» Continental Europe Synchronous Area Separation on 08 January 2021

ICS Investigation Expert Panel » Final Report » 15 July 2021

Annexes

Disclaimer

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Contents

Annex Chapter 1

Annex 1.2.3.1: Load flow situation after 14:00

EMS

Table A1-1 shows the data on power flows for the most important elements that affect the flows in TS Ernestinovo. They are displayed in order: DACF data as sent by HOPS, data from the merged, common day-ahead model, data from the common IDCF model, and real-time data as seen by the dispatcher.

	S. Mitrovica – Ugljevik	S. Mitrovica – Ernestinovo	S. Mitrovica – Mladost	Subotica 3 – Novi Sad	Subotica 3 – Sandorfalva	Subotica 3 – Sombor 3	Djerdap 1 – TPP Kostolac A	Djerdap 1 – Bor 2	Djerdap 1 – Portile de Fier
DACF 13 h	37.50	429.70	–534.00	–598.00	450.70	53.00	521.00	593.00	–89.00
IDCF 13 h	40.20	460.00	–560.20	–614.30	482.50	49.40	513.80	594.10	–81.80
SCADA 13 h	–98.04	597.33	–515.82	–910.78	784.41	36.08	427.19	356.27	288.06
DACF 14 h	28.00	421.50	–512.60	–574.50	438.70	51.80	491.90	589.00	–52.70
IDCF 14 h	30.50	459.50	–543.50	–601.40	478.20	46.50	484.10	591.40	–47.20
SCADA 14 h	–98.85	603.86	–526.95	–932.16	821.98	31.94	375.38	333.19	273.41

Table A1-1: Power flows that affect SS Ernestinovo (in MW)

	S. Mitrovica – Ugljevik	S. Mitrovica – Ernestinovo	S. Mitrovica – Mladost	Subotica 3 – Novi Sad	Subotica 3 – Sandorfalva	Subotica 3 – Sombor 3	Djerdap 1 – TPP Kostolac A	Djerdap 1 – Bor 2	Djerdap 1 – Portile de Fier
ΔPmax	349.2	745.6	511.4	1,198.5	1,447.6	179.3	395.6	583.7	894.3

Table A1-2: Maximum power values in transmission lines connected to EMS substations (in MW)

The figures below show the power flows through the individual elements connected to busbars in SS Sremska Mitrovica 2, SS Subotica 3 and SS Đerdap 1 for the period 13:00–14:15. A sudden change in flows at 14:00 is visible. The maximum power values according to these figures are shown in Table A1-2 (values in MW).

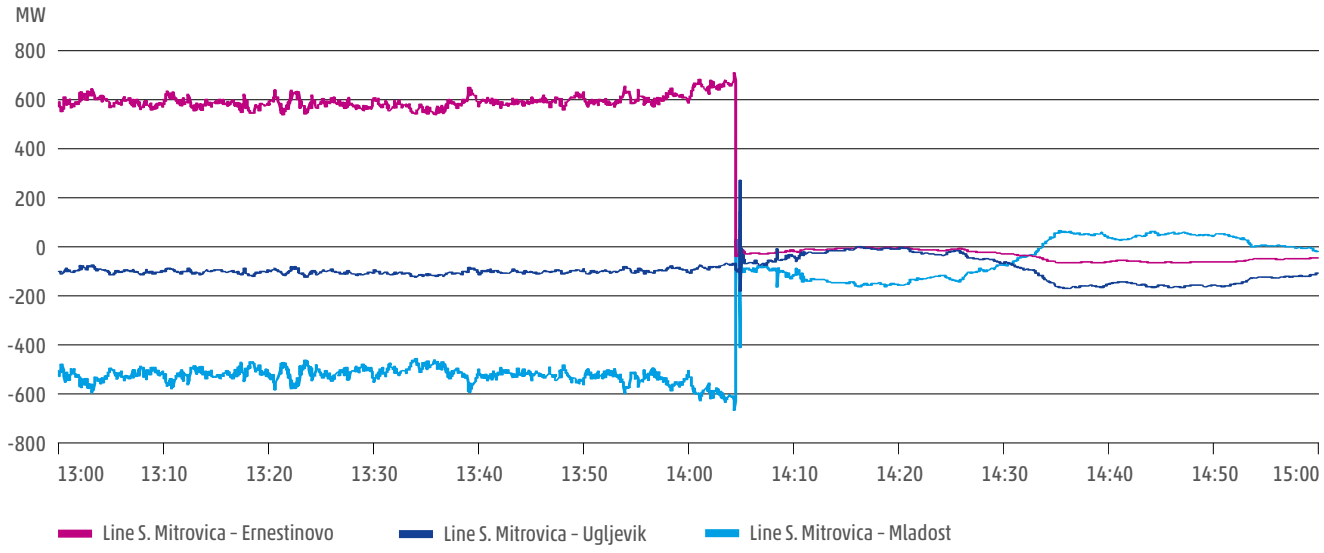

Figure A1-1: Power flows through the individual elements connected to busbars in SS Sremska Mitrovica 2

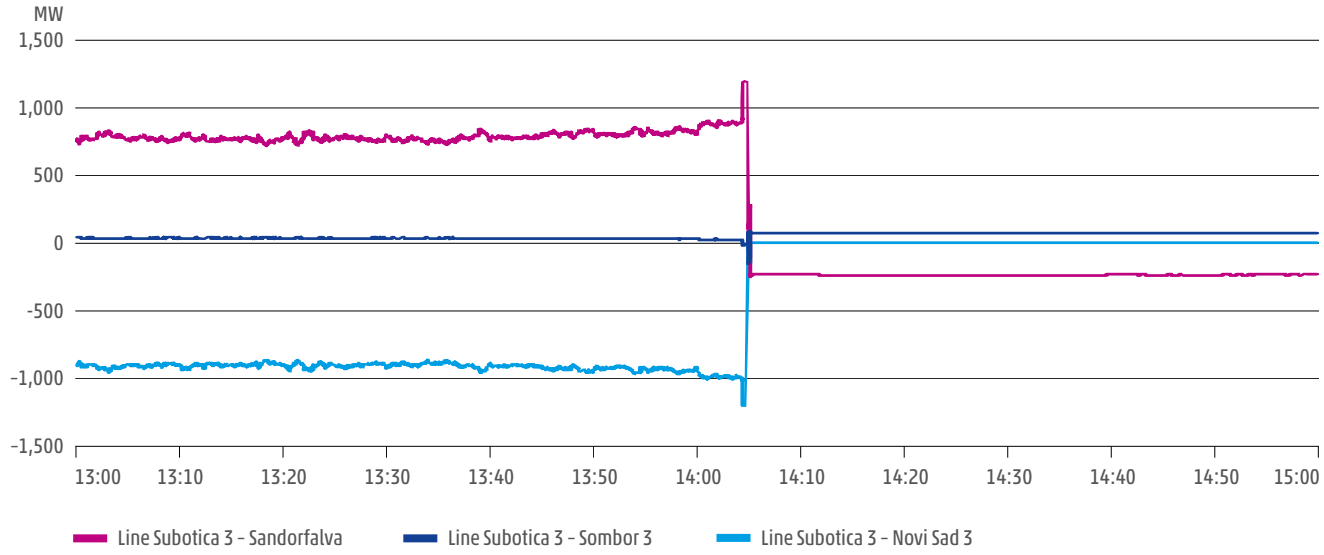

Figure A1-2: Power flows through the individual elements connected to busbars in SS Subotica

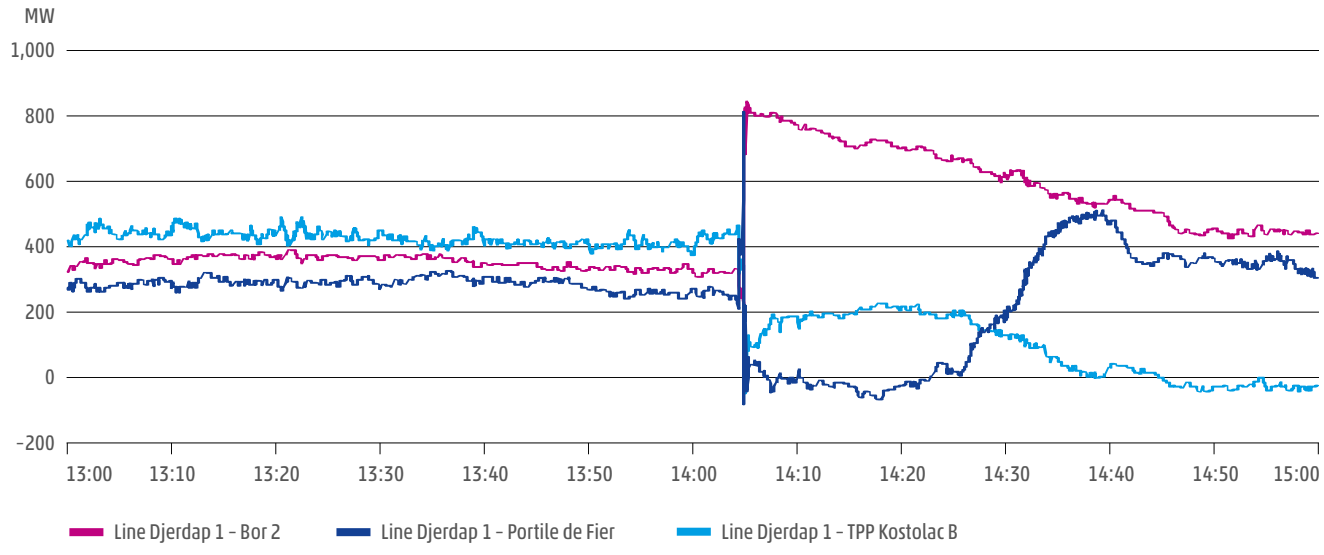

Figure A1-3: Power flows through the individual elements connected to busbars in SS Đerdap 1

Transelectrica

The Romanian transmission grid faced relatively medium to high power flows from the South-East region of the Romanian system (where most of the wind farms are located) to the North-West region. The following tables show the data on power flows for the most relevant elements for the event reconstruction, i.e. all the elements which were tripped after the tripping of the line Subotica – Novi Sad (Table A1-3) and tie-lines (Table A1-4). They are displayed in order: day ahead congestion forecast, intraday congestion forecast and real-time data as monitored by dispatchers on the SCADA system.

Network elements	DACF 13:00	IDCF 13:00	SCADA 13:00	DACF 14:00	IDCF 14:00	SCADA 14:00
220 kV OHL Paroșeni - Târgu Jiu Nord	248	257	276	244	255	316
220 kV OHL Timișoara - Reșița ck.1	268	274	281	268	275	279
220 kV OHL Timișoara - Reșița ck.2	268	274	278	268	275	276
400 kV OHL Mintia - Sibiu Sud	267	277	290	268	279	328
400 kV OHL Iernut - Gădălin	496	515	569	510	534	565
400 kV OHL Iernut - Sibiu Sud	692	714	787	702	729	801
400 MVA, 400/220 kV AT Roșiori SS	86	82	82	78	71	88
220 kV OHL Iernut - Câmpia Turzii	106	109	97	109	112	117
220 kV OHL Fântânele - Ungheni	6	9	16	12	17	23

Table A1-3: Forecasted and realised flows on the network elements that tripped at 14:05 CET (in MW)

Tie lines	DACF 13:00	IDCF 13:00	SCADA 13:00	DACF 14:00	IDCF 14:00	SCADA 14:00
400 kV OHL Roșiori - Mukacevo	394	423	492	424	463	460
400 kV OHL Arad - Sandorfalva	–86	–85	–7	–75	–76	–55
400 kV OHL Nădab - Bekescaba	236	242	301	248	260	262
400 kV OHL Porțile de Fier - Djerdap	–183	–210	–273	–138	–178	–268
400 kV OHL Ţânţăreni - Kozloduy ck.1	–316	–364	–591	–262	–308	–578
400 kV OHL Ţânţăreni - Kozloduy ck.2	0	0	0	0	0	0
400 kV OHL Rahman - Dobrudja	54	35	79	105	86	112
400 kV OHL Varna - Stupina	61	41	126	116	96	150

Table A1-4: Forecasted and realised flows on the tie lines (in MW)

Figure A1-4 and Figure A1-5 display the active power flows on the tie lines in the South-East area and in the North-West area respectively during the incident.

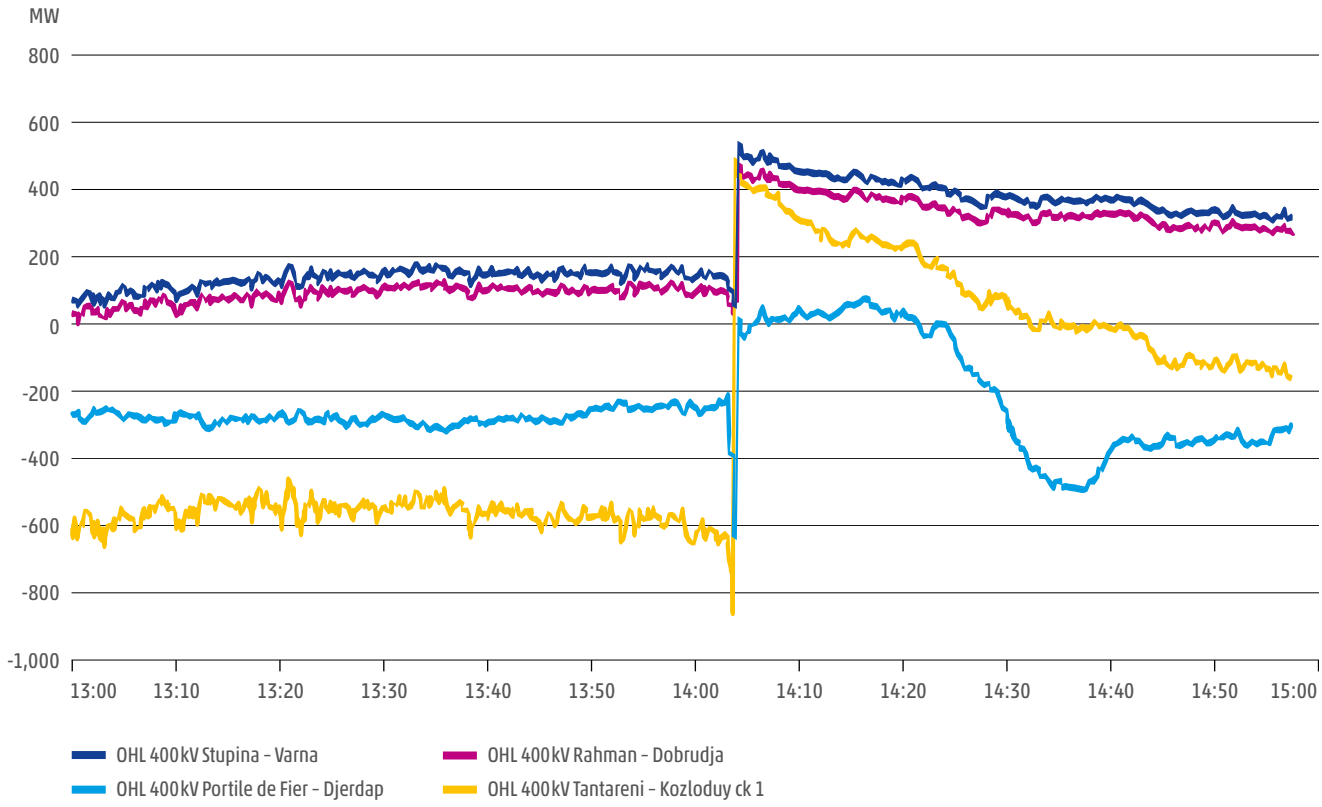

Figure A1-4: Power flows through the Romanian tie-lines within the South-East split area

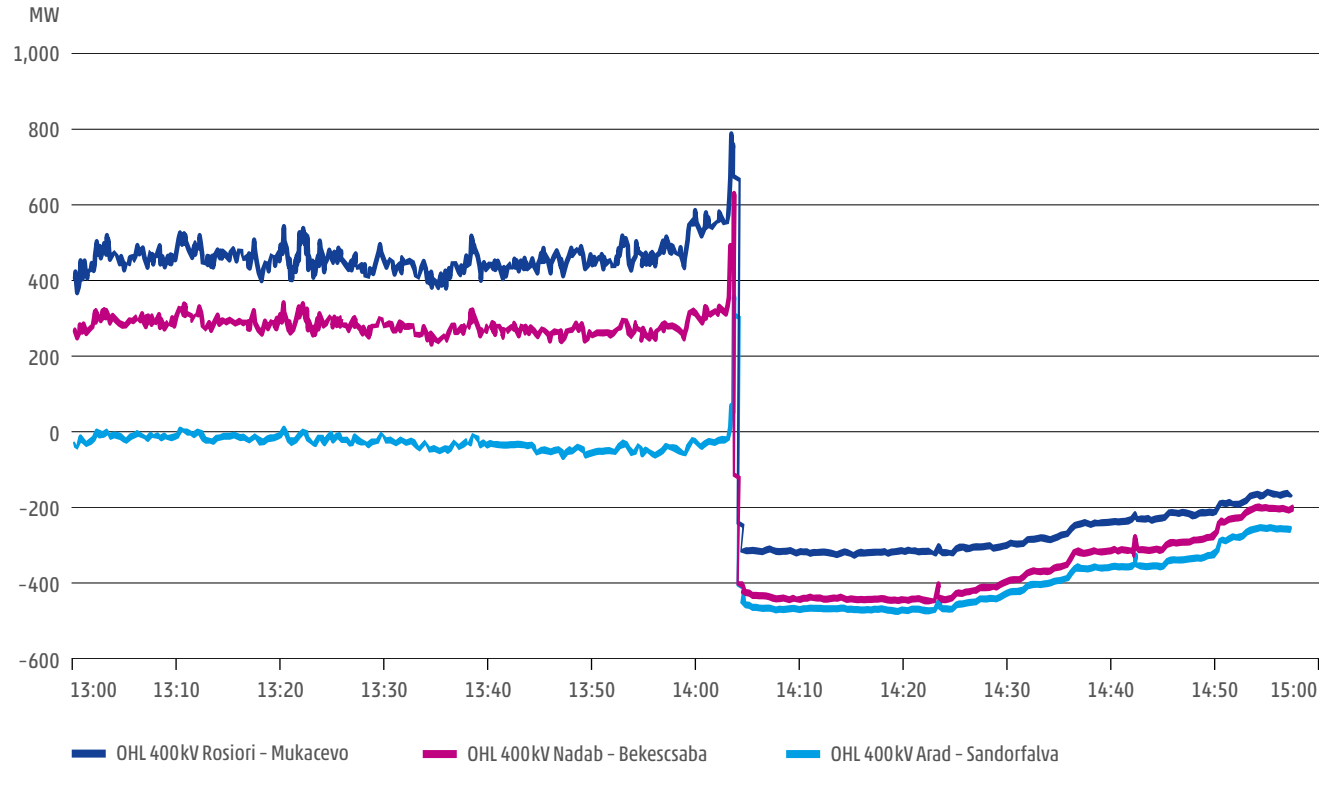

Figure A1-5: Power flows through the Romanian tie-lines within the North-West area

Annex 1.3.3.2: Forecasting security calculation

	time stamp 13:30 AMICA								time stamp 14:30 AMICA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
SS Ernestinovo busbar coupler	1,003	68	N/A	N/A	1,246	84.5	N/A	N/A	996	48.3	N/A	N/A	1,256	85.1	N/A	N/A
400 kV Ernestinovo – Pecs 1	661	48.5	23.6	4.8	881	65	98.1	7.9	658	23.9	24.8	4.8	876	64.6	98.4	7.9
400 kV Ernestinovo – Žerjavinec	327	24	23.6	2.4	375	27.7	98.1	7.7	325	39.6	24.8	2.4	371	27.4	98.4	7.7
400 kV Ernestinovo – Ugljevik	542	39.8	57.5	4.3	626	46.2	6.5	1.7	539	34.4	61.6	4.5	623	46	3	1.5
400 kV Ernestinovo – S. Mitrovica	477	35.2	57.5	5.3	651	48.3	6.5	3.8	467	24.6	61.6	5.5	639	47.3	3	3.7
400 kV Žerjavinec – Heviz 2	321	23.6	308	22.6	382	28.2	397.5	29.4	334	22.2	321.7	23.7	395	29	411.1	30.4
400 kV Đakovo – Gradačac	73	22.3	88.4	27.5	79	23.7	96.1	30.1	73	35.2	86.4	26.8	77	23.6	94.5	29.5
400 kV Đakovo – Tuzla	117	35.5	133	41.5	121	36.8	140.6	44.1	116	59	130.7	40.5	121	36.6	138.6	43.3
400 kV Novi Sad – Subotica	804	60	1,115.2	84.3	N/A	N/A	N/A	N/A	792	11.6	1,101.4	83.2	N/A	N/A	N/A	N/A
400 kV S. Mitrovica – Ugljevik	126	11	142.9	12	19	8.8	16.7	7.4	136	28.9	153.2	12.5	29	8.5	7.9	7.1
400 kV S. Mitrovica – Mladost	407	30	71.2	8.5	686	50.8	173.5	14.7	389.7	14.1	84	9.2	666	49.2	162	14.1
400 kV Đerdap 1 – Portile de Fier	182.5	16.9	315.6	24.9	331	27	605.7	47.3	138	63.5	273.8	22.8	284	23.6	554.3	43.4

Table A1-5: (n-1)-calculation made by HOPS within DACF

	time stamp 13:30 AMICA								time stamp 14:30 AMICA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
220 kV OHL Paroseni – Târgu Jiu Nord	248	64	273.4	72.1	275	72.6	334.6	88.8	240.6	70.2	269.4	71.1	271	71.5	331.3	88
220 kV OHL Timisoara – Resita ck.1	268	70.3	282.9	77.1	286.5	78	328.4	92.8	260.6	70.2	282.1	76.9	285.6	77.8	327.7	92.9
220 kV OHL Timisoara – Resita ck.2	268	70.3	282.9	77.1	286.5	78	328.4	92.8	260.6	20	282.1	76.9	285.6	77.8	327.7	92.9
400 kV OHL Mintia – Sibiu Sud	264	20	305.9	23.2	328	25	424.5	32.9	266	38.2	307	23.4	329	25	426.9	33.3
400 kV OHL Iernut – Gădălin	493	37.2	560	42.1	533	40	645	49.4	510	52.6	573.3	43.2	547	41	659.2	50.9
400 kV OHL Iernut – Sibiu Sud	683	51.8	747.2	57.1	721	55	830	64.6	693	28	755.2	57.8	730	55.8	837.6	65.5
220 kV OHL Iernut – Câmpia Turzii	106	27.7	115.3	30	114	29.7	132.3	33.9	108	12.7	117	30.2	116	30	132.6	34.5
220 kV OHL Fântânele – Ungheni	5.7	10.9	21	13.3	17	12.8	47.9	17.8	12	32.1	27.2	14.8	23	14.6	54.4	19.2
400 kV OHL Roșiori – Mukacevo	393	30	483.5	36.8	384	29.2	503.1	39.2	423	9.3	511.8	39.2	414	31.6	532.7	42.1
400 kV OHL Arad – Sandorfalva	86	9.7	61	7.6	58	9.1	174.4	18.8	75	18.5	50	7.6	67	10	184.8	20.4
400 kV OHL Nădab – Bekescaba	235	17.5	311.7	23.3	295	22.2	432.5	33.3	248		323	24.3	306	23.1	444.6	34.7

	time stamp 13:30 AMICA								time stamp 14:30 AMICA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
SS Ernestinovo busbar coupler	1,077	73.8	N/A	N/A	1,370	94.1	N/A	N/A	1,081	74	N/A	N/A	1,368	94	N/A	N/A
400 kV Ernestinovo – Pecs 1	732	53.8	29	5	966	71.6	104	8.3	724	53.2	20	2	959	71	97	8
400 kV Ernestinovo – Žerjavinec	345	25	29	2.5	400	29.7	104	8.1	356	26.2	20	2	408	30	97	7.5
400 kV Ernestinovo – Ugljevik	568	41.8	59	7.2	667	49.5	2	6	563	41.4	56	6.5	661	49	10	5.6
400 kV Ernestinovo – S. Mitrovica	512	37.8	63	4.6	703	52.3	5	1	518	38.2	55	4.2	707	53	10	1
400 kV Žerjavinec – Heviz 2	345	25	316	23	406	29.8	403	29.7	350	25.6	323	23.5	414	30	412	30.3
400 kV Đakovo – Gradačac	93	28.6	93	28.6	94	28.7	94	28.7	96	29.5	96	29.5	97	29.6	97	29.6
400 kV Đakovo – Tuzla	132	40.2	132	40.2	132	40.1	132	40.1	135	41	135	41	135	41	135	40.8
400 kV Novi Sad – Subotica	848	63.3	1,204	91.6	N/A	N/A	N/A	N/A	849	63.3	1,207	92	N/A	N/A	N/A	N/A
400 kV S. Mitrovica – Ugljevik	116	11	154	12.8	7	9.6	9	7.3	102	10	139	12	6	9	26	7
400 kV S. Mitrovica – Mladost	442	32.7	89	7	741	54.8	162	12.3	458	34	75	6	754	55.7	180	13.7
400 kV Đerdap 1 – Portile de Fier	209	18	367	29.4	366	29.3	686	53.3	178	16	335	27	336	27	651	50.6

Table A1-6: (n-1)-calculation made by HOPS within IDCF

	time stamp 13:30 AMICA								time stamp 14:30 AMICA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
220 kV OHL Paroseni - Târgu Jiu Nord	257	67	293	76.1	292	76	365	96	255	66.5	291	76	289	75	363	95.1
220 kV OHL Timisoara - Resita ck.1	274	72	301	80	303	81	355	99	275	72.5	302	81	304	81	355	99.2
220 kV OHL Timisoara - Resita ck.2	274	72	301	80	303	81	355	99	275	72.5	302	81	304	81	355	99.2
400 kV OHL Mintia - Sibiu Sud	274	21	324	24.8	344	26	456	35.8	277	21	327	25	345	26.4	460	36.5
400 kV OHL Iernut - Gădălin	515	39	591	44.7	557	42	688	53.3	534	40	610	46.3	573	43.3	703	55.3
400 kV OHL Iernut - Sibiu Sud	705	54	780	60	747	57.2	874	69	719	55	793	61.1	758	58.2	881	70.2
220 kV OHL Iernut - Câmpia Turzii	109	28	120	31	118	30.7	139	36	112	28.9	122	31.5	120	31	139	37
220 kV OHL Fântânele - Ungheni	9	12	28	14	23	13.8	59	20	16	13.6	36	15.8	30	15	67	21.4
400 kV OHL Roșiori - Mukacevo	423	32	531	40.7	417	31.8	556	44	463	35.1	568	43.8	452	34.7	587	47.6
400 kV OHL Arad - Sandorfalva	84	10	54	7.3	67	10.3	204	22.1	76	9.7	45	7	76	11	213	24
400 kV OHL Nădab - Bekescaba	242	18	332	25	307	23.2	466	36.6	260	19.5	349	26.6	323	24.6	481	38.7

Annex 1.3.3.3: Real-time security calculation

	time stamp 13:30 SCADA								time stamp 14:00 SCADA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
SS Ernestinovo busbar coupler	1,188	80.5	-	N/A	1,897	128.6	n/A	N/A	1,207	81.8	-	N/A	1,937	131.3	N/A	N/A
400 kV Ernestinovo – Pecs 1	770	56.5	16	7	1,346	98	n/A	N/A	795	57.7	19	6.8	1,379	100.6	N/A	N/A
400 kV Ernestinovo – Žerjavinec	409	31.6	16	7.8	551	42.1	n/A	N/A	412	31.8	19	8.1	559	42.7	N/A	N/A
400 kV Ernestinovo – Ugljevik	626	47.1	29	4.1	812	62.6	n/A	N/A	619	47.1	29	4.1	818	63.1	N/A	N/A
400 kV Ernestinovo – S. Mitrovica	610	46	29	6	1,109	85.2	N/A	N/A	606	46.1	29	6	1,126	86.5	N/A	N/A
400 kV Žerjavinec – Heviz 2	306	22.9	305	22.9	457	33.7	N/A	N/A	324	24.2	327.7	24.3	480.4	35.4	N/A	N/A
400 kV Đakovo – Gradačac	83	27.2	106	35.5	89	28.8	N/A	N/A	83	26.9	101	34	88.1	28.6	N/A	N/A
400 kV Đakovo – Tuzla	131	42.4	152	52.5	135	44.8	N/A	N/A	129	42.2	147	50.8	135	44.7	N/A	N/A
400 kV Novi Sad – Subotica	920	76.3	1,480	127.4	-	N/A	N/A	N/A	949	78.7	1,552	130.3	-	N/A	N/A	N/A
400 kV S. Mitrovica – Ugljevik	103	9.3	74	7	283	25.1	N/A	N/A	101	9.3	75	7.2	297	26.2	N/A	N/A
400 kV S. Mitrovica – Mladost	533	44.5	44	9	1,390	117.7	N/A	N/A	533.7	44.7	48	9.4	1,442	120.1	N/A	N/A
400 kV Đerdap 1 – Portile de Fier	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table A1-7: Calculation made by using real-time data

	time stamp 13:30 SCADA								time stamp 14:00 SCADA							
	base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)		base case (%In)		(n-1)-case for the outage of busbar coupler in Ernestinovo (%In)		(n-1)-case for the outage of the line Novi Sad – Subotica (%In)		(n-2)-case for the outages of the busbar coupler in Ernestinovo as well as of the line Novi Sad – Subotica (%In)	
	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %	MW	I %
220 kV OHL Paroseni – Târgu Jiu Nord	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
220 kV OHL Timisoara – Resita ck.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
220 kV OHL Timisoara – Resita ck.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Mintia – Sibiu Sud	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Iernut – Gădălin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Iernut – Sibiu Sud	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
220 kV OHL Iernut – Câmpia Turzii	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
220 kV OHL Fântânele – Ungheni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Roșiori – Mukacevo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Arad – Sandorfalva	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
400 kV OHL Nădab – Bekescaba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Annex 1.3.4.2: Post-incident analysis by SCC

For the comparison of flows, the DACF and IDCF CGMs (14:30, 08 January 2021) from regular processes are used. The real-time snapshot (RTSN) calculations are performed using a CGM snapshot (14:00) created by Swissgrid which was then delivered to the RSCs (Coreso, SCC and TSCNET) for post event security assessment.

Most of the results are extracted from the SCC regular reports, while additional analyses are performed to include additional elements from HOPS, MAVIR and TRANSELECTRICA that originally are not part of the monitoring lists of SCC's service users. In order to perform a consistent Load flow and N-1 analyses on RTSN CGM, the following corrections were made:

- PST Camporosso (IT) tap position decreased from –16 to –6 in order to reach target flow from CGM (43 MW), otherwise LF divergence;
- topology adjustment in SS Ernestinovo – such that the initial event can be simulated;
  - adding the busbar coupler in SS Ernestinovo with 1,920 A PATL (HERNES11 HERNES12 1);
  - moving the 400 kV line Ernestinovo (HR) – Ugljevik (BA) and 400 kV line Ernestinovo (HR) – Sremska Mitrovica 2 (RS) to the 2nd busbar system in SS Ernestinovo (creation of lines HERNES12 XER_SM11 1 and HERNES12 XUG_ER11 1);
- complete clean-up of "fake" PV nodes in APG and Transelectrica in order to avoid huge reactive power loops that could give unrealistic results for certain substations;
- setting up completely new voltages in PV nodes of EMS (agreed internally with EMS) because the provided snapshot contained base voltages for all power plants in the EMS area.

The regular procedures require the monitoring of all elements which are loaded above 90% (either in the base case or after any contingency from the contingency area). In the following two chapters, elements which were loaded above 70% are listed.

