

EPRI European workshop

Distribution – Beyond Pilots for Distribution Services

Northern Cluster: Litgrid demonstration

Deividas Šikšnys (Litgrid) – Lithuanian demonstration



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739

Agenda

1. Northern cluster participants
2. Baltics energy system and upcoming changes
3. Northern cluster architecture of the platform
 - 3.1 OneNet products and correlation with existing electricity market
 - 3.2 New developed flexibility register and coordination platform
4. Litgrid demonstration main goals and NRT-P-E product use case
5. Existing independent aggregation in Lithuania balancing market



Northern Cluster Demonstrator parties

Implement in TSO-DSO pairs from

- Finland
- Estonia
- Latvia
- Lithuania



Market operators

- Nordpool (Norway)
- Piclo (UK)



Energy retailer & flexibility service provider

- VattenFall (Sweden)



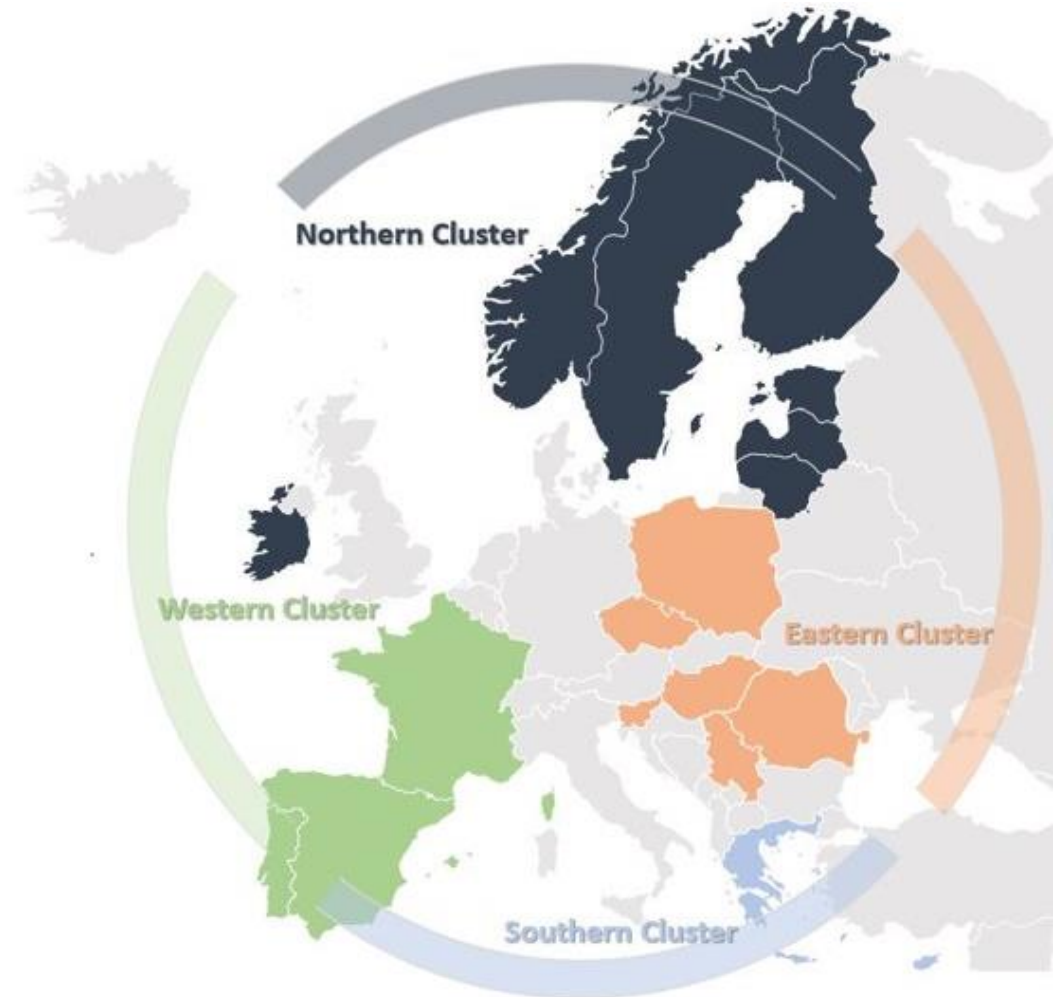
Energy market service provider, IT company

- Enerim (Finland)
- Cybernetica (Estonia)

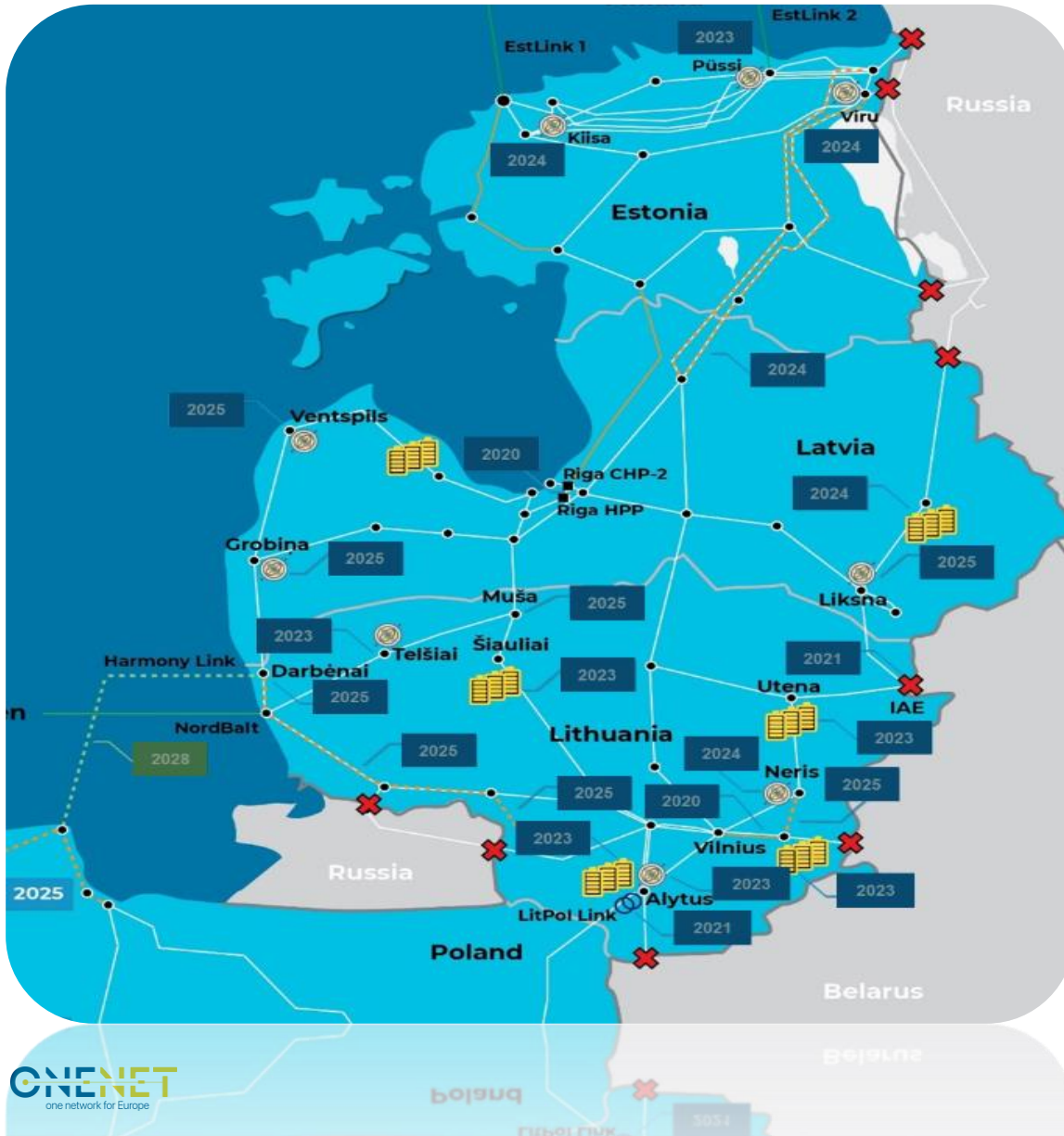


Research Center

- Vito (Belgium)



Desynchronization -> synchronization



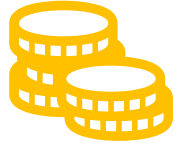
In coming years Baltic countries will **desynchronize from BRELL system and synchronize to continental European synchronous zone**

