Reference WBS: R14677

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BALDER Crude Oil
Quality evaluation
December 2021 Update

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REVISOR

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SUMMARY AND CONCLUSION

A quality evaluation of North Sea production, Balder crude, and a quality comparison of this crude with various reference crudes has been requested, for marketing purposes, by Var Energi.

Main chemical-physical parameters of analysed Balder sample, received on end December 2021, are reported in Tab.1

Tab.1	BALDER Refining Characteristics
	Production Country: NORWAY
Whole crude	The crude, 26,5°API, 0,59 %m/m S, is Low Sulfur, Medium Heavy, Naphtenic. Acidity is high.
	It gives 45,7 %m/m yield in fractions until 370°C and 74,9 %m/m yield in fractions until 530°C
	Main fractions slate:
	• **C5-160 Light Distillates**: 10,7 %m/m
	• **160-370 Middle Distillates**: 34,4 %m/m
	• **370-530 Vacuum Distillates**: 29,2 %m/m
	• **370+ Atmospheric Resid**: 54,3 %m/m
Light distillates	**80-160°C heavy naphtha fraction** yield is 8,3 %m/m, 77,6 %m/m of C5-160 light distillates.
	80-160°C heavy naphtha (N+2A = 74,9 %v/v), is a good feedstock to catalytic reforming for gasoline production.
Middle distillates	**160-230°C kero cut**: fraction yield is 7,54 %m/m, 21,9 %m/m of 160-370 middle distillates. Poor combustion properties (smoke point), and good cold properties (freezing point)
	230-370°C atmospheric gasoil cut: fraction yield is 26,87 %m/m, 78,1 %m/m of 160-370 middle distillates. Poor combustion properties (cetane index), and good cold properties (cloud point and pour point). Acidity is medium
Vacuum distillates	**370-530° vacuum distillate cut**: high sulfur, very high acidity content. UOP K factor = 11,6, resulting in mediocre feedstock for catalytic cracker or hydrocracker
Vacuum resid	**530+°C vacuum resid**: Ni+V metal content = 58 ppm; low asphaltene content

Balder crude assay summary table is reported in APPENDIX 1

BALDER shows similarities with LS medium heavy acid crudes from North Sea, (Johan Sverdrup, Grane blend) and West Africa (Mondo, Bonga, Djeno, Emeraude). Other comparisons can be made with medium density HS crudes (e.g. Foinaven, Schiehallion) taking into account differences in terms of acidity content.

In comparison with previous reference crude quality (September 2021) 29.1°API, 0.53 %m/m S, the actual quality is heavier, and shows an increase in resid yields: +5.8 %m/m 370+°C resid yield, with a consequent yield decrease in distillates, in 80-160°C heavy naphtha cut (-1.5 pts. %m/m) and 160-370°C middle distillates: 160-230°C kerosine (-1.3 pts %m/m) and 230-370°C gasoil cut (-2.7 pts. %m/m).

INTRODUCTION AND SCOPE OF WORK

A quality evaluation of North Sea production, Balder crude, has been requested by Var Energi.