Annex Chapter 3

Annex 3.1: Frequency support during the system separation

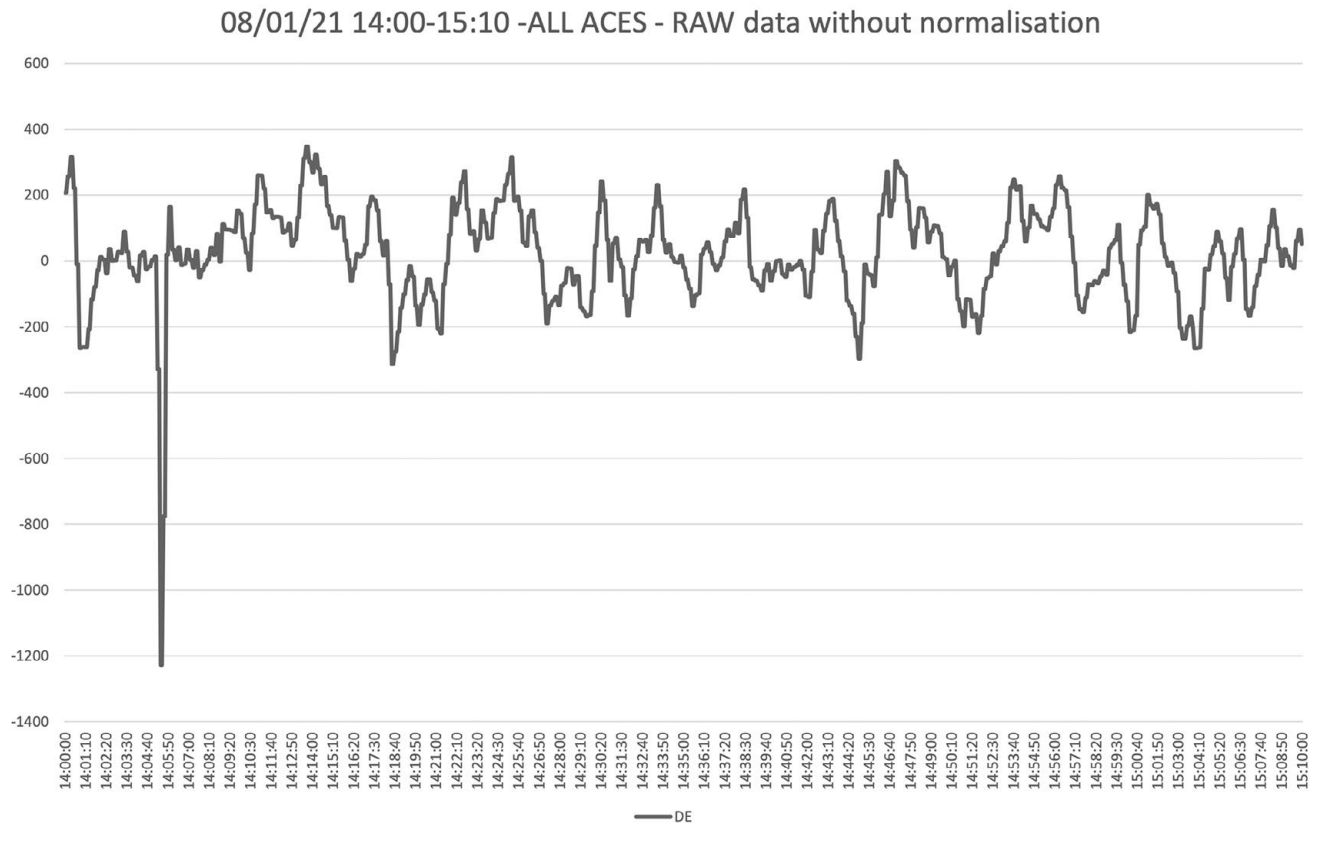

Figure A2-1: DE ACE

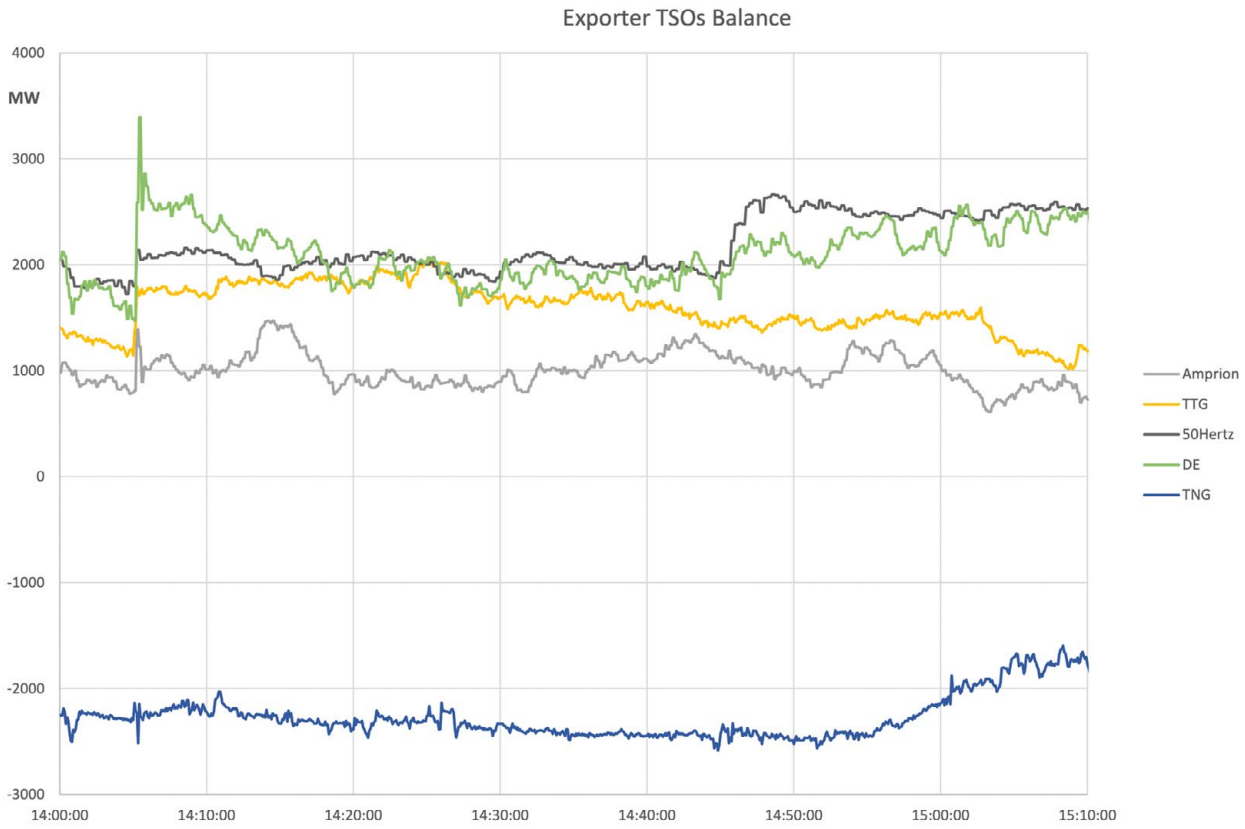

Figure A2-2: DE Balance

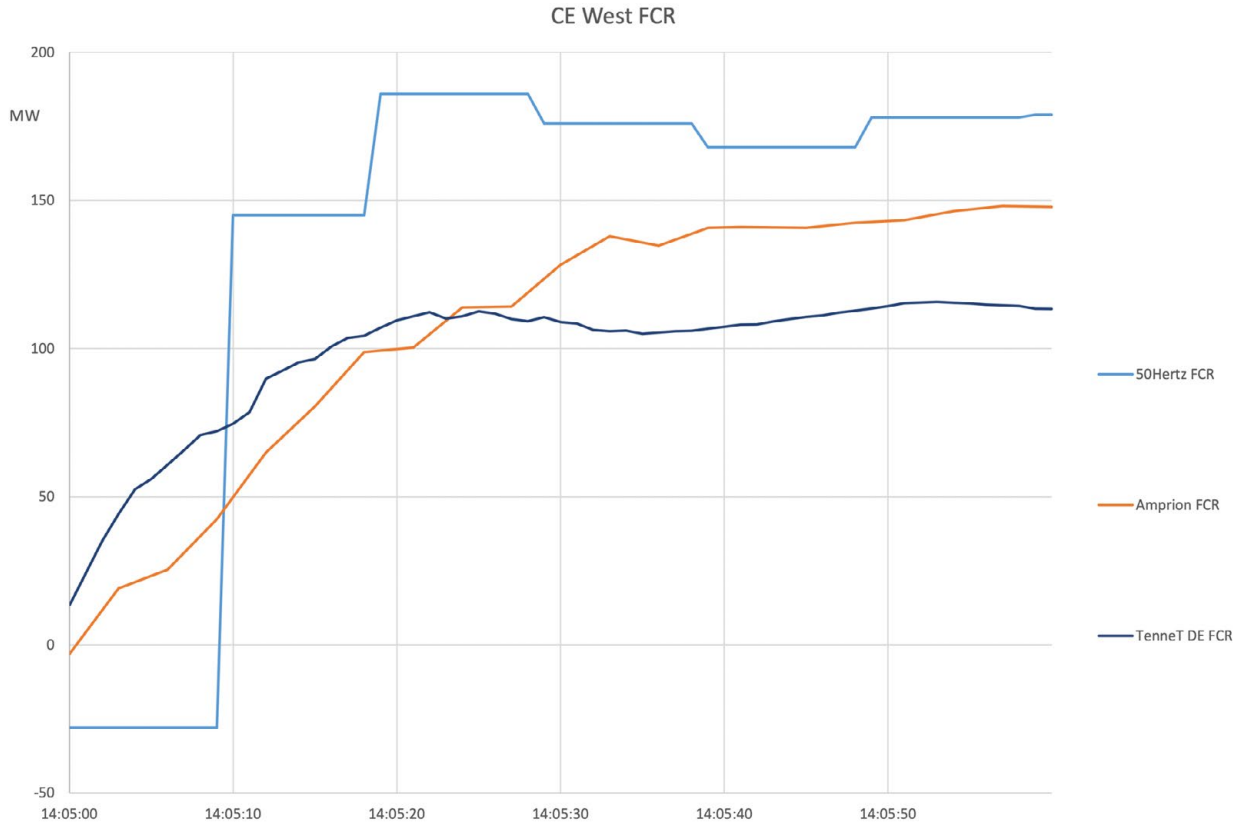

Figure A2-3: DE FCR

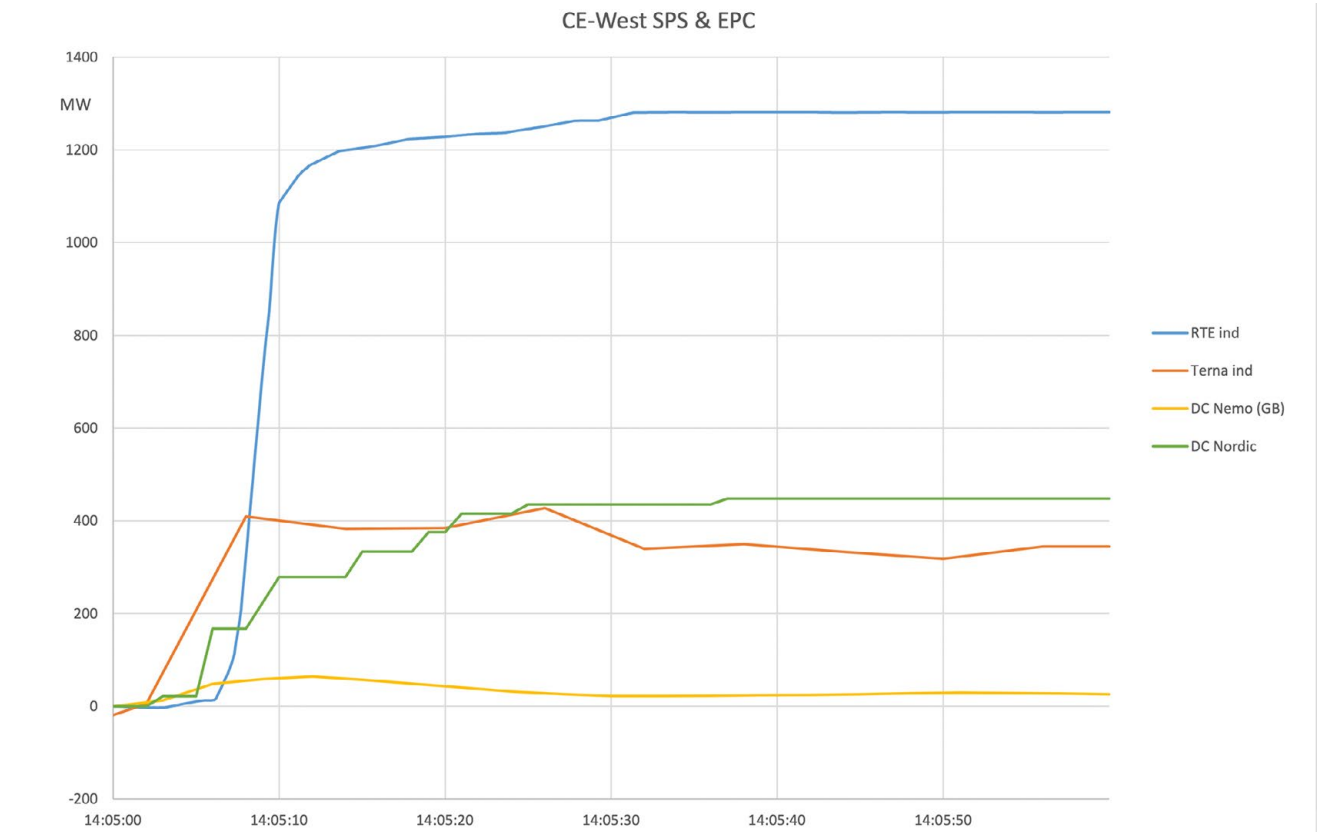

Figure A2-4: EPC and SPS Support

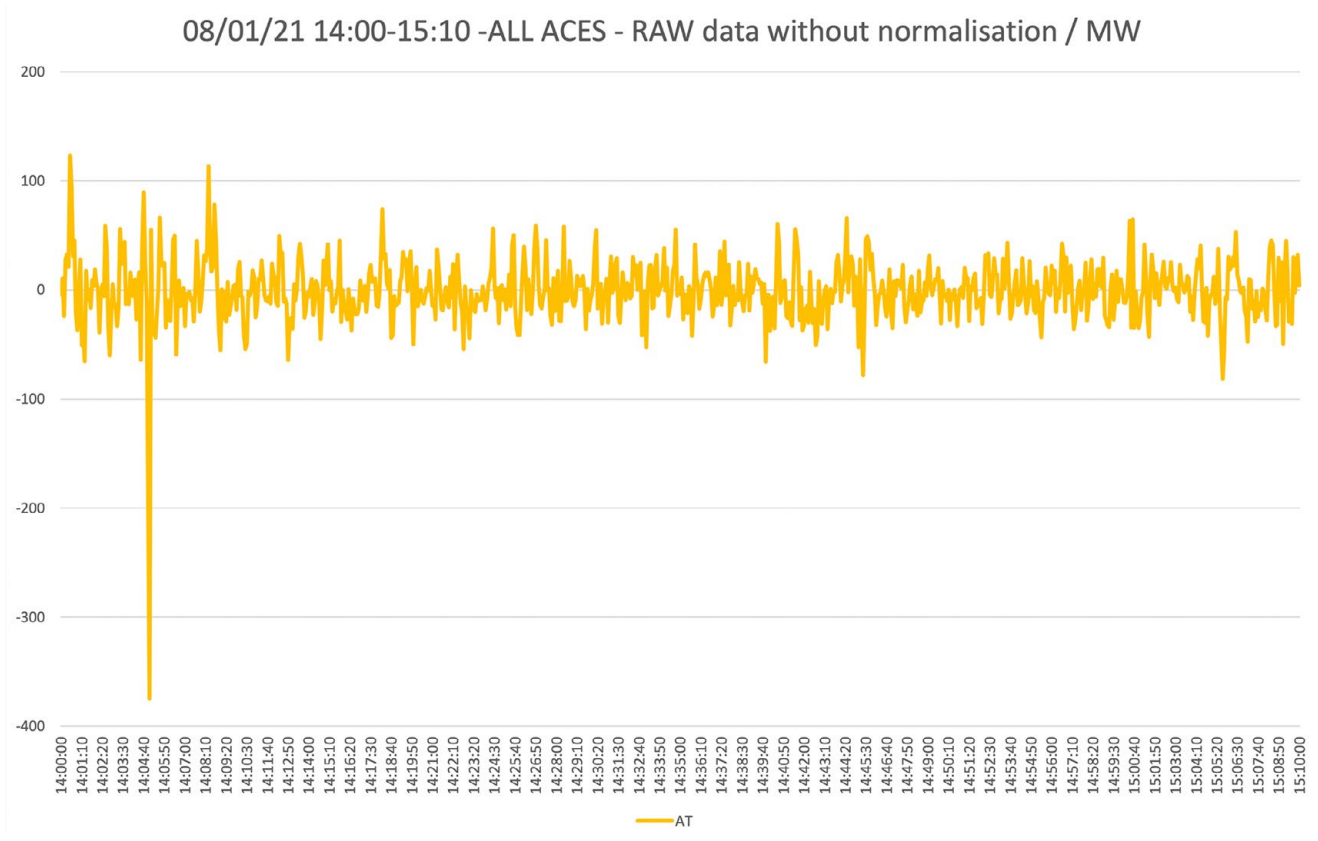

Figure A2-5: APG ACE

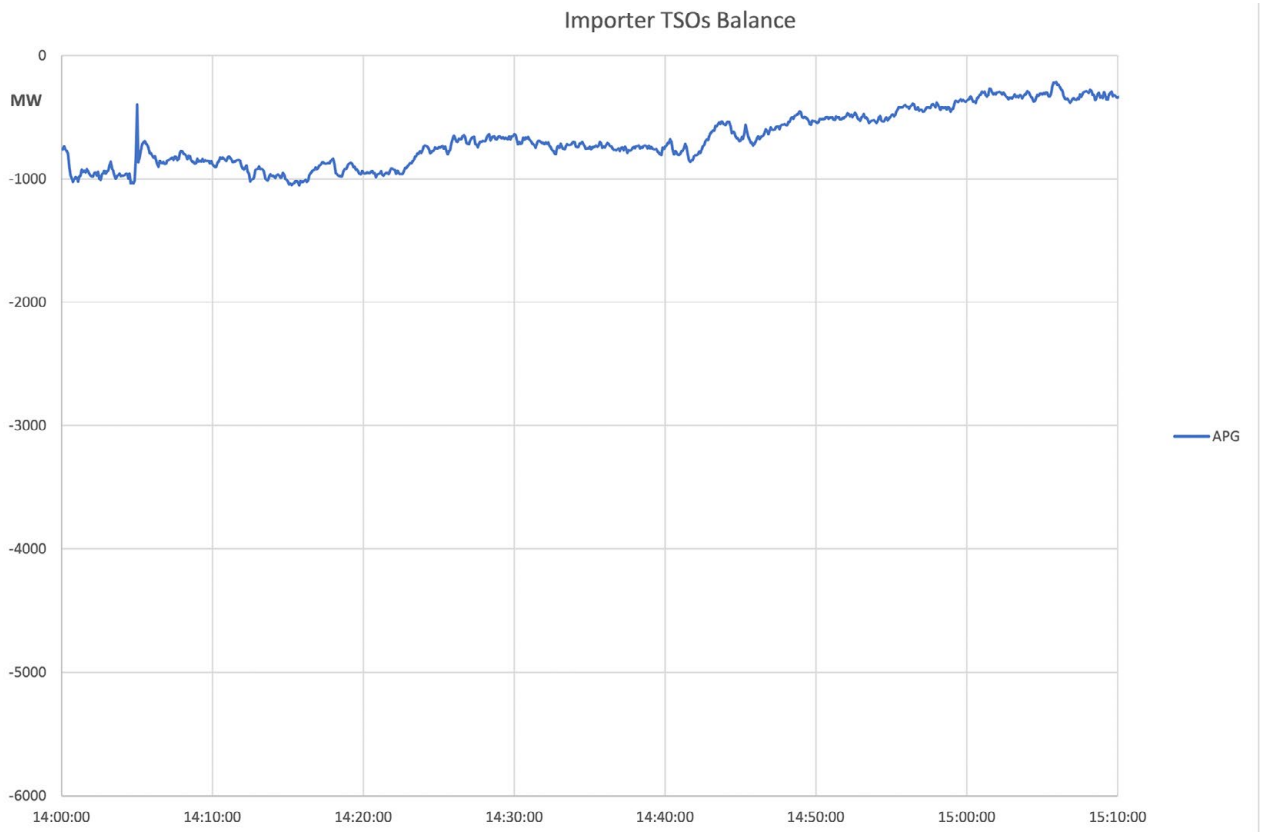

Figure A2-6: APG Balance

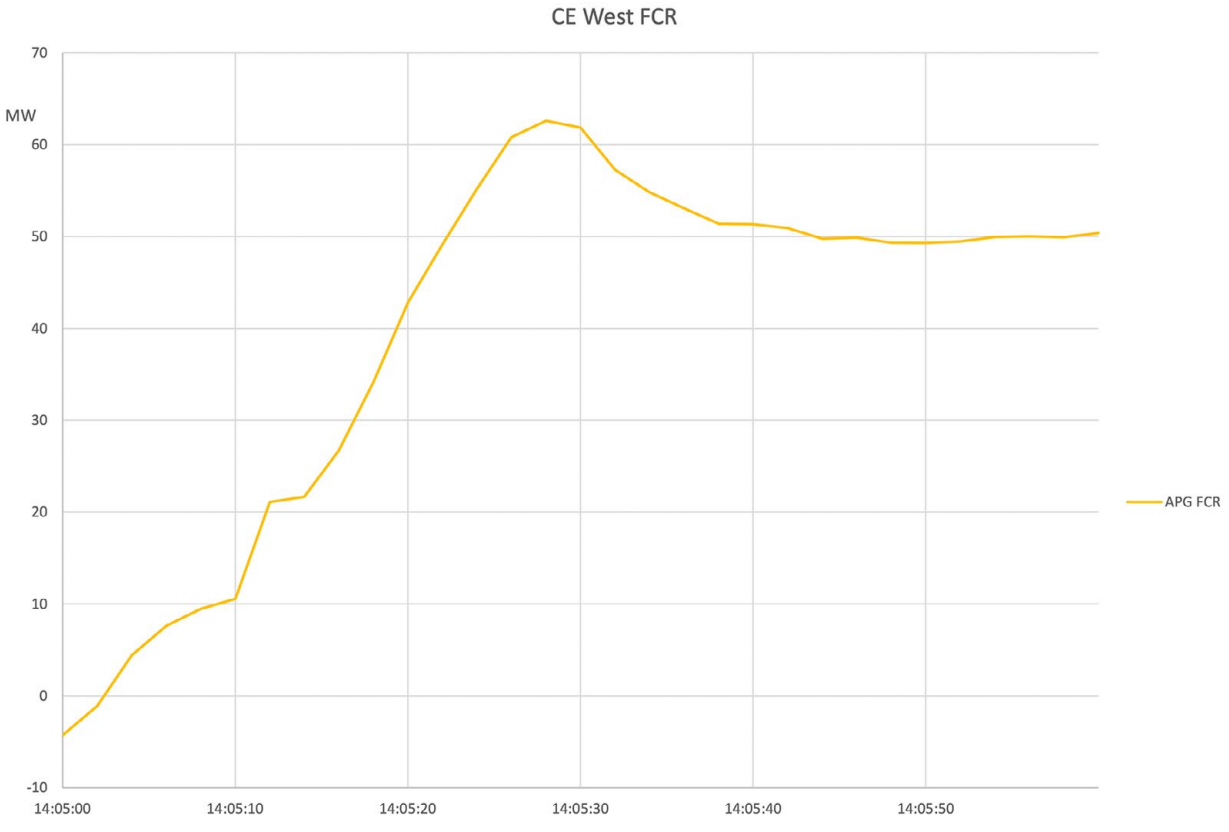

Figure A2-7: APG FCR

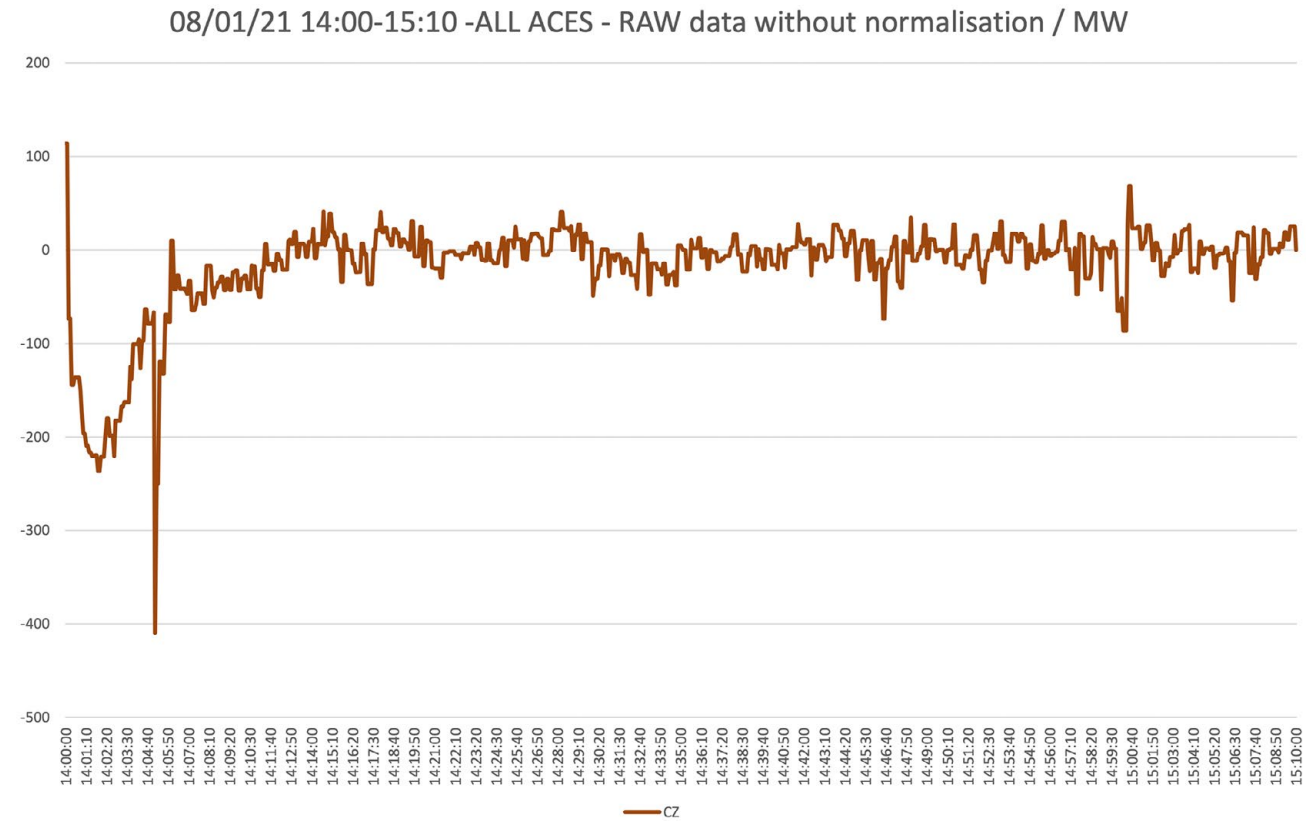

Figure A2-8: CEPS ACE

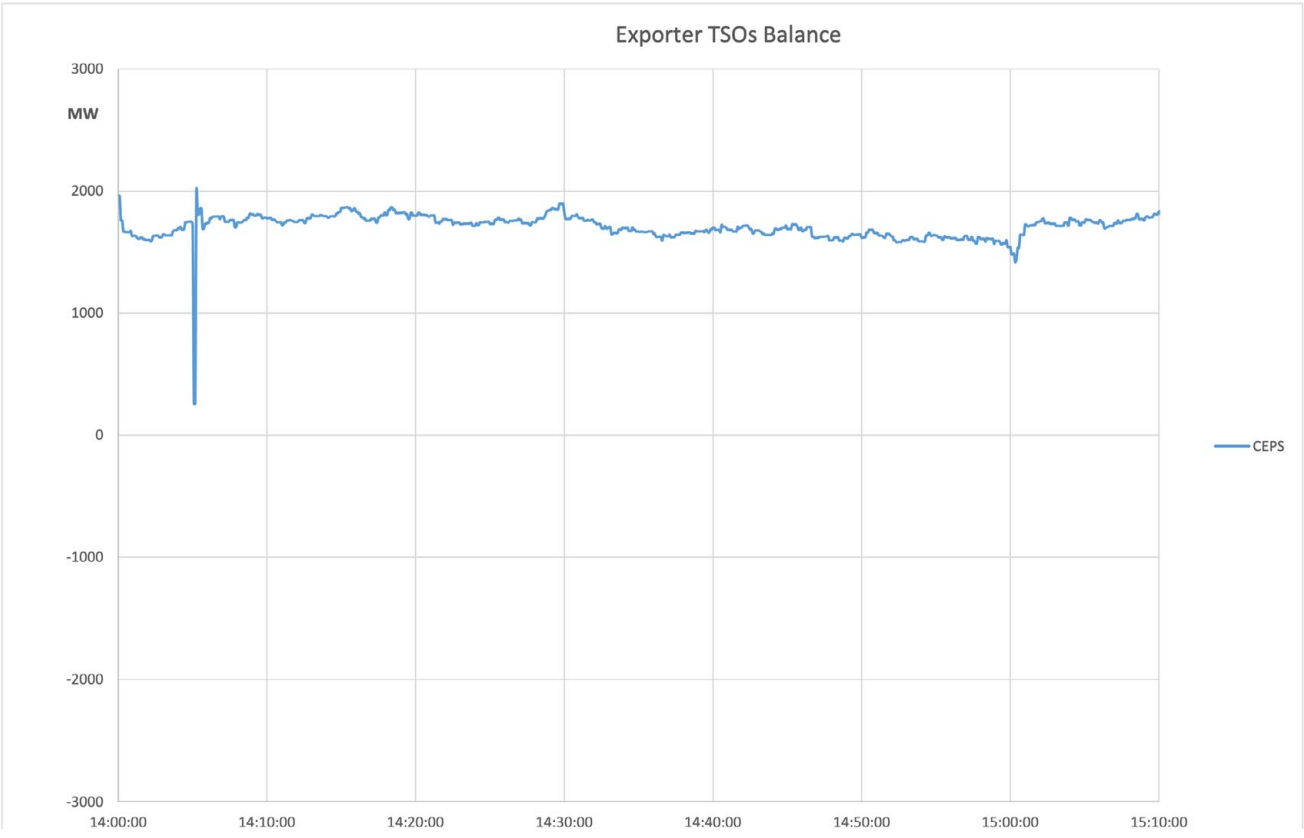

Figure A2-9: CEPS Balance

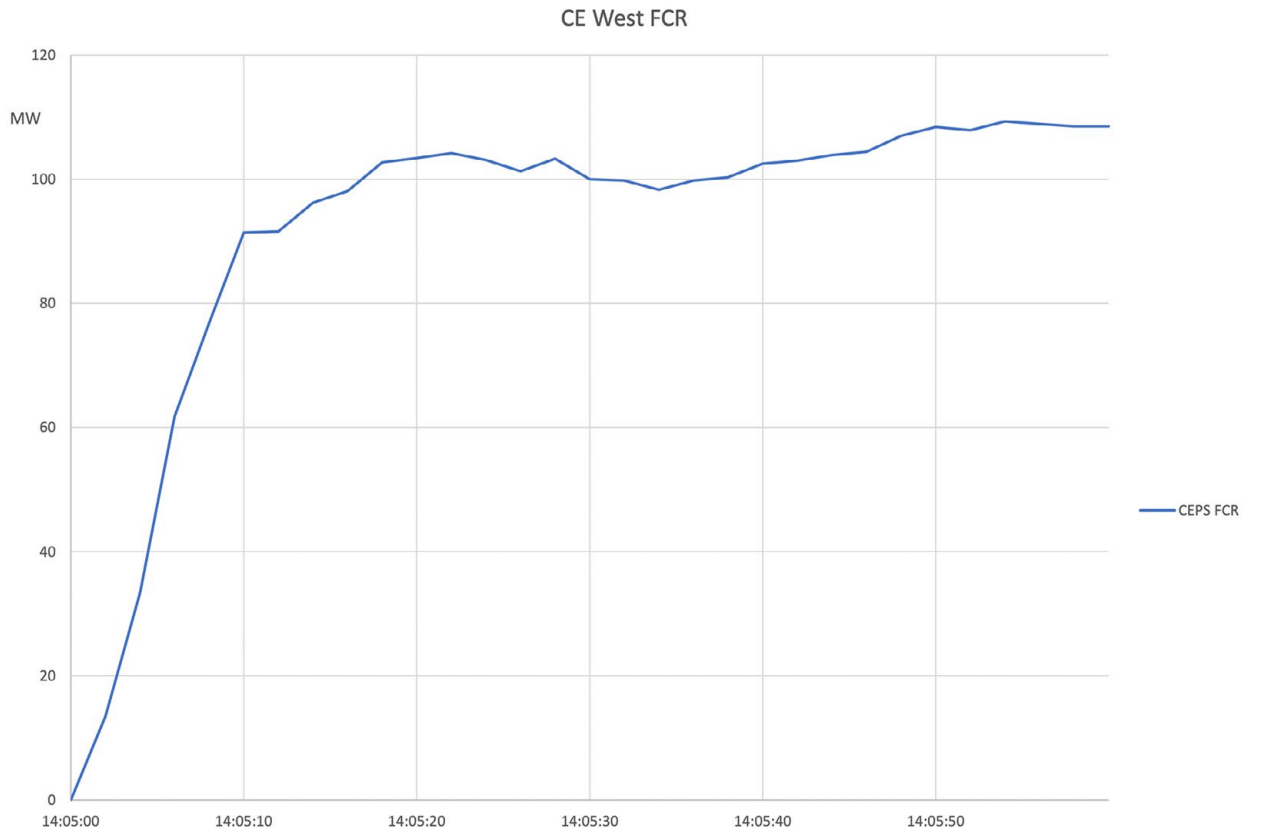

Figure A2-10: CEPS FCR

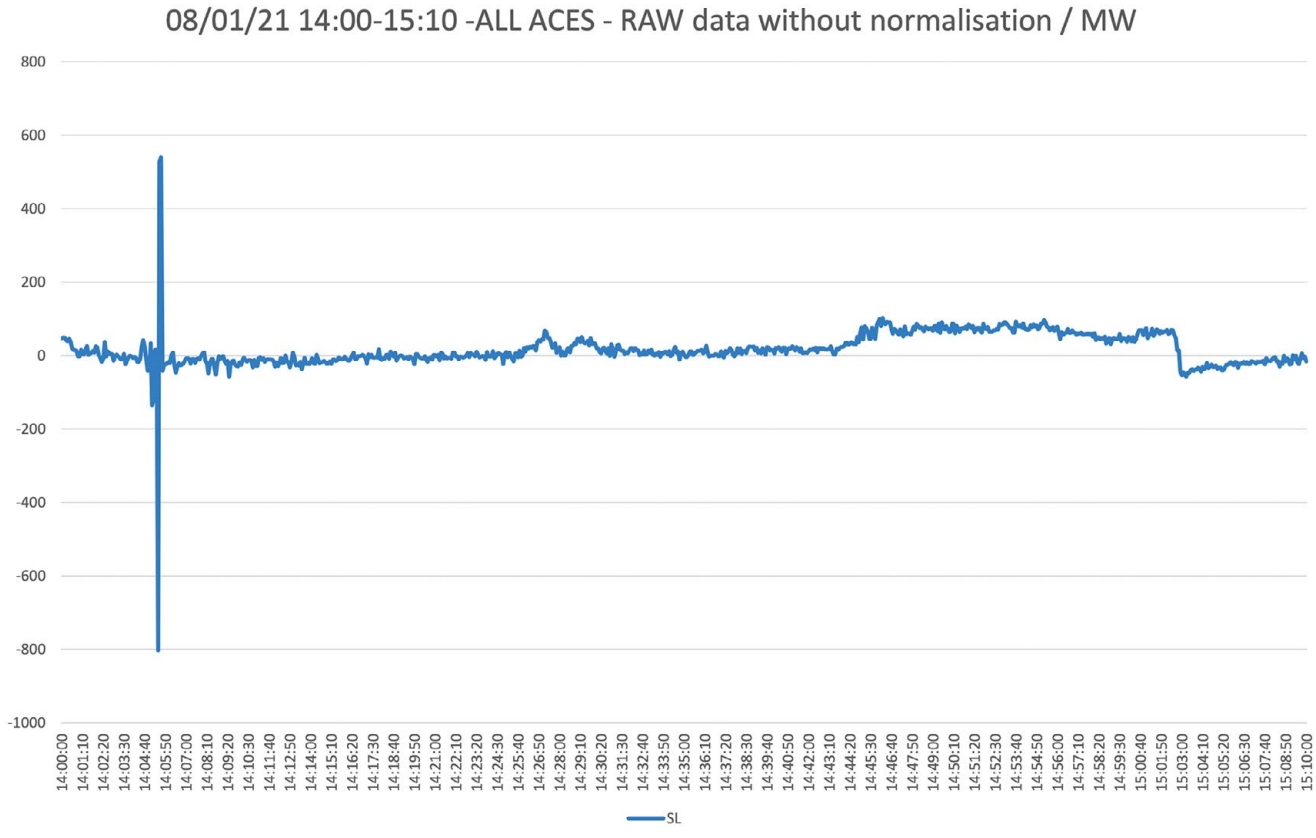

Figure A2-11: ELES ACE

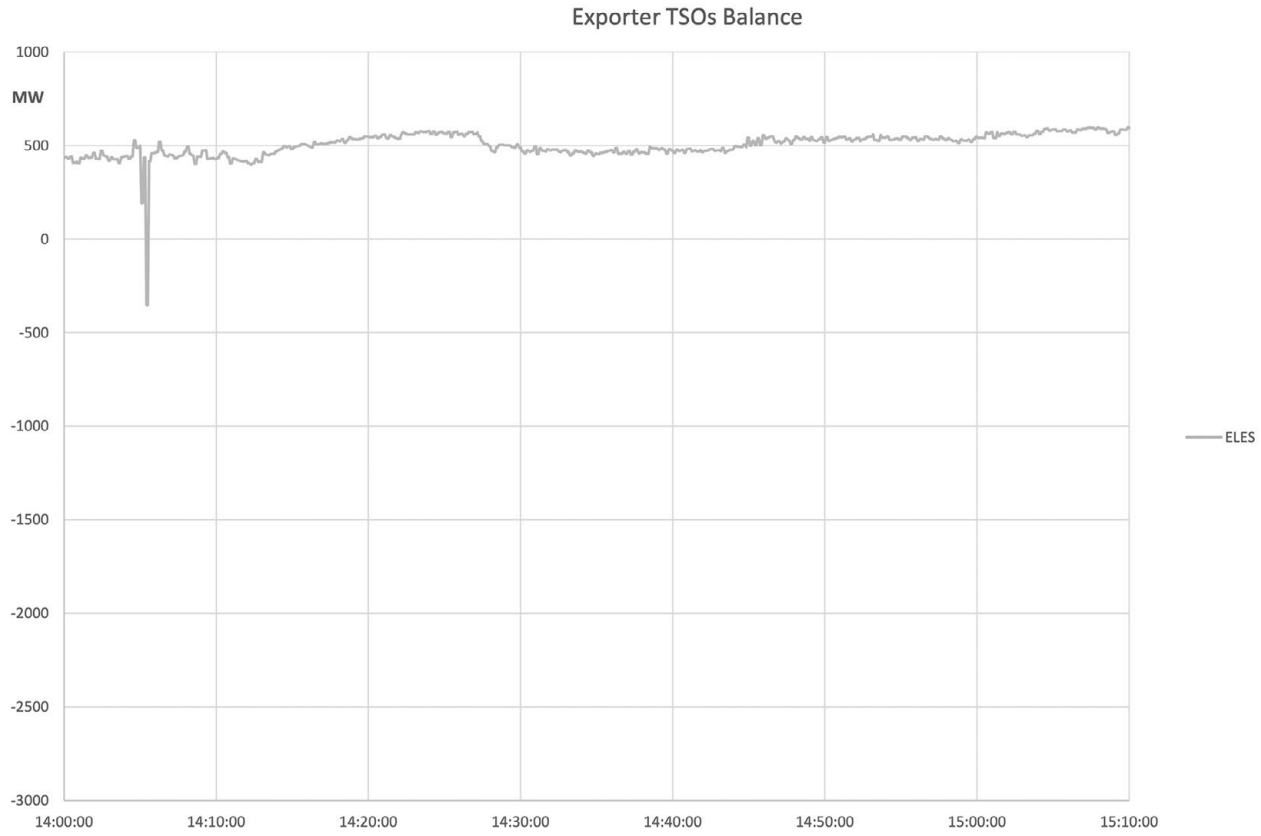

Figure A2-12: ELES Balance

