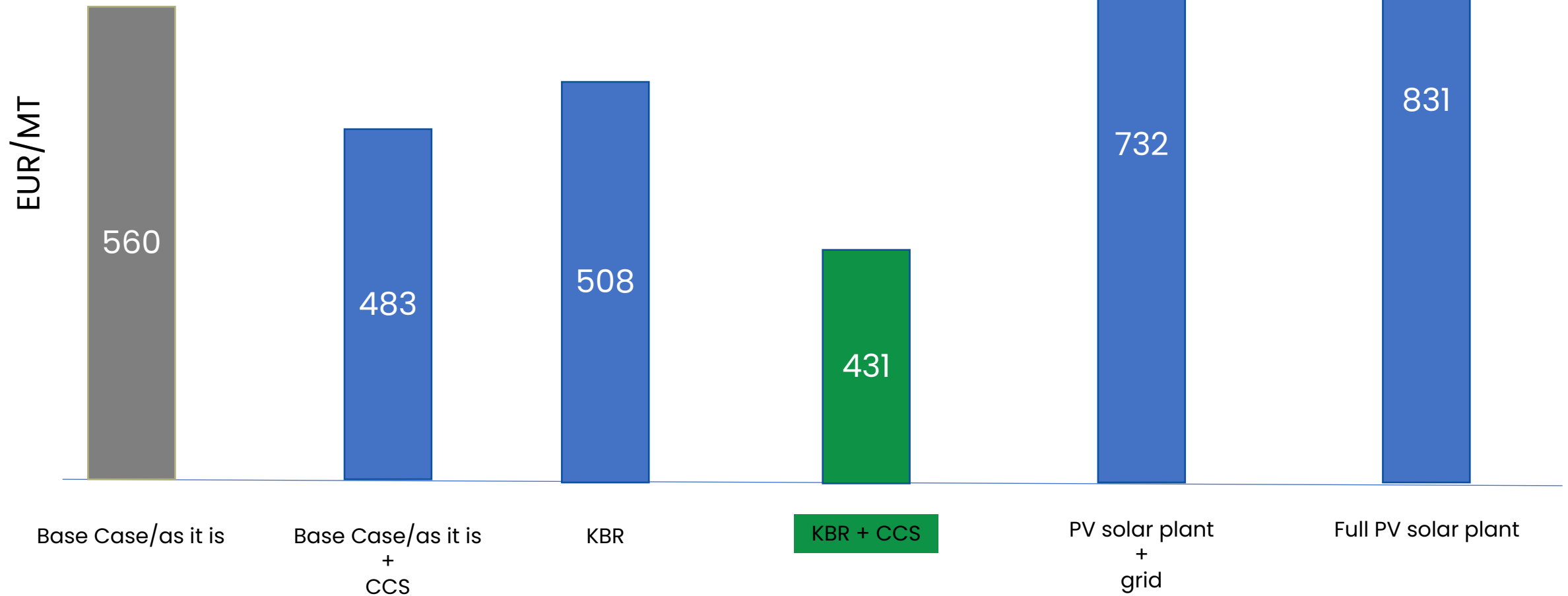
„Green Ammonia” – full PV solar plant (sensitivity analysis)

Payback period (year) – Sensitivity analysis – Natural gas & CO ₂												
Natural gas price (€/MWh)	100	10,48	10,31	10,15	9,99	9,84	9,69	9,55	9,41	9,27	9,14	9,01
	95	10,99	10,80	10,62	10,45	10,28	10,12	9,96	9,81	9,66	9,52	9,38
	90	11,54	11,34	11,14	10,95	10,77	10,59	10,42	10,25	10,09	9,93	9,78
	85	12,15	11,93	11,71	11,50	11,30	11,10	10,92	10,73	10,56	10,39	10,22
	80	12,84	12,59	12,34	12,11	11,89	11,67	11,46	11,26	11,07	10,88	10,70
	75	13,60	13,32	13,05	12,79	12,54	12,30	12,07	11,85	11,63	11,42	11,22
	70	14,46	14,14	13,84	13,55	13,27	13,00	12,74	12,49	12,26	12,03	11,80
	65	15,44	15,08	14,73	14,40	14,09	13,78	13,49	13,22	12,95	12,69	12,45
	60	16,56	16,14	15,75	15,37	15,01	14,67	14,34	14,03	13,73	13,44	13,17
	55	17,85	17,37	16,91	16,48	16,07	15,67	15,30	14,95	14,61	14,28	13,97
	50	19,37	18,80	18,26	17,76	17,28	16,83	16,40	15,99	15,60	15,23	14,88
	45	21,16	20,48	19,85	19,26	18,70	18,17	17,67	17,19	16,75	16,32	15,92
	40	23,32	22,50	21,74	21,03	20,36	19,74	19,15	18,59	18,07	17,58	17,11
	35	25,97	24,96	24,03	23,16	22,35	21,60	20,90	20,24	19,62	19,04	18,49
	30	29,30	28,02	26,85	25,77	24,78	23,86	23,00	22,21	21,47	20,77	20,12
	25	33,61	31,94	30,42	29,05	27,79	26,64	25,58	24,60	23,69	22,85	22,06
20	39,40	37,12	35,10	33,28	31,64	30,15	28,80	27,56	26,43	25,39	24,42	
15	47,61	44,33	41,46	38,95	36,72	34,74	32,95	31,35	29,89	28,56	27,34	
	50	60	70	80	90	100	110	120	130	140	150	
CO ₂ price (€/t(CO ₂))												