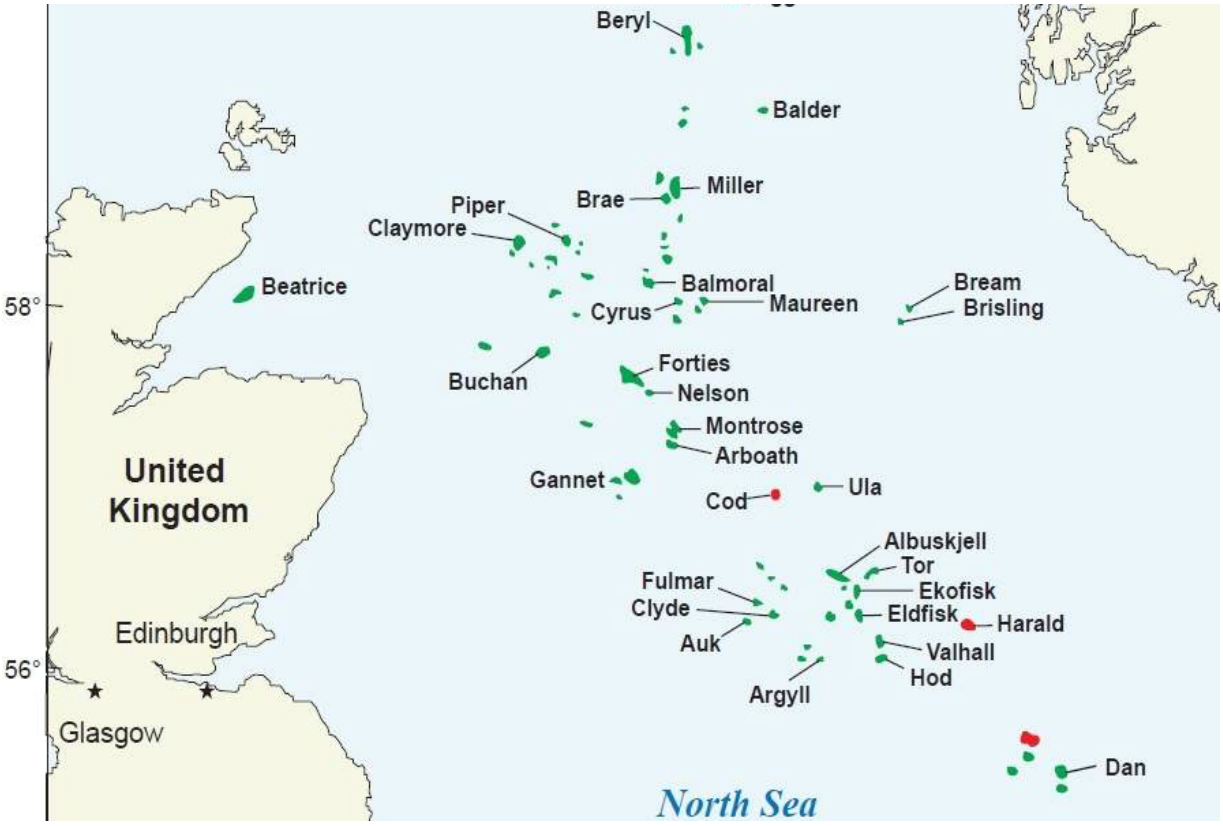


Fig.1 - OCTP Location Map

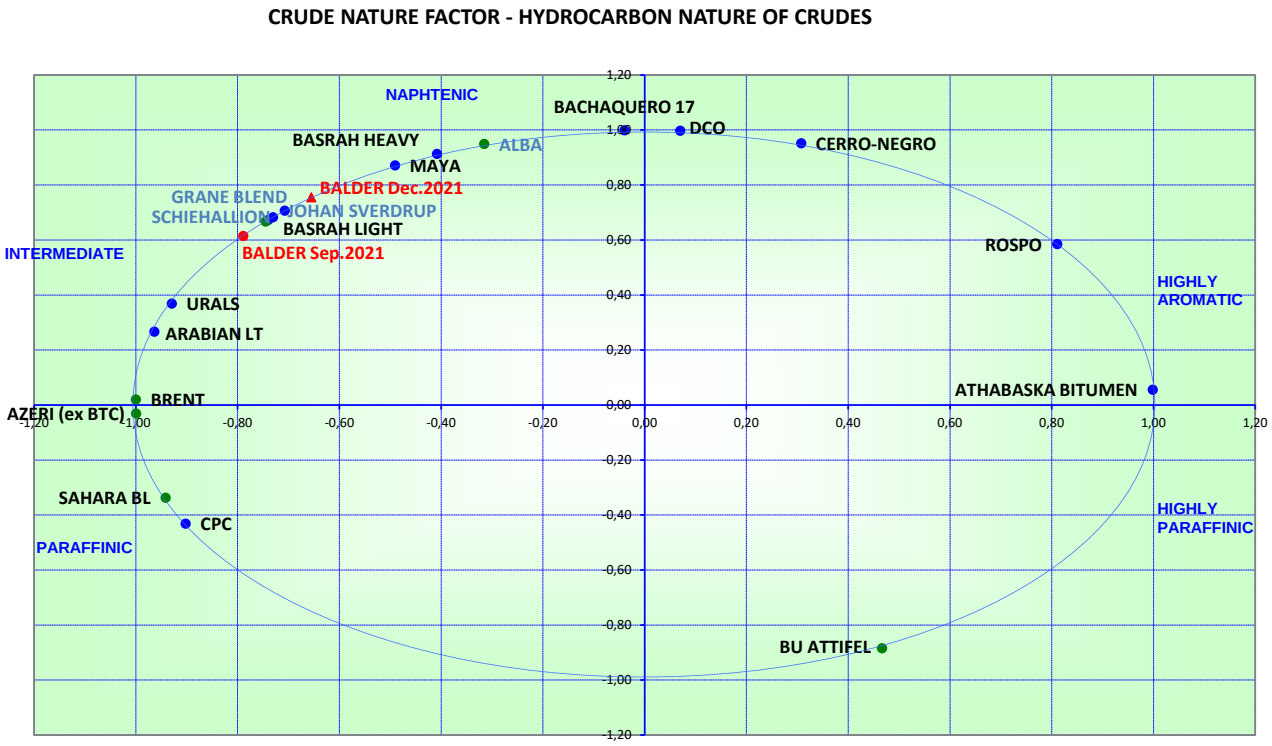
In this report results of evaluation are reported.