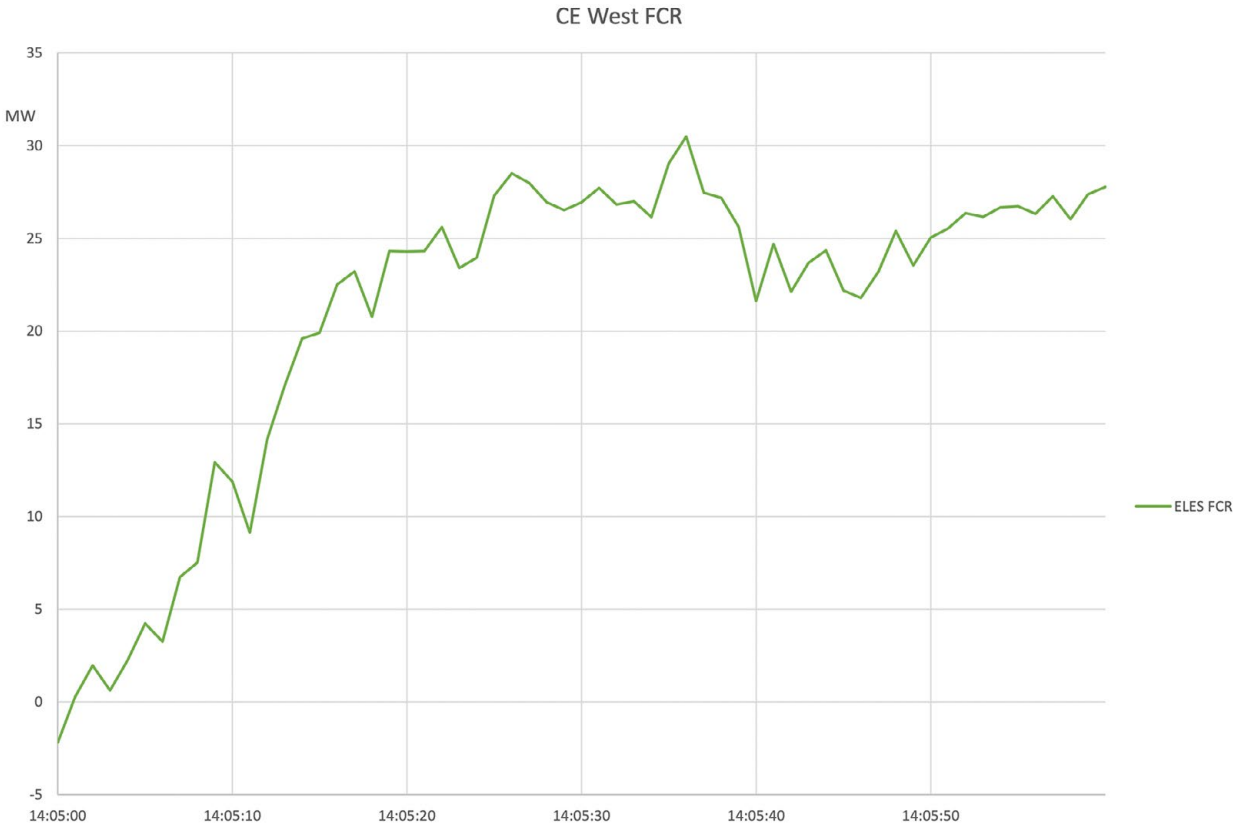

Figure A2-13: ELES FCR

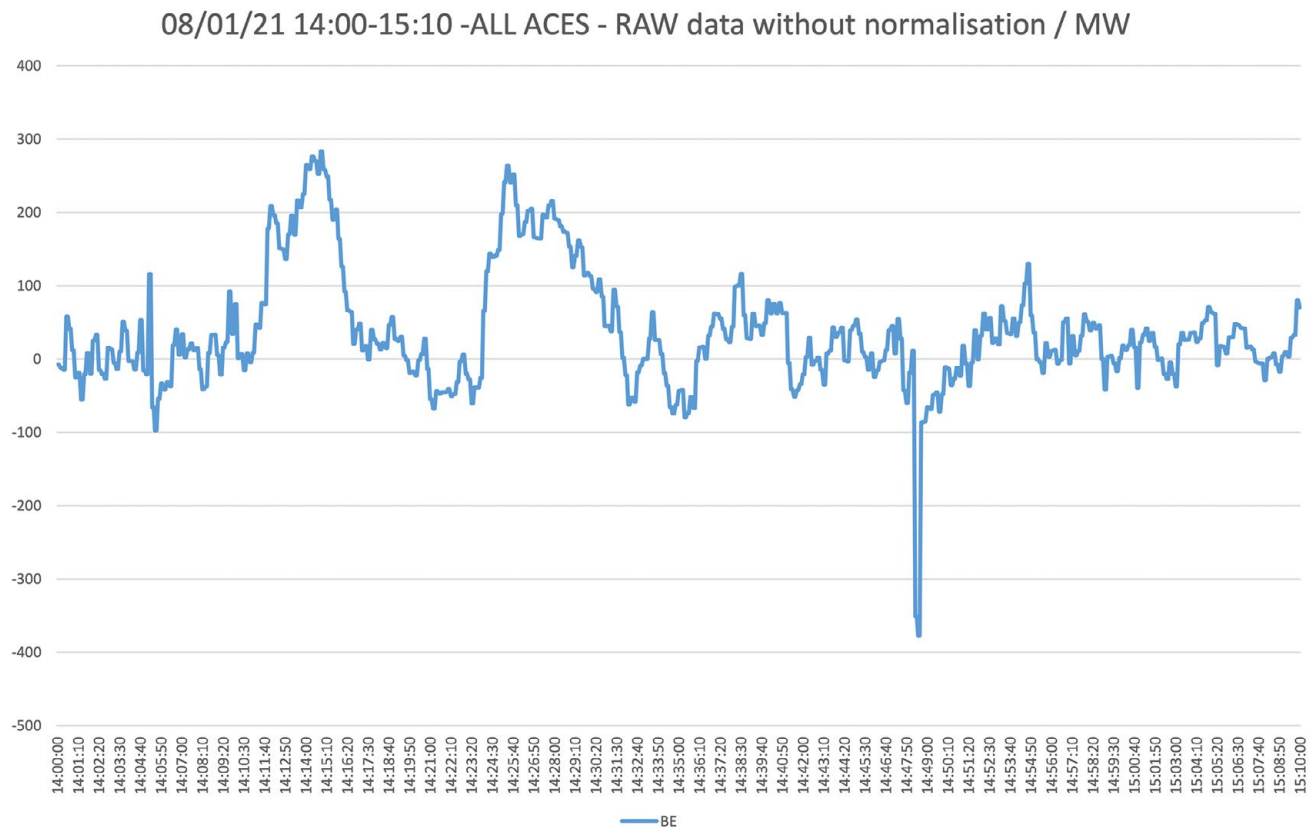

Figure A2-14: ELIA ACE

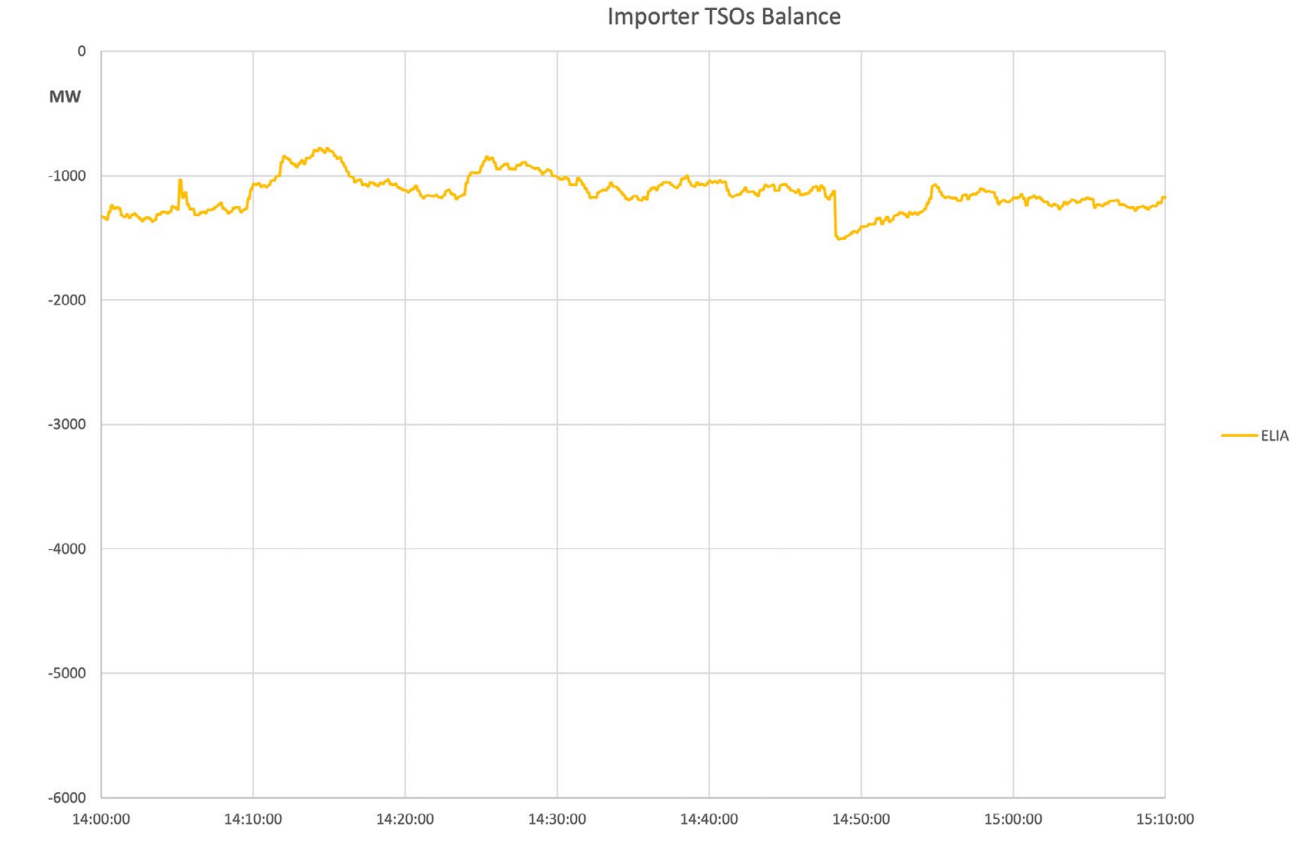

Figure A2-15: ELIA Balance

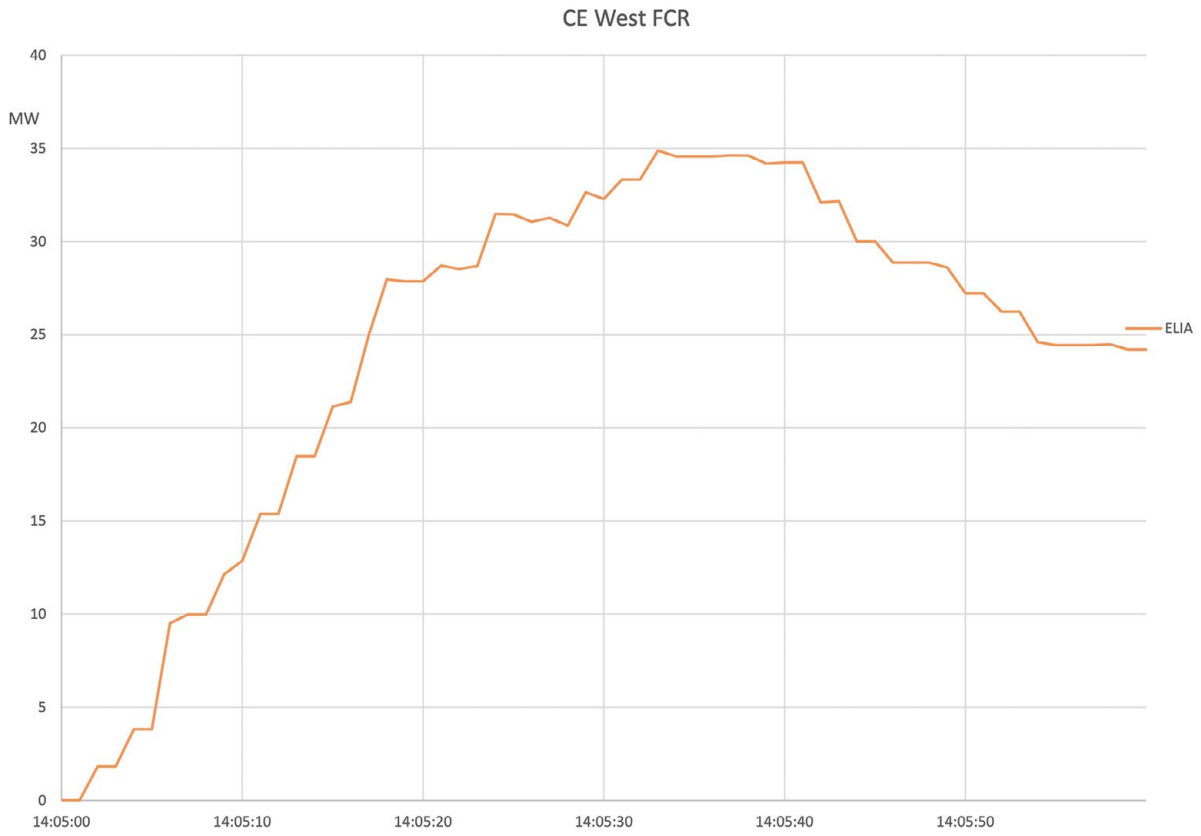

Figure A2-16: ELIA FCR

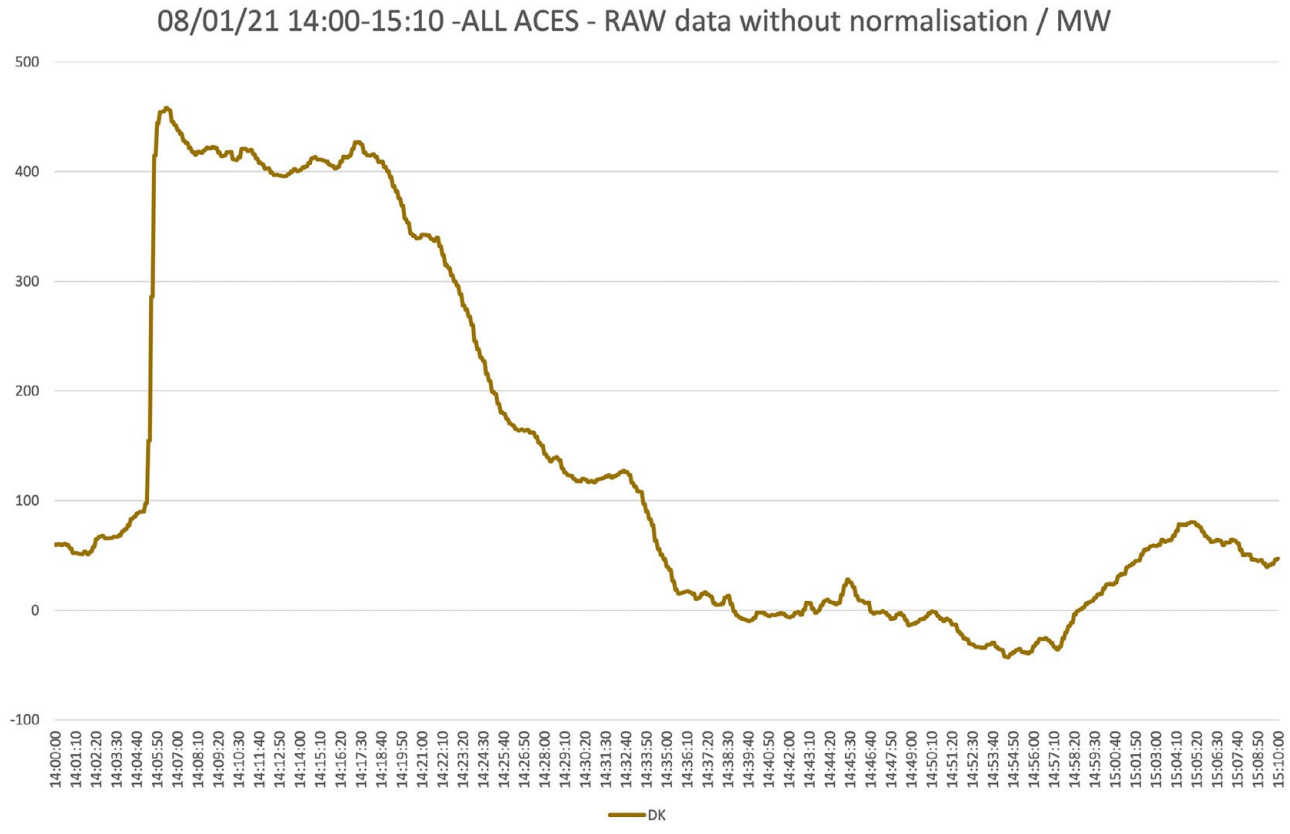

Figure A2-17: Energinet ACE

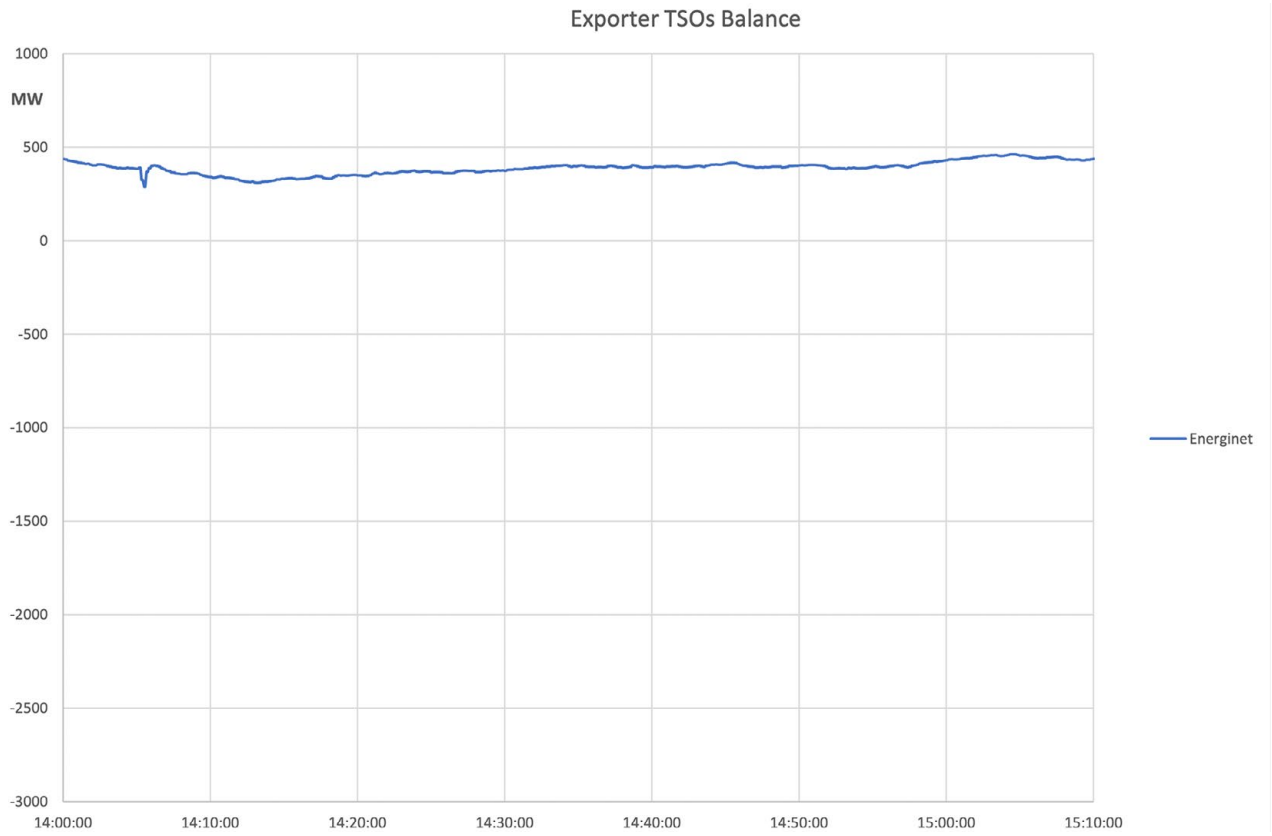

Figure A2-18: Energinet Balance

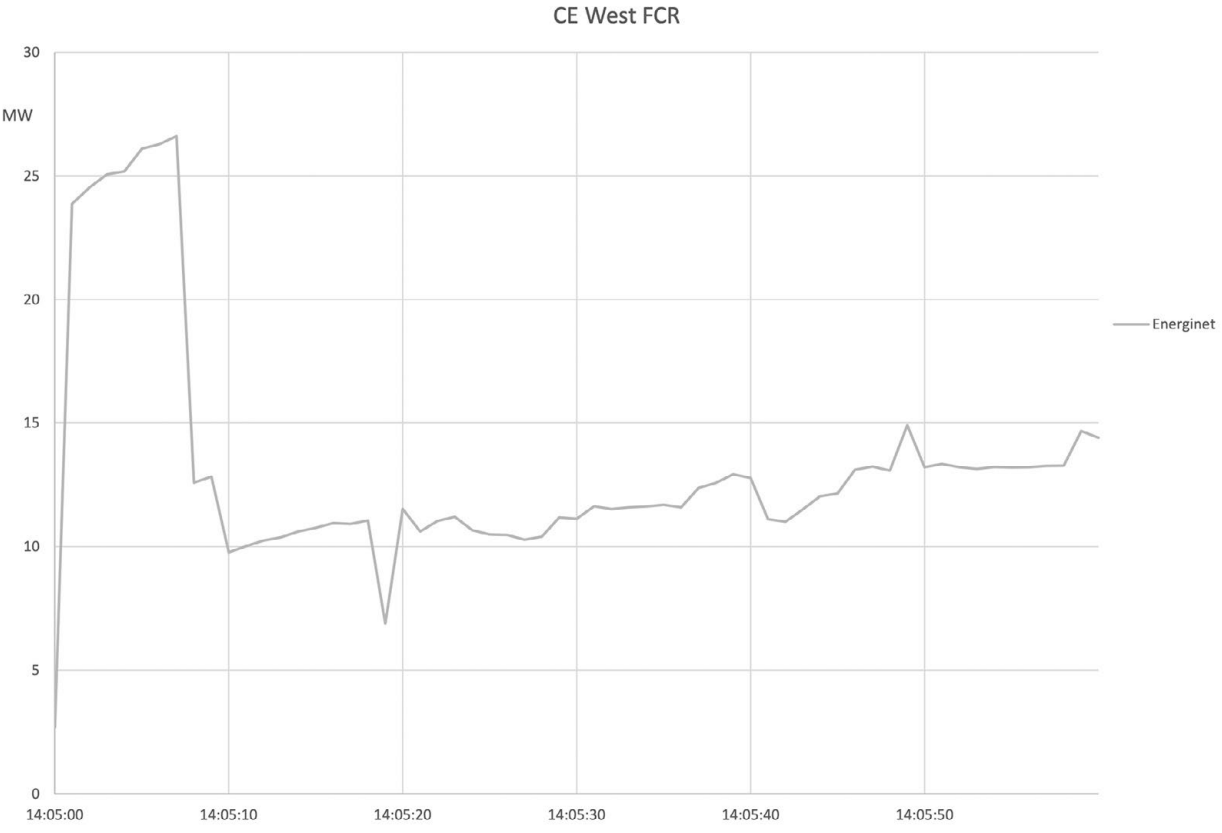

Figure A2-19: Energinet FCR

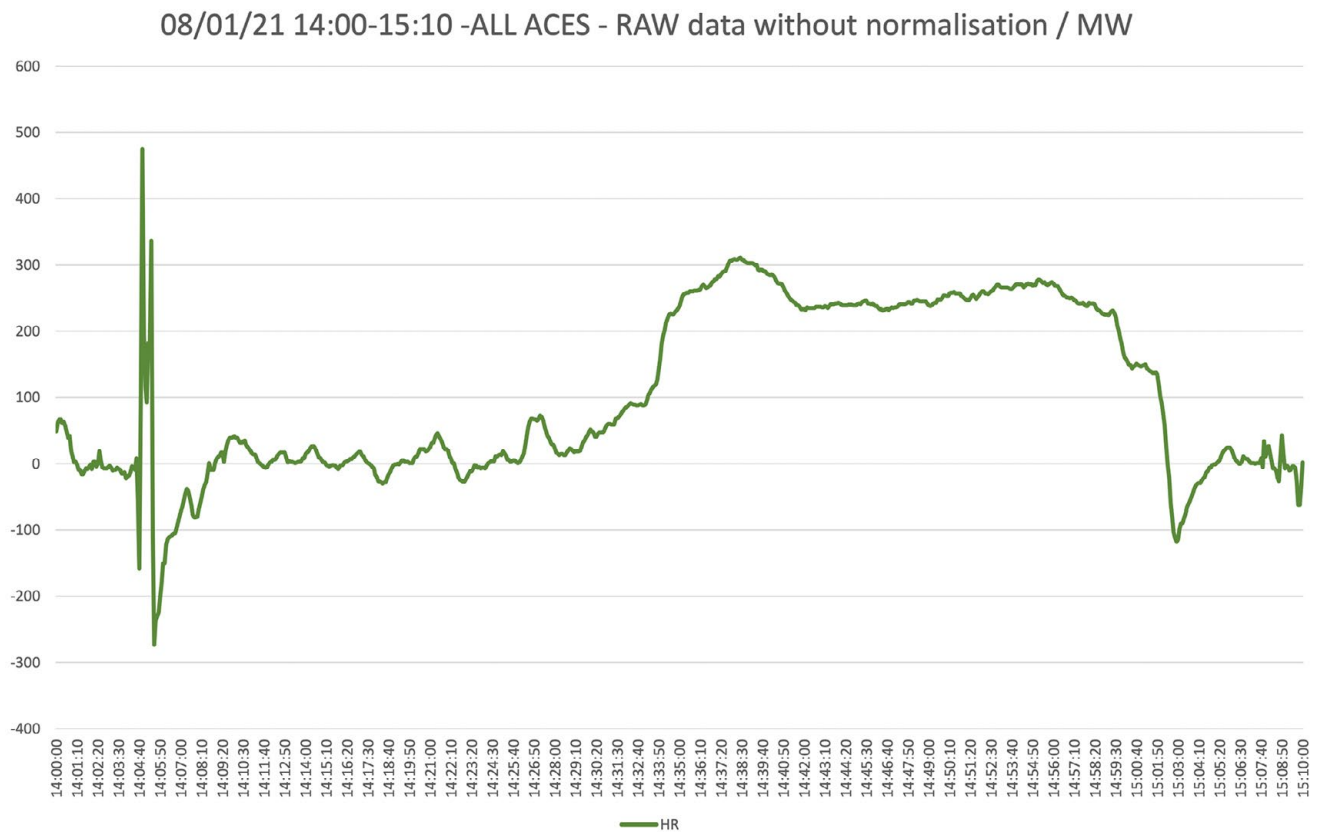

Figure A2-20: HOPS ACE

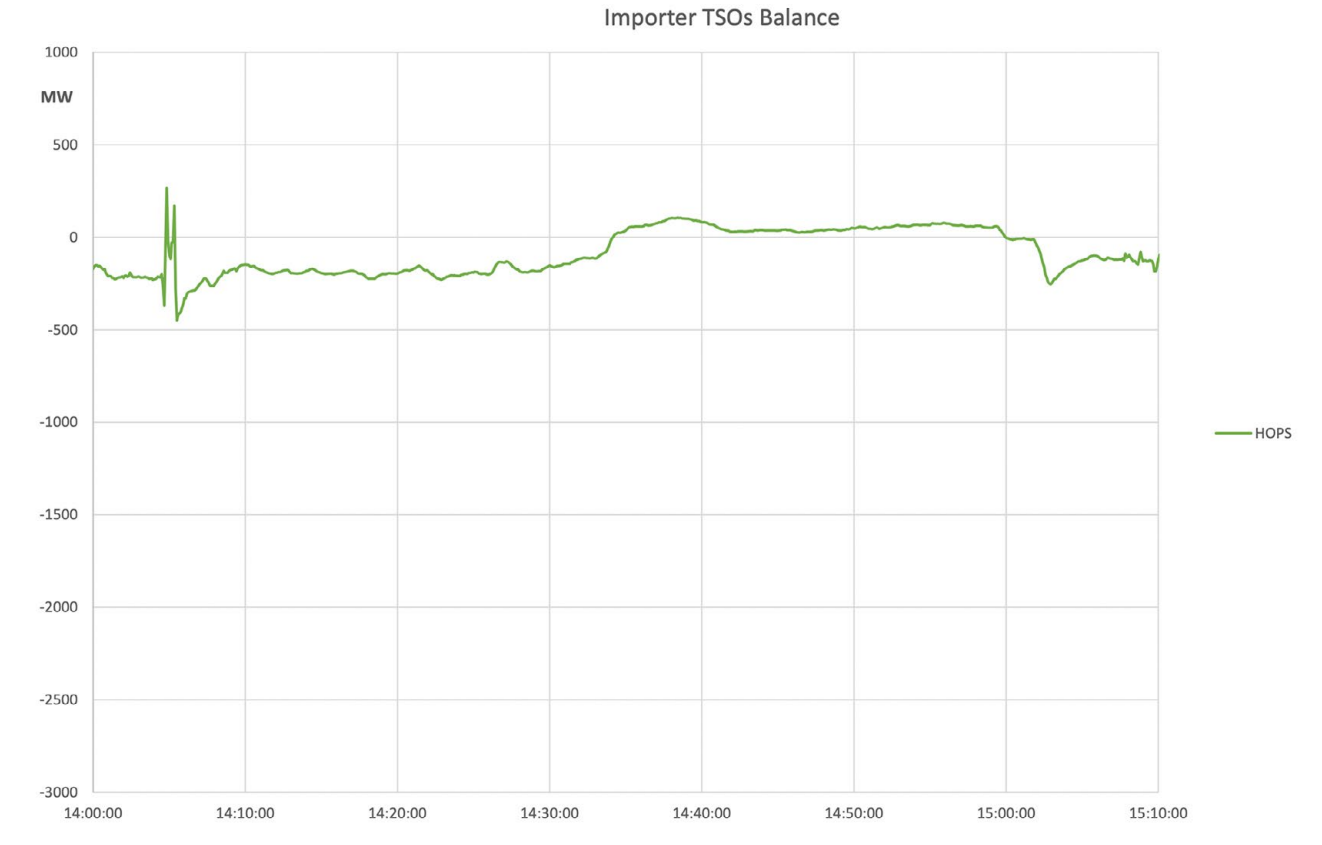

Figure A2-21: HOPS Balance

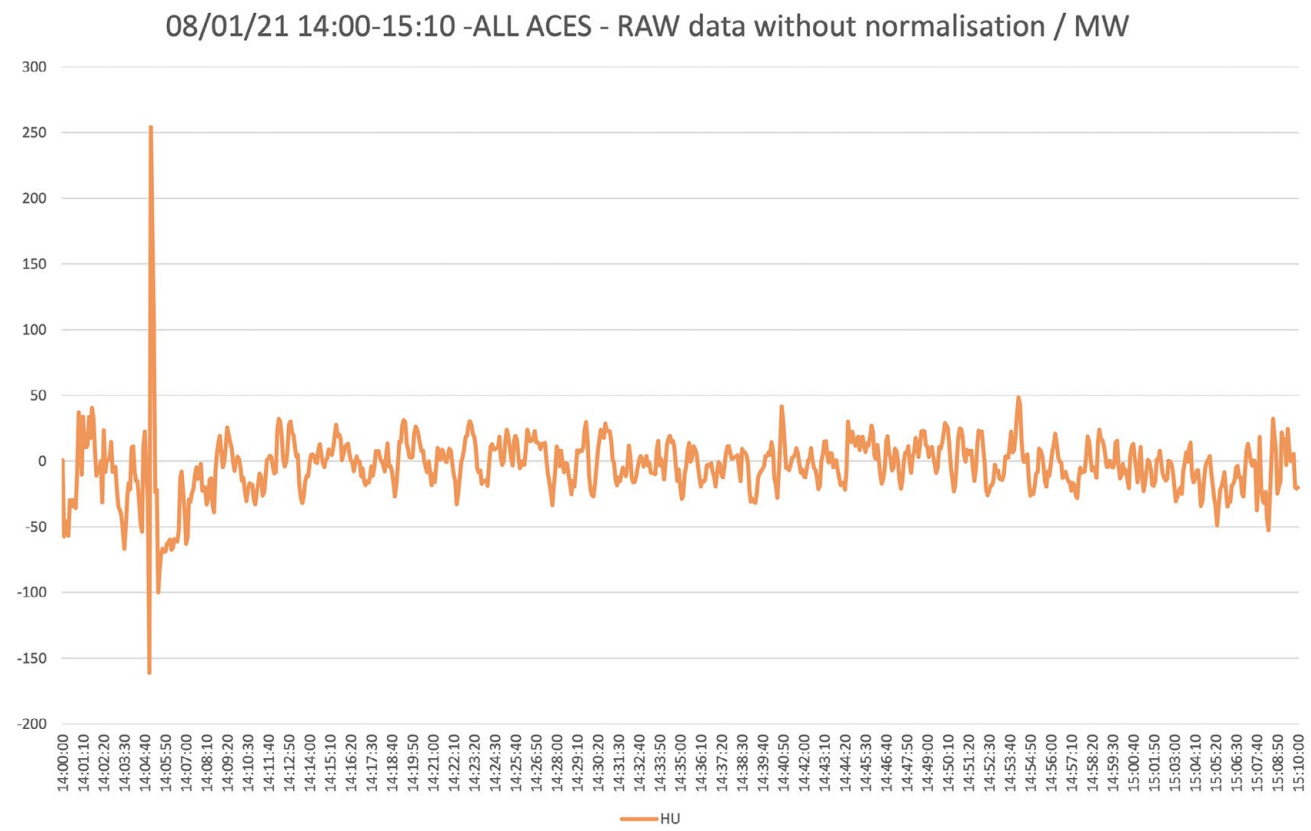

Figure A2-22: Mavir ACE

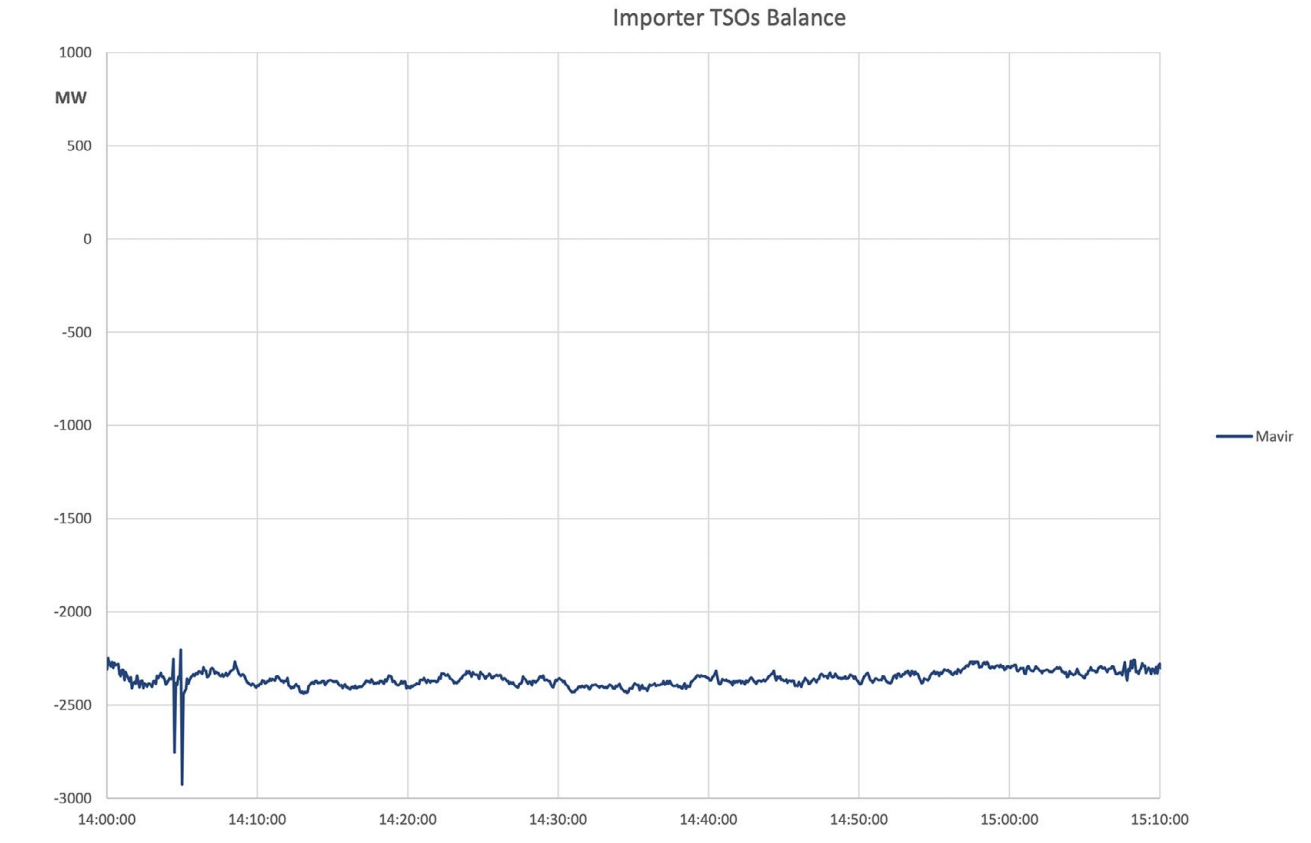

Figure A2-23: Mavir Balance

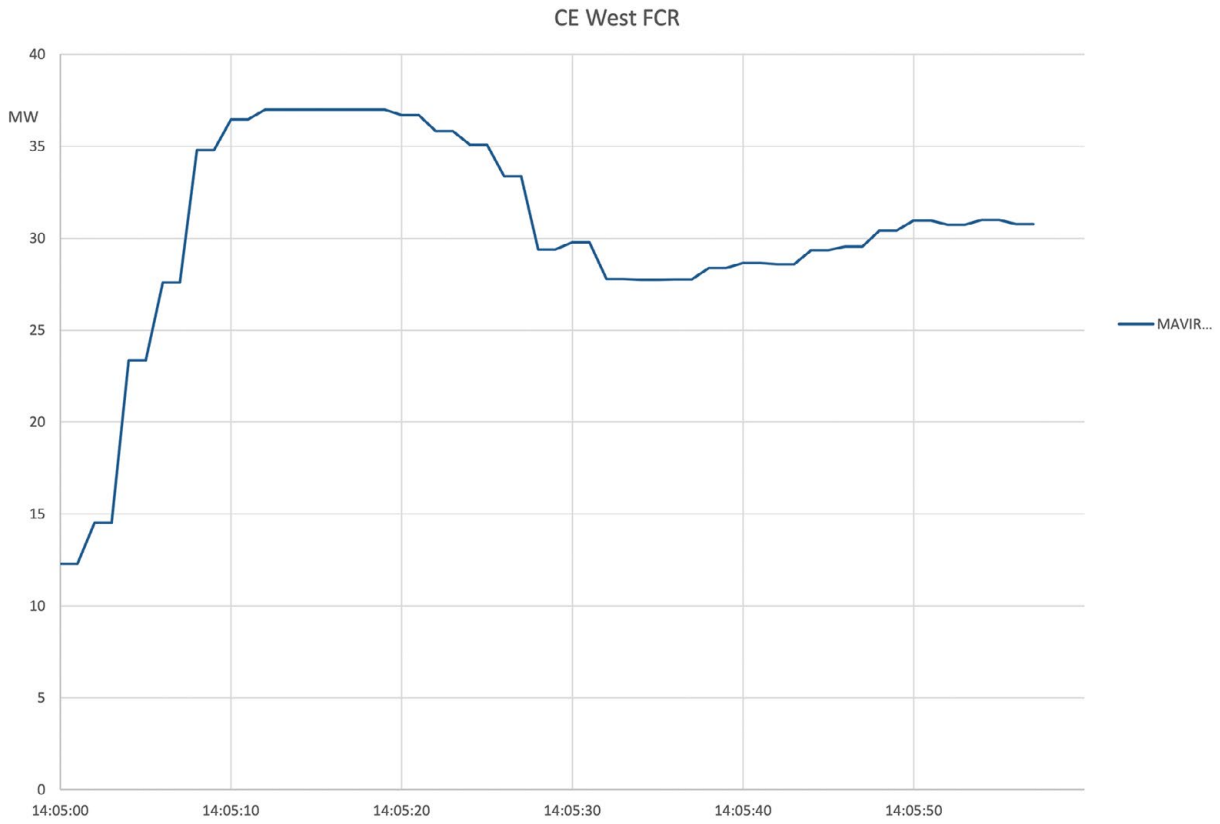

Figure A2-24: Mavir FCR

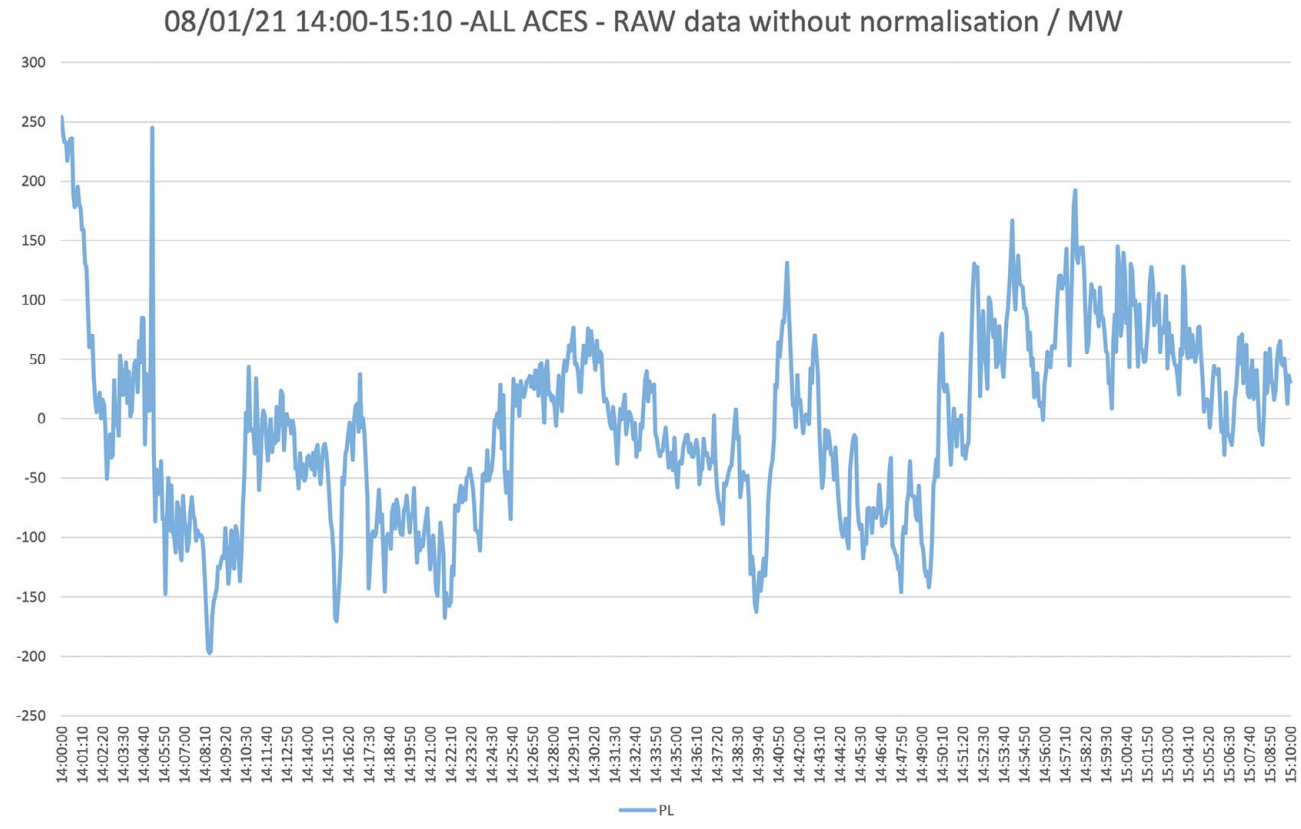

Figure A2-25: PSE ACE