This project was initiated in 2007 with the aim of being implemented until 2025

From 1MW battery to 200MW implementation in Lithuania system

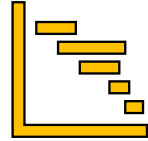


Europe electricity market structure



Forward
market

*Years /
months
before*



Day-ahead
market

*Day
before*



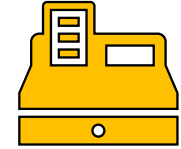
Intraday
continuous
market

*Hours
before*



Balancing
market

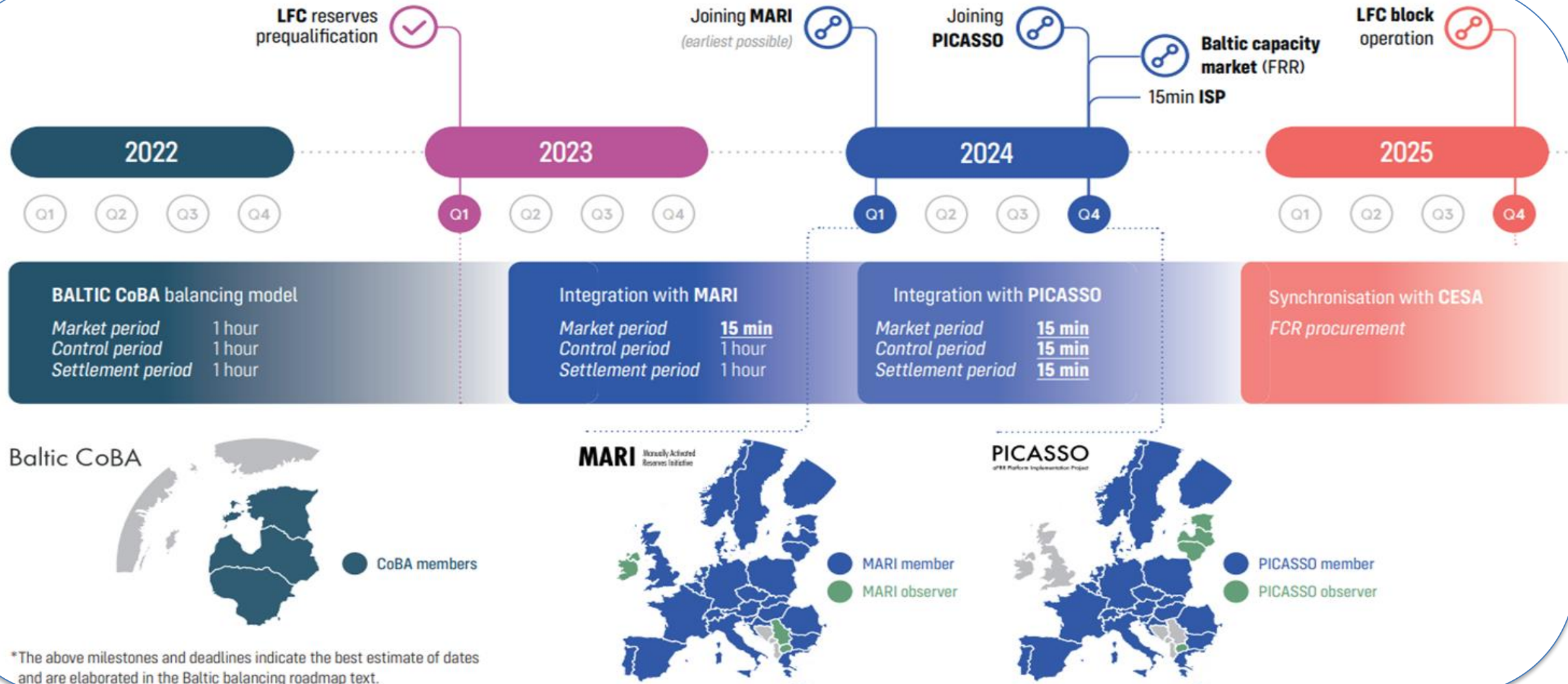
*Minutes
before*



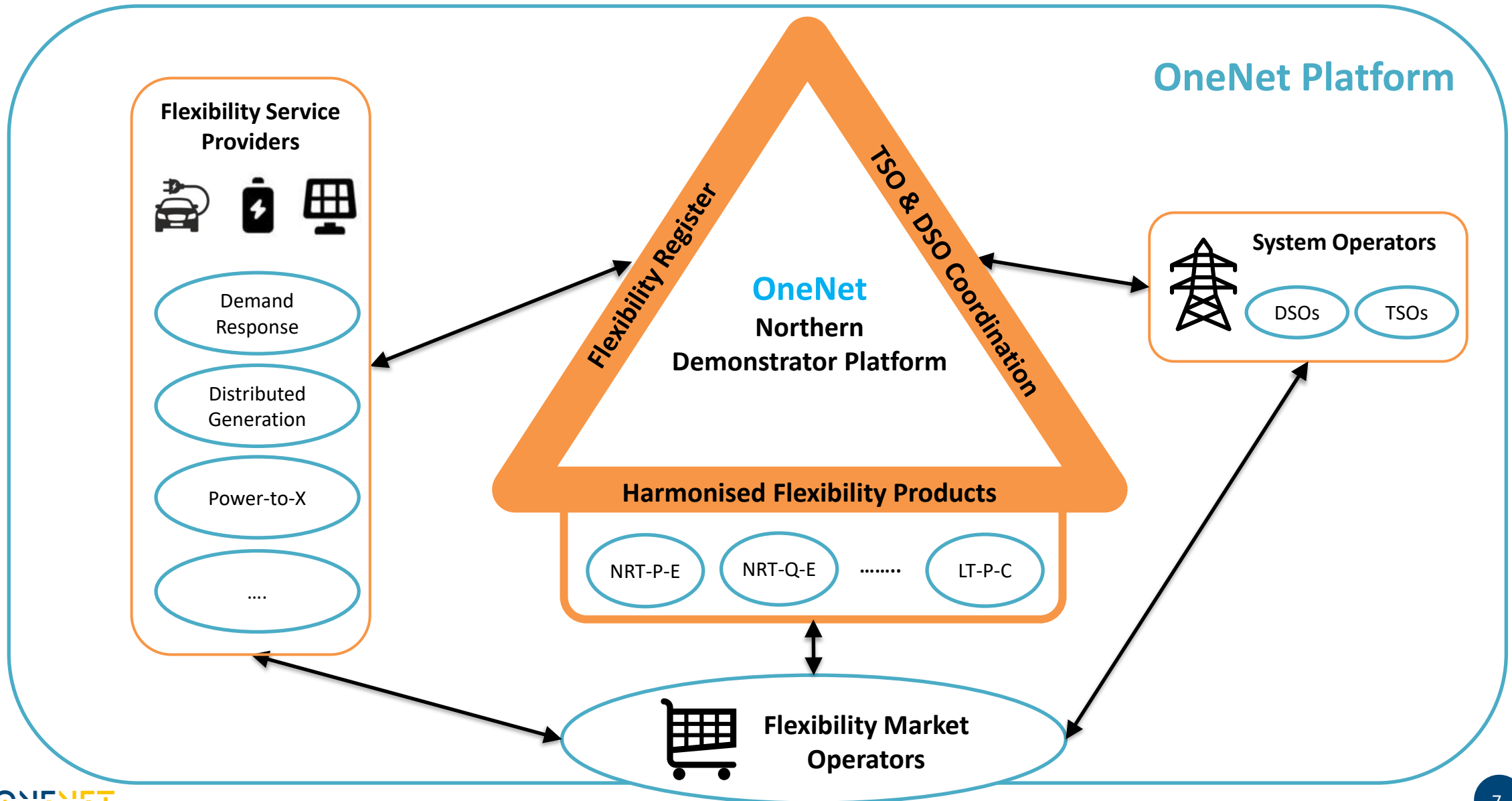
Imbalance
settlement

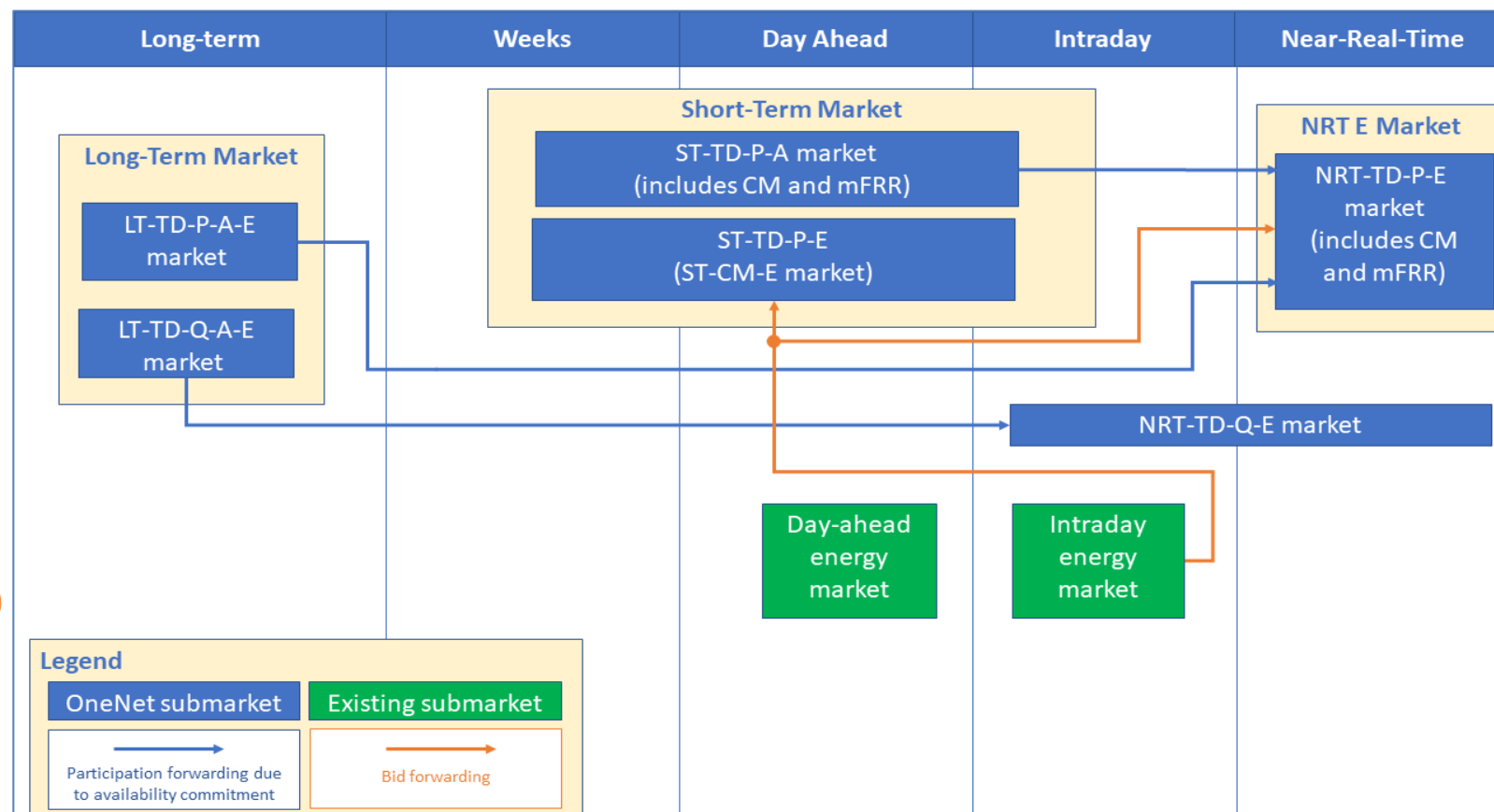
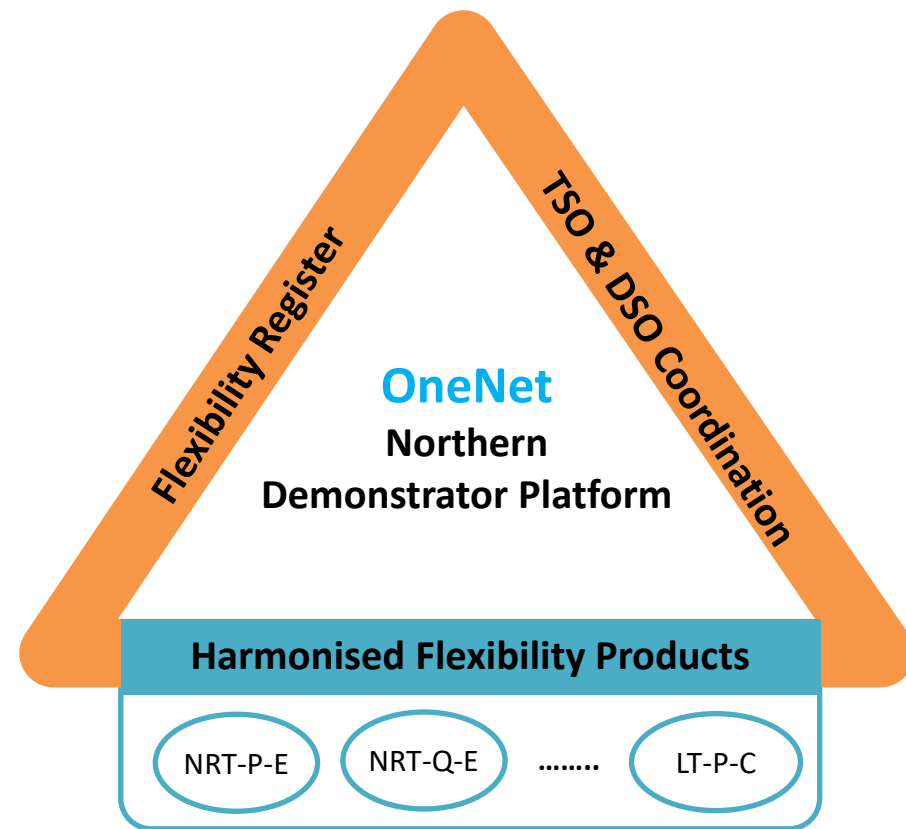
After

Baltic TSO balancing markets