QUALITY OF BALDER CRUDE OIL

BALDER, 26,5°API, 0.59 %m/m S, is a medium density, low sulphur, naphtenic crude with high acidity and a low content in mercaptan compounds.

In Fig.2 a comparison of BALDER hydrocarbon nature (paraffinic, naphtenic, aromatic) with other reference crudes is reported.

Fig.2



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SIMILARITY OF BALDER CRUDE WITH OTHER REFERENCE CRUDES

Quality has been compared, in order to verify its similarity (from their hydrocarbon nature point of view) with other crudes, by mean of a similarity analysis tool for supporting preliminary crudes evaluations/selections, built at eni DOW R&D laboratories in San Donato Milanese.

Global similarity index (from 1 to 7) gives an indication about the quality nearness of a crude to other to be compared: the lower the value the higher the similarity.

Analysis has been performed on crudes from various areas.

Output values with similarity between 1 and 3 are reported in Tab.2.

BALDER shows similarities with LS medium heavy acid crudes from North Sea, (Johan Sverdrup, Grane blend) and West Africa (Mondo, Bonga, Djeno, Emeraude). Other comparisons can be made with medium density HS crudes (e.g. Foinaven, Schiehallion) taking into account differences in terms of acidity content.

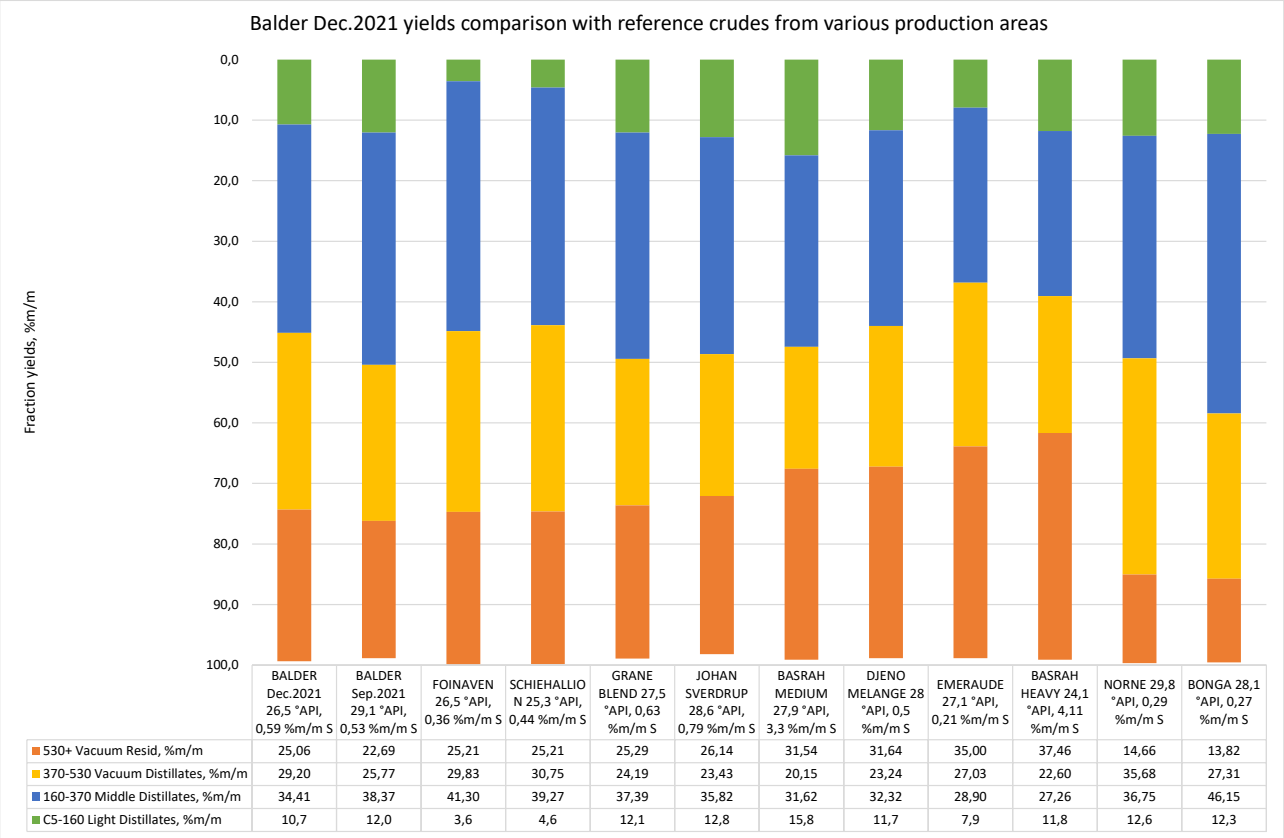
Output values with similarity between 1 and 3 are reported in Tab.2.