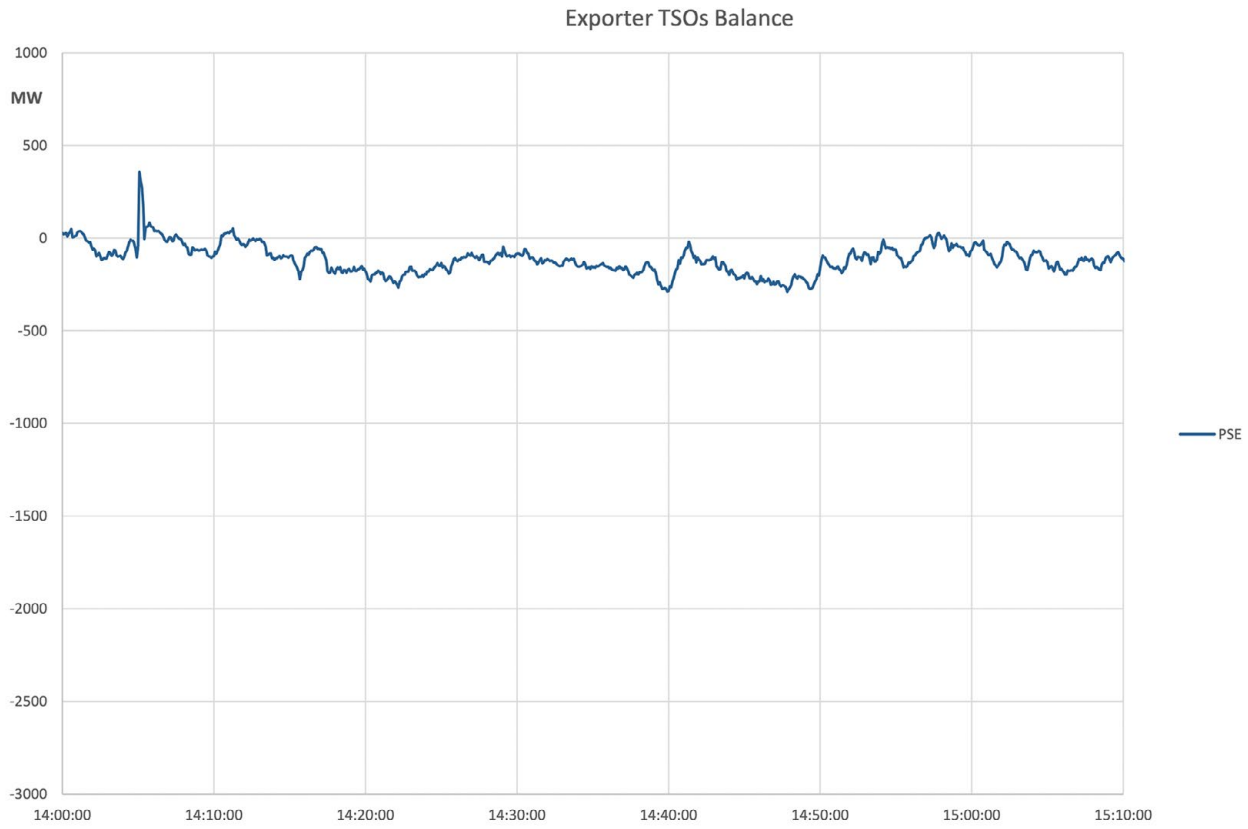

Figure A2-26: PSE Balance

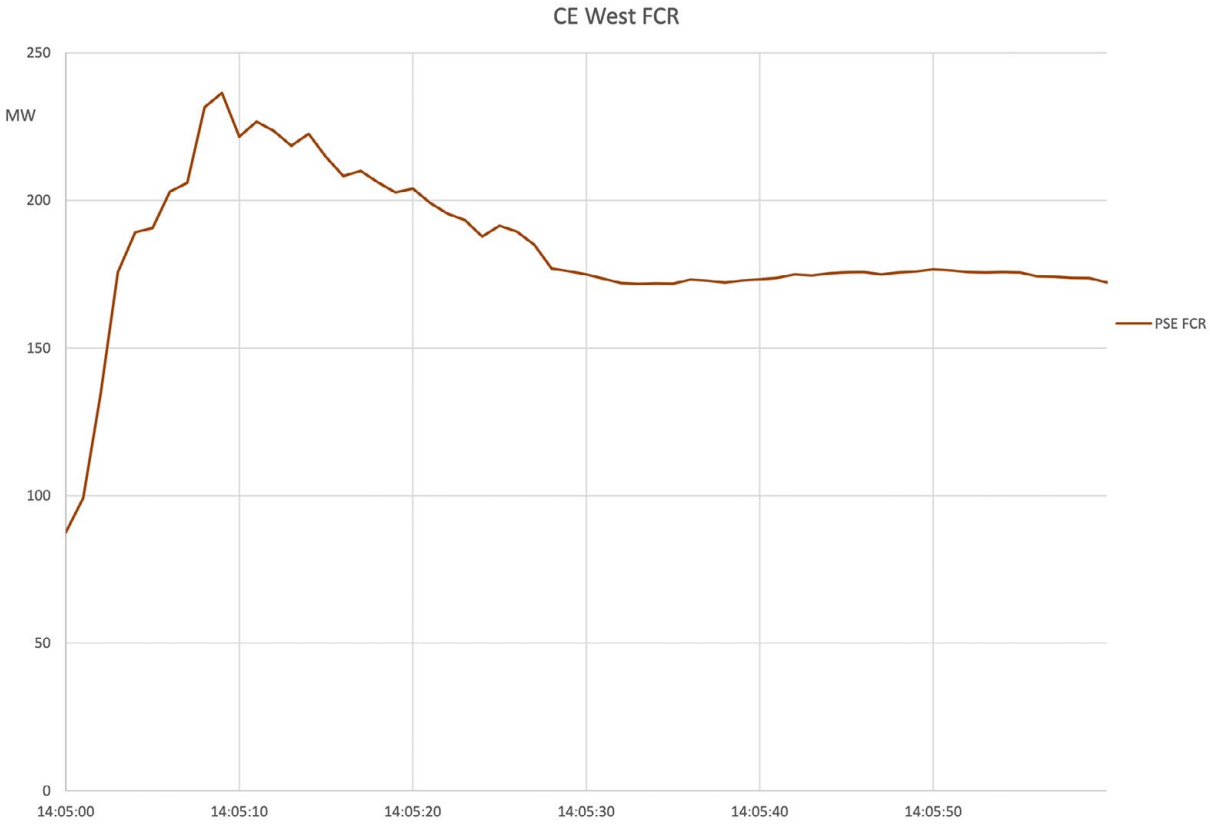

Figure A2-27: PSE FCR

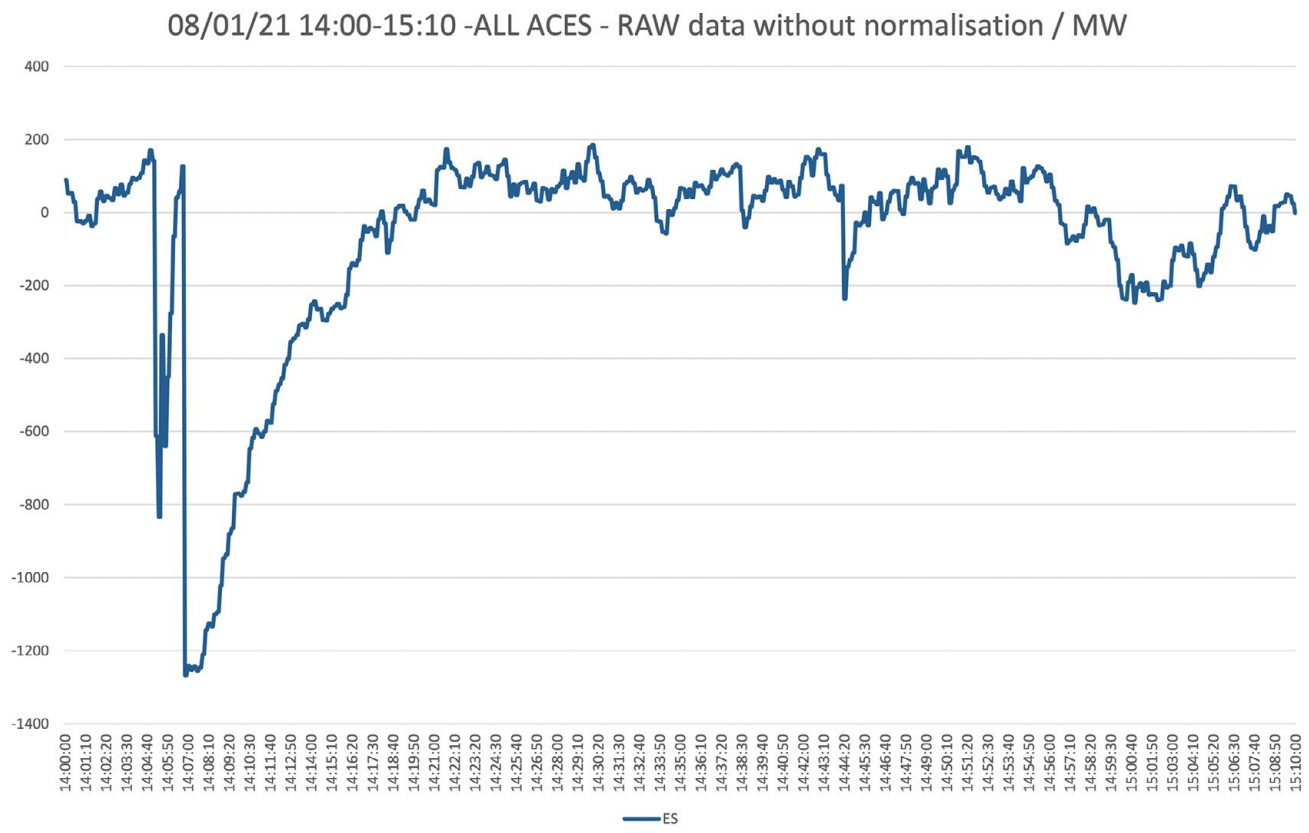

Figure A2-28: REE ACE

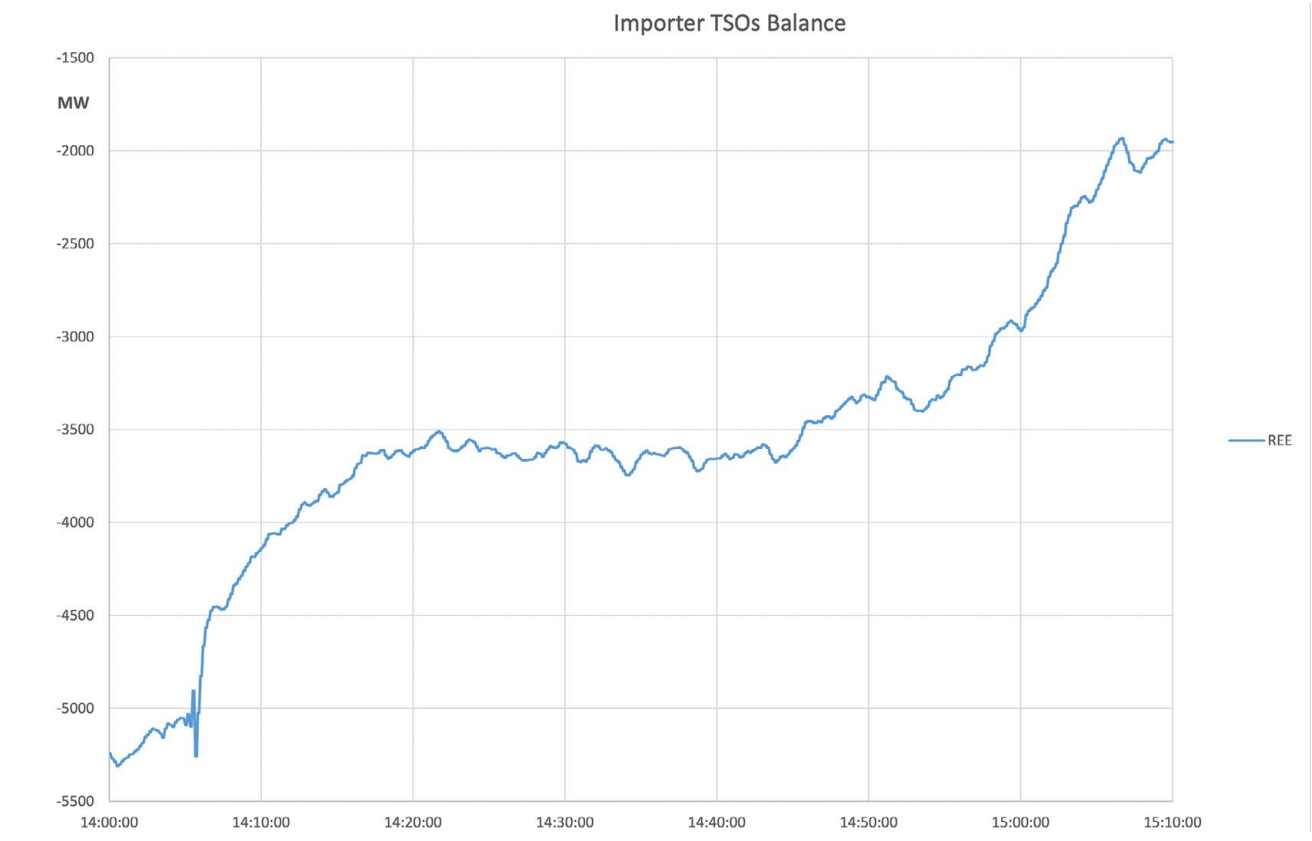

Figure A2-29: REE Balance

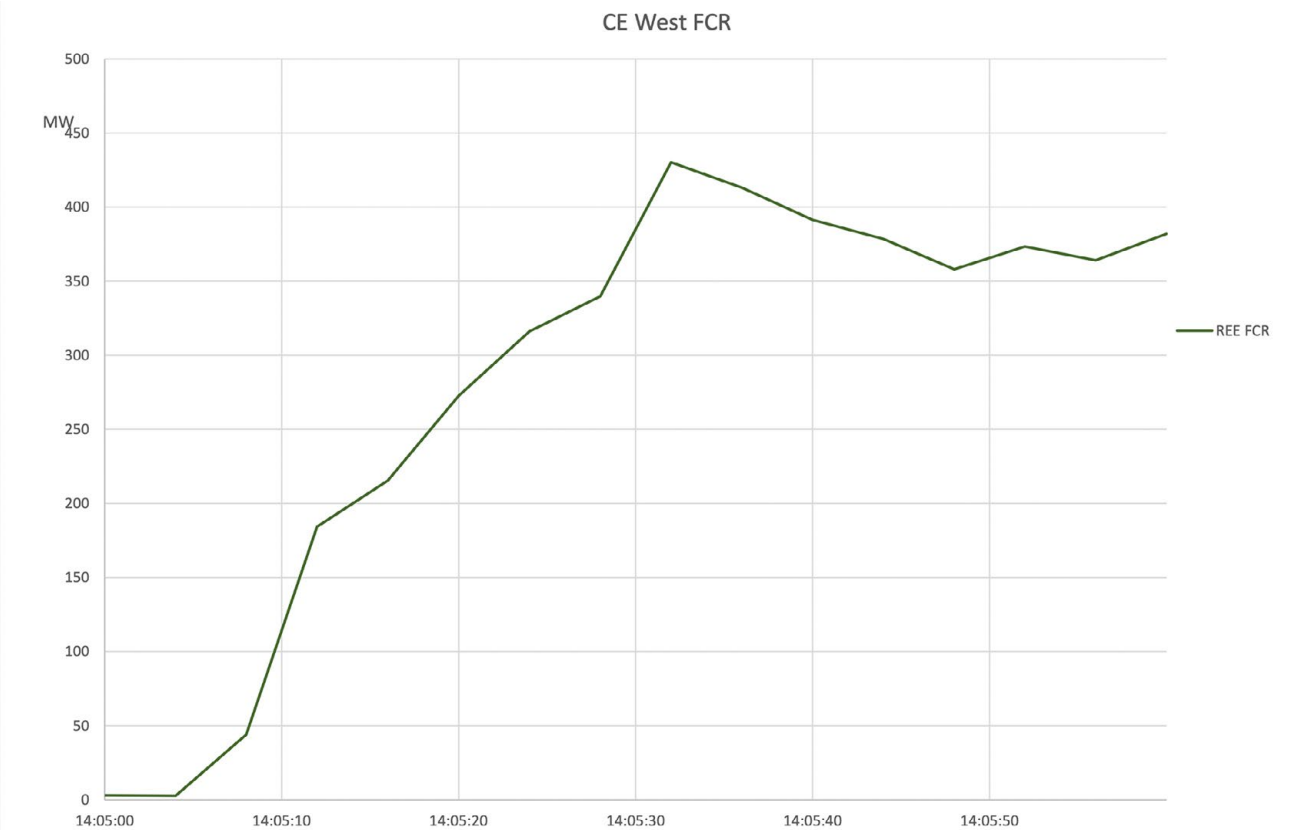

Figure A2-30: REE FCR

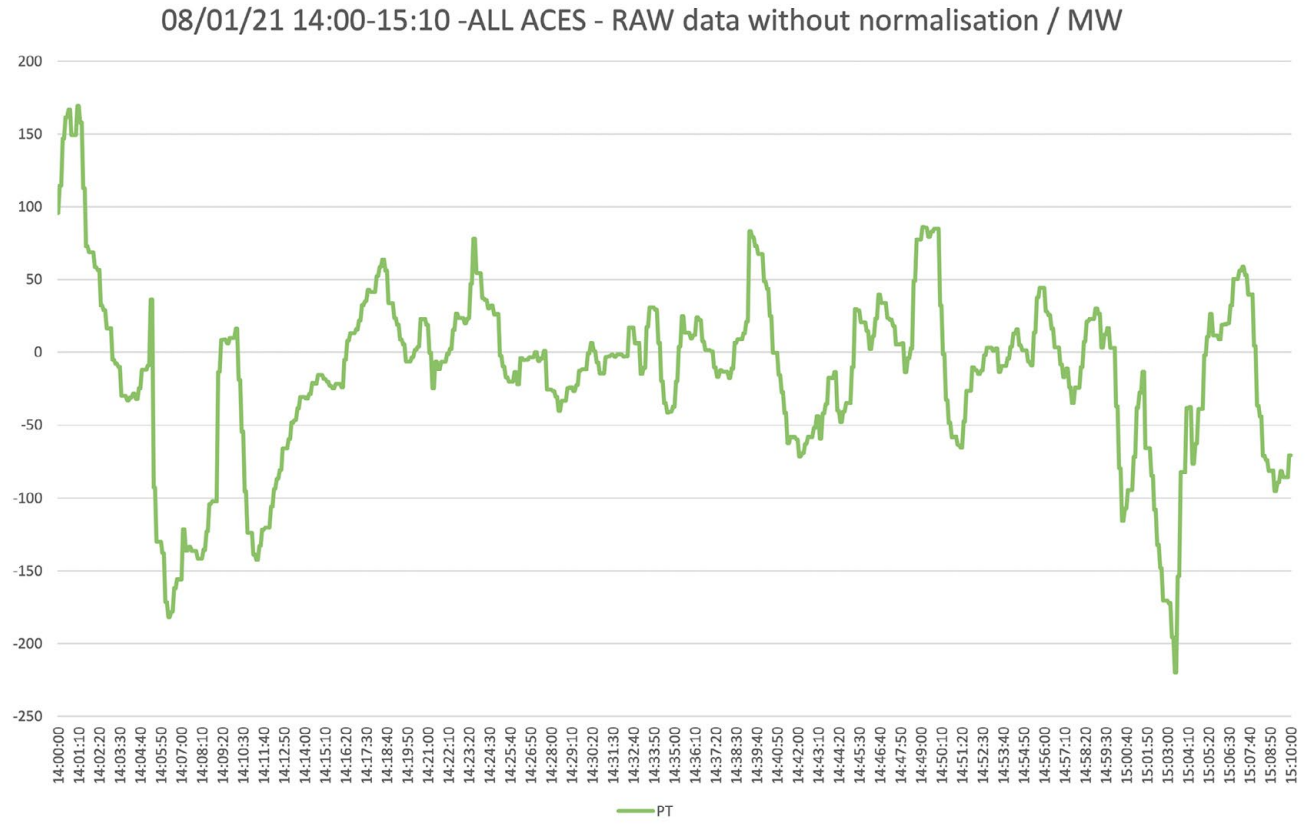

Figure A2-31: REN ACE

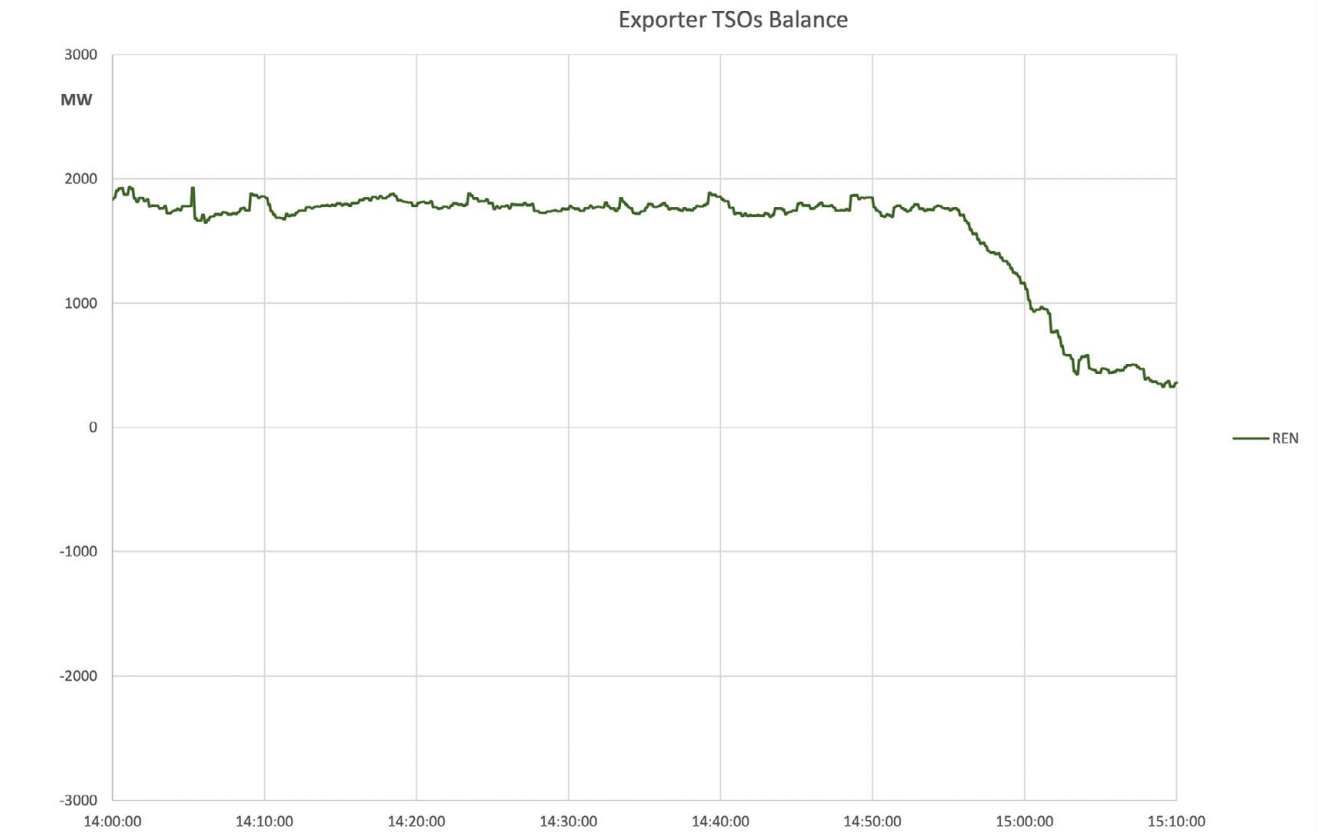

Figure A2-32: REN Balance

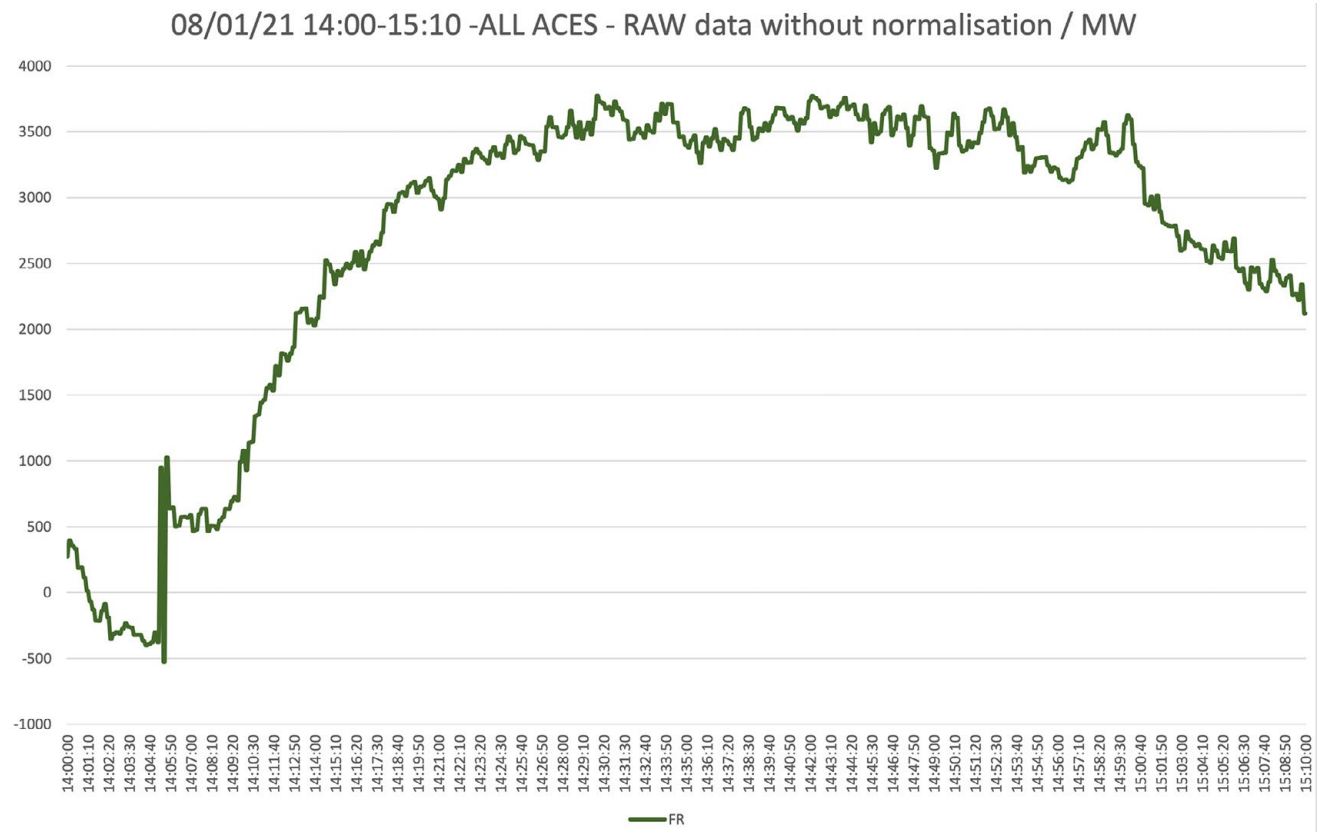

Figure A2-33: RTE ACE

Figure A2-34: RTE Balance

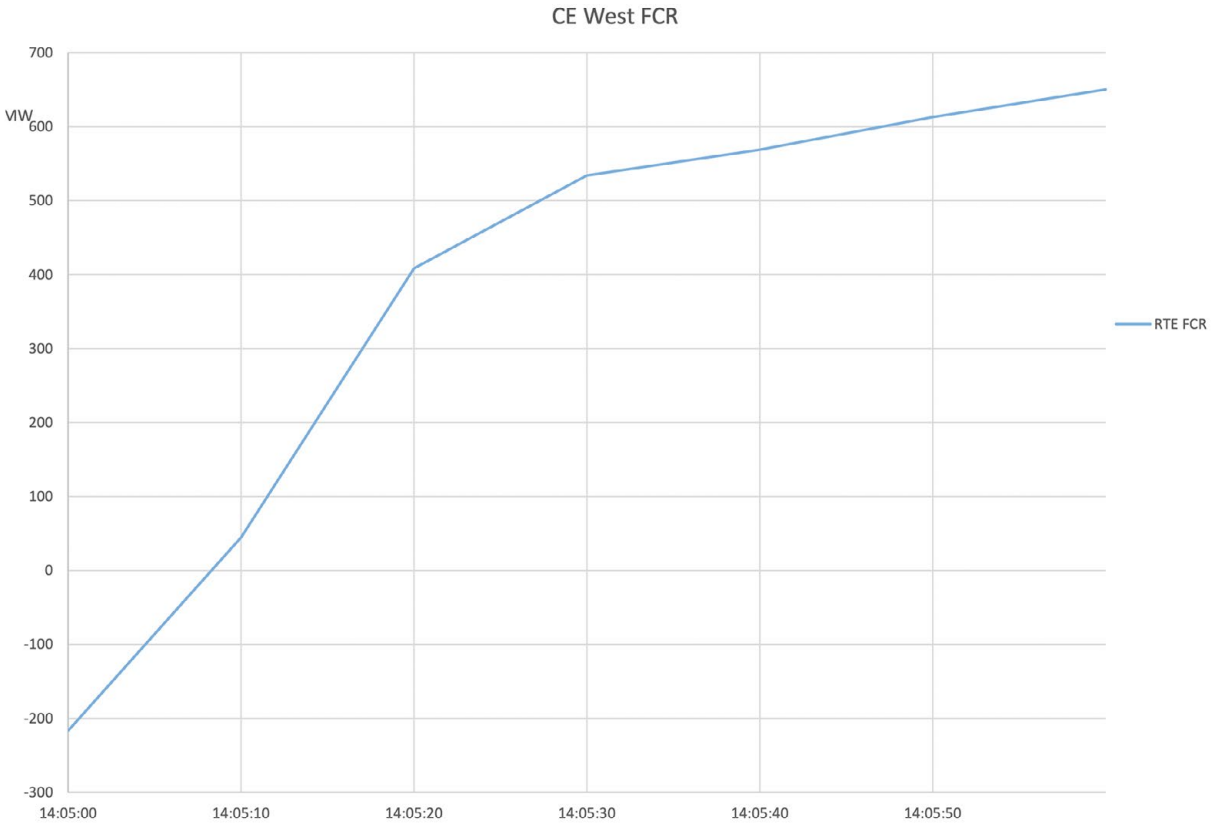

Figure A2-35: RTE FCR

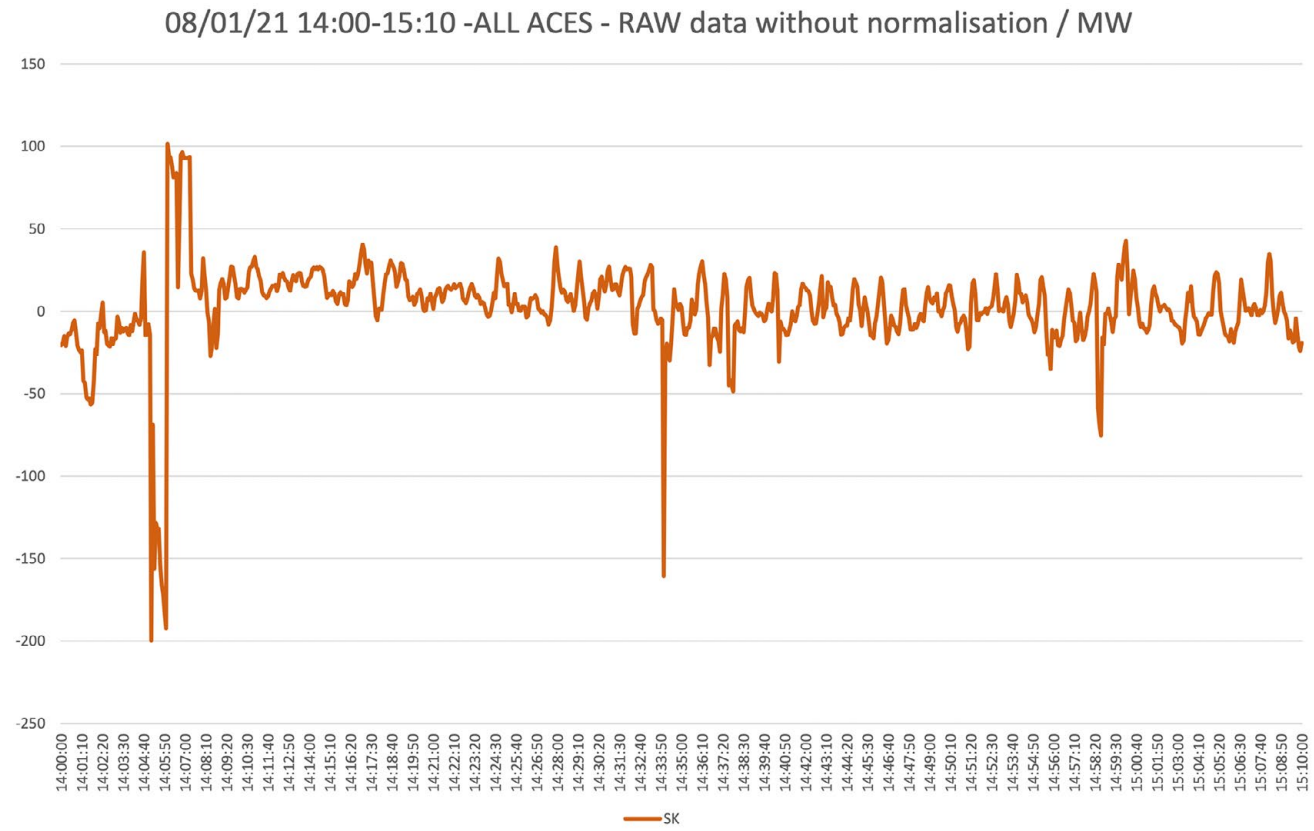

Figure A2-36: SEPS ACE

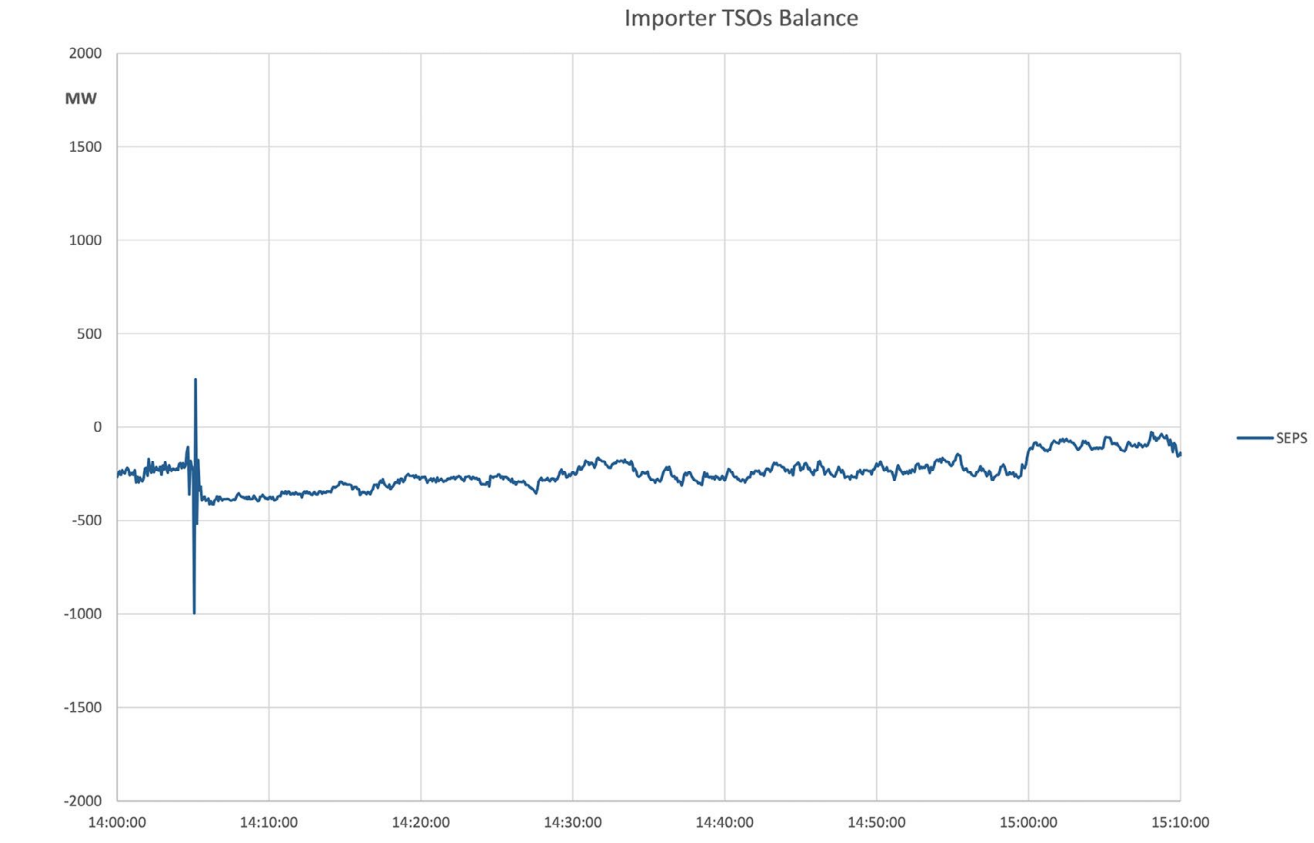

Figure A2-37: SEPS Balance

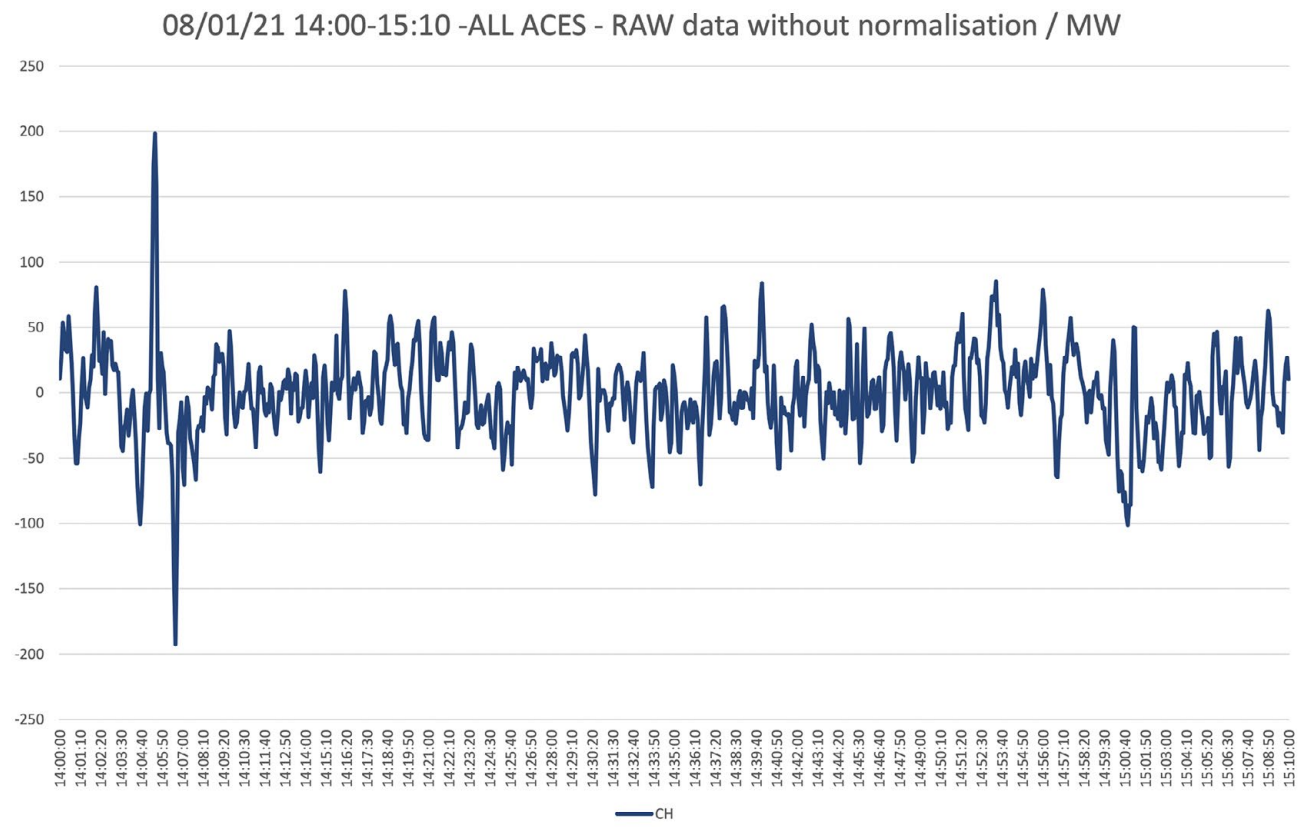

Figure A2-38: Swissgrid ACE

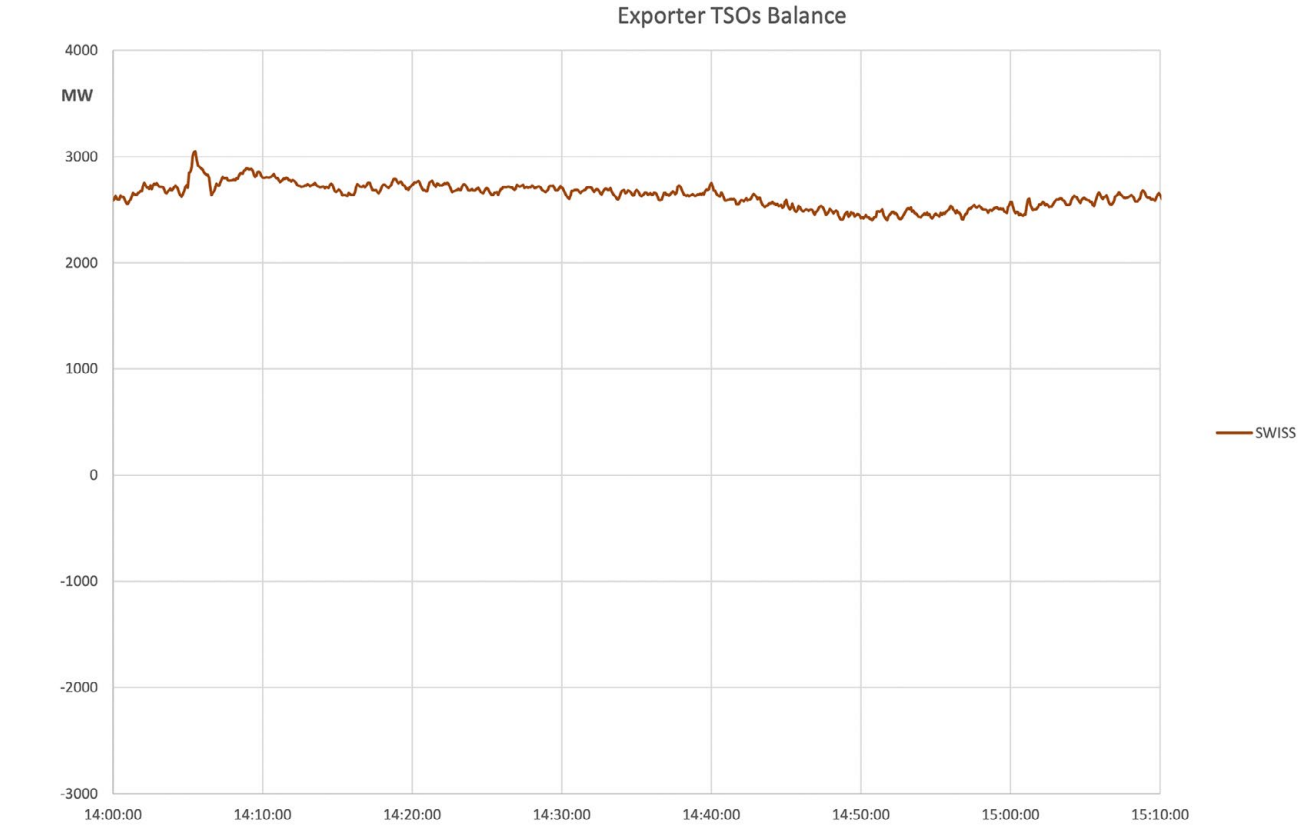