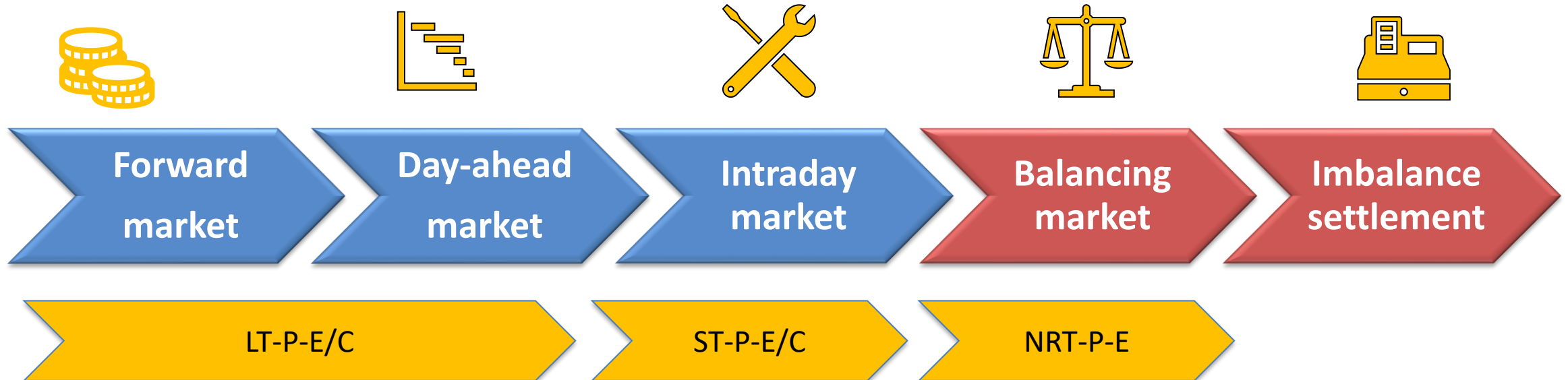
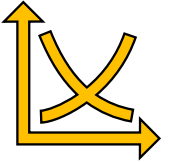
Architecture of Northern Cluster platform





- Near real-time active energy product (NRT-P-E)
- Near real-time reactive energy product (NRT-Q-E)
- Short term active energy product (ST-P-E)
- Short term active power product (ST-P-C)
- Long term active power product (LT-P-C)
- Long term reactive power product (LT-Q-C/E)

Europe electricity market + OneNet



Flexibility Register

stores information about

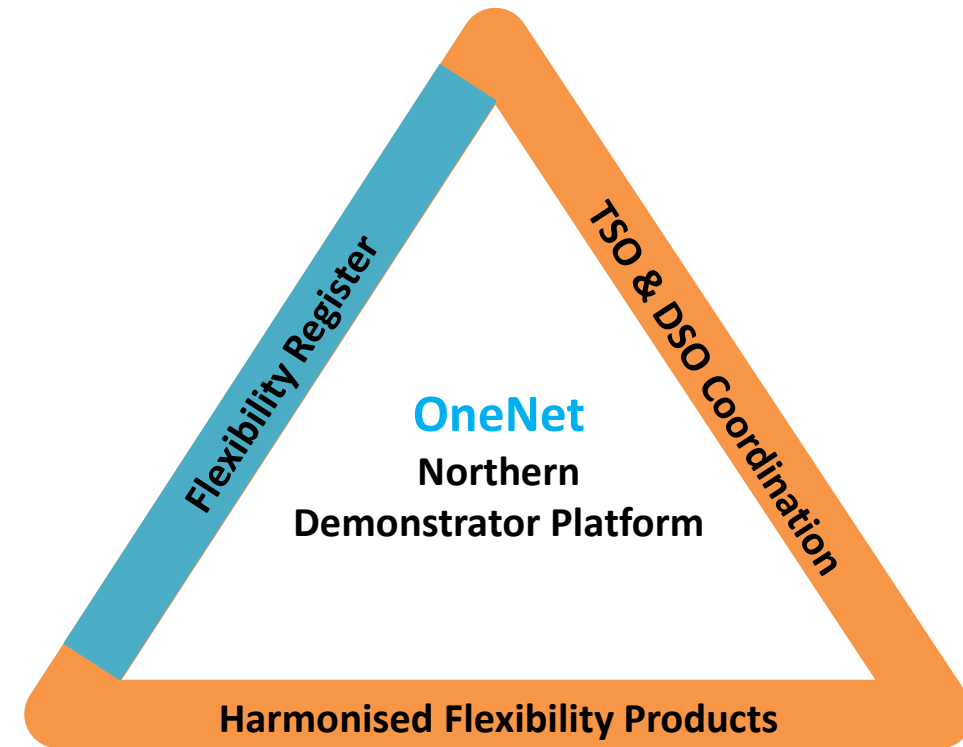
- flexibility assets,
- results of qualification (both product and grid),
- market results,
- grid information