Tab.2 – Similarity of BALDER with other crudes

Global Similarity	Country	Crude	API	S, %m/m	RSH, ppm	Viscosity @ 20°C, cSt	Pour P., °C	TAN, mg KOH/g	Ni, ppm	V, ppm	n-C7 Asphaltenes, %m/m	CCR, %m/m
1 *(Rif)*	NORWAY	BALDER Dec.2021	**26,5**	0,59	9	34,38	-6	1,35	3,89	10,69	0,63	3,78
1	UNITED KINGDOM	FOINAVEN	**26,5**	0,36	7	57,92	9	0,27	3,88	5,82	0,22	2,13
2	NORWAY	GRANE BLEND	**27,5**	0,63	15	28,17	0	1,18	3,96	13,19	0,84	4,16
2	NORWAY	JOHAN SVERDRUP	**28,6**	0,79	25	21,30	0	0,55	4,52	14,01	1,98	5,14
2	UNITED KINGDOM	SCHIEHALLION	**25,3**	0,44	9	67,45	12	0,37	5,93	7,91	0,44	3,21
3	SAUDI ARABIA	ARABIAN HEAVY	**26,7**	3,05	142	35,09	<-36	0,15	13,79	44,93	3,88	8,72
3	IRAQ	BASRAH MEDIUM	**28,4**	3,28	99	21,88	<-36	0,21	14,17	52,90	2,88	7,38
3	COLOMBIA	VASCONIA	**24,3**	1,02	13	66,11	<-36	0,32	44,48	199,66	6,13	9,52
3	KUWAIT	KHAFJI	**27,2**	2,88	65	37,41	-30	0,51	17,67	53,53	4,05	8,41
3	NORWAY	NORNE	**29,8**	0,29	6	17,64	-6	0,20	2,59	2,16	0,48	1,89
3	VENEZUELA	MESA FURRIAL BLEND	**29,7**	1,05	17	18,58	-18	0,03	11,50	46,44	2,20	5,50
3	ANGOLA	MONDO	**29,9**	0,39	3	19,32	<-36	0,75	24,00	6,98	1,63	5,47
3	NIGERIA	BONGA	**27,6**	0,26	5	14,54	<-36	0,66	3,77	0,63	0,09	1,40
3	CONGO	DJENO MELANGE	**28,0**	0,50	173	45,88	-21	0,86	41,41	21,46	1,40	5,45
3	CONGO	EMERAUDE	**27,1**	0,21	341	103,40	3	0,95	25,76	< 2	0,90	5,52
3	ARGENTINA	CANADON SECO	**25,9**	0,15	0	277,70	-3	0,49	1,70	1,70	1,74	7,47

Yields comparison of Balder Dec.2021 with Balder Sep.2021 and reference crudes is reported in Fig.3

