NIEUWE STROOM energie voor slimme ondernemers

Energy markets financially encourage exploiting flexible assets for grid stability

Challenges energy transition

- Balance demand and supply (long intervals – 15 minute)
  - Non-flexible renewable generation
  - Adapt consumption on generation
  - Integration of as much renewable generation as possible
- Grid stability (short intervals – max 1 minute)
  - Larger deviations in generation (clouds)
  - Forecast errors

Assumption: dynamic (market) pricing for generation and consumption

NIEUWE STROOM energie voor slimme ondernemers

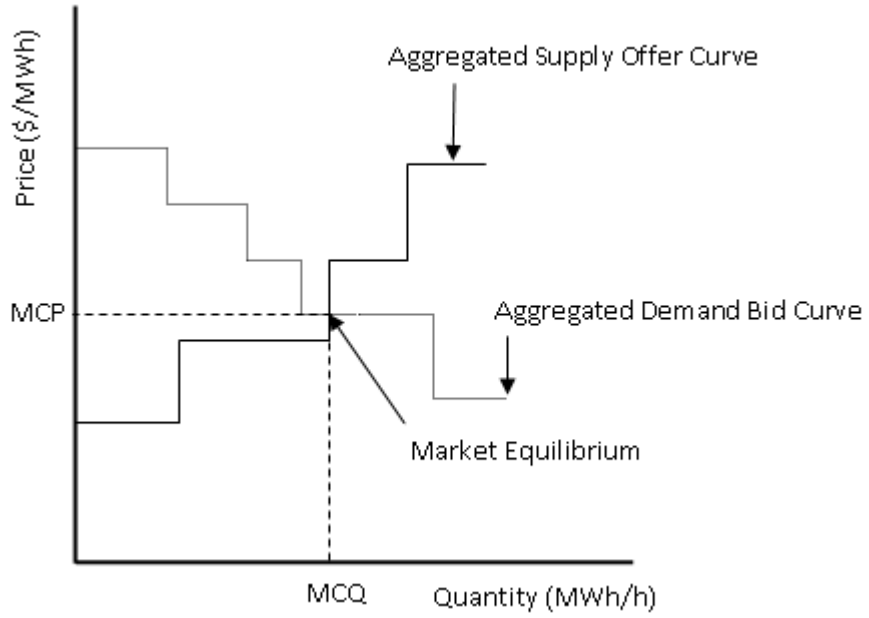
Markets

- Balancing Responsible parties (BRP)
  - Buy/generate as much as you sell/consume (15 minute interval)