Figure A2-39: Swissgrid Balance

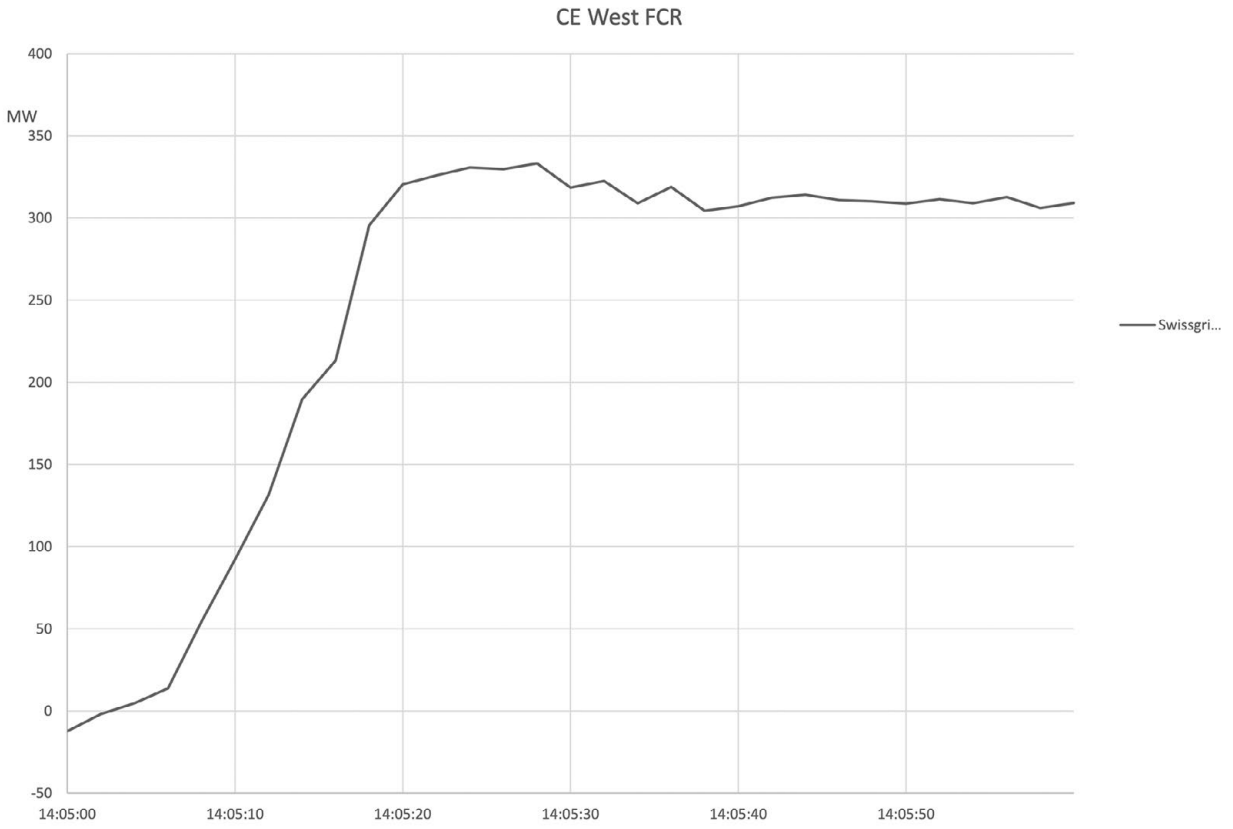

Figure A2-40: Swissgrid FCR

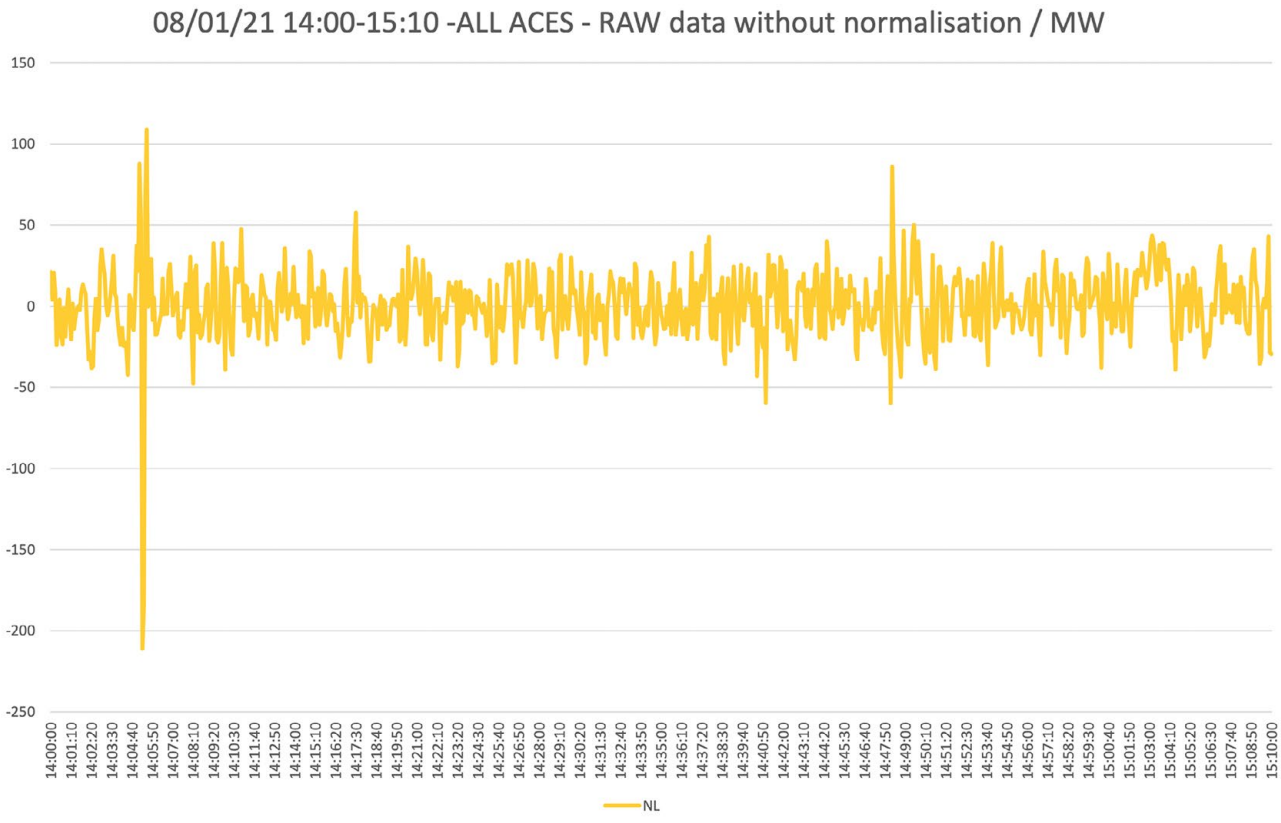

Figure A2-41: TenneT NL ACE

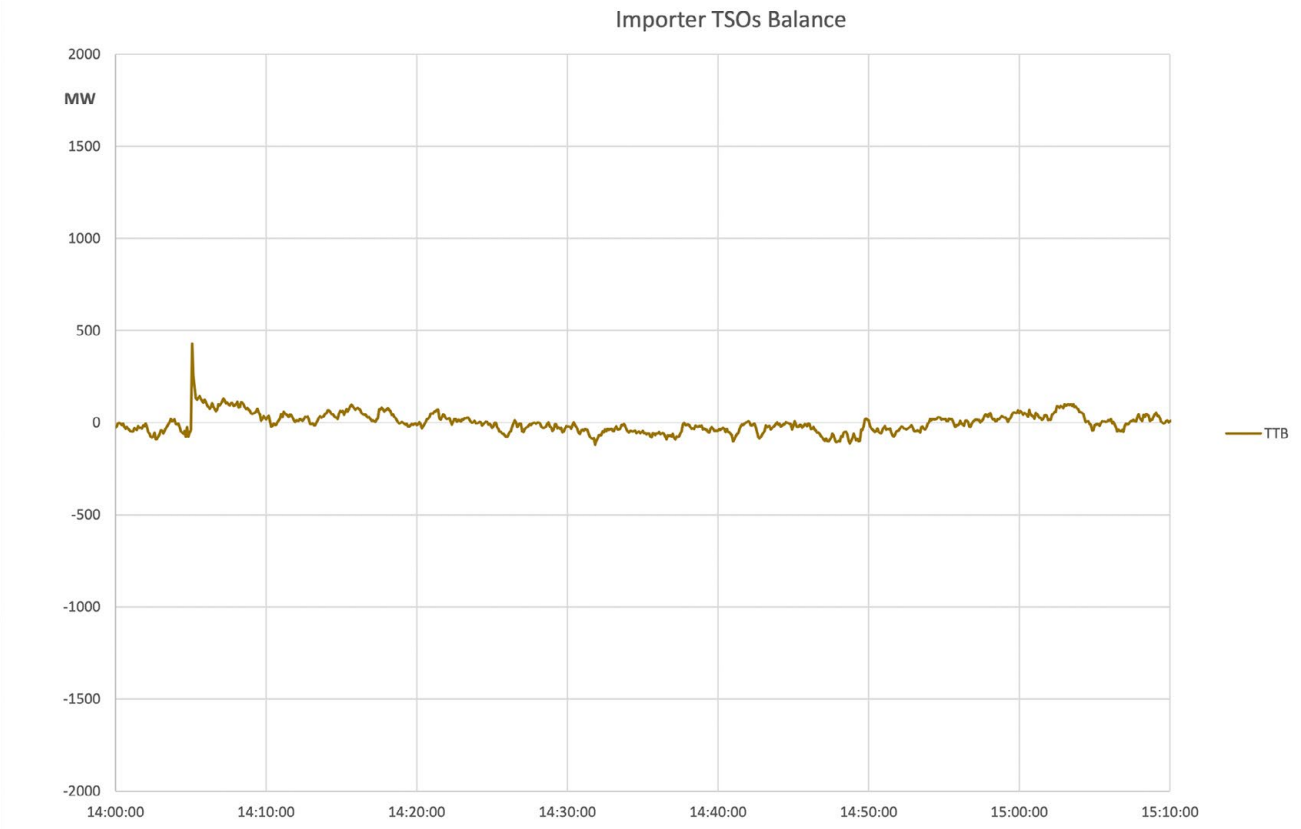

Figure A2-42: TenneT NL Balance

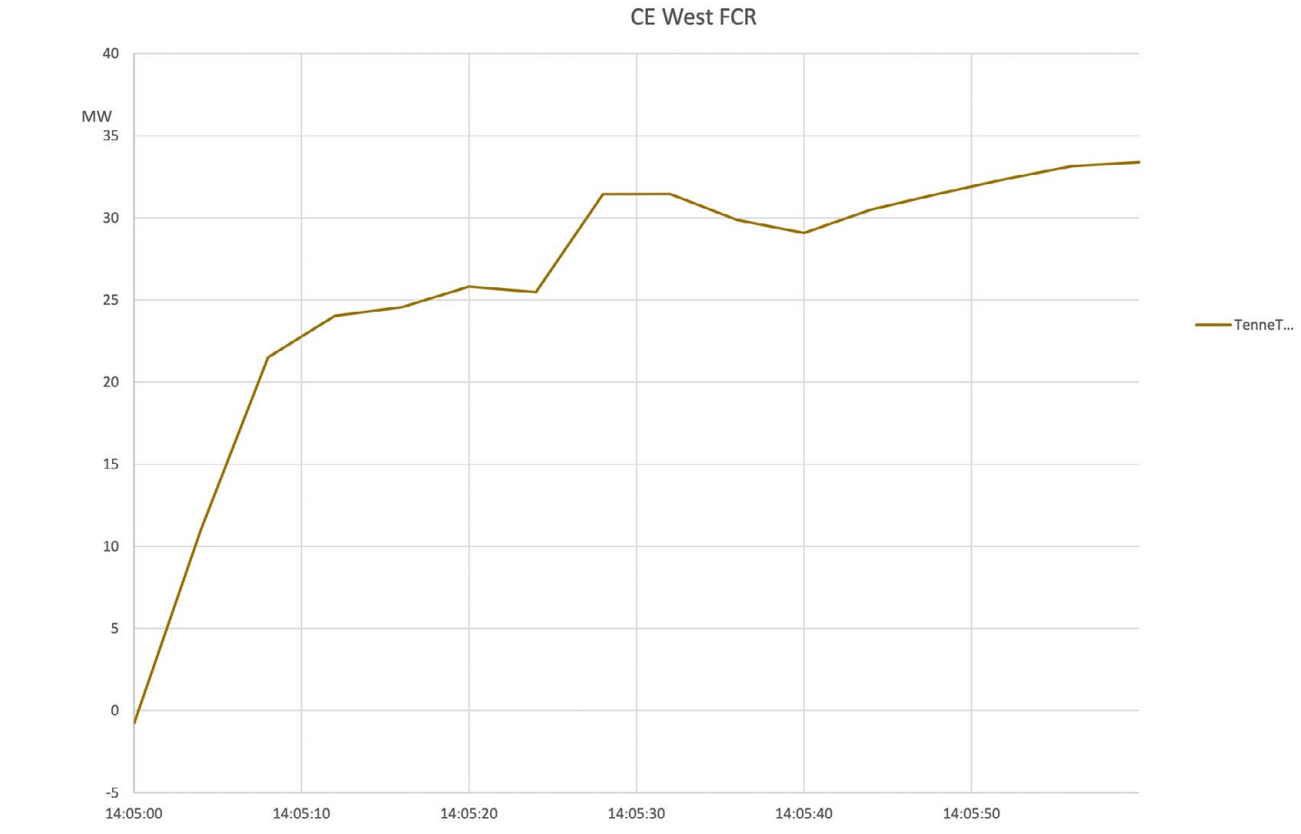

Figure A2-43: TenneT NL FCR

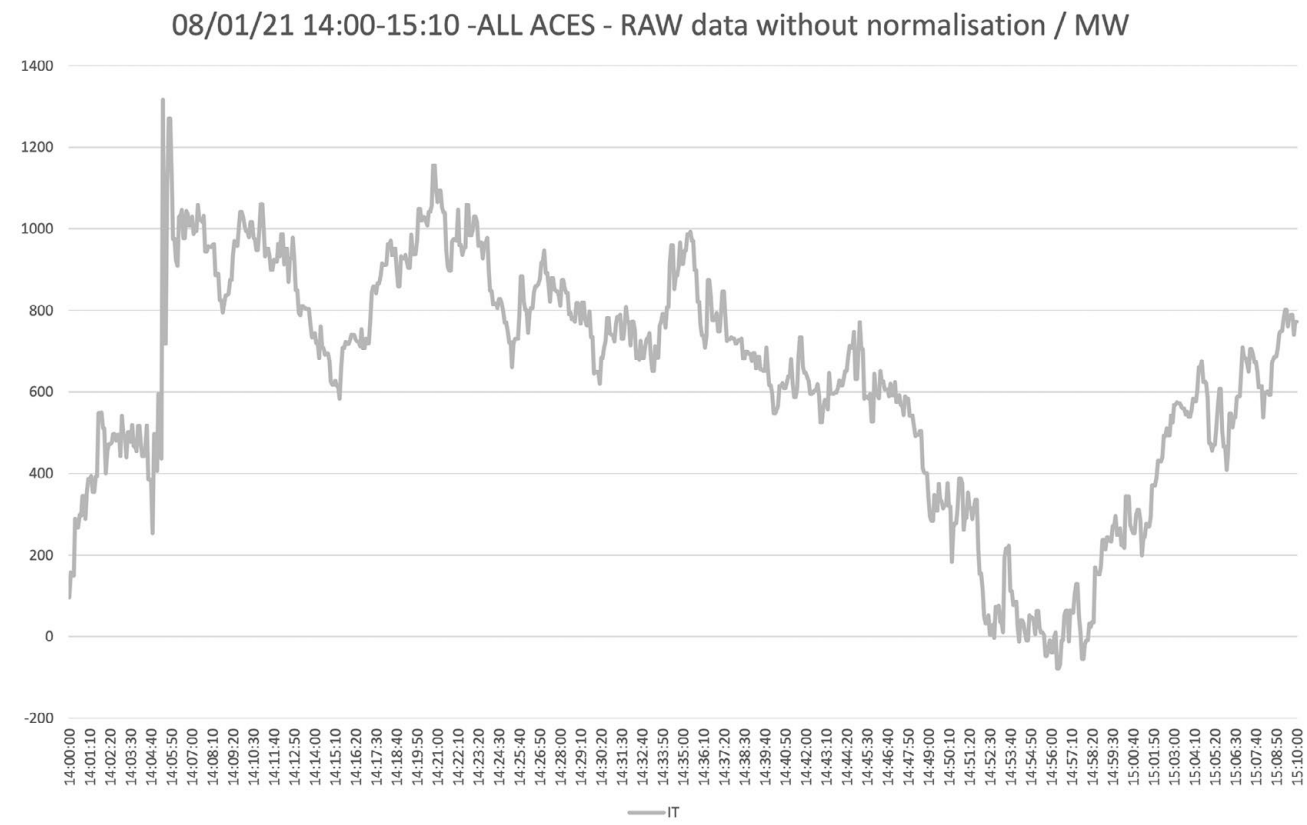

Figure A2-44: Terna ACE

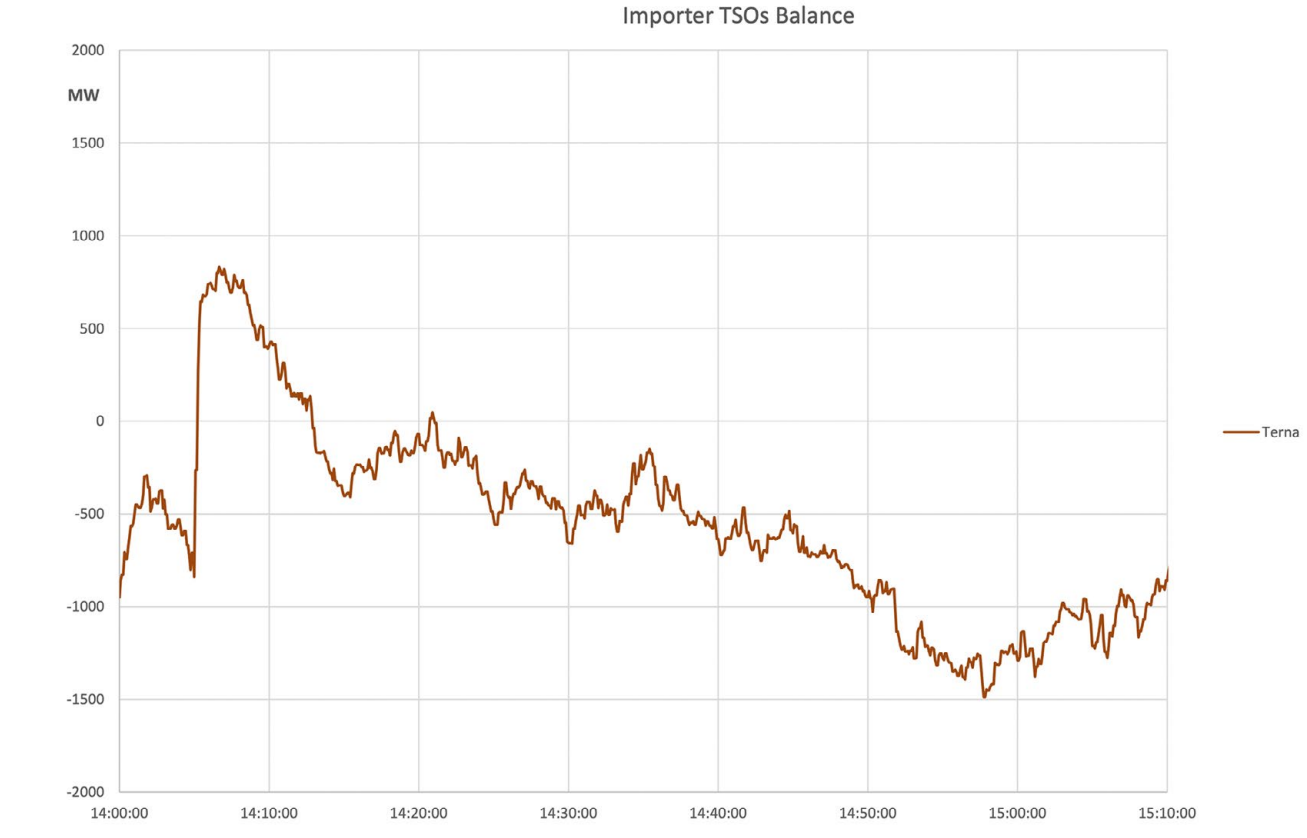

Figure A2-45: Terna Balance

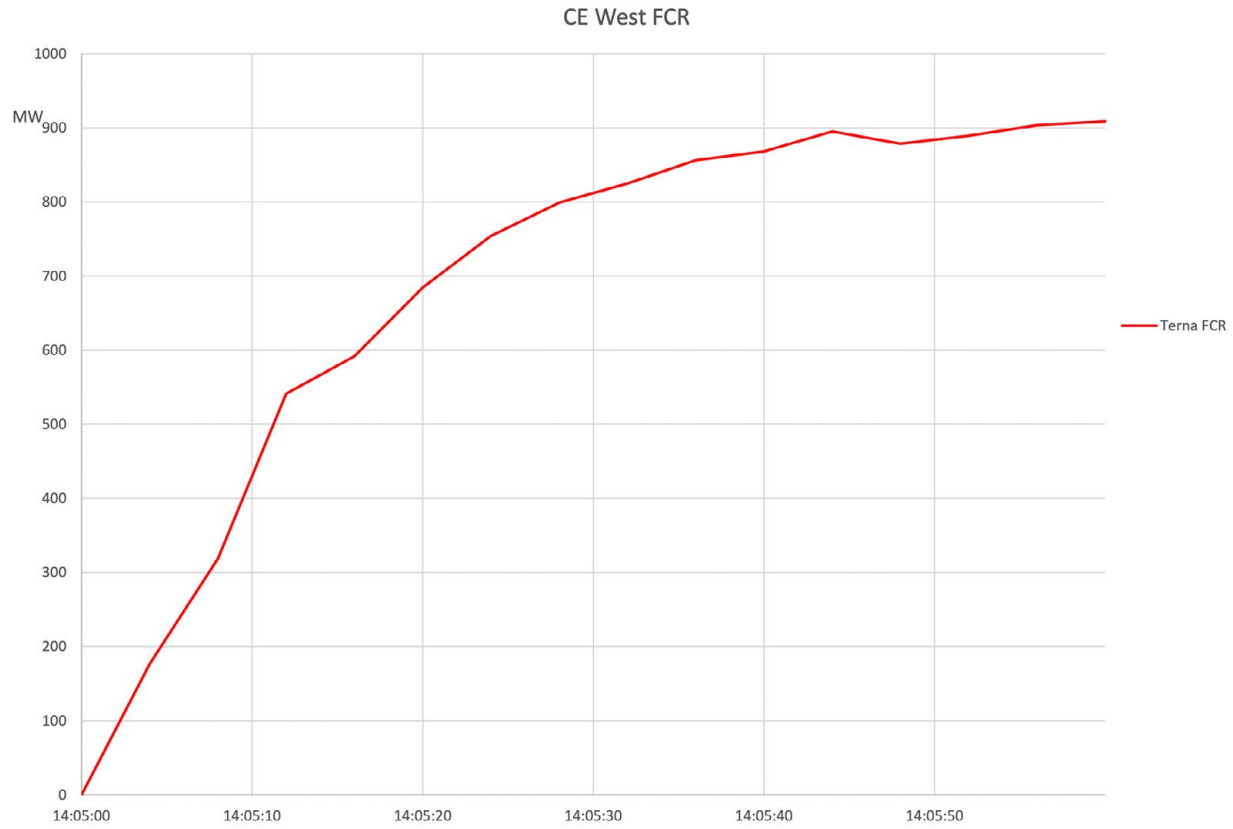

Figure A2-46: Terna FCR

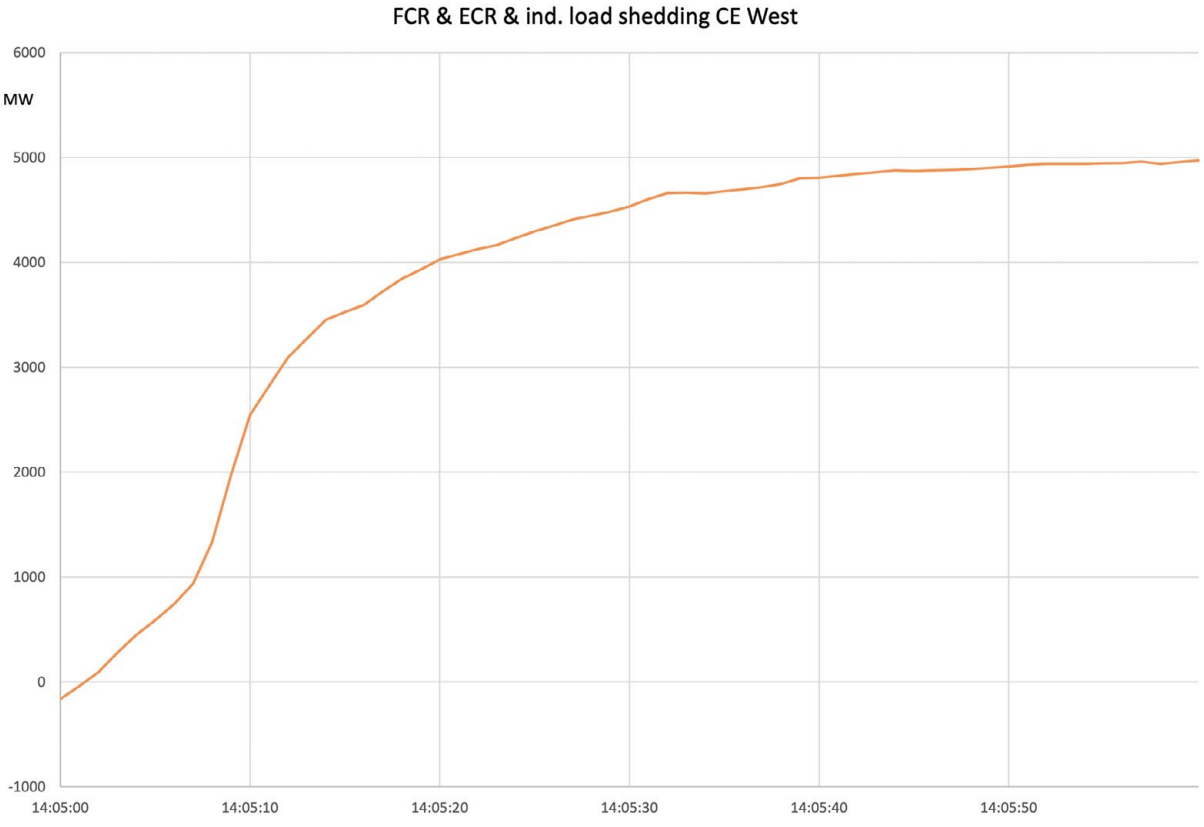

Figure A2-47: CE West Sum of FCR & EPC & SPS

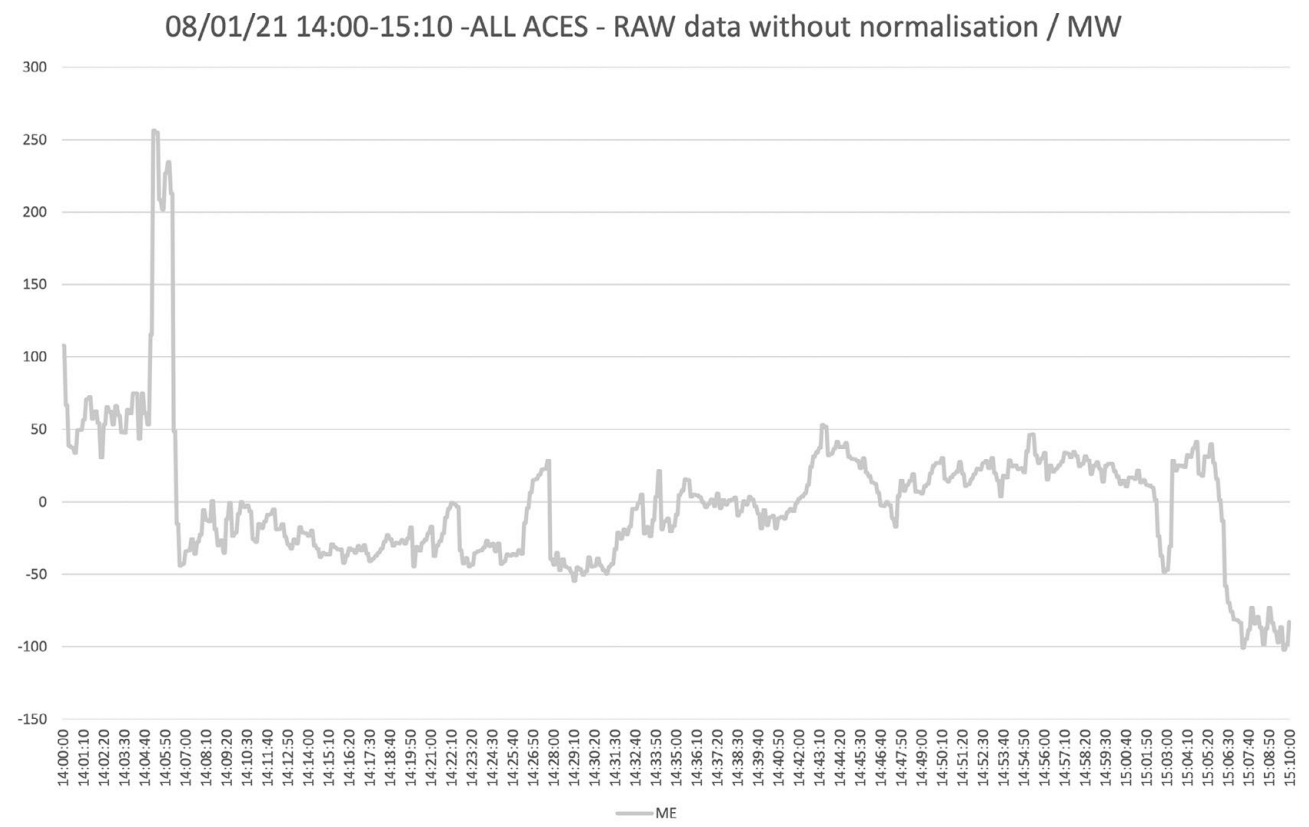

Figure A2-48: CGES ACE

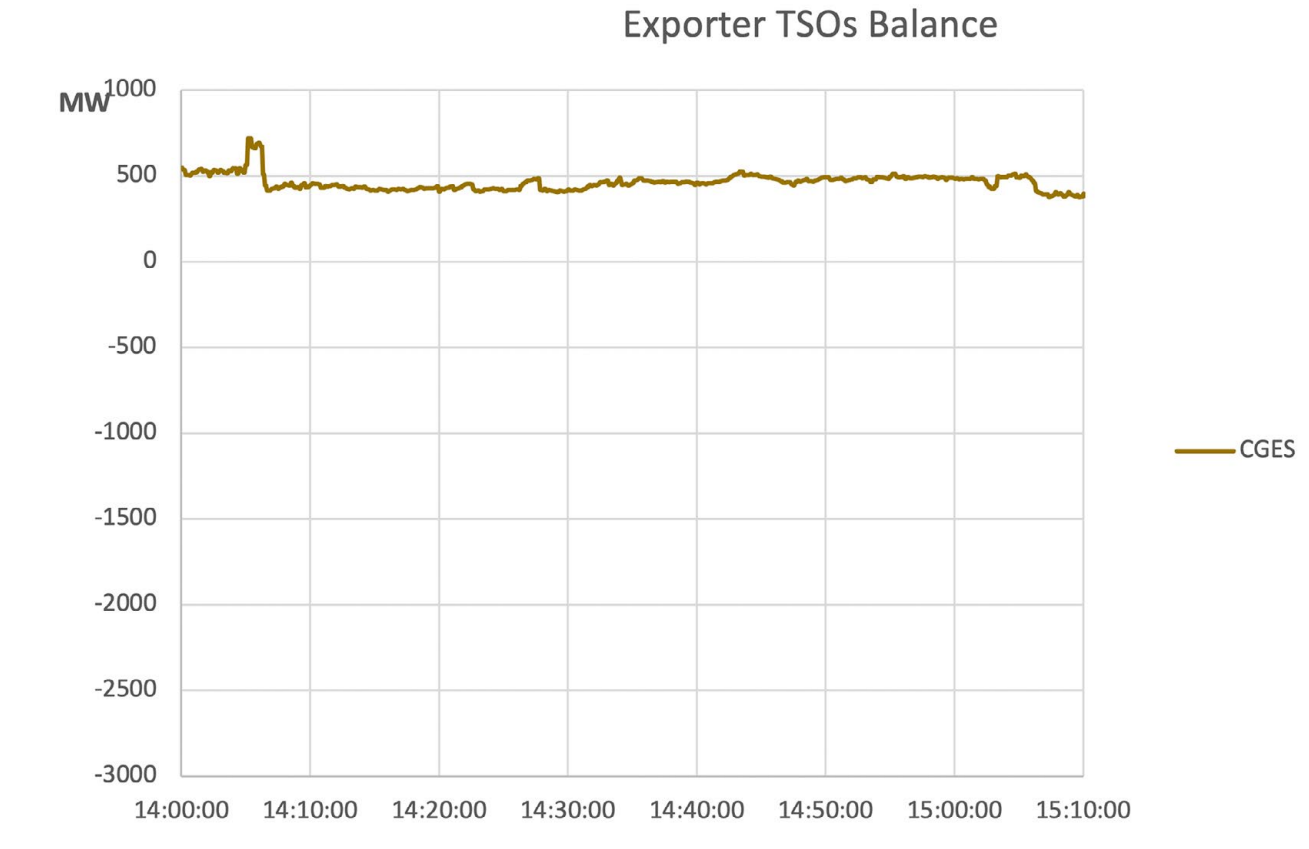

Figure A2-49: CGES Balance

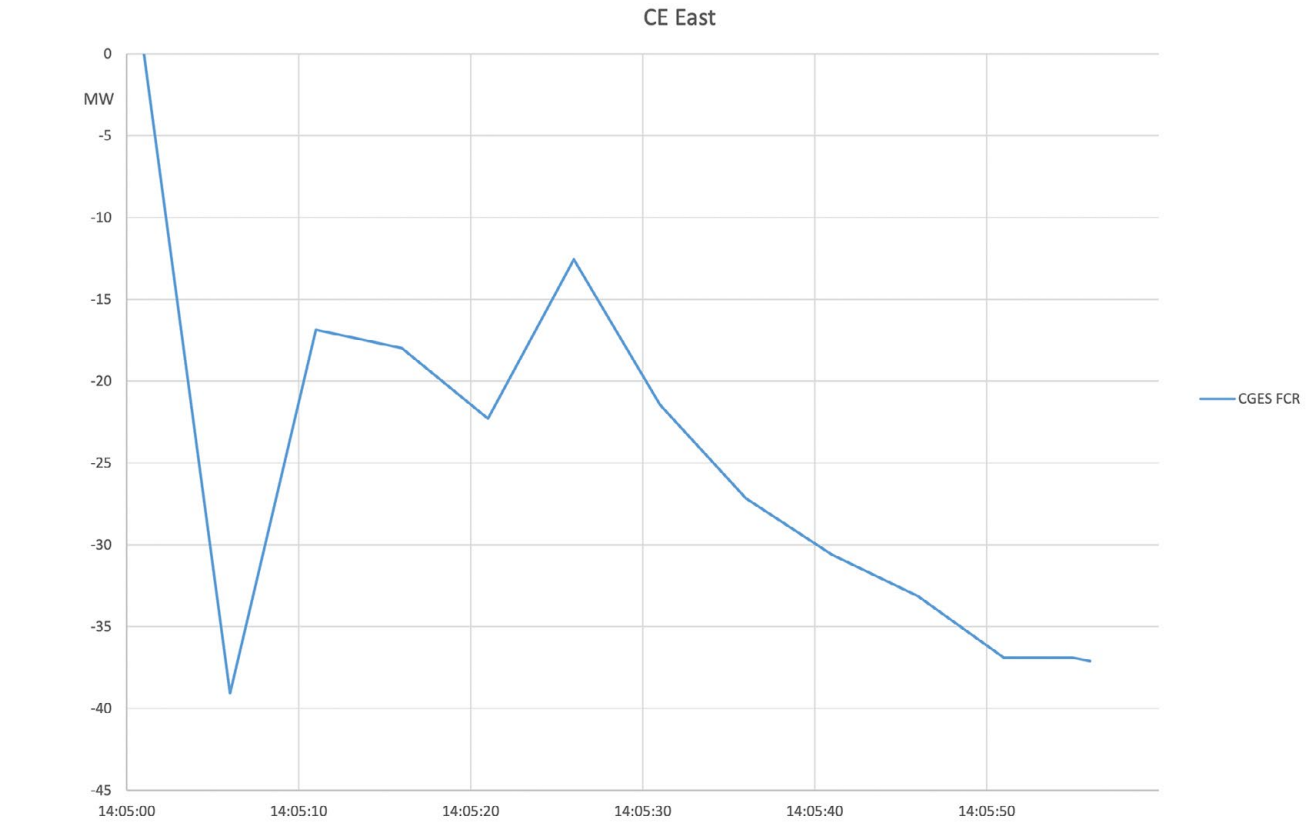

Figure A2-50: CGES FCR

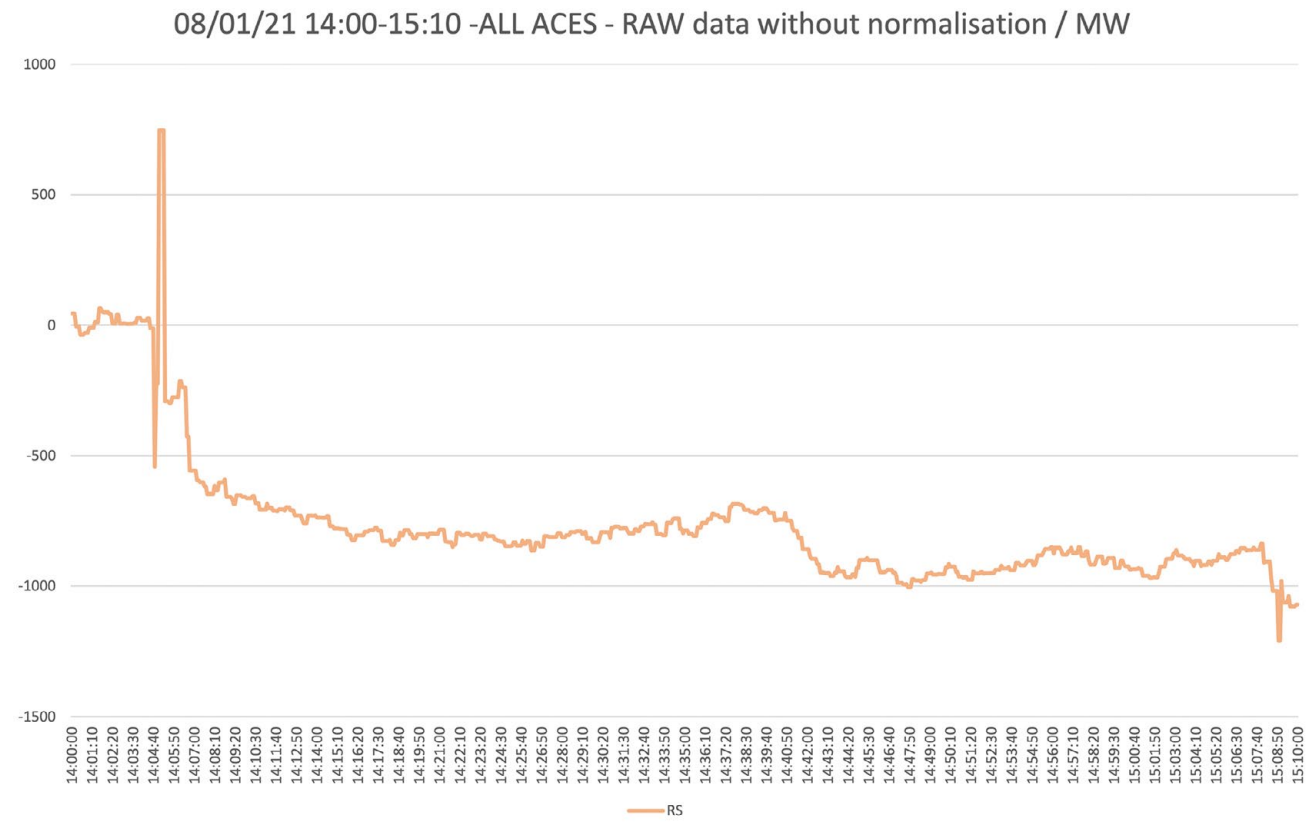

Figure A2-51: EMS ACE