Fig.3

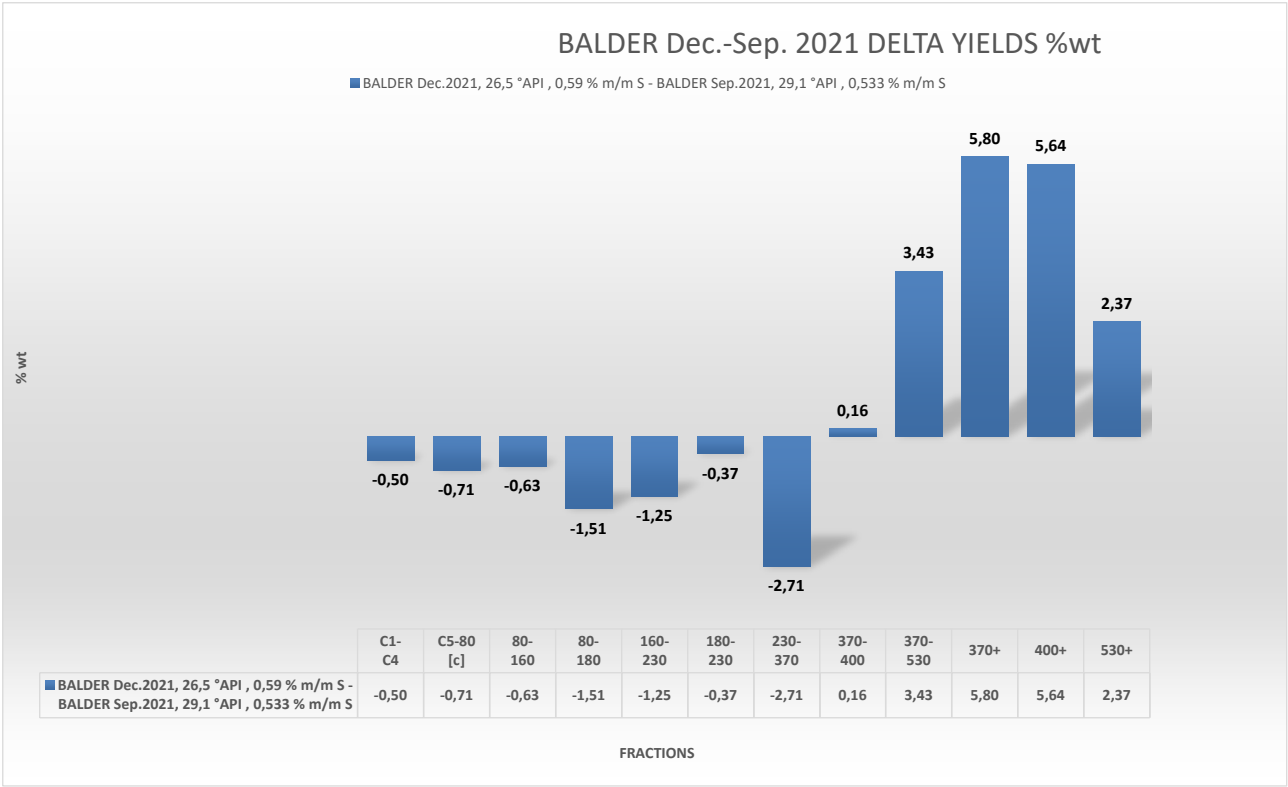


	BALDER Dec.2021 26,5 °API, 0,59 %m/m S	BALDER Sep.2021 29,1 °API, 0,53 %m/m S	FOINAVEN 26,5 °API, 0,36 %m/m S	SCHIEHALLION 25,3 °API, 0,44 %m/m S	GRANE BLEND 27,5 °API, 0,63 %m/m S	JOHAN SVERDRUP 28,6 °API, 0,79 %m/m S	BASRAH MEDIUM 27,9 °API, 3,3 %m/m S	DJENO MELANGE 28 °API, 0,5 %m/m S	EMERAUDE 27,1 °API, 0,21 %m/m S	BASRAH HEAVY 24,1 °API, 4,11 %m/m S	NORNE 29,8 °API, 0,29 %m/m S	BONGA 28,1 °API, 0,27 %m/m S
530+ Vacuum Resid, %m/m	25,06	22,69	25,21	25,21	25,29	26,14	31,54	31,64	35,00	37,46	14,66	13,82
370-530 Vacuum Distillates, %m/m	29,20	25,77	29,83	30,75	24,19	23,43	20,15	23,24	27,03	22,60	35,68	27,31
160-370 Middle Distillates, %m/m	34,41	38,37	41,30	39,27	37,39	35,82	31,62	32,32	28,90	27,26	36,75	46,15
C5-160 Light Distillates, %m/m	10,7	12,0	3,6	4,6	12,1	12,8	15,8	11,7	7,9	11,8	12,6	12,3