Summary – ammonia prices

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)

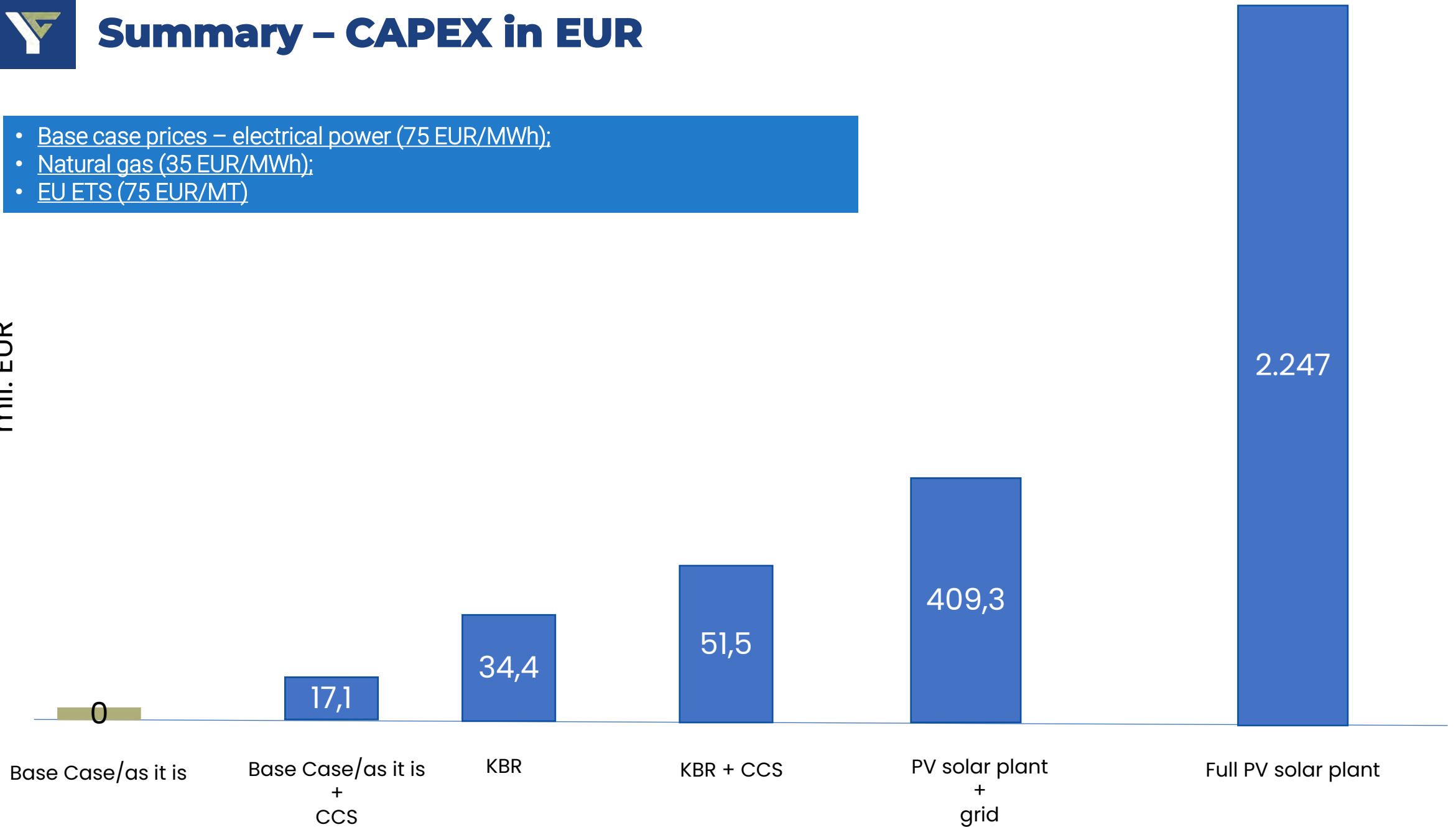




Summary – CAPEX in EUR

- Base case prices – electrical power (75 EUR/MWh);
- Natural gas (35 EUR/MWh);
- EU ETS (75 EUR/MT)

mil. EUR





Conclusion

- Base Case/as it is do not provide sustainable solution due to upcoming CBAM directive
- Base Case/as it is + CCS project significantly reduce the price of ammonia but depends about INA support
- Standalone KBR projects give some space but without longer sustainability
- KBR + CCS gives the maximum reduction in ammonia price but depends about INA support
- Both „Green Ammonia” projects from financial point of view without significant Government subsidy do not have any commercial justification

In order to achieve resilience against import activities and achieve sustainability the best approach is step-by-step investment plan which will consist of combination of KBR + CCS projects together with construction of import/export terminal at Adriatic Sea coast.

Total CAPEX cost for this combination is cca. 100 mil. EUR with the time window of five (5) years for final implementation



THANK YOU