- Long-term markets, bilateral, etc (out-of-scope)
  - Portfolio management

Markets – Day ahead market

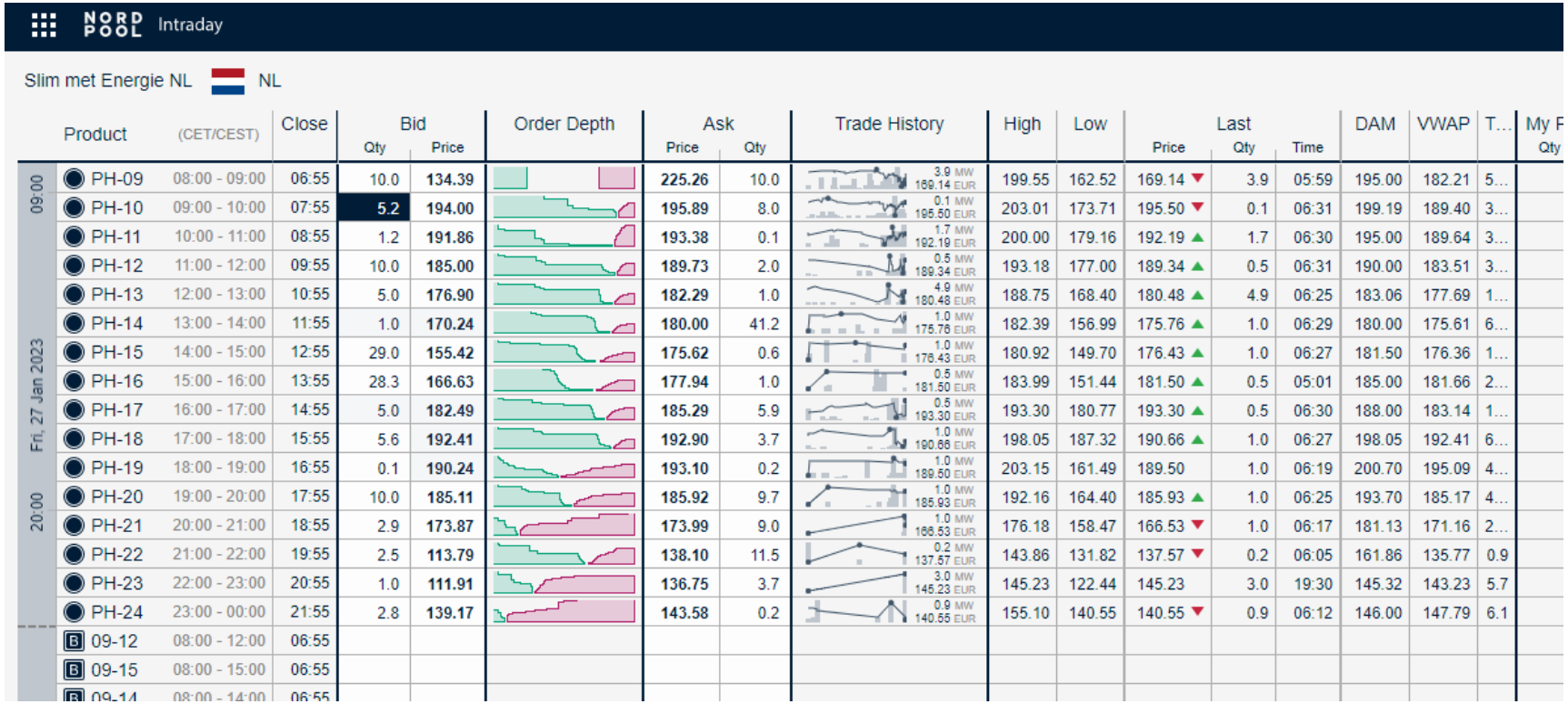
- Day-ahead market
  - Up to D-1 14.00
  - Double sided auction



NIEUWE STROOM energie voor slimme ondernemers

Markets - Intraday

- Intra-day market
  - Up to T-5 minute
  - Epex market
  - (Bilateral)