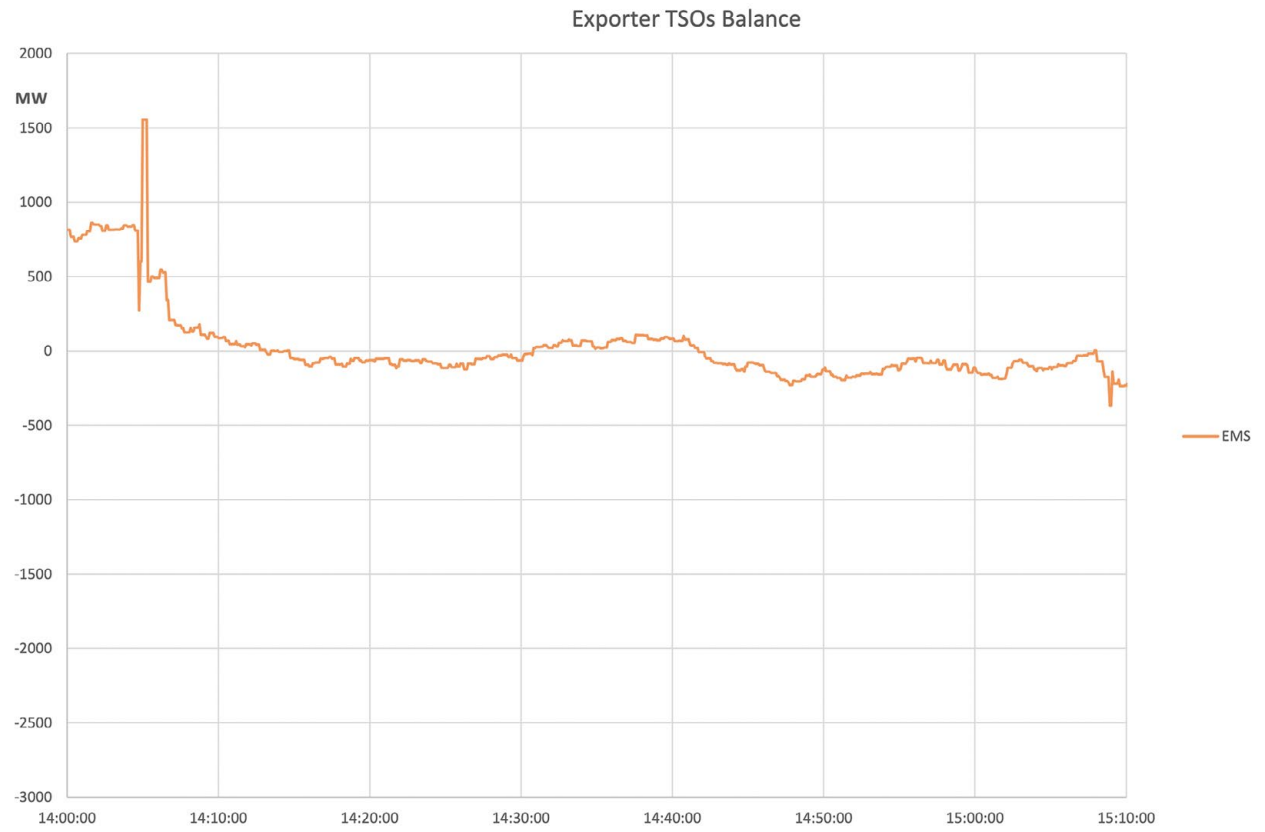

Figure A2-52: EMS Balance

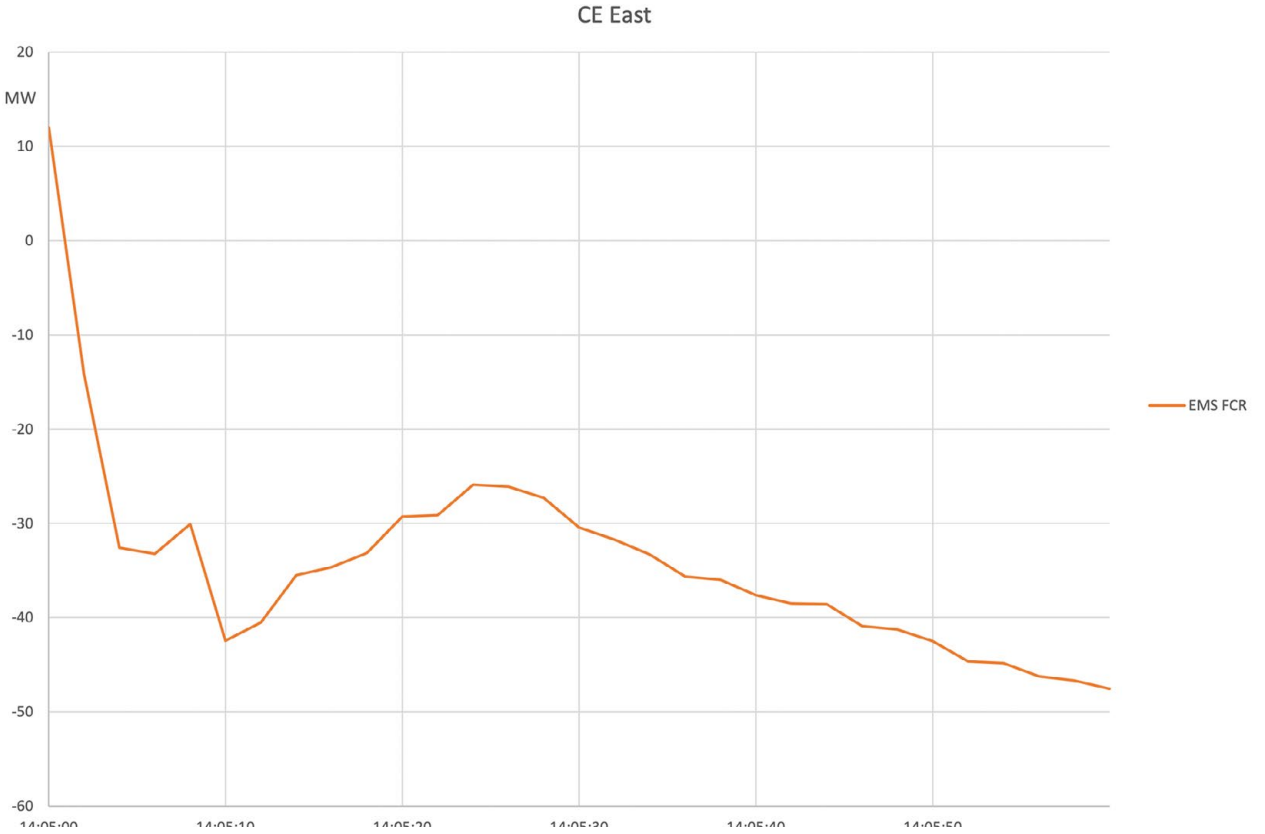

Figure A2-53: EMS FCR

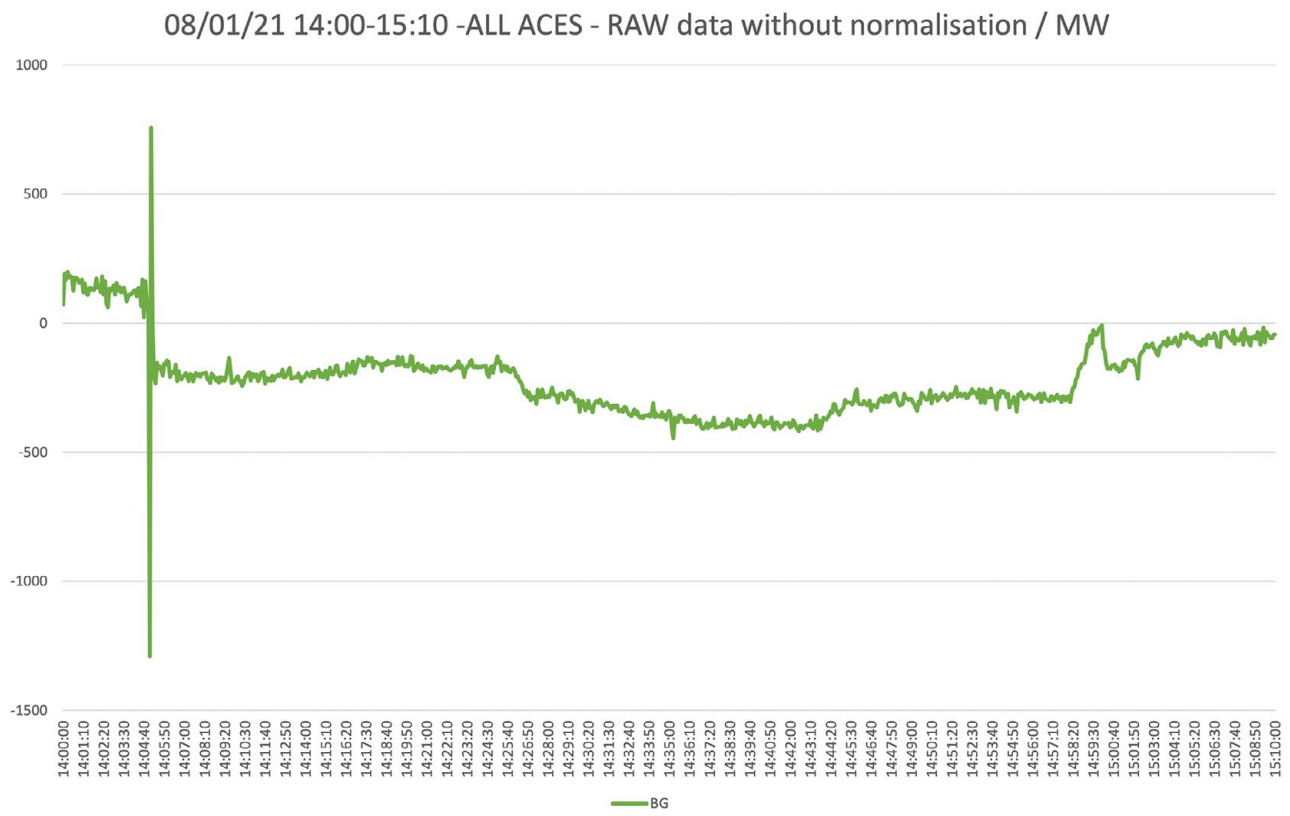

Figure A2-54: ESO EAD ACE

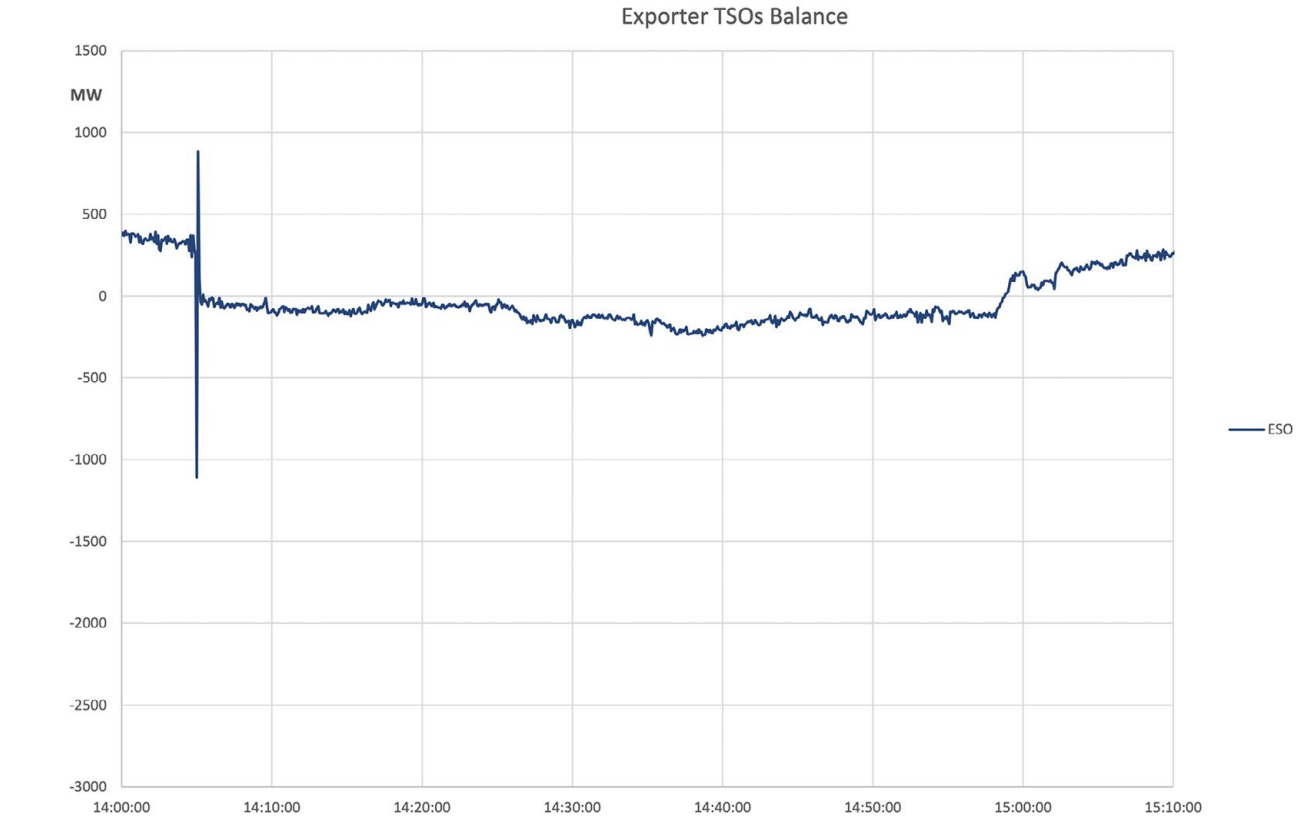

Figure A2-55: ESO EAD Balance

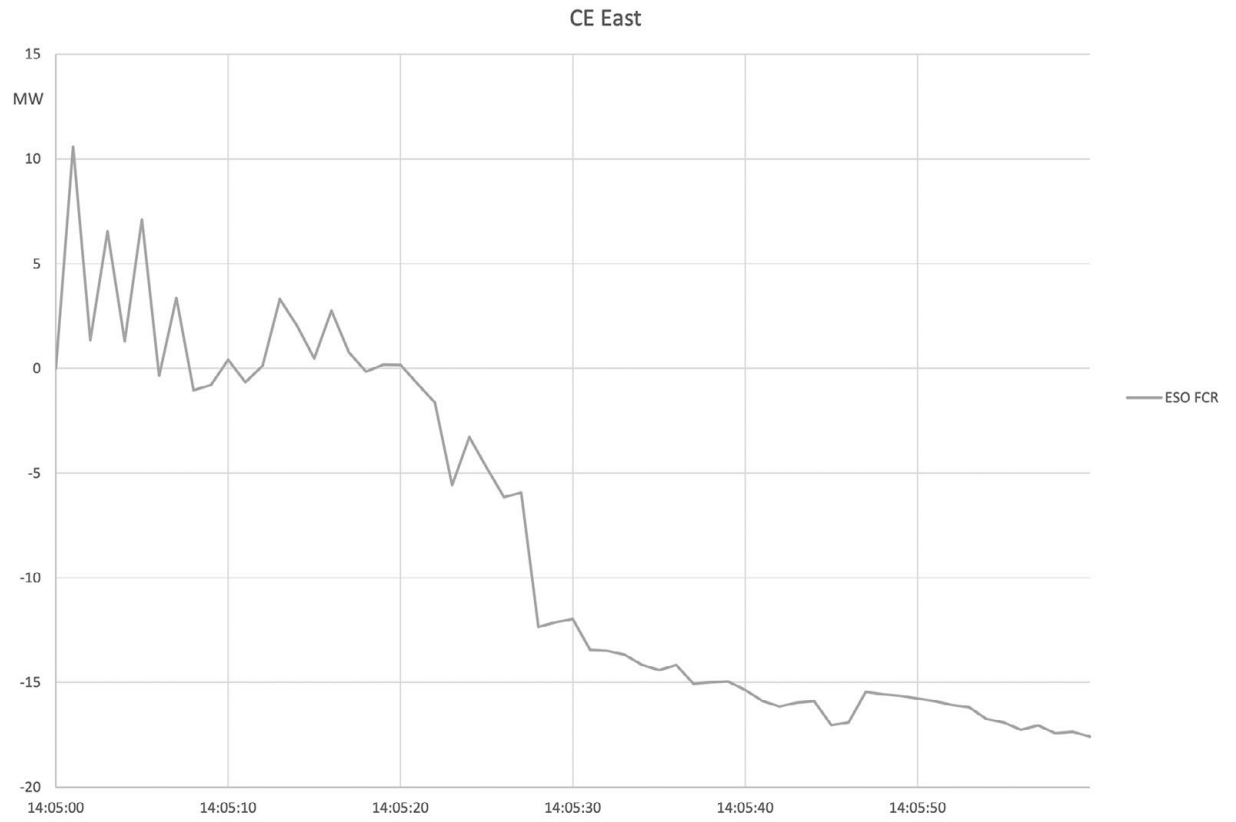

Figure A2-56: ESO EAD FCR

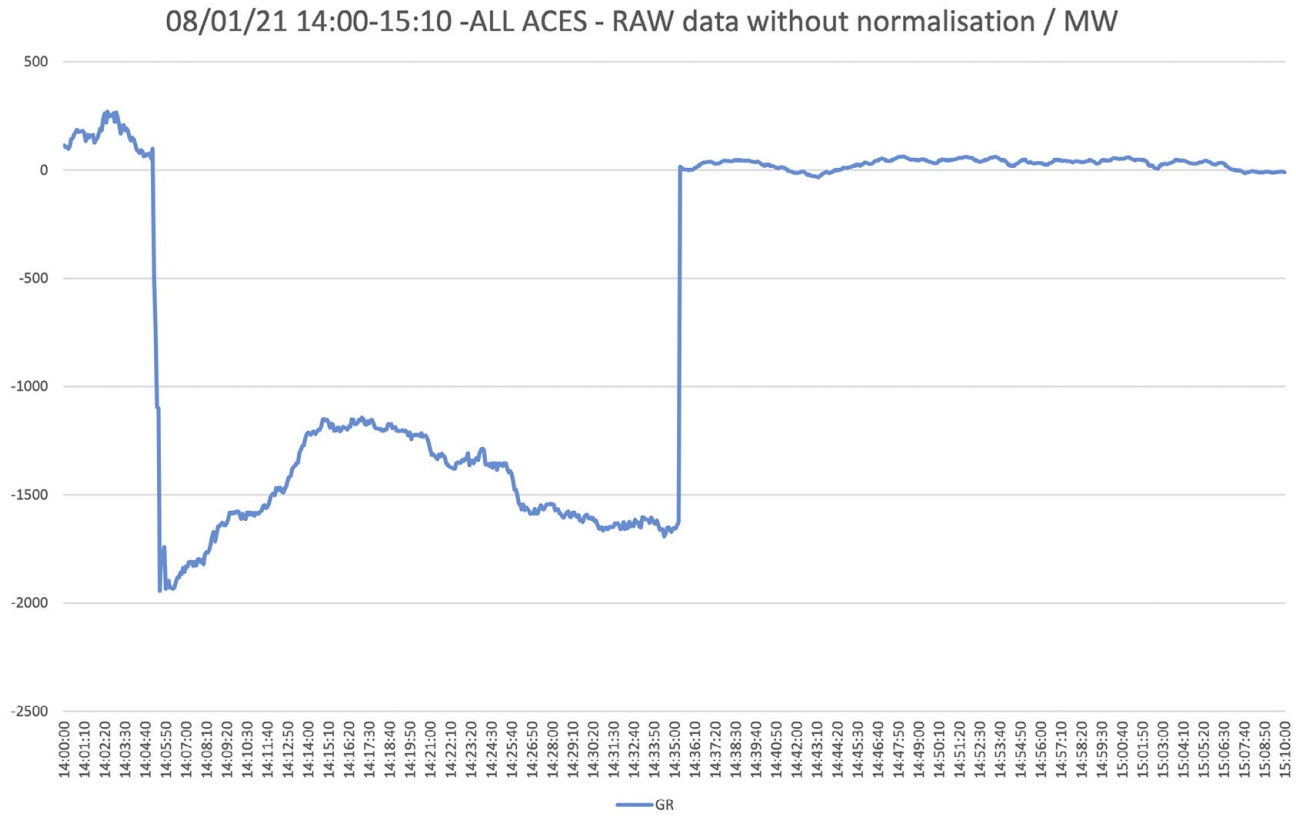

Figure A2-57: IPTO ACE

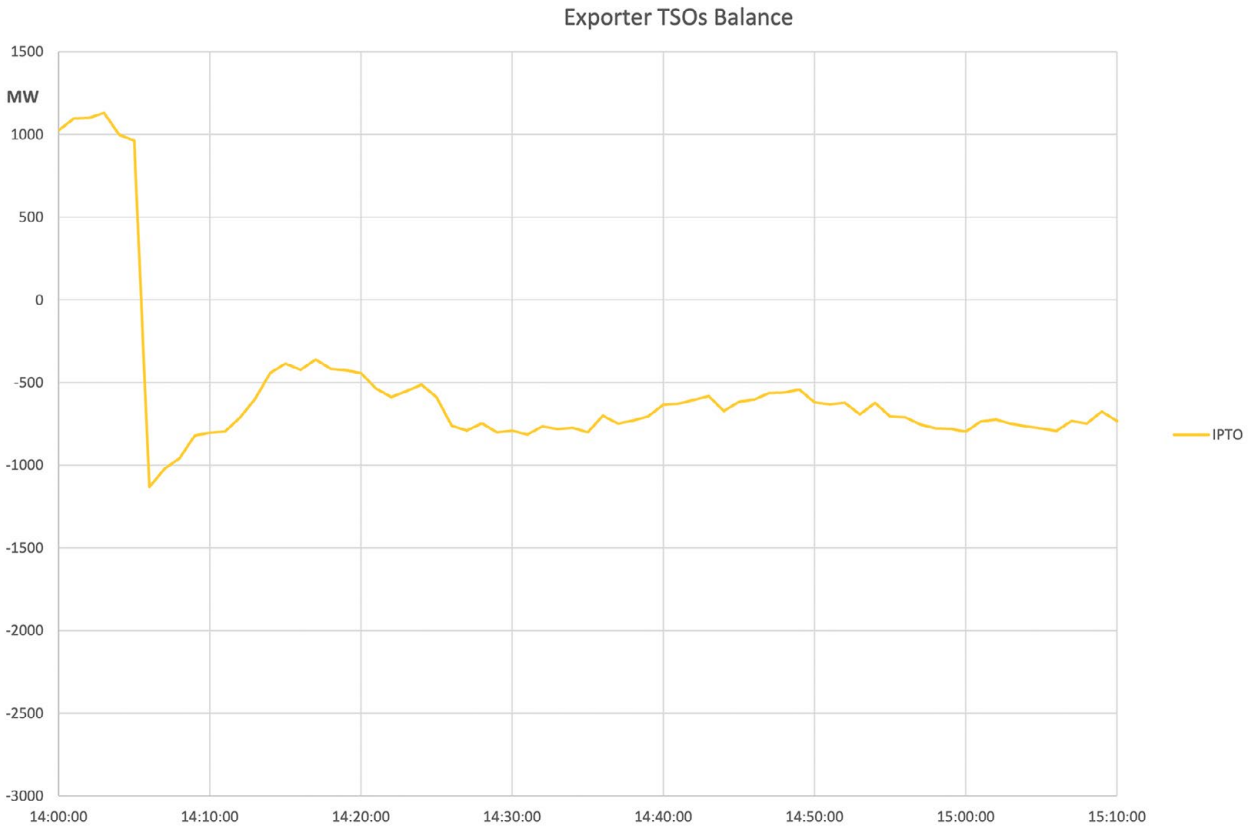

Figure A2-58: IPTO Balance

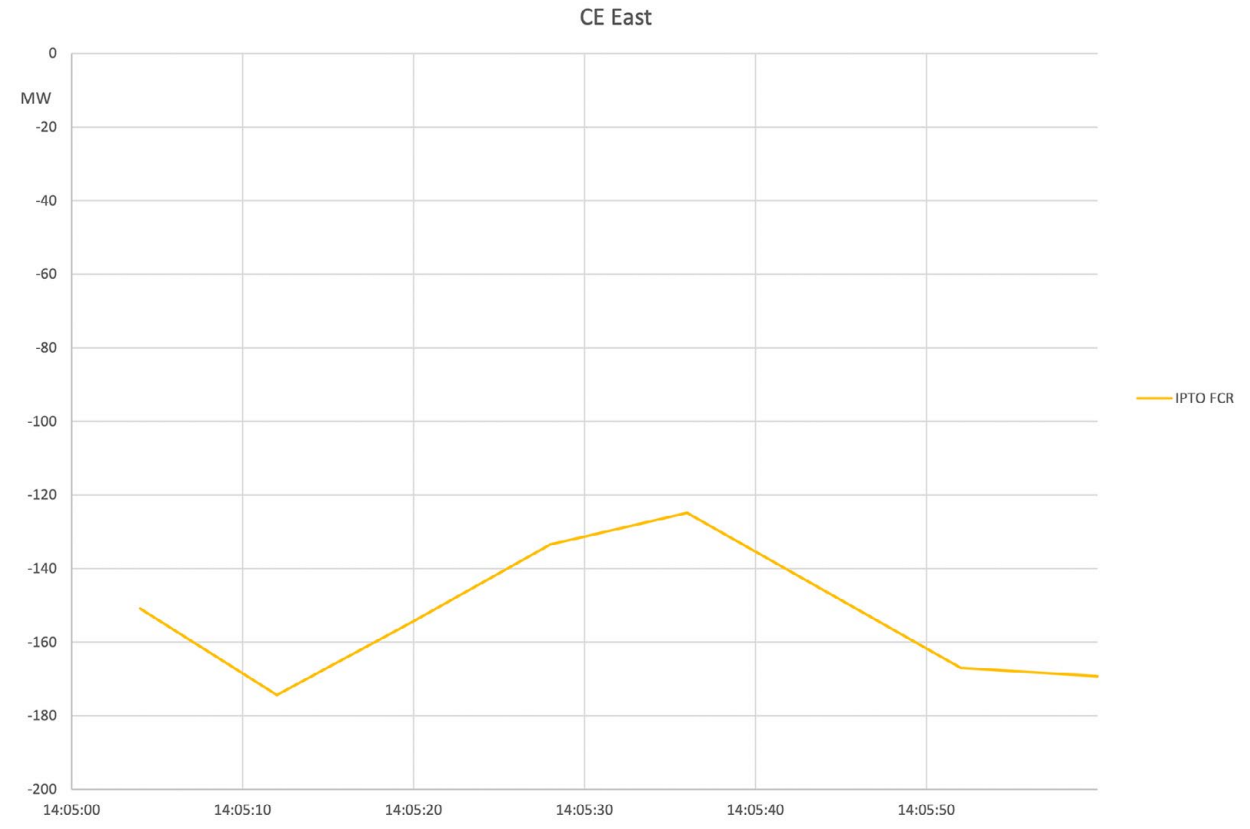

Figure A2-59: IPTO FCR

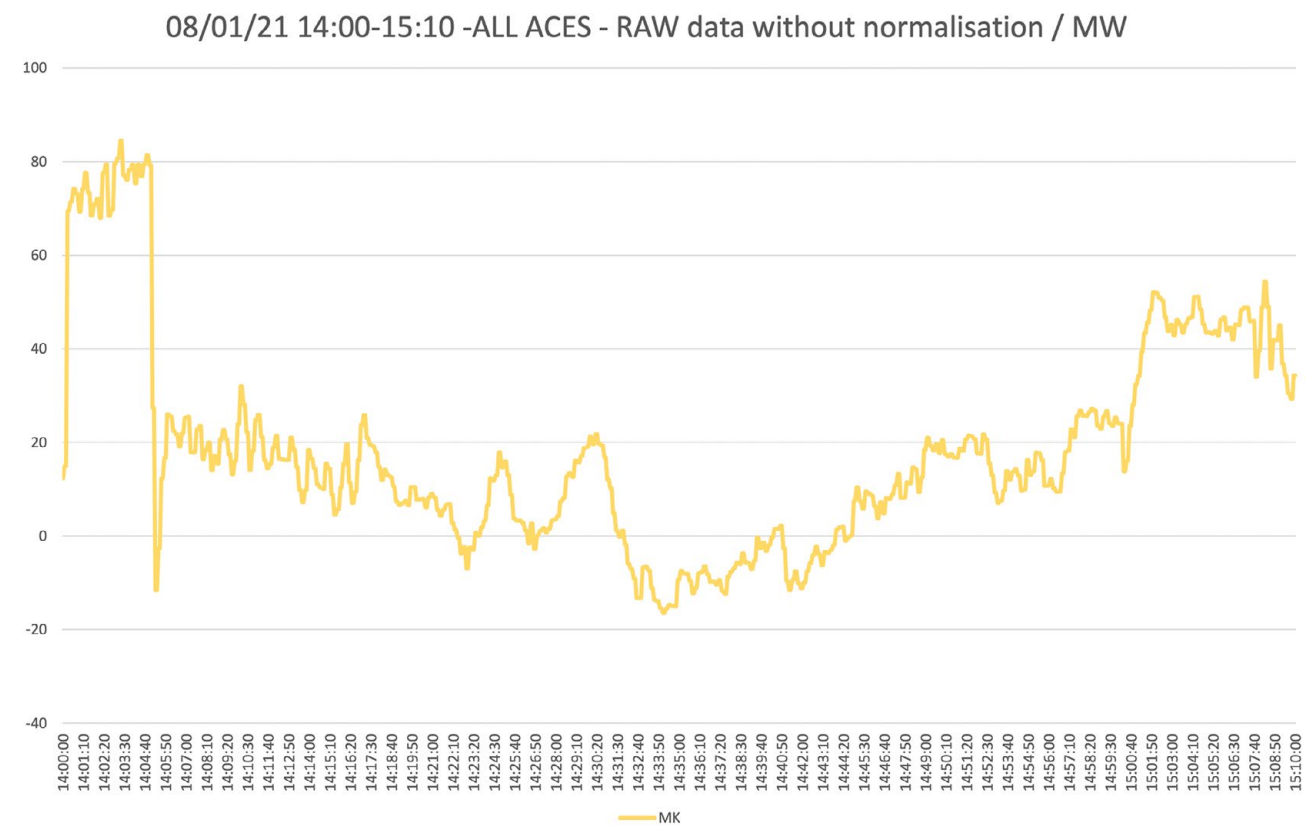

Figure A2-60: MEPSO ACE

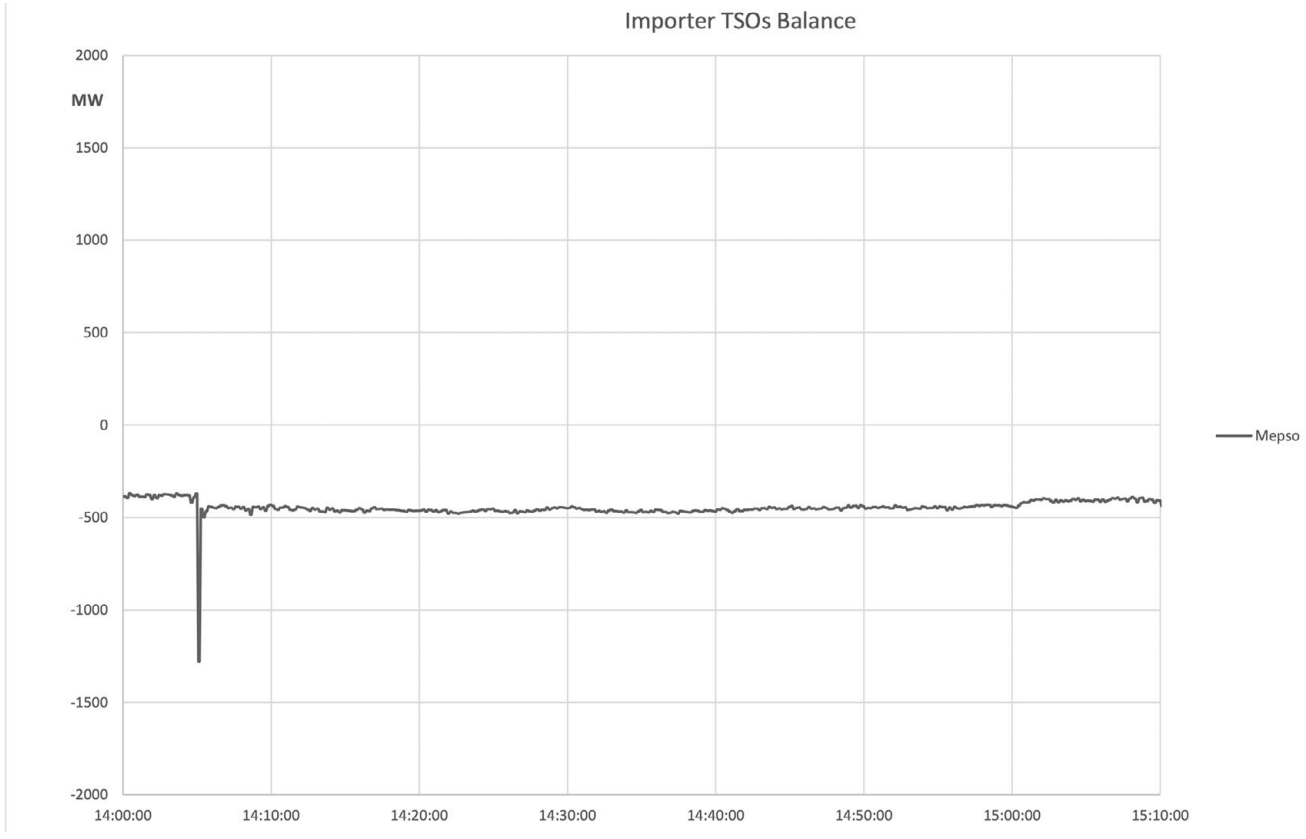

Figure A2-61: MEPSO Balance

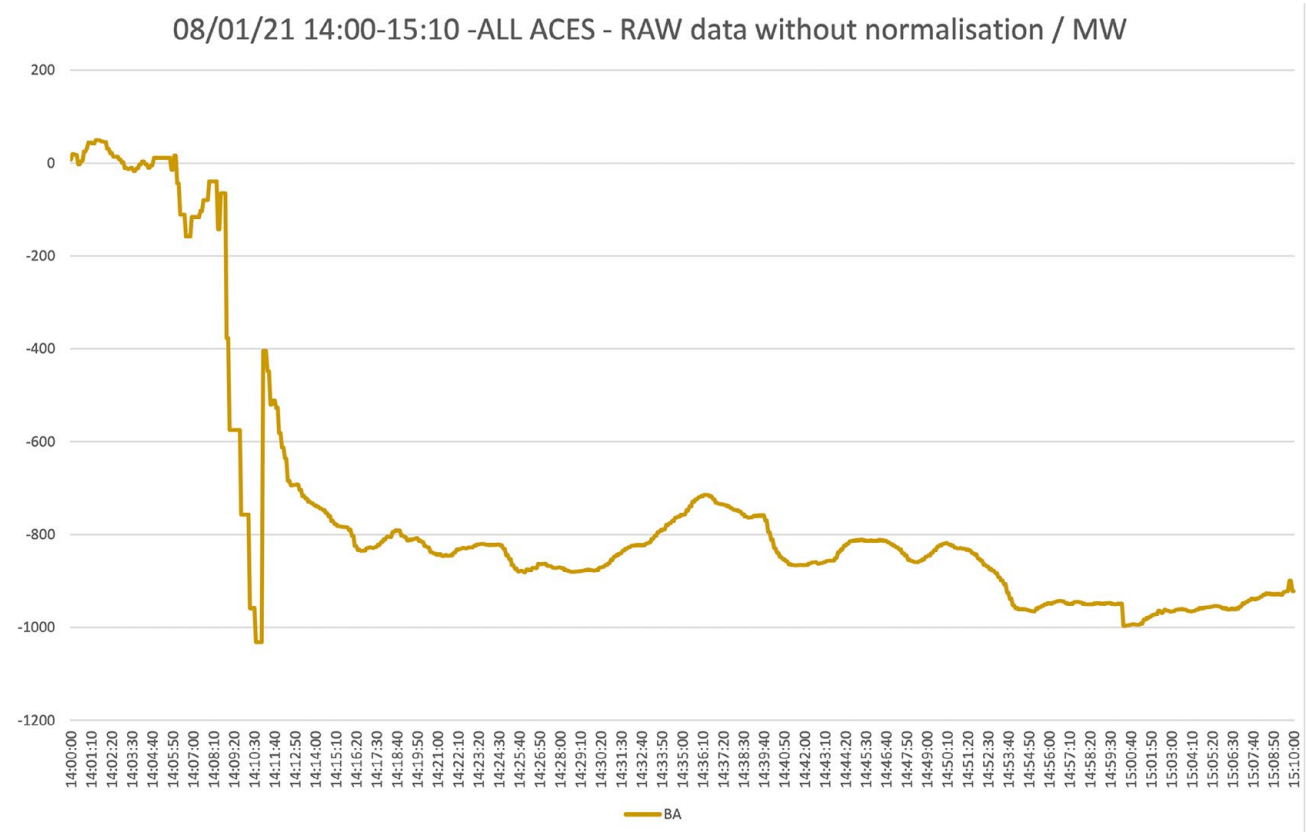

Figure A2-62: NOS BiH ACE

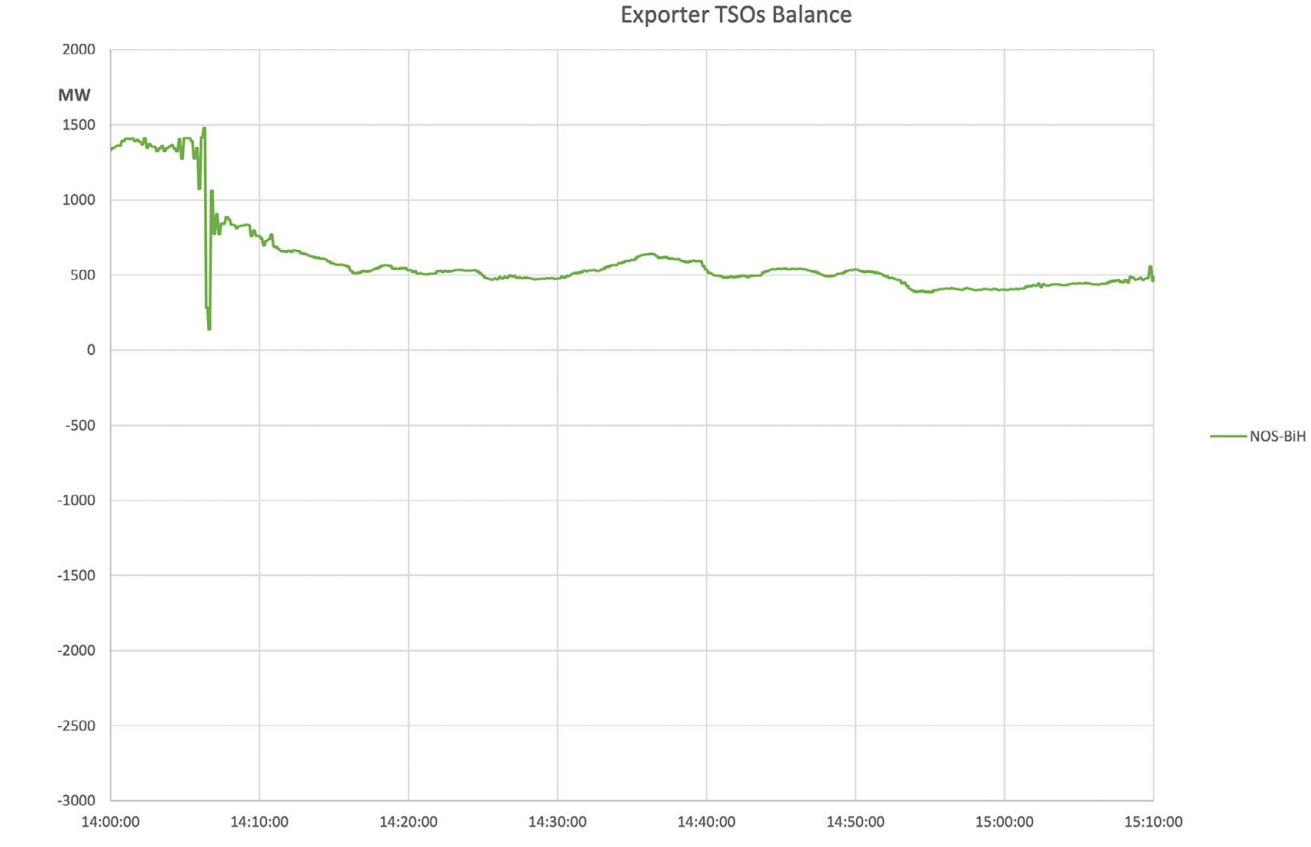

Figure A2-63: NOS BiH: Balance

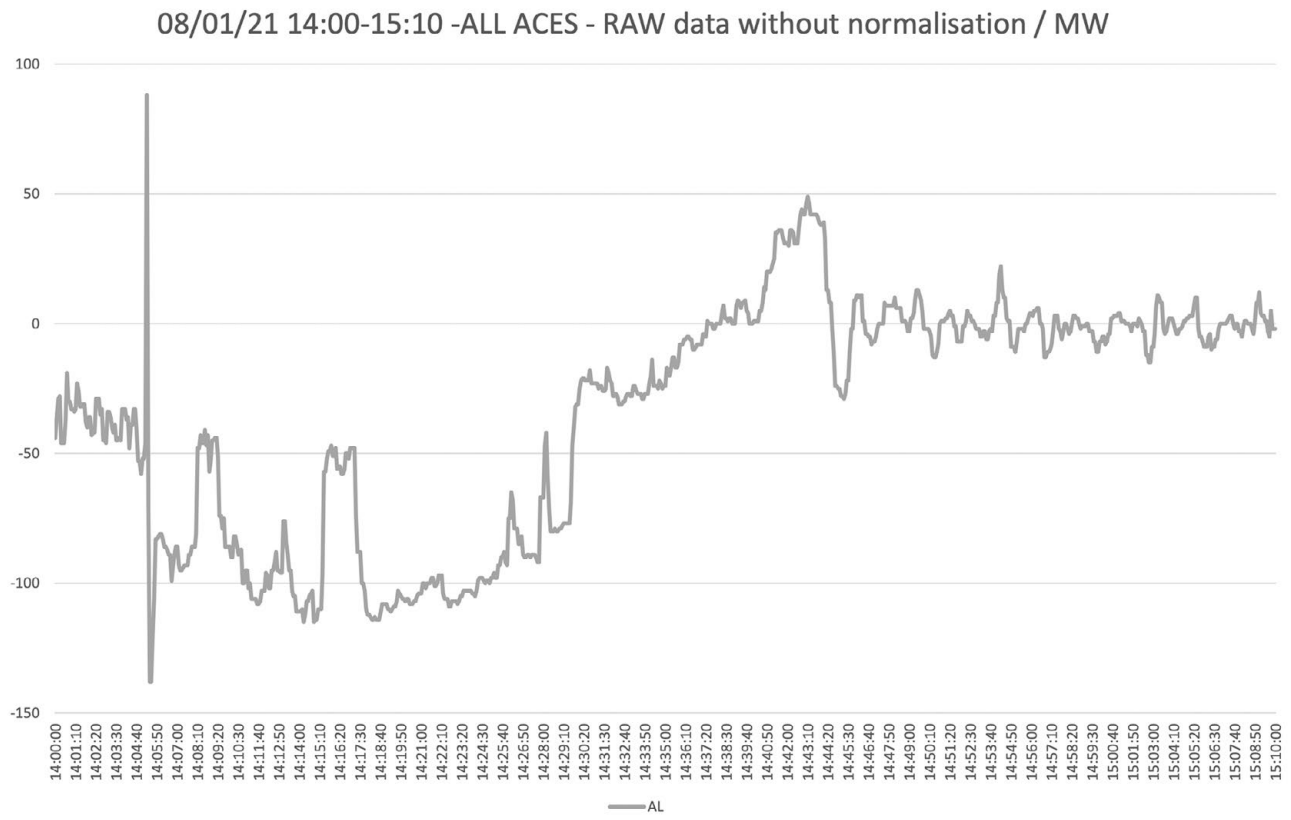

Figure A2-64: OST ACE