perform flexibility verification and settlement

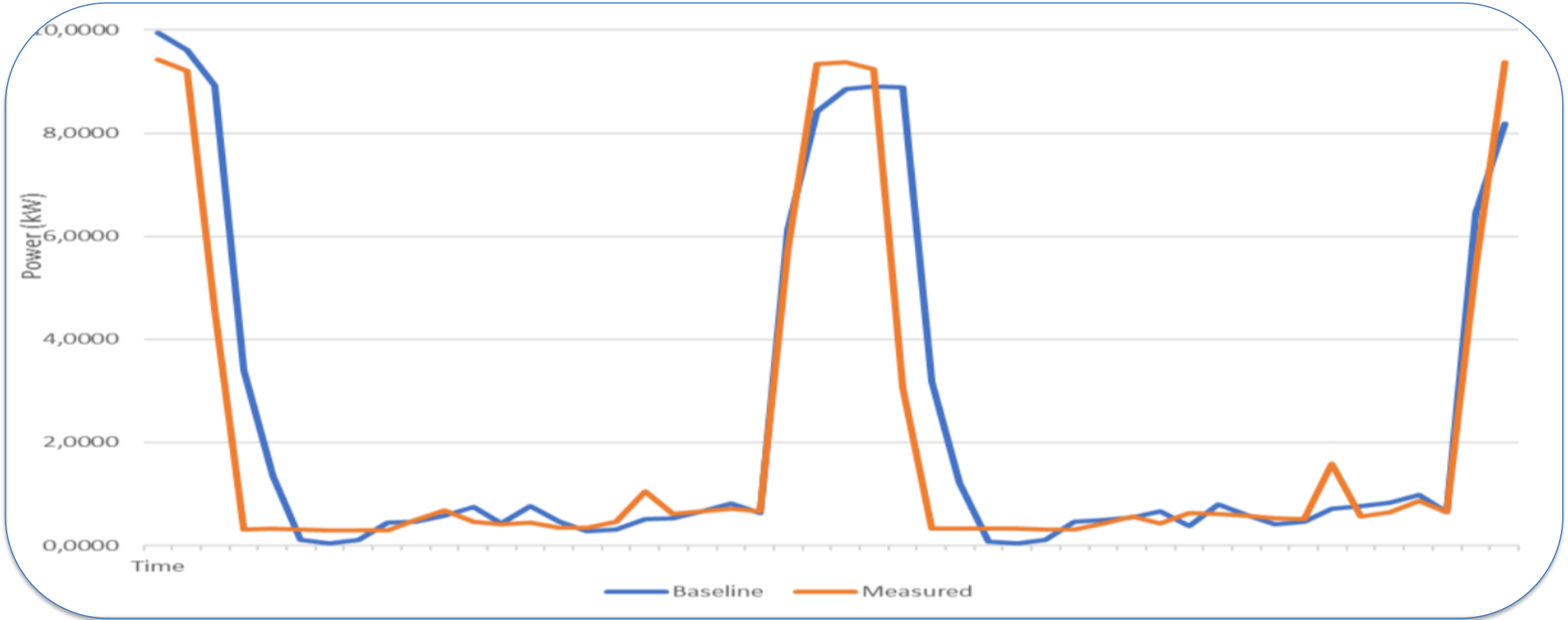
aggregates flexibility information

allocates access rights to the various actors

controls the level of access

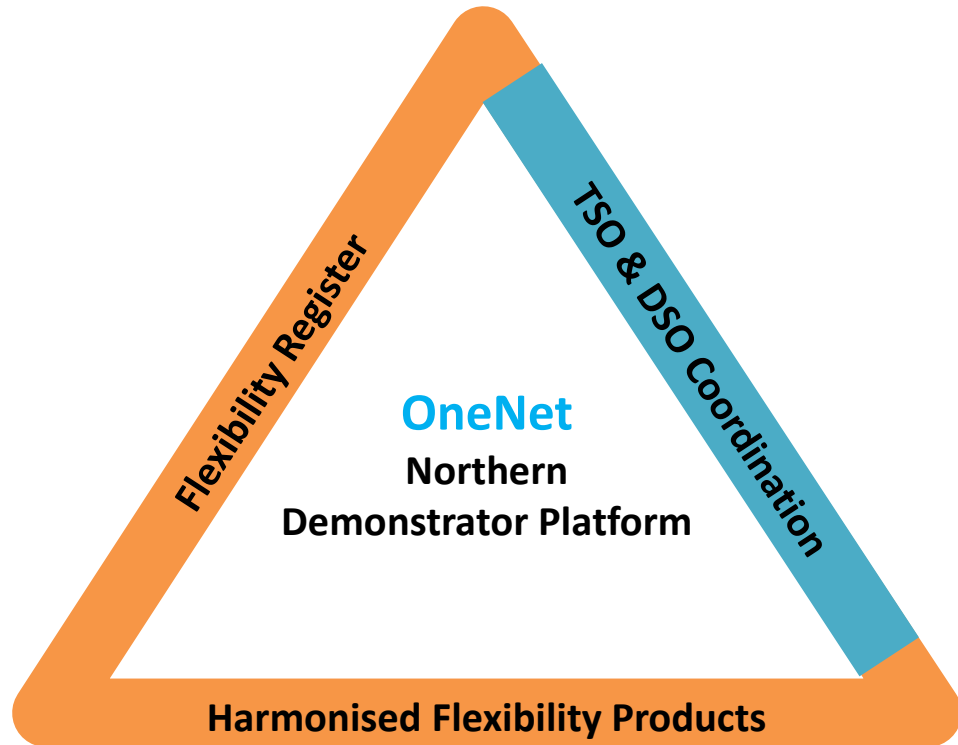


Baseline calculation based on the X of Y method



Baseline evaluation is based on the historical metering data. On the other hand, scheduling approach can also be applicable

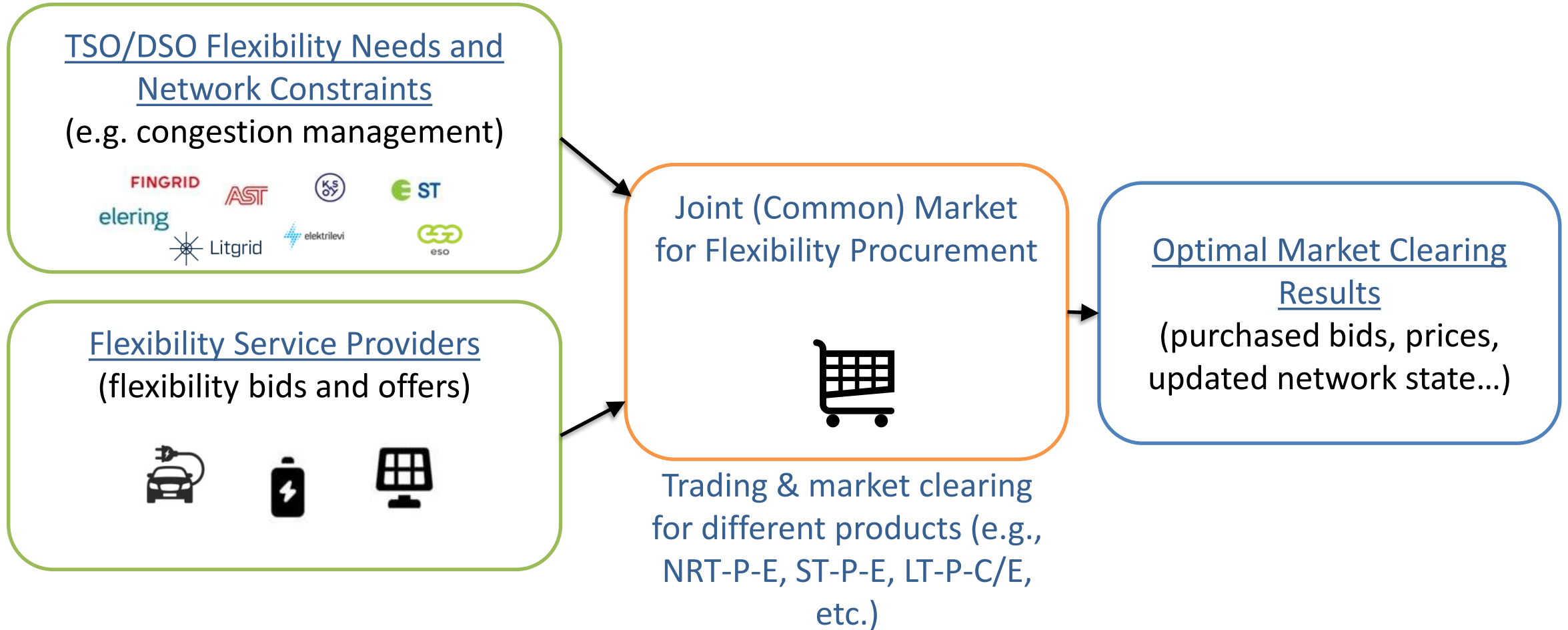
TSO-DSO coordination platform (T&D CP)



Avoid activation of flexibilities that either do not contribute to solving system needs or even worsen the situation (constraint setting process)

Find the best value-stack of available flexibilities to be activated (optimization process).