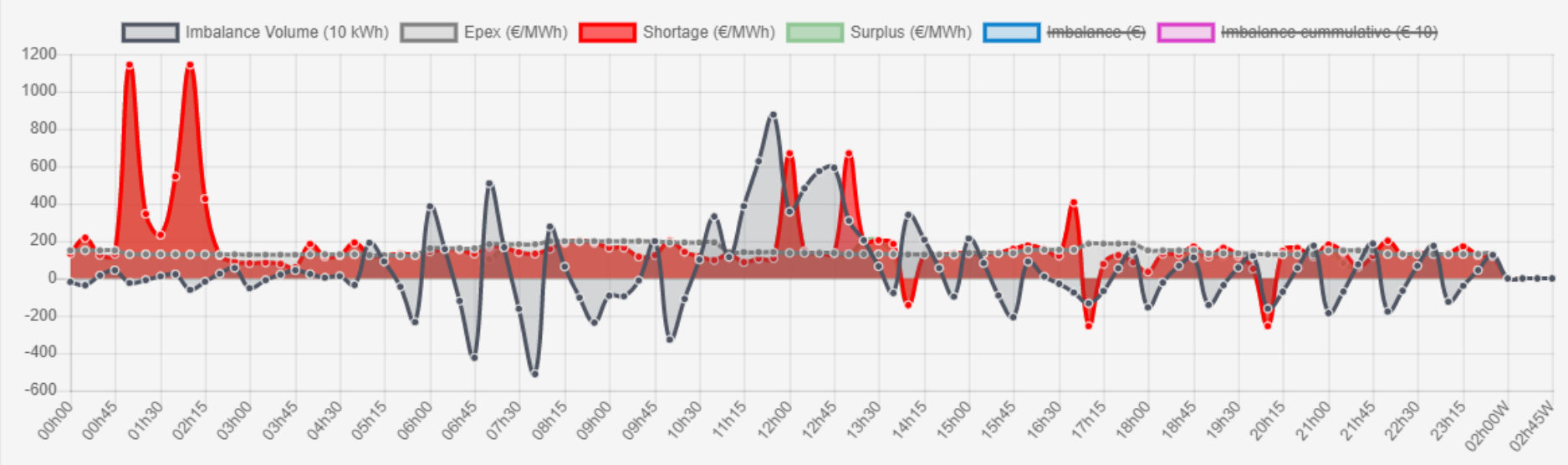


	Product	(CET/CEST)	Close	Bid Qty	Bid Price	Order Depth	Ask Price	Ask Qty	Trade History	High	Low	Last Price	Last Qty	Last Time	DAM	VWAP	T...	My P Qty
09:00	PH-09	08:00 - 09:00	06:55	10.0	134.39		225.26	10.0	3.9 MW 169.14 EUR	199.55	162.52	169.14 ▼	3.9	05:59	195.00	182.21	5...	
	PH-10	09:00 - 10:00	07:55	5.2	194.00		195.89	8.0	0.1 MW 195.50 EUR	203.01	173.71	195.50 ▼	0.1	06:31	199.19	189.40	3...	
	PH-11	10:00 - 11:00	08:55	1.2	191.86		193.38	0.1	1.7 MW 192.19 EUR	200.00	179.16	192.19 ▲	1.7	06:30	195.00	189.64	3...	
	PH-12	11:00 - 12:00	09:55	10.0	185.00		189.73	2.0	0.5 MW 189.34 EUR	193.18	177.00	189.34 ▲	0.5	06:31	190.00	183.51	3...	
	PH-13	12:00 - 13:00	10:55	5.0	176.90		182.29	1.0	4.9 MW 180.48 EUR	188.75	168.40	180.48 ▲	4.9	06:25	183.06	177.69	1...	
	PH-14	13:00 - 14:00	11:55	1.0	170.24		180.00	41.2	1.0 MW 175.76 EUR	182.39	156.99	175.76 ▲	1.0	06:29	180.00	175.61	6...	
	PH-15	14:00 - 15:00	12:55	29.0	155.42		175.62	0.6	1.0 MW 176.43 EUR	180.92	149.70	176.43 ▲	1.0	06:27	181.50	176.36	1...	
	PH-16	15:00 - 16:00	13:55	28.3	166.63		177.94	1.0	0.5 MW 181.50 EUR	183.99	151.44	181.50 ▲	0.5	05:01	185.00	181.66	2...	
	PH-17	16:00 - 17:00	14:55	5.0	182.49		185.29	5.9	0.5 MW 193.30 EUR	193.30	180.77	193.30 ▲	0.5	06:30	188.00	183.14	1...	
	PH-18	17:00 - 18:00	15:55	5.6	192.41		192.90	3.7	1.0 MW 190.66 EUR	198.05	187.32	190.66 ▲	1.0	06:27	198.05	192.41	6...	
	PH-19	18:00 - 19:00	16:55	0.1	190.24		193.10	0.2	1.0 MW 189.50 EUR	203.15	161.49	189.50	1.0	06:19	200.70	195.09	4...	
20:00	PH-20	19:00 - 20:00	17:55	10.0	185.11		185.92	9.7	1.0 MW 185.93 EUR	192.16	164.40	185.93 ▲	1.0	06:25	193.70	185.17	4...	
	PH-21	20:00 - 21:00	18:55	2.9	173.87		173.99	9.0	1.0 MW 166.53 EUR	176.18	158.47	166.53 ▼	1.0	06:17	181.13	171.16	2...	
	PH-22	21:00 - 22:00	19:55	2.5	113.79		138.10	11.5	0.2 MW 137.57 EUR	143.86	131.82	137.57 ▼	0.2	06:05	161.86	135.77	0.9	
	PH-23	22:00 - 23:00	20:55	1.0	111.91		136.75	3.7	3.0 MW 145.23 EUR	145.23	122.44	145.23	3.0	19:30	145.32	143.23	5.7	
	PH-24	23:00 - 00:00	21:55	2.8	139.17		143.58	0.2	0.9 MW 140.55 EUR	155.10	140.55	140.55 ▼	0.9	06:12	146.00	147.79	6.1	
Fri, 27 Jan 2023	B 09-12	08:00 - 12:00	06:55															
	B 09-15	08:00 - 15:00	06:55															
	B 09-14	08:00 - 14:00	06:55															