Comparison with previous crude assay

In comparison with previous reference crude quality (September 2021) 29.1°API, 0.53 %m/m S, the actual quality is heavier, and shows an increase in resid yields: +5.8 %m/m 370+°C resid yield, with a consequent yield decrease in distillates, in 80-160°C heavy naphtha cut (-1.5 pts. %m/m) and 160-370°C middle distillates: 160-230°C kerosine (-1.3 pts %m/m) and 230-370°C gasoil cut (-2.7 pts. %m/m). (Fig.4).

Fig.4 -



APPENDIX 1 – EXPERIMENTAL DATA

		CRUDE OIL	YIELDS AND CHARACTERISTICS OF PRODUCTS											
			GAS	NAPHTHAS			KEROSENES		GASOILS		V.DIST	RESIDUES		
TBP Range :			C1-C4	C5-80 [c]	80-160	80-180	160-230	180-230	230-370	370-400	370-530	370+	400+	530+
TBP Yield	%m/m		0,62	2,43	8,28	9,80	7,54	6,02	26,87	5,69	29,20	54,26	48,57	25,06
TBP Yield	%v/v		1,01	3,20	9,69	11,39	8,22	6,52	27,55	5,62	28,12	50,40	44,79	22,29
Density @15°C	Kg/l	0,8954	0,5502	0,6801	0,7651	0,7706	0,8215	0,8267	0,8732	0,9072	0,9298	0,9639	0,9710	1,0069
API Gravity @ 60°F		26,5												
Viscosity @ 20°C	mm²/s	34,38												
Viscosity @ 50°C	VBN						3,31	4,56	16,08	24,76	31,19	38,47	40,08	46,96
Sulphur	%m/m	0,59		0,0003	0,0026	0,0043	0,0236	0,0262	0,26	0,54	0,66	0,97	1,02	1,33
Mercaptan Sulphur	ppm	9						3						
Hydrogen Sulphide	%m/m	<1												
Acidity	mgKOH/g	1,35					0,02	0,03	0,50	1,65	1,84			
Paraffins	%v/v			74,2	40,7	42,8								
Naphthenes	%v/v			24,3	43,8	40,7								
Aromatics	%v/v			1,5	15,5	16,6	23,9	24,2						
N+2A				27,3	74,9	73,9								
Smoke Pt.	mm						23	22						
Freezing Pt.	°C						-68	-64						
Cloud Pt.	°C								-14	+15				
Pour Pt.	°C	-6							-15	+12		+18	+21	+51
Cetane Index									46,3	58,7				
Total Nitrogen	%m/m									452	0,11	0,36	0,40	0,65
Basic Nitrogen	ppm									150	382	1069	1194	1903
Nickel	ppm	4									< 1 [c]	7	8	16
Vanadium	ppm	10,7									< 2 [c]	20	22	43
P.Value													>5	
Asphaltenes in NC7	%m/m	0,6										1,15	1,30	2,50
R.C.C.	%m/m	3,8									0,2	7,0	7,8	14,8
Penetration @ 25°C	dmm													
UOP K Factor		11,7									11,6	11,7	11,7	

TBP Distillation	
Cut Point	%m/m Cum
C1	0,00
C2	0,01
C3	0,17
IC4	0,31
NC4	0,62
IC5	0,88
NC5	1,22
80	3,05
100	5,01
120	6,92
140	8,98
160	11,33
180	12,85
210	15,99
230	18,87
250	22,66
270	26,42
290	28,85
320	35,87
350	41,55
370	45,74
400	51,43
530	74,94
550	77,32

NB: see corresponding tabs for notes associated to each cut.

[c] calculated value

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Eni S.p.A
Downstream R&D

	BALDER				26,5
State	NORVEGIA	Report	3-GR-202	Record	BAL14.2022.02.ET