Optimization-Based Market Clearing

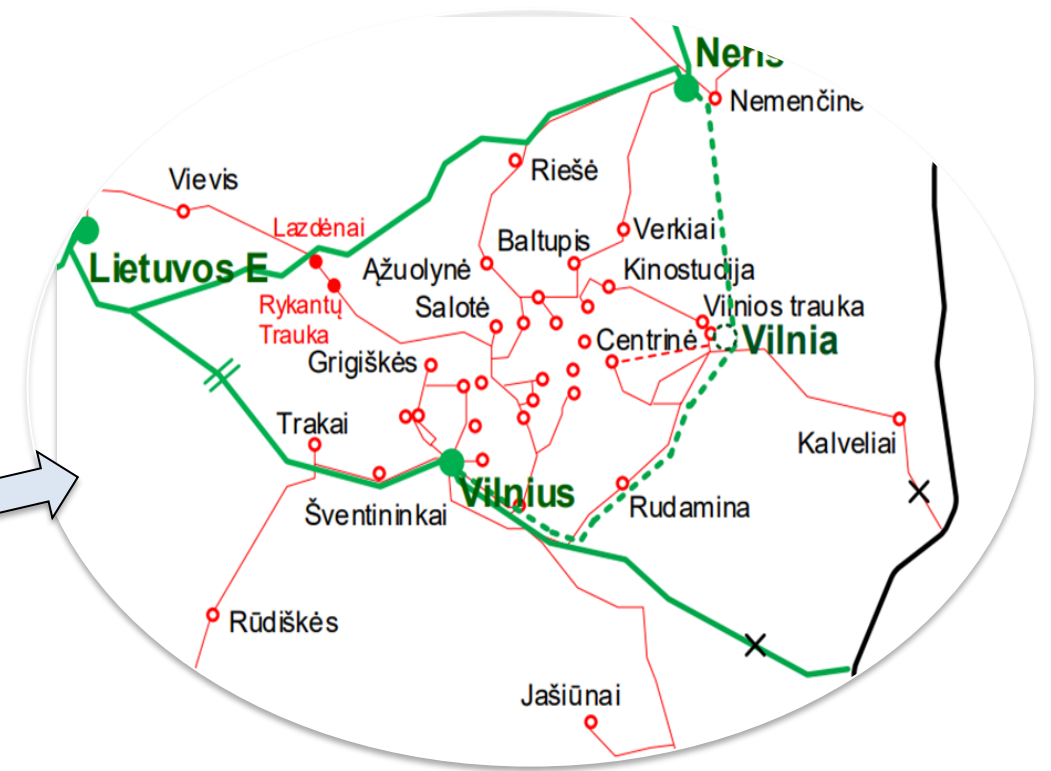
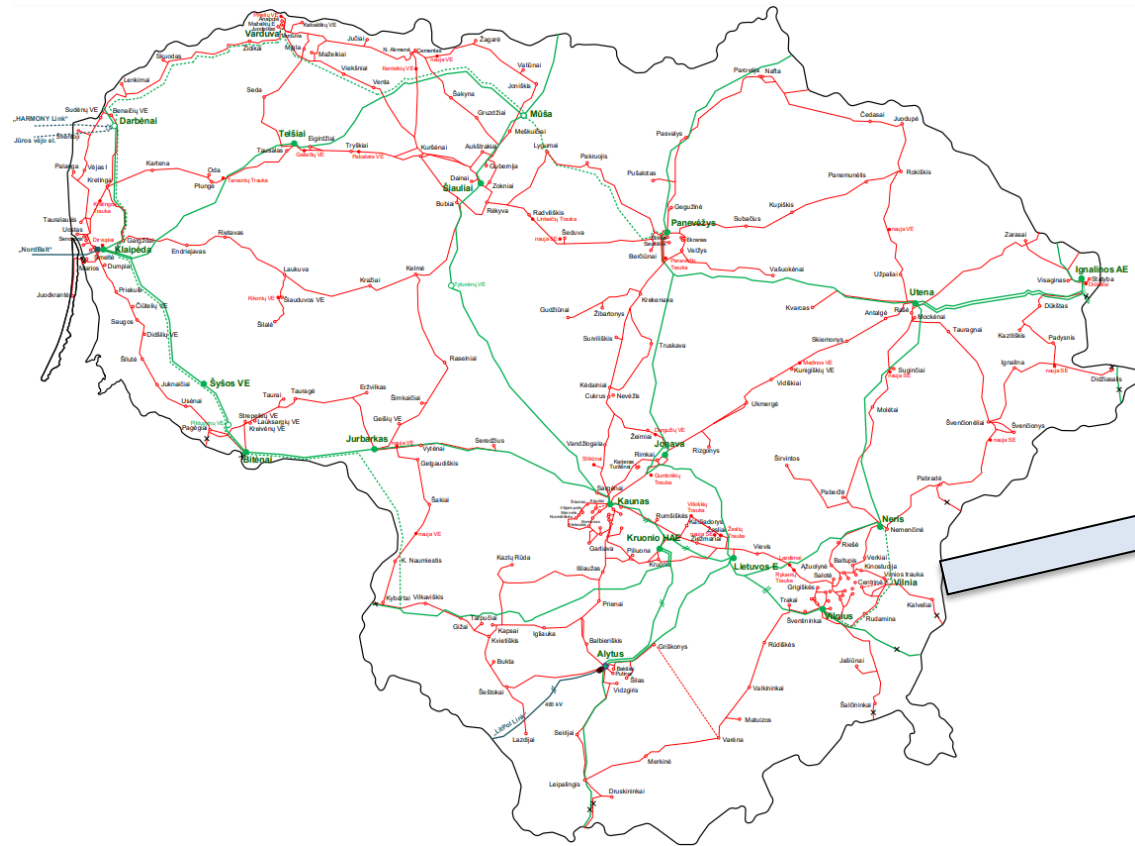




Litgrid demonstration main goals

- Manage **network congestion** with defined disturbances to system stability
- Market optimization output redispatch power flows and helps to avoid generation or consumption restrictions
- Use coordination platform to **coordinate** flexibility provision between TSO and DSO
- Create a new market with **lower entry barriers** to empower flexibility service providers
- Showcase the entire **NRT-P-E product usage process** in Lithuania to highlight the benefits of market-based solutions

Real network topology



330kV lines
110kV lines

Purchase Offer

Type: NRT-P-E

Timestamp:

start: 2020-04-30T04:00:00.000Z

end: 2020-04-30T04:15:00.000Z

Imbalance Position:

actual	min	max
-338.81	-438.81	-238.81

Transmission network data

	Node base info		Line base info
	Connection TN-DN		Sensitivity matrix

Node TN:

Id	System Id	Slack	Connected DN	DN System Id	Interface Capacity	Base Interface Flow DN
1	TN	1	0			
2	TN	0	0			
3	TN	0	0			
4	TN	0	0			
5	TN	0	0			
6	TN	0	0			
7	TN	0	0			
8	TN	0	0			
9	TN	0	0			
10	TN	0	0			
11	TN	0	0			
12	TN	0	0			
13	TN	0	0			
14	TN	0	0			
15	TN	0	0			
16	TN	0	0			
17	TN	0	0			
18	TN	0	1	DN_1	100	-4.7
19	TN	0	0			
20	TN	0	0			
21	TN	0	0			
22	TN	0	0			

Line TN:

Id	System Id	From Node Id	To Node Id	Capacity	Critical	Base Flow
1	TN	1	2	2144.6	1	-130.2
2	TN	2	3	300	1	-325.31
3	TN	3	4	84.7	1	8.54
4	TN	3	5	97.2	1	11.83
5	TN	3	6	63	1	4.91
6	TN	3	7	97.2	1	51.56
7	TN	3	8	169.4	1	29.34
8	TN	8	9	169.4	1	33.69
9	TN	9	10	84.7	1	-15.52
10	TN	10	13	84.7	1	-6.84
11	TN	9	11	84.7	1	-22.26
12	TN	11	13	84.7	1	-39.56
13	TN	11	12	169.4	1	-67.92
14	TN	12	13	97.2	1	48.53
15	TN	12	14	84.7	1	-37.06
16	TN	14	15	85.74	1	14.52
17	TN	15	16	169.4	1	-8.46
18	TN	16	13	115.27	1	77.21
19	TN	16	17	115.27	1	69.89
20	TN	17	13	231.47	1	104.67
21	TN	3	18	194.4	1	131.22
22	TN	18	13	97.2	1	-57.61
23	TN	18	19	95	1	-61.64
24	TN	19	13	97.2	1	-56.62
25	TN	19	20	116	1	-28.18
26	TN	3	21	169.4	1	82.07
27	TN	21	20	168	1	-70.57
28	TN	20	13	116.2	1	-32.08
29	TN	19	22	116	1	-21.17
30	TN	22	13	84.7	1	-21.09

Transmission network data

Reminder: all entries must represent the **impact of increasing the injection** at the node on the flow over the lines!