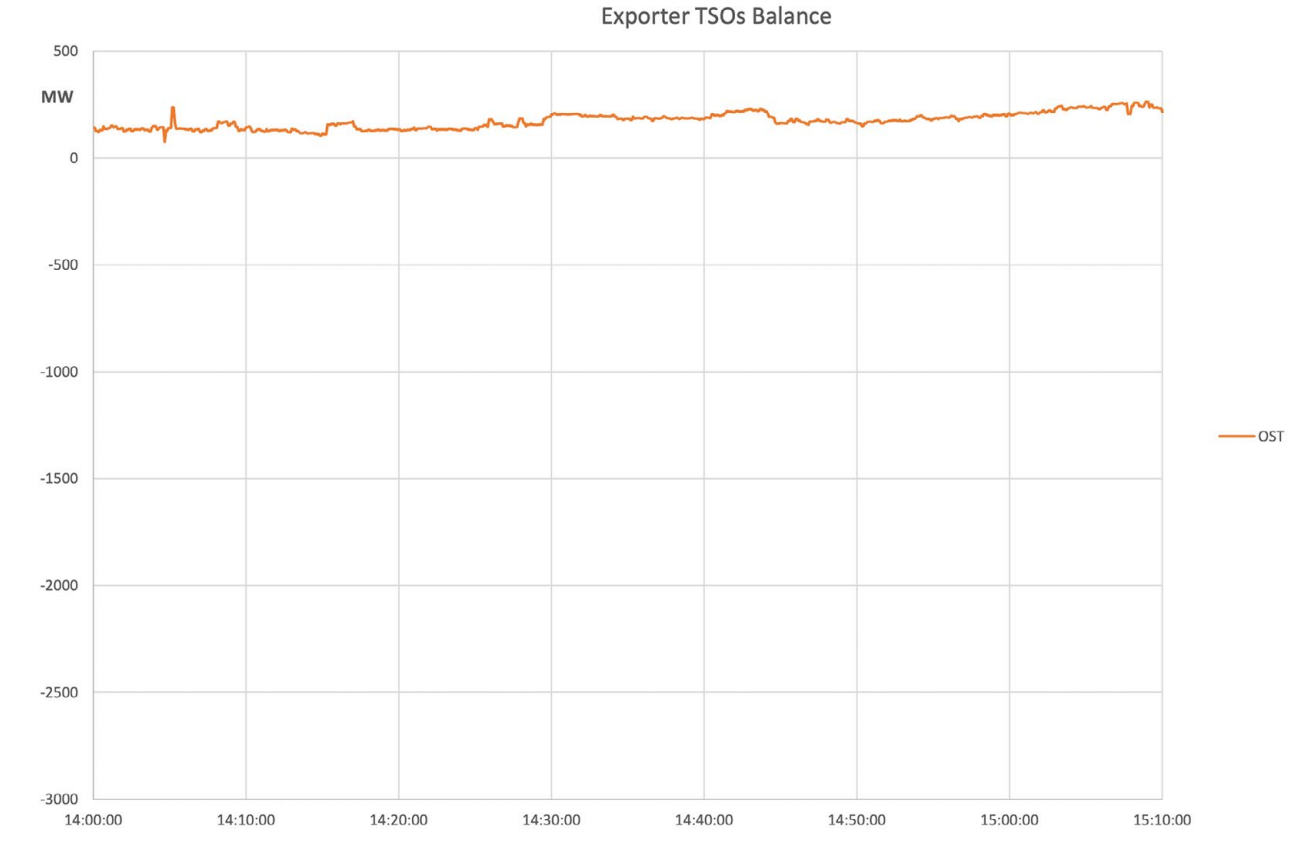

Figure A2-65: OST Balance

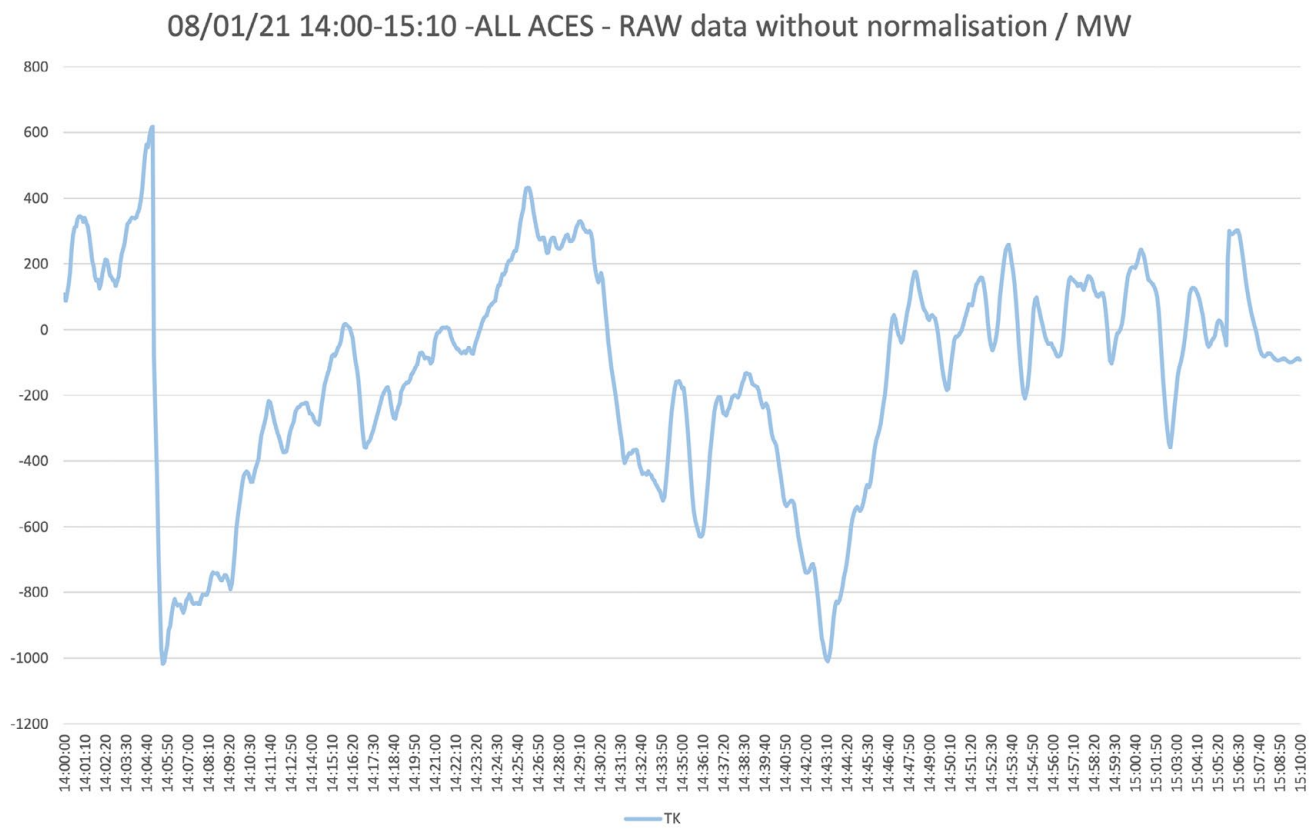

Figure A2-66: TEIAS ACE

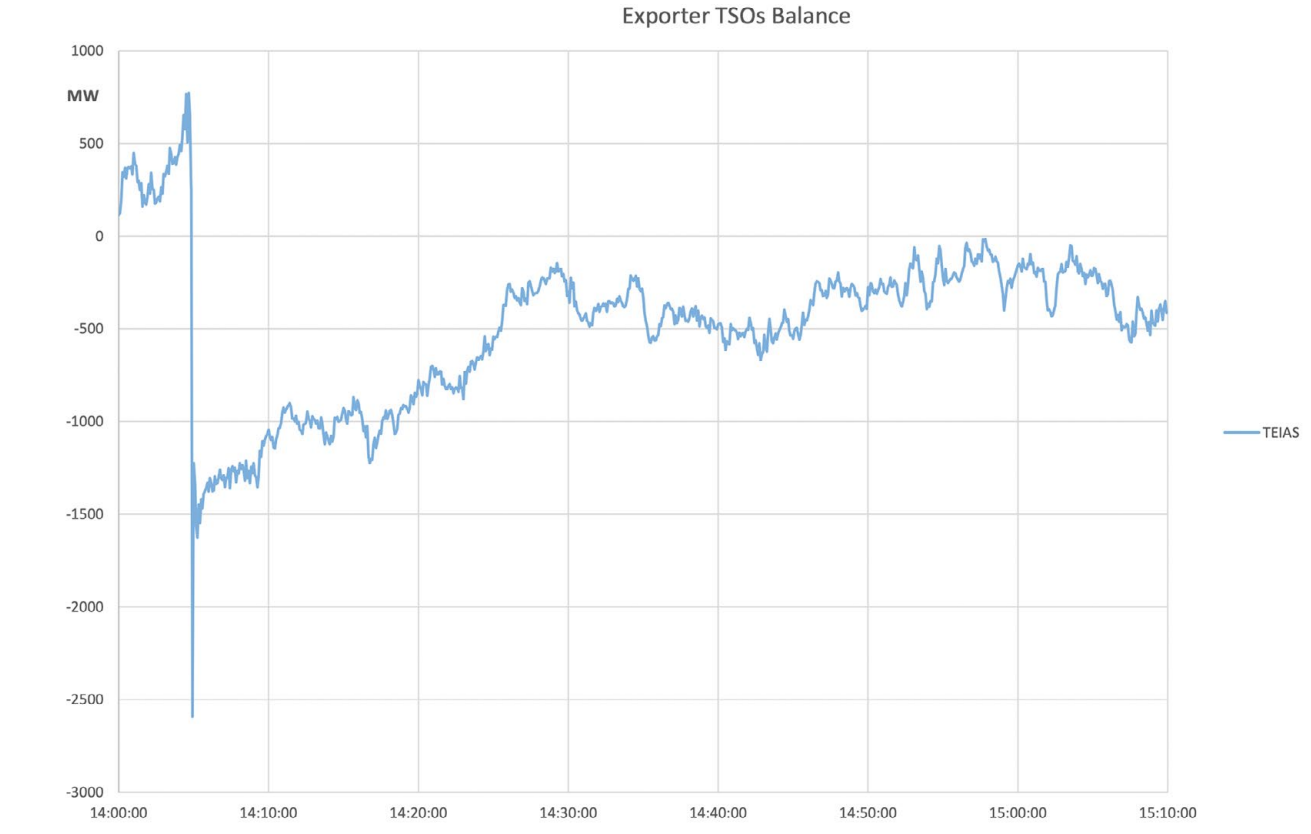

Figure A2-67: TEIAS Balance

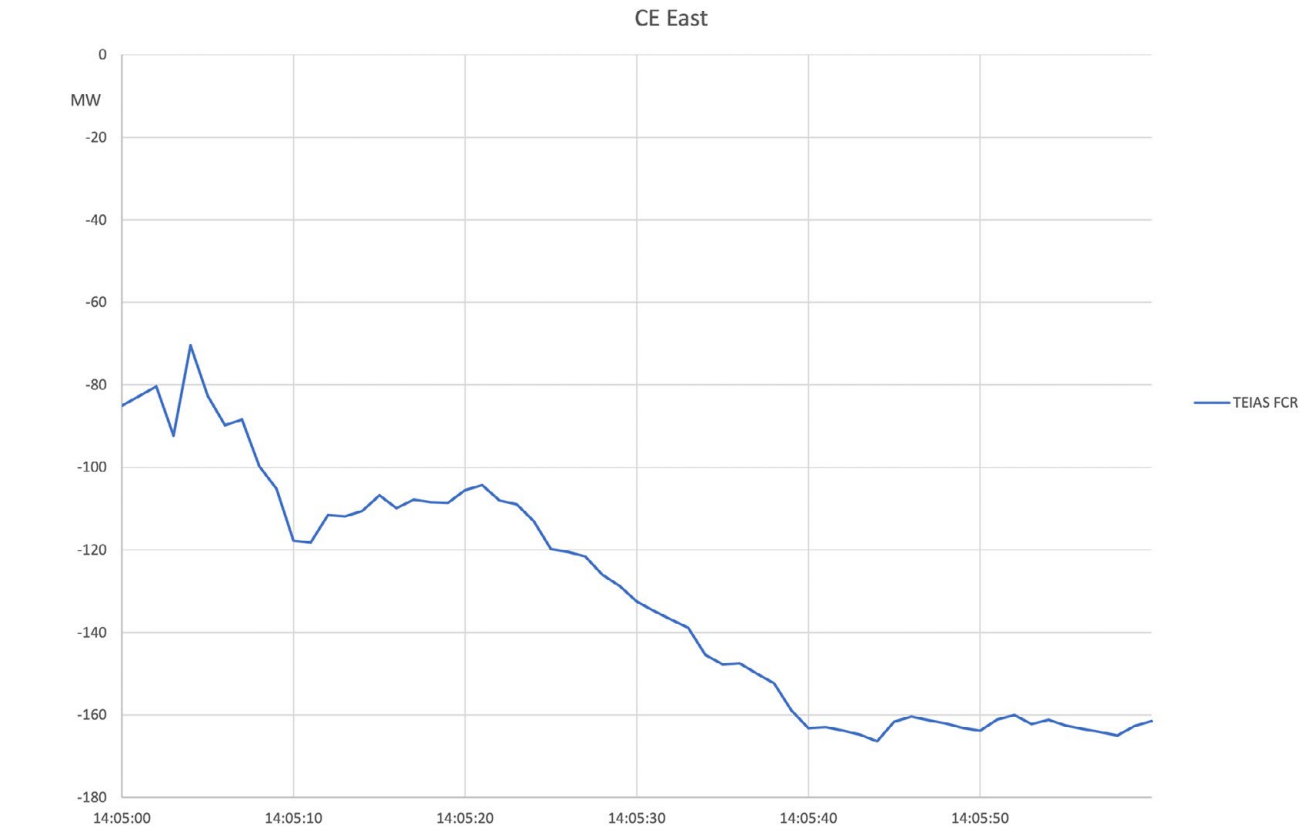

Figure A2-68: TEIAS FCR

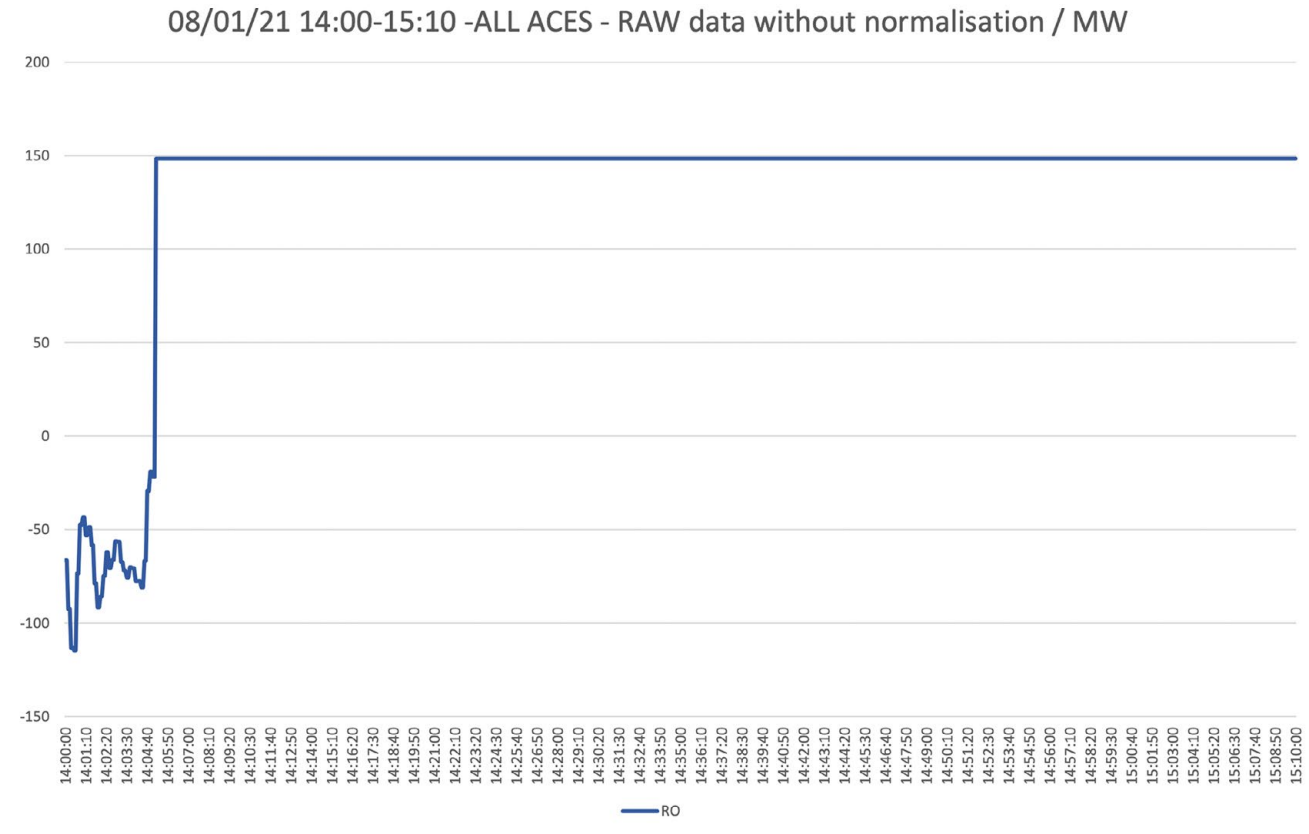

Figure A2-69: Transelectrica ACE

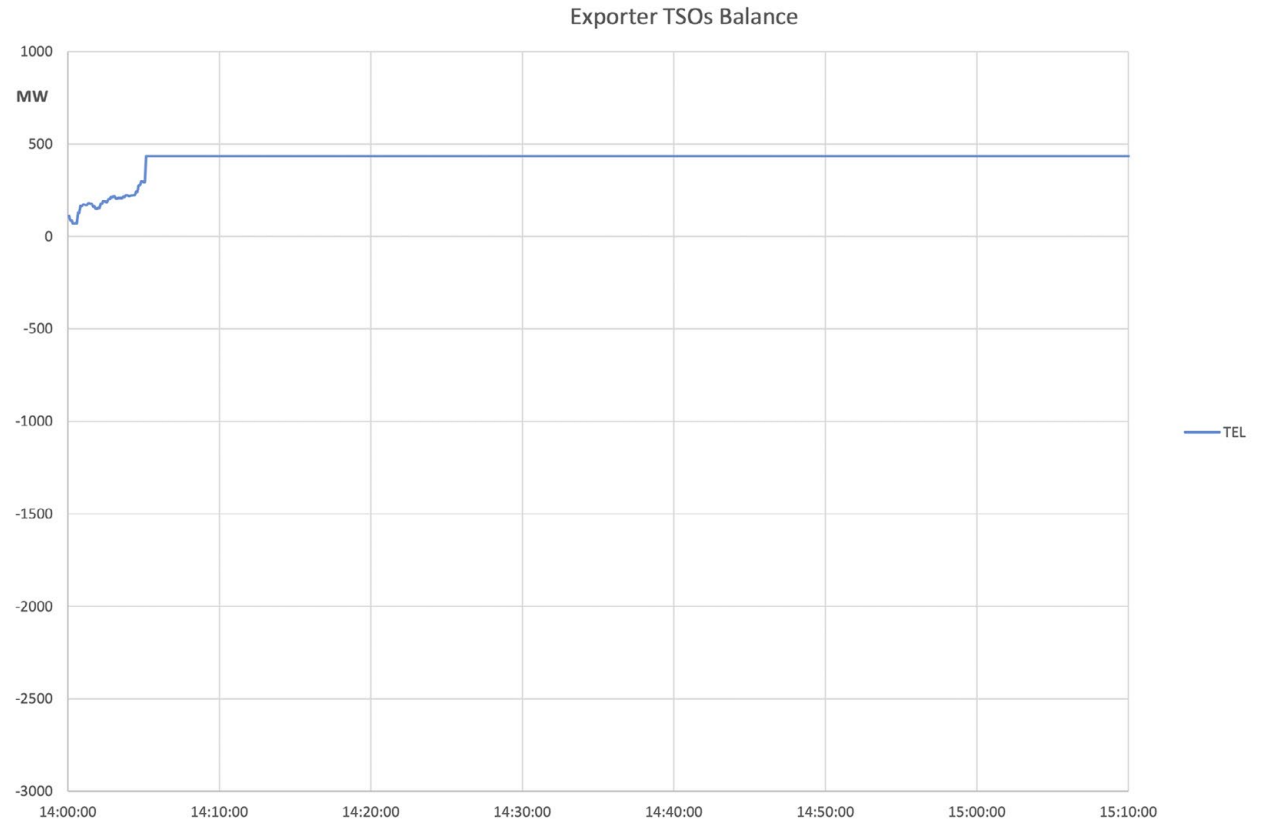

Figure A2-70: Transelectrica Balance

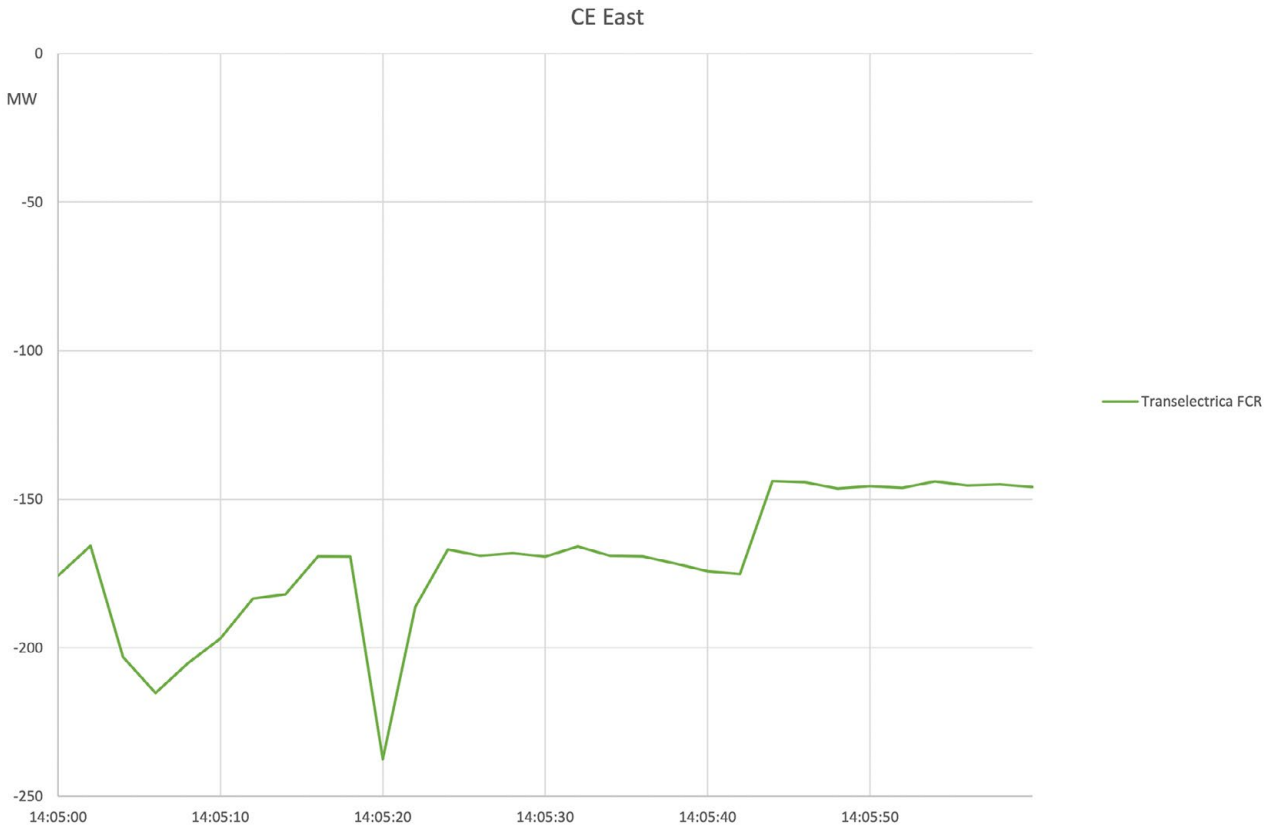

Figure A2-71: Transelectrica FCR

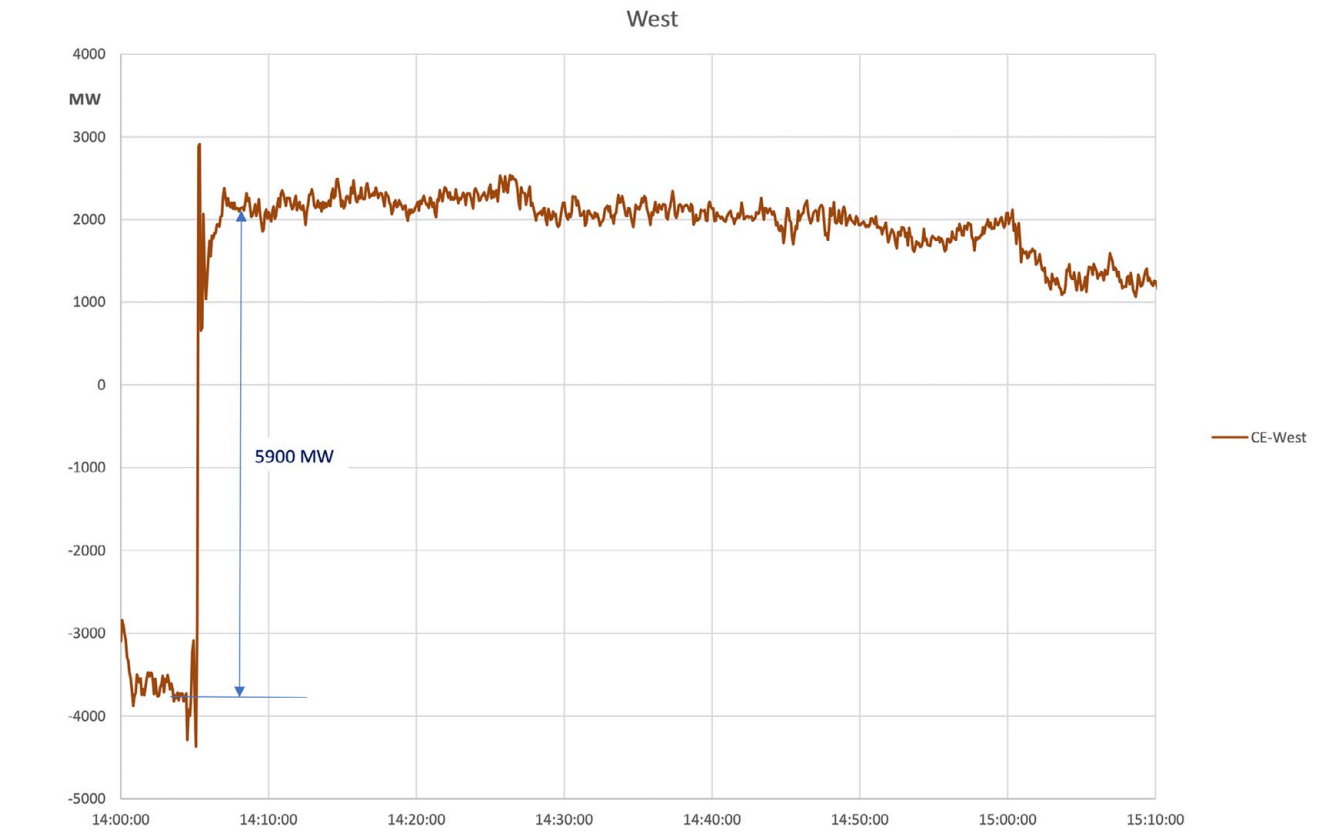

Figure A2-72: Balance CE West Sum

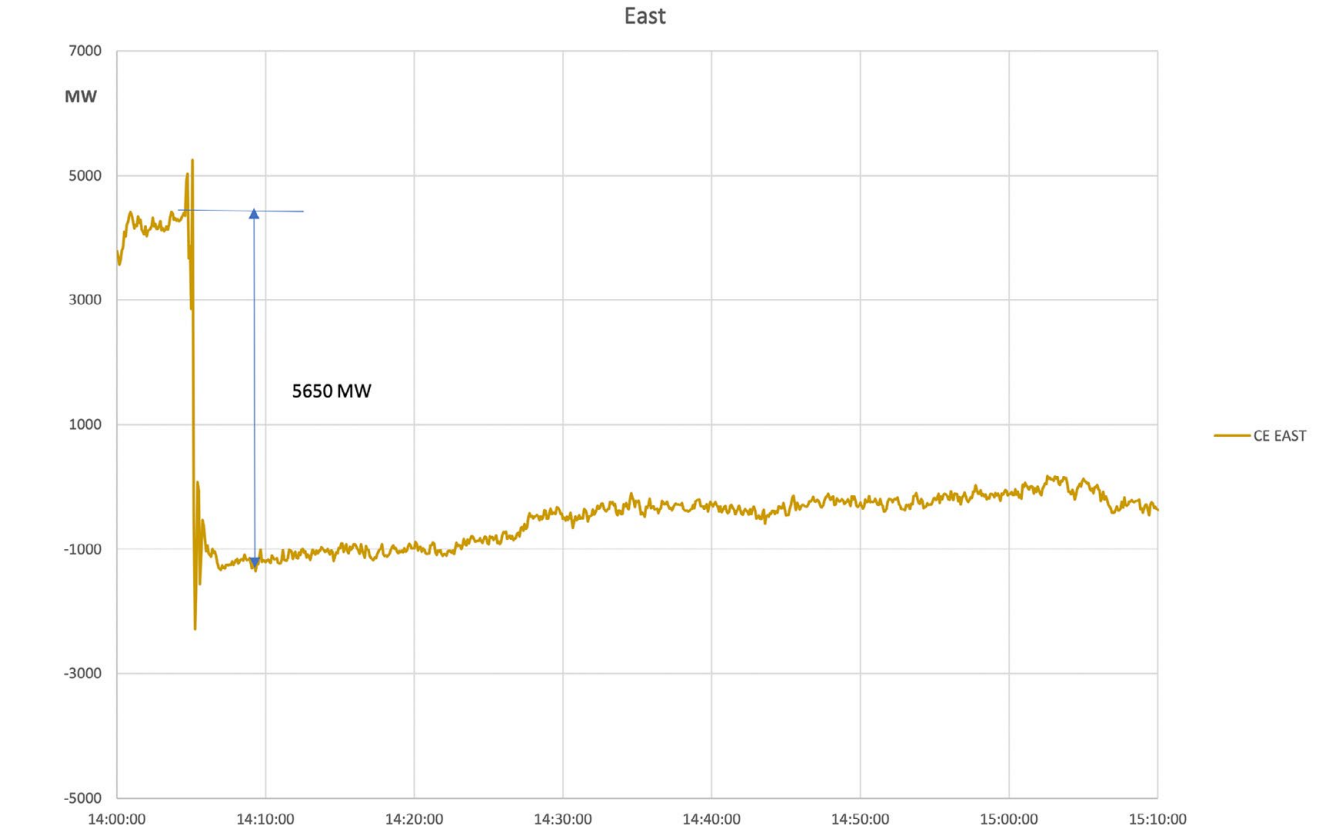

Figure A2-73: Balance CE East Sum

Annex 3.2: South Marmara Region Special Protection Scheme

This SPS is designed to be activated in Bandırma-1 NGCCP (2 × 290 MW + 1 × 320 MW), Bandırma-2 NGCCP (1 × 600) and İçdaş (3 × 135 MW) Power Plants in the following situations.