Flow Sensitivity Matrix TN:

Transmission System																						
Line\Node	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	-0.7073	-0.6827	-0.707	-0.7068	-0.6913	-0.6919	-0.6802	-0.6731	-0.6645	-0.6645	-0.6646	-0.6645	-0.6685	-0.6685	-0.6669	-0.6919	-0.6729	-0.6813	-0.6913	-0.6659
3	0	0	1	-0.9365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	1	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	0	0	0	-0.6419	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	1	0	0	0	0	-0.6602	-0.4137	-0.2612	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0.3398	-0.4137	-0.2612	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0.3398	0.5863	0.2599	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0.5864	0.3398	-0.7402	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0.4304	0.4304	0	0.6115	0.4304	0.4304	0.4304	0.4304	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	-0.4304	0	-0.4304	-0.4304	-0.4304	-0.4304	-0.4304	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	1	0	0	1	-0.4304	1	-0.4304	-0.4304	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	-0.9999	-0.9999	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0.2937	0	0.4043	0.4058	0.2475	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0.296	0	0.4091	0.4091	-0.3761	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	0.296	0	0.4091	0.4091	0.6239	0	0	0	0	0
21	0	0	-0.217	0	0	0	-0.1264	-0.217	-0.217	-0.1646	-0.217	-0.217	-0.2177	-0.217	-0.217	-0.1915	-0.201	-0.6864	-0.3613	-0.1152	0	-0.2081
22	0	0	-0.2113	0	0	0	-0.1226	-0.2113	-0.2113	-0.1613	-0.2113	-0.2113	-0.2123	-0.2113	-0.2113	-0.1866	-0.2093	0.3084	-0.1842	-0.1125	0	-0.2044
23	0	0	-0.217	0	0	0	-0.1264	-0.217	-0.217	-0.1646	-0.217	-0.217	-0.2177	-0.217	-0.217	-0.1915	-0.2142	0.3136	-0.3613	-0.1152	0	-0.2081
24	0	0	-0.2171	0	0	0	-0.1264	-0.2171	-0.2171	-0.1646	-0.2173	-0.2171	-0.2177	-0.2171	-0.2171	-0.1915	-0.2142	0.3136	0.6387	-0.1152	0	-0.2082
25	0	0	0.1227	0	0	0	0	0.1227	0.1227	0	0.1227	0.1227	0.1232	0.1227	0.1227	0.1084	0.1215	0	0.2164	-0.5461	-0.3445	0.1494
26	0	0	-0.1225	0	0	0	0	-0.1225	-0.1225	0	-0.1225	-0.1225	-0.1229	-0.1225	-0.1225	-0.1081	-0.1209	0	-0.1059	-0.4562	-0.6569	-0.1175
27	0	0	-0.1225	0	0	0	0	-0.1225	-0.1225	0	-0.1225	-0.1225	-0.1229	-0.1225	-0.1225	-0.1081	-0.1208	0	-0.1059	-0.4562	-0.3431	-0.1175
28	0	0	-0.1225	0	0	0	0	-0.1225	-0.1225	0	-0.1225	-0.1225	-0.1229	-0.1225	-0.1225	-0.1081	-0.1208	0	-0.1059	0.5438	0.3431	-0.1175
29	0	0	-0.1227	0	0	0	0	-0.1227	-0.1227	0	-0.1227	-0.1227	-0.1232	-0.1227	-0.1227	-0.1084	-0.1215	0	0.7836	0.5461	0.3445	-0.1494
30	0	0	-0.1227	0	0	0	0	-0.1227	-0.1227	0	-0.1227	-0.1227	-0.1232	-0.1227	-0.1227	-0.1084	-0.1215	0	0.7836	0.5461	0.3445	0.8506

Distribution network data

	Node base info		Line base info
	Connection TN-DN		Sensitivity matrix

Node DN:

Id	System Id	Root
180	DN_1	1
181	DN_1	0
182	DN_1	0
183	DN_1	0
184	DN_1	0

Line DN:

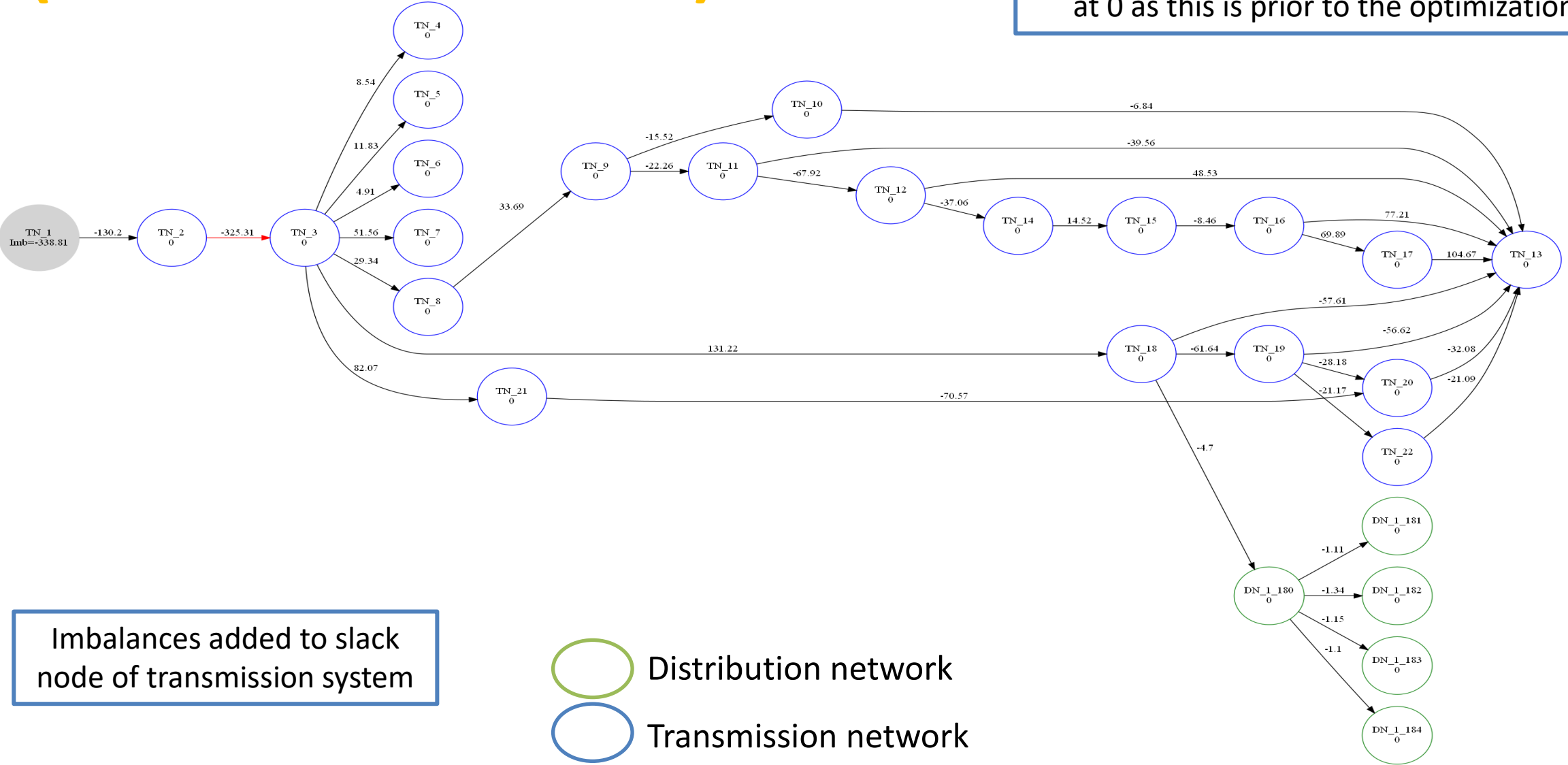
Id	System Id	From Node Id	To Node Id	Capacity	Critical	Base Flow
181	DN_1	180	181	20.8	1	-1.11
182	DN_1	180	182	9	1	-1.34
183	DN_1	180	183	17.3	1	-1.15
184	DN_1	180	184	17.3	1	-1.1

Flow Sensitivity

Distribution System (DN_1)					
Line\Node	180	181	182	183	184
181	0	1	0	0	0
182	0	0	1	0	0
183	0	0	0	1	0
184	0	0	0	0	1

Flows before market clearing (from Network Data)

The numbers shown on the lines/edges are the line flows in the provided Network Data. The number in the node will indicate the amount of purchased flexibility from every node (currently at 0 as this is prior to the optimization run)



Imbalances added to slack
node of transmission system

Bids data

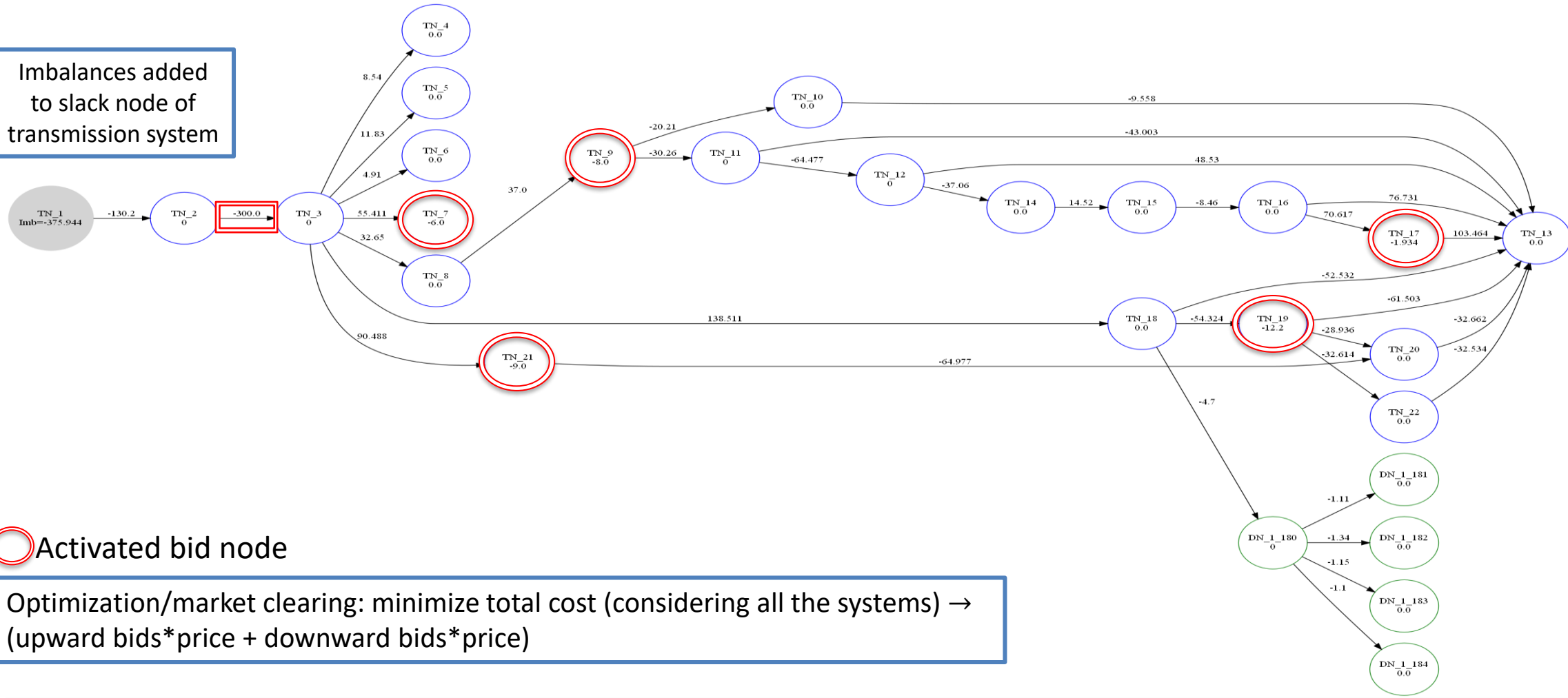
Id	System Id	Node Id	Sense	Price	Quantity	Bid Type	Minimum Quantity
1	TN	8	UPWARD	264	5	PartiallyDivisible	2.00
2	TN	22	UPWARD	326	7	FullyDivisible	
3	TN	8	UPWARD	68	4.3	FullyIndivisible	
4	TN	13	DOWNWARD	113	8	PartiallyDivisible	4.00
5	TN	14	UPWARD	279	5.5	PartiallyDivisible	3.00
6	TN	10	DOWNWARD	159	10	FullyDivisible	
7	TN	21	DOWNWARD	146	11	FullyDivisible	
8	TN	10	DOWNWARD	233	8	FullyIndivisible	
9	TN	4	DOWNWARD	123	15	PartiallyDivisible	10.00
10	TN	16	UPWARD	242	12	FullyIndivisible	
11	TN	19	DOWNWARD	48	8.2	FullyIndivisible	
12	TN	6	DOWNWARD	114	9.2	PartiallyDivisible	5.00
13	TN	20	DOWNWARD	283	8.4	PartiallyDivisible	4.00
14	TN	7	DOWNWARD	141	8	FullyDivisible	
15	TN	18	DOWNWARD	226	2.5	PartiallyDivisible	1.00
16	TN	16	UPWARD	99	5	FullyDivisible	
17	TN	19	UPWARD	298	7	FullyIndivisible	
18	TN	22	UPWARD	24	5	FullyDivisible	
19	TN	17	UPWARD	29	5	PartiallyDivisible	2.00
20	TN	10	UPWARD	201	2.3	FullyDivisible	
21	TN	7	DOWNWARD	225	2.6	FullyDivisible	
22	TN	5	UPWARD	148	3	FullyIndivisible	
23	TN	10	UPWARD	178	4	PartiallyDivisible	1.00
24	TN	19	UPWARD	194	6	FullyIndivisible	
25	TN	13	DOWNWARD	318	4.1	FullyDivisible	
26	TN	16	UPWARD	218	7.5	FullyDivisible	
27	TN	19	UPWARD	133	2.3	FullyIndivisible	
28	TN	23	DOWNWARD	131	3.2	FullyIndivisible	
29	TN	17	UPWARD	24	1.1	FullyIndivisible	
30	TN	5	UPWARD	283	8.2	FullyDivisible	
31	TN	9	DOWNWARD	263	6.1	PartiallyDivisible	2.00
32	TN	22	DOWNWARD	316	2.8	FullyDivisible	
33	TN	24	DOWNWARD	275	6.3	FullyDivisible	
34	TN	5	UPWARD	64	4.1	PartiallyDivisible	2.00
35	TN	4	DOWNWARD	238	7	FullyIndivisible	
36	TN	17	DOWNWARD	98	3.8	FullyDivisible	
37	TN	14	DOWNWARD	184	4	FullyDivisible	
38	TN	15	DOWNWARD	266	6	FullyIndivisible	
39	TN	20	UPWARD	72	2.6	FullyIndivisible	
40	TN	17	DOWNWARD	264	1.2	FullyIndivisible	

Id	System Id	Node Id	Sense	Price	Quantity	Bid Type	Minimum Quantity
41	TN	13	UPWARD	257	3	FullyIndivisible	
42	TN	6	UPWARD	262	6.1	FullyIndivisible	
43	TN	18	DOWNWARD	108	3.9	FullyIndivisible	
44	TN	20	UPWARD	243	3.6	FullyDivisible	
45	TN	15	UPWARD	289	3.4	PartiallyDivisible	2.00
46	TN	19	DOWNWARD	73	4	FullyDivisible	
47	TN	9	UPWARD	182	5	FullyDivisible	
48	TN	14	UPWARD	293	6.4	FullyIndivisible	
49	TN	17	DOWNWARD	22	1.3	FullyIndivisible	
50	TN	21	UPWARD	279	3.4	PartiallyDivisible	1.00
51	TN	20	UPWARD	208	5	FullyDivisible	
52	TN	18	DOWNWARD	164	4	FullyDivisible	
53	TN	16	UPWARD	323	6	FullyIndivisible	
54	TN	6	UPWARD	294	8	FullyIndivisible	
55	TN	6	DOWNWARD	346	4	FullyIndivisible	
56	TN	7	DOWNWARD	46	6	PartiallyDivisible	2.00
57	TN	9	UPWARD	223	8	FullyIndivisible	
58	TN	9	DOWNWARD	44	8	FullyDivisible	
59	TN	21	UPWARD	24	6	PartiallyDivisible	2.00
60	TN	9	UPWARD	132	4	FullyIndivisible	
61	TN	22	DOWNWARD	174	8	FullyDivisible	
62	TN	21	DOWNWARD	48	9	FullyIndivisible	
63	TN	10	UPWARD	41	4	FullyDivisible	
64	TN	4	DOWNWARD	228	3	FullyDivisible	
65	TN	15	UPWARD	282	7	FullyIndivisible	
66	TN	17	UPWARD	261	6	PartiallyDivisible	3.00
67	TN	9	UPWARD	113	7	FullyIndivisible	
68	TN	8	DOWNWARD	121	9	PartiallyDivisible	2.00
69	TN	24	DOWNWARD	181	4	PartiallyDivisible	2.00
70	TN	16	UPWARD	22	7	FullyIndivisible	
71	TN	6	UPWARD	27	5	FullyIndivisible	
72	TN	18	UPWARD	253	5	FullyIndivisible	
73	TN	17	DOWNWARD	127	2	FullyDivisible	
74	TN	6	DOWNWARD	189	9	FullyIndivisible	
75	TN	21	UPWARD	177	4	PartiallyDivisible	1.00
76	DN_1	181	UPWARD	140	1.5	FullyIndivisible	
77	DN_1	182	DOWNWARD	188	1	FullyIndivisible	
78	DN_1	183	DOWNWARD	192	1	FullyIndivisible	
79	DN_1	184	UPWARD	202	2	PartiallyDivisible	1.00

Flows after market clearing

The number in the nodes (circles) shows the cumulative amount of flexibility bids purchased from every node (positive for upward flexibility, negative for downward flexibility).