PBan-Bur = where the average of 5 seconds of the active power of the 400 kV Bandırma – Bursa ETL 1.5 seconds ago

1. If PBan-Bur > 980 MW;

When 400 kV Bandırma NGCCPP – Bursa NGCCPP OHL opens, 1 gas turbine from Bandırma NGCCPP will be tripped. If the active power of the 400 kV Bandırma-1 NGCCPP – Bandırma-2 NGCCPP is more than 383 MW when SPS signal is generated, 1 gas turbine will be tripped from the Bandırma-2 NGCCPP instead of the Bandırma-1 NGCCPP.

2. If PBan-Bur > 750 MW;

If the sudden increase in the active load flow of 400 kV Bandırma NGCCPP – Bursa NGCCPP OHL is more than 35%, SPS will trip one gas turbine at Bandırma NGCCPP and three steam turbines at İçdaş TPP. If the active power of the 400 kV Bandırma-1 NGCCPP – Bandırma-2 NGCCPP is more than 383 MW when the SPS signal is generated, instead of Bandırma-1 NGCCPP, the gas turbine service will be tripped from Bandırma-2 NGCCPP.

Annex Chapter 4

Annex 4.1: Manual countermeasures and system stabilisation in individual areas

General description of the CE Extraordinary Procedure and dedicated traffic lights in EAS

Two procedures are in place in RG CE to avoid serious system disturbances, and especially large frequency deviations with the risk of the uncoordinated disconnection of generation or load. The aim of the procedure is to coordinate countermeasures in the event of steady-state frequency deviations between the CCS and TSOs in a fast and effective manner in order to keep the steady-state frequency between 49.9 Hz and 50.1 Hz.

The "Extraordinary procedure for frequency monitoring and countermeasures in case of large steady-state frequency deviations" (50/100 mHz-Procedure) is triggered when the following criteria are fulfilled:

Stage 1

- system frequency of 50.05 Hz or 49.95 Hz is exceeded for a time interval longer than 15 minutes
- system frequency of 50.1 Hz or 49.9 Hz is exceeded for a time interval longer than 5 minutes
- action: contact and discussion of measures between the dedicated CC and the impacting TSOs

Stage 2 (Activation of five TSOs Telco)

- system frequency of 50.05 Hz or 49.95 Hz is exceeded for a time interval longer than 20 minutes
- system frequency of 50.1 Hz or 49.9 Hz is exceeded for a time interval longer than 10 minutes
- action: Telephone Conference and discussion of measures by Amprion, Swissgrid, REE, RTE and Terna

On 10 January 2019, a huge frequency deviation of 192 mHz under frequency was caused by the convergence of a long-lasting steady-state frequency deviation due to a frozen measurement in the LFC-System of one TSO and a high Deterministic Frequency Deviation (DFD) during the evening peak-load at the hourly schedule transition. After this event, the CCs decided, with the confirmation of the SOC Subgroup CSO, to establish a second procedure the "Procedure for frequency monitoring and countermeasures in case of long-lasting steady-state frequency deviations" (6s-Procedure/LLFD-Procedure). The aim of this procedure is to detect long-lasting frequency deviations (LLFDs) at an early stage based on grid time deviations, to prevent the occurrence of critical frequency deviations.

Since 2020 "Frequency States", Traffic Lights dedicated to the 50/100 mHz-Procedure and the LLFD-Procedure were implemented in the EAS. These Traffic Lights should inform all CE TSOs in case of frequency deviations. The Frequency States are triggered automatically via the local LFCs of the CCs in the event of large steady-state frequency deviations and manually by operators of the CCs in the event of long-lasting steady-state frequency deviations.

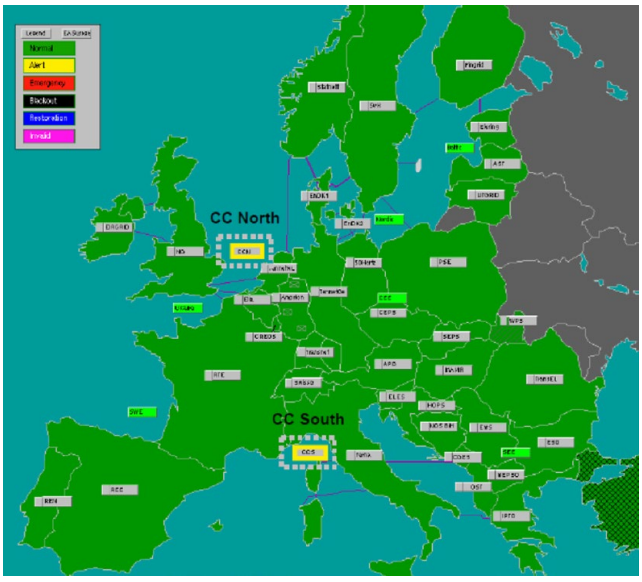

Figure 1.1: EAS frequency state traffic lights with status "yellow"

Application of the CE Extraordinary Procedure on 08 January 2021

On 08 January 2021 at 14:10 CET, the trigger for Stage 1 of the CE Extraordinary Procedure was reached (Frequency deviation $|\Delta f| > 100$ mHz for a time period $t > 5$ min). This was signalised in EAS by an "Alert State" for the Frequency Traffic-Light. Because 5 minutes before, a frequency drop down to 49.74 Hz occurred, the actual cause of the incident was not clear at this time and the incident appeared to have a significant impact. With more need for coordination, the CCs in their role as SAM decided to launch the Stage 2 telephone conference of the CE Extraordinary Procedure proactively, although the criteria for Stage 2 was not reached in the North-West area of the system separation.

The conference call was used for:

1) Gathering information:

- about the frequency drop, the trigger for the CE Extraordinary Procedure and the current results of the first short analysis of the CCs in EAS.
- about contractual load shedding in France (RTE) and in Italy (Terna)
- about the tripping of HVDC link between France (RTE) and Spain (REE) and the resulting adaption of production in France and Spain.

2) Analysing the situation:

- During the call, the CCs detected the probable system separation in the EAS frequency map. A separate island with the TSOs HOPS, Transelectrica, NOSBiH, EMS, ESO, MEPSO, OST and IPTO was indicated.

3) Coordinating necessary countermeasures:

- Because the frequency deviation in the North-West area decreased by primary control FCR and automatic measures to less than 50 mHz and was still recovering, the 5 TSOs decided that, at this moment, no further measures were necessary to stabilise the frequency in the North-West area.
- The CCs decided to focus their investigations
  - on the reasons for the system separation and a possible resynchronisation of the South-East Area,
  - on the monitoring of the frequency in the North-West area, and
  - on the coordination of measures to bring the North-West area back to normal operation

Annex 4.2: Activation of production in separated systems

4.2.1 Activation of production in North-West area

TSO	Time	Production unit	Action
HOPS	14:18	HPP Čakovec (NW)	UP (+12 MW)
HOPS	14:39	HPP Čakovec (NW)	UP (+17 MW)
HOPS	13:30	HPP Varaždin (NW)	START (66 MW)
HOPS	14:21	HPP Varaždin (NW)	UP (+8 MW)
HOPS	14:34	HPP Varaždin (NW)	UP (+13 MW)
HOPS	13:30	HPP Rijeka (NW)	START (10 MW)
HOPS	14:05	HPP Rijeka (NW)	UP (+8 MW)
HOPS	14:37	HPP Rijeka (NW)	UP (+18 MW)
HOPS	14:06	HPP Vinodol (SE)	UP (+41 MW)
HOPS	14:26	HPP Vinodol (SE)	UP (+15 MW)
HOPS	14:45	HPP Vinodol (SE)	DOWN (-60 MW)
HOPS	15:07	HPP Vinodol (SE)	UP (+55 MW)
HOPS	15:20	HPP Vinodol (SE)	DOWN (-30 MW)
HOPS	13:30	TPP Plomin 2 (NW)	START (140 MW)
HOPS	14:35	TPP Plomin 2 (NW)	UP (+25 MW)
Transelectrica (NW area)	13:35	HPP Șugag	stop (-74 MW)
Transelectrica (NW area)	13:44	HPP Râul Mare	stop (-100 MW)
Transelectrica (NW area)	13:44	BSP Râul Mare	setpoint change for (-25 MW
Transelectrica (NW area)	14:00	BSP Râul Mare	stop (-15 MW)
Transelectrica (NW area)	14:30	HPP Șugag	start for (+60 MW)
Transelectrica (NW area)	14:33	HPP Șugag	start for (+75 MW)
Transelectrica (NW area)	14:34	HPP Gâlceag	start for (+75 MW)
Transelectrica (NW area)	14:35	HPP Munteni	start for (+20 MW) - reconnection
Transelectrica (NW area)	14:35	BSP Cris Aval	start for (+14 MW) - reconnection
Transelectrica (NW area)	14:36	HPP Remeți	start for (+50 MW) - reconnection
Transelectrica (NW area)	14:38	HPP Gâlceag	start for (+75 MW)
Transelectrica (NW area)	14:38	HPP Remeți	start for (+38 MW)
Transelectrica (NW area)	14:39	HPP Munteni	start for (+18 MW)
Transelectrica (NW area)	14:48	HPP Mărișelu	start for (+70 MW) - reconnection
Transelectrica (NW area)	14:54	HPP Mărișelu	start for (+73 MW)
Transelectrica (NW area)	14:50	BSP Râul Mare	start for (+25 MW)
Transelectrica (NW area)	14:52	HPP Râul Mare	start for (+102 MW)
Transelectrica (NW area)	15:05	BSP Râul Mare	start for (+25 MW)
Transelectrica (NW area)	15:08	HPP Mărișelu	start for (+73 MW)

TSO	Time	Production unit	Action
Transelectrica (NW area)	15:10	HPP Râul Mare	start for (+110 MW)
TenneT Germany	15:00–15:30	Vorarlberger Kraftwerke	UP 100 MW
TenneT Germany	15:00–15:30	Control Area APG	DOWN 100 MW
MAVIR	14:05	Photovoltaic production: 21 units disconnected (close to substation Sandorfalva)	DOWN 8 MW
MAVIR	14:05–14:10	Reconnection of the photovoltaic	UP 8 MW
RTE	14:07:49	G.MAIZH	go from (283/48/150) to (1401/64/210)
RTE	14:21:04	SSAL7T 1	continue (1324/0/0) instead of going to (0/0/0) - delayed stop
RTE	14:21:16	GOLF5T 1	go from (1317/0/0) to (1220/27/70)
RTE	14:21:34	G.RIVT 1	go from (429/0/0) to (398/11/20)
RTE	14:21:35	GRACIT 1	go from (427/0/0) to (396/11/20)
RTE	14:21:33	FOSCCT 1	go from (416/0/0) to (385/11/20)
RTE	14:22:03	MORANT 1	go from (366/0/0) to (338/10/18)
RTE	14:22:51	QUAR5T 1	go from (437/0/0) to (406/11/20)
RTE	14:22:22	C.ME5T01	go from (427/0/0) to (396/11/20)
RTE	14:23:43	GOLF5T 2	go from (1307/0/0) to (1210/27/70)
RTE	14:24:09	N.SE5T 2	go from (1320/0/0) to (1223/27/70)
RTE	14:24:53	CATTET 3	go from (1282/0/0) to (1190/22/70)
RTE	14:26:15	CRUA5T 3	go from (928/0/0) to (858/20/50)
RTE	14:26:45	D.BURT 1	go from (890/0/0) to (822/18/50)
RTE	14:27:08	D.BURT 3	go from (925/0/0) to (857/18/50)
RTE	14:52:56	G.MAIZH	go from (1401/64/210) to (911/64/210)
RTE	14:58:17	ARRI5T 2	go from (0/0/0) to (98/6/23) - start
RTE	14:58:37	BRENNT 3	go from (0/0/0) to (132/0/0) - start
RTE	14:59:28	ARRI5T 1	go from (0/0/0) to (131/0/0) - start
RTE	15:08:13	BATHIH	go from (600/30/222) to (348/30/222)
RTE	15:09:01	TIGNEH	go from (374/22/80) to (225/22/80)
RTE	15:10:38	G.MAIZH	go from (911/64/210) to (283/48/150)
RTE	15:30:56	REVI5ZH	go from (90/10/0) to (0/0/0)

Table A4-1: Applied measures (manual or automatic) regarding power generation units

Note: In the above Table, for the RTE data, the setpoint is defined as: (Active Power Setpoint, FCR, aFRR). For instance, 1220/27/70 means an active setpoint at 1220 MW, 27 MW FCR and 70 MW aFRR. As can be seen from this table, operators started mFRR and RR, and switched as many units as possible to a setpoint with FCR and aFRR to support the frequency.

4.2.2 Activation of production in South-East area

TSO	Time	Production unit	Action
HOPS	14:01	HPP Orlovac (SE)	DOWN (- 50 MW)
HOPS	14:40	HPP Orlovac (SE)	UP (+ 232 MW)
HOPS	15:06	HPP Orlovac (SE)	DOWN (- 76 MW)
HOPS	15:23	HPP Orlovac (SE)	UP (+ 76 MW)
HOPS	13:30	HPP Peruća (SE)	START (40 MW)
HOPS	14:09	HPP Peruća (SE)	UP (+11 MW)
HOPS	14:22	HPP Peruća (SE)	DOWN (- 51 MW)
HOPS	14:36	HPP Peruća (SE)	UP (+ 40 MW)
HOPS	15:02	HPP Peruća (SE)	DOWN (- 20 MW)
HOPS	13:30	HPP Zakučac (SE)	START (538 MW)
HOPS	15:06	HPP Zakučac (SE)	DOWN (- 286 MW)
HOPS	15:18	HPP Zakučac (SE)	UP (- 286 MW)
HOPS	13:30	HPP Dubrovnik (SE)	START (90 MW)
HOPS	13:42	HPP Dubrovnik (SE)	DOWN (-19 MW)
HOPS	14:11	HPP Dubrovnik (SE)	UP (+19 MW)
HOPS	14:28	HPP Dubrovnik (SE)	UP (+ 29 MW)
HOPS	14:46	HPP Dubrovnik (SE)	DOWN (- 38 MW)
HOPS	15:01	HPP Dubrovnik (SE)	DOWN (-15 MW)
HOPS	15:20	HPP Dubrovnik (SE)	UP (+15 MW)
HOPS	14:11	RHPP Velebit (SE)	DOWN (-139 MW)
NOSBiH	14:06:00	G1 HE Salakovac	Automatic down 62 MW
NOSBiH	14:06:00	G2 HE Salakovac	Automatic down 62 MW
NOSBiH	14:06:00	G3 HE Salakovac	Automatic down 62 MW
NOSBiH	14:06:00	TE Kakanj V (G7)	Automatic down 200 MW
NOSBiH	14:06:00	G1 HE Mostar	Automatic down 21 MW
NOSBiH	14:06:00	G2 HE Mostar	Automatic down 22 MW
NOSBiH	14:06:00	G3 HE Mostar	Automatic down 22 MW
NOSBiH	14:11:00	G1 HE Bocac	Automatic down 35 MW
NOSBiH	14:16:00	G1 HE Mostar	UP 21 MW
NOSBiH	14:16:00	G2 HE Mostar	UP 22 MW
NOSBiH	14:20:00	G3 HE Mostar	UP 22 MW
NOSBiH	14:22:00	TE Kakanj G6	Automatic down 85 MW
NOSBiH	14:23:00	G1 HE Peć Mlini	Automatic down 15 MW
NOSBiH	14:23:00	G2 HE Peć Mlini	Automatic down 15 MW

TSO	Time	Production unit	Action
NOSBiH	14:26:00	G1 HE Rama	Manual action Down 58 MW
NOSBiH	14:26:00	HE Jajce 2	Automatic down 27 MW
NOSBiH	14:33:00	G1 HE Salakovac	UP 62 MW
NOSBiH	14:33:00	TE Kakanj V (G7)	UP 0 > 200 MW
NOSBiH	14:40:00	HE Jajce 2	UP 27 MW
NOSBiH	14:41:00	G1 PHE Čapljina	Manual action Down 145 MW
NOSBiH	14:45:00	G2 HE Peć Mlini	UP 15 MW
NOSBiH	14:54:00	G2 HE Grabovica	Manual action Down 35 MW
NOSBiH	14:54:00	G3 HE Visegrad	Manual action Down 100 MW
NOSBiH	15:23:00	G1 HE Peć Mlini	UP 15 MW
NOSBiH	15:24:00	G3 HE Salakovac	UP 62 MW
NOSBiH	15:28:00	G1 HE Bocac	UP 3 5 MW
Transelectrica (SE area)	14:00	HPP Oltul Superior	setpoint change for (-15 MW)
Transelectrica (SE area)	14:05	HPP Portile de Fier	setpoint change for (- 220 MW)
Transelectrica (SE area)	14:15	GPP OMV Petrom	setpoint change for (-100 MW)
Transelectrica (SE area)	14:15	GPP CET Nord	start for (+ 20 MW) - reconnection
Transelectrica (SE area)	14:20	HPP Lotru	setpoint change for (-140 MW)
Transelectrica (SE area)	14:26	HPP Nehoiasu	stop for (- 40 MW)
Transelectrica (SE area)	14:30	HPP Portile de Fier	setpoint change for (-180 MW)
Transelectrica (SE area)	14:30	HPP Oltul Inferior	setpoint change for (-100 MW)
Transelectrica (SE area)	14:30	HPP Oltul Mijlociu	setpoint change for (- 200 MW)
Transelectrica (SE area)	14:30	HPP Motru	stop (- 25 MW)
Transelectrica (SE area)	14:30	HPP Tismana	stop (- 43 MW)
Transelectrica (SE area)	14:30	GPP OMV Petrom	setpoint change for (-100 MW)
Transelectrica (SE area)	14:40	HPP Oltul Inferior	setpoint change for (-100 MW)
Transelectrica (SE area)	14:40	HPP Oltul Mijlociu	setpoint change for (- 80 MW)
Transelectrica (SE area)	15:00	HPP Oltul Mijlociu	setpoint change for (+100 MW)
Transelectrica (SE area)	15:00	HPP Oltul Superior	setpoint change for (+10 MW)
Transelectrica (SE area)	15:16	GPP OMV Petrom	setpoint change for (+ 200 MW)
Transelectrica (SE area)	15:25	HPP Lotru	start for (+158 MW)
Transelectrica (SE area)	15:25	HPP Lotru	start for (+158 MW)
EMS	13:30-15:00	HPP Pirot	80 MW - mFRR Up
EMS	14:40-15:07	HPP Djerdap 1	300 MW - mFRR Down
EMS	15:07-15:16	HPP Djerdap 1	450 MW - mFRR Down
EMS	15:16-15:30	HPP Djerdap 1	73 MW - mFRR Up
IPTO	14:10	GAS units	Reduce 300 MW

TSO	Time	Production unit	Action
IPTO	14:10	Lignite units	No change
IPTO	14:15	Hydro units	Reduce 200 MW
IPTO	14:25	Hydro units	Reduce 100 MW
IPTO	14:30	Gas units	Reduce 300 MW
IPTO	14:40	Lignite units	Reduce 100 MW
ESO	14:04:54	187 MW of RES	Stop (by frequency automatics)
ESO	14:05:10	TPP Maritsa Iztok 1, Unit 2	15 MW reduction (by primary LF control)
ESO	14:05:10	TPP Maritsa Iztok 2, Unit 7	10 MW reduction (by primary LF control)
ESO	14:05:10	TPP Varna, Unit 4	10 MW reduction (by primary LF control)
ESO	14:05:10	TPP Bobov dol, Unit 2	10 MW reduction (by primary LF control)
ESO	14:29	HPP Ivailovgrad	Stop (manually) - 70 MW
ESO	14:26	HPP Krichim - 1 Unit	Stop (manually) - approx. 33 MW
ESO	14:26	HPP Orfej - 1 Unit	Stop (manually) - approx. 30 MW
ESO	15:07:31	187 MW of the previously disconnected RES	Start (reconnected manually)
TEIAS	14:30-15:05	KEBAN HPP (105 MW)	starts
TEIAS	14:30-15:05	KEBAN HPP (105 MW)	starts
TEIAS	14:10-15:59	BİRECİK HPP (472 MW)	starts
TEIAS	14:16-15:39	KARAKAYA HPP (250 MW)	starts
TEIAS	14:10-14:59	ATATÜRK HPP (250 MW)	starts
TEIAS	14:15-14:58	BOYABAT HPP (141 MW)	starts
TEIAS	14:15-14:58	BOYABAT HPP (141 MW)	starts
TEIAS	14:19-14:59	ÖZLÜCE (51 MW)	starts
TEIAS	14:05-14:15	ÇAN-2 TES (39 MW)	change in setpoint (load shedding)
TEIAS	14:05-14:15	BAĞIŞTAŞ-2 HPP (16 MW)	stop
TEIAS	14:05-14:11	İÇ ANADOLU DG (173 MW)	change in setpoint (load shedding)
TEIAS	14:05-14:16	KOZBÜKÜ HPP (81 MW)	stop
TEIAS	14:05-14:13	UZUNDERE-1 HPP (10 MW)	stop
TEIAS	14:05-14:16	BAĞIŞTAŞ-2 HPP (16 MW)	stop
TEIAS	14:05-14:21	YEDİGÖZE HPP (155 MW)	stop
TEIAS	14:05-14:16	ALAKÖPRÜ HPP (13 MW)	stop
TEIAS	14:05-14:16	YUKARI MANAHOZ HPP (22 MW)	stop
TEIAS	14:05-14:16	ÇAN-2 TES (30 MW)	change in setpoint (load shedding)
TEIAS	15:05	HASAN UĞURLU HPP (95 MW)	stop
TEIAS	15:59	ATATÜRK HPP (70 MW)	change in setpoint (load shedding)
TEIAS	15:59	ATATÜRK HPP (220 MW)	stop

Table A4-2: Applied measures (manual or automatic) regarding power generation units

Annex Chapter 5

Annex 5.1: Market aspects

Croatia (market schedules)

The net exchange values for Croatia for 08 January 2021 are shown in Table A5-1. The market schedules show high imports to Croatia from Bosnia and Herzegovina and Serbia beginning at 08:00 in the morning. The net exchange during this time is close or even equal to the full NTC value. Furthermore, Croatia exports energy to Slovenia and Hungary during this time.

Hour	BA » HR	SI » HR	HU » HR	RS » HR
00:00 - 01:00	755	-374	-591	-20
01:00 - 02:00	838	-470	-755	-16
02:00 - 03:00	845	-719	-724	122
03:00 - 04:00	845	-828	-707	102
04:00 - 05:00	832	-751	-762	108
05:00 - 06:00	804	-653	-739	123
06:00 - 07:00	618	-395	-655	224
07:00 - 08:00	965	-394	-743	215
08:00 - 09:00	983	-516	-771	512
09:00 - 10:00	979	-515	-715	538
10:00 - 11:00	980	-574	-695	537
11:00 - 12:00	979	-502	-697	522
12:00 - 13:00	1,000	-481	-688	492
13:00 - 14:00	1,000	-365	-943	524
14:00 - 15:00	1,000	-598	-795	600
15:00 - 16:00	1,000	-606	-857	591
16:00 - 17:00	1,000	-636	-791	560
17:00 - 18:00	1,000	-628	-616	416
18:00 - 19:00	1,000	-616	-660	411
19:00 - 20:00	989	-637	-648	414
20:00 - 21:00	716	-653	-349	362
21:00 - 22:00	638	-820	-63	337
22:00 - 23:00	564	-815	-108	290
23:00 - 24:00	544	-848	-280	322

Table A5-1: Net exchange values of Croatia (in MW)

Serbia (market schedules)

Therefore, market schedules were mainly from the east to the west, and net exchange values for 08 January 2021 are provided in Table A5-2.

Hour	Net exchange EMS – NOS BIH	Net exchange EMS – ESO EAD	Net exchange EMS – HOPS	Net exchange EMS – MAVIR	Net exchange EMS – CGES	Net exchange EMS – MEPSO	Net exchange EMS – TRANSELECTRICA
01	-301	40	-20	614	-114	-40	201
02	-332	40	-16	613	-99	-73	240
03	-313	104	122	722	-114	-155	217
04	-306	122	102	748	-157	-135	209
05	-290	39	108	803	-157	-115	218
06	-290	65	123	648	-132	-129	281
07	-338	25	224	685	-36	-165	161
08	-288	-64	215	769	-142	-210	301
09	-386	35	512	840	-185	-210	192
10	-389	-177	538	943	-180	-225	208
11	-388	-239	537	926	-144	-197	151
12	-387	-206	522	949	-148	-232	148
13	-312	-187	492	989	-84	-235	33
14	-307	-231	524	1,000	-85	-228	74
15	-246	-97	600	1,000	-86	-212	-122
16	-304	-155	591	1,000	-90	-201	-9
17	-376	-162	560	1,000	-134	-198	-3
18	-377	-190	416	986	-184	-196	110
19	-397	-142	411	835	-186	-5	51
20	-417	-99	414	784	-186	10	73
21	-334	-77	362	661	-98	-46	127
22	-278	-55	337	605	-56	33	-36
23	-294	-59	290	555	48	-6	-51
24	-331	-49	322	436	163	0	-73
TOTAL (MWh)	**-7,981**	**-1,719**	**8,286**	**19,111**	**-2,586**	**-3,170**	**2,701**

Table A5-2: Net exchange values at EMS's borders (in MW)

Romania (market schedules)

Market schedules for Romania can be found in Table A5-3.

Hour	Net exchange RO»HU	Net exchange RO»RS	Net exchange RO»BG	Net exchange RO»UA	Total Net exchange
01	800	-201	33	-37	599
02	800	-240	4	-38	530
03	788	-217	-15	-38	522
04	759	-209	-81	-38	435
05	793	-218	-152	-38	388
06	450	-281	-132	-37	4
07	31	-161	-162	-34	-324
08	99	-301	-467	-27	-694
09	36	-192	-803	-18	-976
10	114	-208	-734	-26	-851
11	276	-151	-764	-35	-672
12	511	-148	-807	-34	-476
13	623	-33	-810	-33	-251
14	800	-74	-613	-31	84
15	800	122	-573	-11	340
16	800	9	-430	-2	379
17	732	3	-829	0	-92
18	738	-110	-753	0	-123
19	748	-51	-739	0	-39
20	701	-73	-507	0	122
21	760	-127	-272	-6	357
22	787	36	-81	-19	725
23	786	51	-88	-31	722
24	788	73	-11	-34	820

Table A5-3: Net exchange values at Transelectrica's borders (in MW)

Hour	Totale	Italia (Senza Vincoli)	Calabria	Centro Nord	Centro Sud	Nord	Sardegna	Sicilia	Sud	Austria	Corsica AC	Corsica	Francia	Grecia	Slovenia	Svizzera	BSP	Malta	Svizzera Coupling	Montenegro
1	1400,132	1362,955	28,295	103,032	123,442	658,516	31,428	132,73	173,717	0	0	0	0	0	0	149		0		0
2	1632,611	1598,093	22,884	103,01	107,683	878,547	27,509	168,43	174,545	0	0	0	0	0	0	150		0		0
3	1515,94	1486,729	19,541	78,694	85,765	841,753	22,277	146,73	171,179	0	0	0	0	0	0	150		0		0
4	1504,658	1470,979	26,978	82,114	99,032	835,113	23,128	137,85	164,698	0	0	0	0	0	0	136		0		0
5	1648,81	1613,466	43,834	76,866	124,588	892,788	28,748	131,68	200,31	0	0	0	0	0	0	150		0		0
6	1833,73	1796,881	45,596	86,522	119,447	1083,565	27,694	117,12	203,791	0	0	0	0	0	0	150		0		0
7	1154,115	1117,473	24,363	90,999	89,6	670,184	27,201	79,951	171,817	0	0	0	0	0	0	0		0		0
8	888,533	886,76	24,546	103,709	78,391	495,4	23,917	35,586	91,984	0	0	0	0	0	0	0		0		35
9	1477,833	1547,91	24,775	184,023	86,696	909,324	26,358	48,822	80,835	0	0	0	0	0	0	0		0		117
10	1417,731	1592,148	29,34	154,128	108,836	717,067	29,246	57,283	204,831	0	0	0	0	0	0	0		0		117
11	1989,653	2081,779	33,824	200,313	108,615	1188,422	30,166	70,162	258,151	0	0	0	0	0	0	0		0		100
12	1135,668	1653,983	38,57	200,073	117,235	329,618	28,583	77,805	216,784	0	0	0	0	0	0	0		0		127
13	1130,217	1430,072	43,932	101,159	111,953	495,006	24,122	82,52	189,525	0	0	0	0	0	0	20		0		62
14	1135,385	1412,043	42,198	102,333	113,752	467,12	19,085	84,271	237,626	0	0	0	0	0	0	20		0		49
15	1135,357	1606,265	50,214	137,546	108,83	443,487	16,909	119,72	235,655	0	0	0	0	0	0	0		0		23
16	1015,634	1502,459	55,127	127,372	87,338	313,16	13,222	113,99	278,426	0	0	0	0	0	0	0		0		27
17	1037,564	1088,08	61,889	127,955	90,596	350,552	11,624	81,243	215,705	0	0	0	0	0	0	0		0		98
18	1132,363	1206,063	64,982	201,386	85,613	295,702	11,212	49,553	257,915	0	0	0	0	0	0	0		0		166
19	1101,059	1036,365	63,569	153,32	80,651	320,311	6,808	82,007	262,393	0	0	0	0	0	0	0		0		132
20	1412,494	1187,954	57,768	92,071	81,503	543,149	8,161	92,534	437,308	0	0	0	0	0	0	0		0		100
21	1191,732	1164,294	53,513	92,64	73,108	532,752	19,895	122,01	247,811	0	0	0	0	0	0	0		0		50
22	1152,063	934,946	49,111	109,766	91,447	712,81	32,39	27,152	129,387	0	0	0	0	0	0	0		0		0
23	1101,773	930,299	49,115	98,817	96,283	588,121	34,047	47,844	163,653	0	0	0	0	0	0	24		0		0
24	991,327	820,347	39,442	81,252	81,862	563,28	30,107	55,708	139,676	0	0	0	0	0	0	0		0		0

Table A5-4: Intraday volumes in zone M1

Hour	Totale	Italia (Senza Vincoli)	Calabria	Centro Nord	Centro Sud	Nord	Sardegna	Sicilia	Sud	Austria	Corsica AC	Corsica	Francia	Grecia	Slovenia	Svizzera	BSP	Malta	Svizzera Coupling	Montenegro
1	1400,132	1362,955	25,296	4,124	37,45	1278,44	1,638	22,255	30,926	0	0	0	0	0	0	0		0		0
2	1632,611	1598,093	23,425	9,637	202,959	1333,68	0,93	22,773	39,207	0	0	0	0	0	0	0		0		0
3	1515,94	1486,729	17,013	14,632	206,117	1225,74	0,714	25,73	25,993	0	0	0	0	0	0	0		0		0
4	1504,658	1470,979	8,123	14,683	208,988	1215,97	1,145	29,447	26,303	0	0	0	0	0	0	0		0		0
5	1648,81	1613,466	7,253	13,826	212,043	1186,35	1,744	27,886	199,712	0	0	0	0	0	0	0		0		0
6	1833,73	1796,881	8,317	8,081	296,334	1290,75	2,556	22,471	205,223	0	0	0	0	0	0	0		0		0
7	1154,115	1117,473	15,939	2,819	48,107	832,348	3,079	27,699	219,124	0	0	0	0	0	0	0		0		5
8	888,533	886,76	45,717	5,108	165,634	594,001	2,253	35,586	35,234	0	0	0	0	0	0	0		0		5
9	1477,833	1547,91	26,807	21,245	261,819	1072,1	4,48	23,05	63,33	0	0	0	0	0	0	0		0		5
10	1417,731	1592,148	28,594	7,889	420,242	863,306	10,835	22,277	59,588	0	0	0	0	0	0	0		0		5
11	1989,653	2081,779	30,588	9,762	413,09	1378,97	11,522	23,37	60,348	0	0	0	0	0	0	0		52		10
12	1135,668	1653,983	28,668	10,562	375,698	519,129	12,255	32,402	146,954	0	0	0	0	0	0	0		0		10
13	1130,217	1430,072	18,709	7,185	285,696	608,98	12,018	33,292	154,337	0	0	0	0	0	0	0		0		10
14	1135,385	1412,043	11,823	7,394	351,828	582,059	10,658	22,731	143,892	0	0	0	0	0	0	0		0		5
15	1135,357	1606,265	8,973	7,334	334,641	560,699	11,052	20,256	132,402	0	0	0	0	0	0	13		42		5
16	1015,634	1502,459	9,871	6,68	289,035	408,852	116,4	11,416	60,384	0	0	0	0	0	0	25		83		5
17	1037,564	1088,08	11,454	18,23	385,561	435,277	9,395	81,243	66,404	0	0	0	0	0	0	25		0		5
18	1132,363	1206,063	12,004	6,8	314,553	490,288	14,423	87,351	196,944	0	0	0	0	0	0	0		0		10
19	1101,059	1036,365	15,611	6,99	332,704	466,641	13,369	82,007	173,737	0	0	0	0	0	0	0		0		10
20	1412,494	1187,954	16,632	9,662	267,23	834,309	12,309	92,534	174,818	0	0	0	0	0	0	0		0		5
21	1191,732	1164,294	13,999	8,575	372,759	562,167	11,632	122,013	95,587	0	0	0	0	0	0	0		0		5
22	1152,063	934,946	14,437	6,68	527,826	410,192	13,811	27,152	146,965	0	0	0	0	0	0	0		0		5
23	1101,773	930,299	15,867	7,082	541,372	329,179	16,102	20,844	139,327	0	0	0	0	0	0	0		27		5
24	991,327	820,347	14,763	6,845	66,982	836,732	18,017	4,513	38,475	0	0	0	0	0	0	0		0		5

Hour	Totale	Italia (Senza Vincoli)	Calabria	Centro Nord	Centro Sud	Nord	Sardegna	Sicilia	Sud	Austria	Corsica AC	Corsica	Francia	Grecia	Slovenia	Svizzera	BSP	Malta	Svizzera Coupling	Montenegro
1	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46	53,46		53,46		53,46
2	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09	51,09		51,09		51,09
3	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06		51,06		51,06
4	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77	47,77		47,77		47,77
5	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78	45,78		45,78		45,78
6	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06	51,06		51,06		51,06
7	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22	64,22		64,22		64,22
8	73,49	70	81,07	70	70	81,07	70	76,1	70	81,07	70	81,07	81,07	70	81,07	81,07		76,1		70
9	100	81,5	109,5	81,5	81,5	109,5	81,5	81,5	81,5	109,5	81,5	109,5	109,5	81,5	109,5	109,5		81,5		81,5
10	100,45	73	111,5	73	73	111,5	73	73	73	111,5	73	111,5	111,5	73	111,5	111,5		73		73
11	99	69,04	110	69,04	69,04	110	69,04	69,04	69,04	110	69,04	110	110	69,04	110	110		69,04		69,04
12	70	66,39	106,8	66,39	66,39	106,8	66,39	66,39	66,39	106,8	66,39	106,8	106,8	66,39	106,8	106,8		66,39		66,39
13	69,01	61	95	61	61	95	61	61	61	95	61	95	95	61	95	95		61		61
14	69	61	87,5	61	61	87,5	61	61	61	87,5	61	87,5	87,5	61	87,5	87,5		61		61
15	70	66	95	66	66	95	66	66	66	95	66	95	95	66	95	95		66		66
16	70	69	98,42	69	69	98,42	69	69	69	98,42	69	98,42	98,42	69	98,42	98,42		69		69
17	90	70	100	70	70	100	70	92,27	70	100	70	100	100	70	100	100		92,27		70
18	105	95	110	95	95	110	95	95	95	110	95	110	110	95	110	110		95		95
19	100	84,17	107,4	84,17	84,17	107,4	84,17	100	84,17	107,4	84,17	107,4	107,4	84,17	107,4	107,4		100		84,17
20	85	83,06	83,06	83,06	83,06	83,06	83,06	107,6	83,06	83,06	83,06	83,06	83,06	83,06	83,06	83,06		107,6		83,06
21	69,5	69	69,4	69	69	69,4	69	106,6	69	69,4	69	69,4	69,4	69	69,4	69,4		106,6		69
22	63	62,29	62,29	62,29	62,29	62,29	62,29	90,96	62,29	62,29	62,29	62,29	62,29	62,29	62,29	62,29		90,96		62,29
23	60	58,93	58,93	58,93	58,93	58,93	58,93	70,8	58,93	58,93	58,93	58,93	58,93	58,93	58,93	58,93		70,8		58,93
24	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7	57,7		57,7		57,7

Table A5-5: Intraday prices (EUR) in zone M1

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