Imbalances added to slack node of transmission system



Optimization/market clearing: minimize total cost (considering all the systems) → (upward bids*price + downward bids*price)

Results after optimization

Cleared bids:

id	SystemId	RequestSense	BidType	Price	Dispatch
11	TN	Downward	FullyIndivisible	48	8.2
36	TN	Downward	FullyDivisible	98	0.63
46	TN	Downward	FullyDivisible	73	4
49	TN	Downward	FullyIndivisible	22	1.3
56	TN	Downward	PartiallyDivisible	46	6
58	TN	Downward	FullyDivisible	44	8
62	TN	Downward	FullyIndivisible	48	9

Updated flows over interface lines:

System Id (TN)	System Id (DN)	Flow	Overflow
TN	DN_1	-4.7	0

Updated flows over lines:

Line Id	System Id	From Node	To Node	Flow	Overflow
1	TN	1	2	-130.2	0
2	TN	2	3	-300	0
3	TN	3	4	8.54	0
4	TN	3	5	11.83	0
5	TN	3	6	4.91	0
6	TN	3	7	55.4114	0
7	TN	3	8	32.6496	0
8	TN	8	9	36.9996	0
9	TN	9	10	-20.2104	0
10	TN	10	13	-9.5584	0
11	TN	9	11	-30.26	0
12	TN	11	13	-43.0032	0
13	TN	11	12	-64.4768	0
14	TN	12	13	48.53	0
15	TN	12	14	-37.06	0
16	TN	14	15	14.52	0
17	TN	15	16	-8.46	0
18	TN	16	13	76.73143	0
19	TN	16	17	70.61723	0
20	TN	17	13	103.4636	0
21	TN	3	18	138.5109	0
22	TN	18	13	-52.5321	0
23	TN	18	19	-54.3236	0
24	TN	19	13	-61.5028	0
25	TN	19	20	-28.9361	0
26	TN	3	21	90.48785	0
27	TN	21	20	-64.9765	0
28	TN	20	13	-32.6623	0
29	TN	19	22	-32.6139	0
30	TN	22	13	-32.5339	0
181	DN_1	180	181	-1.11	0
182	DN_1	180	182	-1.34	0
183	DN_1	180	183	-1.15	0
184	DN_1	180	184	-1.1	0

Total cost:

€ 1,836.29

Optimization status:

ALL CONGESTION RESOLVED

New imbalance position:

-375.944 MW

Activated energy:

Downward bids: 37,13 MW

Upward bids: 0 MW

Timestamp:

- start: 2020-04-30T04:00:00.000Z
- end: 2020-04-30T04:15:00.000Z

Optimization Time:

1.02 sec

Left bids can be forwarded to the MARI

Bid To MARI:

id	SystemId	NodeId	Sense	Price	Quantity	BidType	MinimumQuantity
4	TN	13	DOWNWARD	113	8	PartiallyDivisible	4
6	TN	10	DOWNWARD	159	10	FullyDivisible	
7	TN	21	DOWNWARD	146	11	FullyDivisible	
8	TN	10	DOWNWARD	233	8	FullyIndivisible	
9	TN	4	DOWNWARD	123	15	PartiallyDivisible	10
12	TN	6	DOWNWARD	114	9	PartiallyDivisible	5
13	TN	20	DOWNWARD	283	8	PartiallyDivisible	4
14	TN	7	DOWNWARD	141	8	FullyDivisible	
15	TN	18	DOWNWARD	226	2	PartiallyDivisible	1
21	TN	7	DOWNWARD	225	2	FullyDivisible	
25	TN	13	DOWNWARD	318	4	FullyDivisible	
31	TN	9	DOWNWARD	263	6	PartiallyDivisible	2
32	TN	22	DOWNWARD	316	2	FullyDivisible	
33	TN	24	DOWNWARD	275	6	FullyDivisible	
35	TN	4	DOWNWARD	238	7	FullyIndivisible	
36	TN	17	DOWNWARD	98	3	FullyDivisible	
37	TN	14	DOWNWARD	184	4	FullyDivisible	
38	TN	15	DOWNWARD	266	6	FullyIndivisible	
52	TN	18	DOWNWARD	164	4	FullyDivisible	
55	TN	6	DOWNWARD	346	4	FullyIndivisible	
61	TN	22	DOWNWARD	174	8	FullyDivisible	
64	TN	4	DOWNWARD	228	3	FullyDivisible	
68	TN	8	DOWNWARD	121	9	PartiallyDivisible	2
69	TN	24	DOWNWARD	181	4	PartiallyDivisible	2
73	TN	17	DOWNWARD	127	2	FullyDivisible	
74	TN	6	DOWNWARD	189	9	FullyIndivisible	
77	DN_1	182	DOWNWARD	188	1	FullyIndivisible	
78	DN_1	183	DOWNWARD	192	1	FullyIndivisible	

MARI Check Status:

MARI CHECK OK

MARI Check Time:

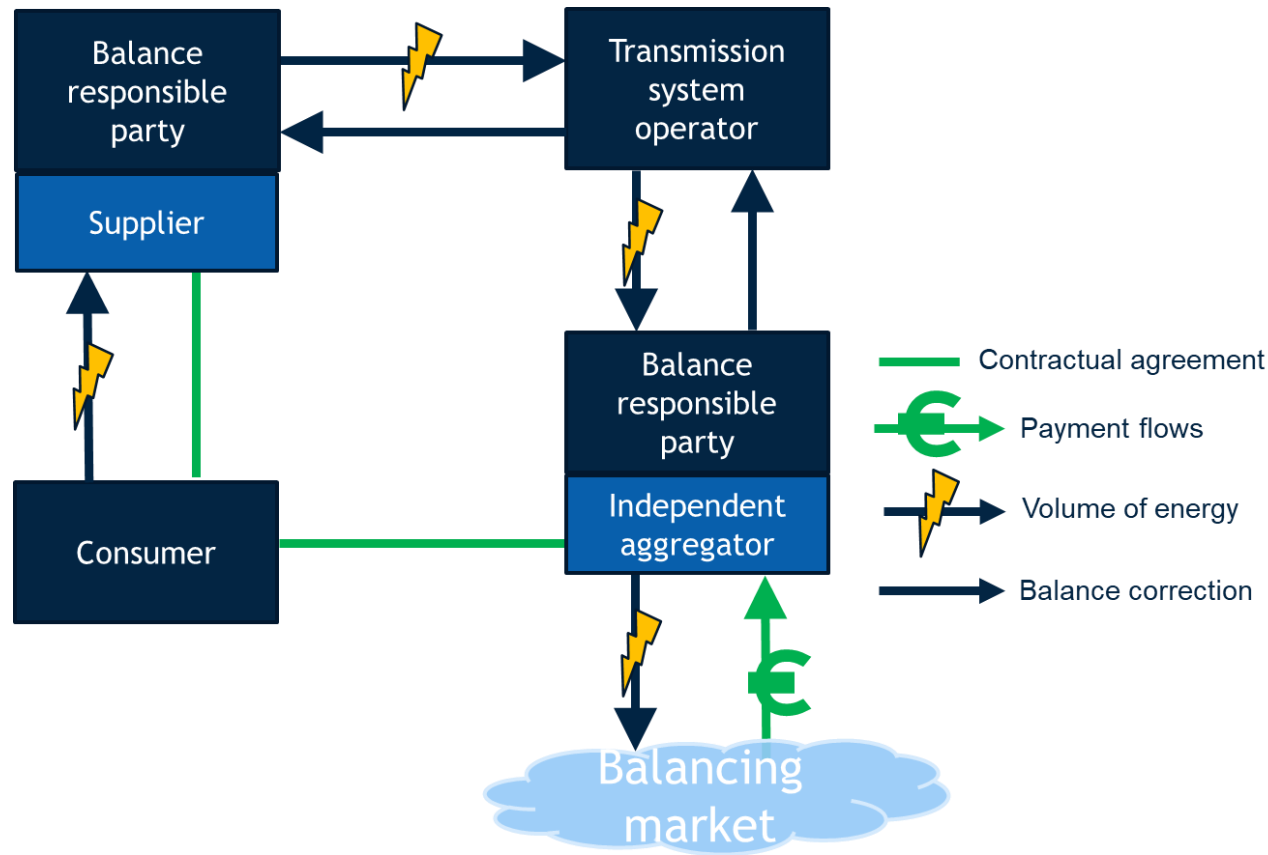
84.93 sec

Bids that can be forwarded to MARI without individually causing further congestions in the updated network.

Individually means that the full quantity of each of these bids can be activated, once at the time, without causing congestion.

Updated network means that the grid flows are updated considering the activation of the cleared bids.

Open balancing market for flexibility providers



1. Created new entity – **Independent aggregator** in the market
2. **Baseline methodology** developed
3. **Coordination** between System operator are validated

EPRI European workshop

Distribution – Beyond Pilots for Distribution Services

Northern Cluster: Litgrid demonstration

Deividas Šikšnys (Litgrid) – Lithuanian demonstration

Further details: <https://onenet-project.eu/>



This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957739