NIEUWE STROOM energie voor slimme ondernemers

Markets - imbalance

- Energy programm - sum of bought/sould per 15 minute interval
- Allocation – what you (and your customers) actually generated/consumed (15 minute interval)
- Imbalance – difference between E-programm and allocation – must be bought/sold on imbalance market

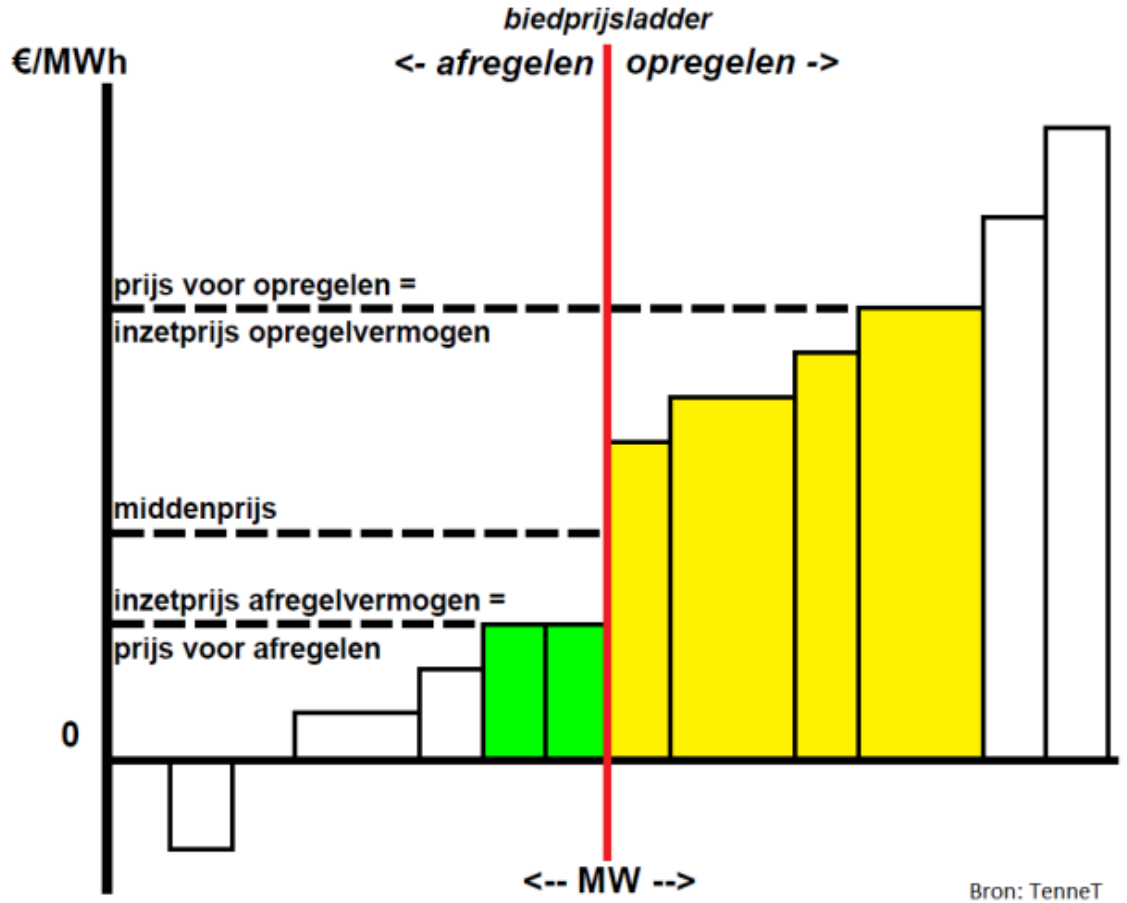


NIEUWE STROOM energie voor slimme ondernemers

Markets – imbalance markets

- Bid price ladder

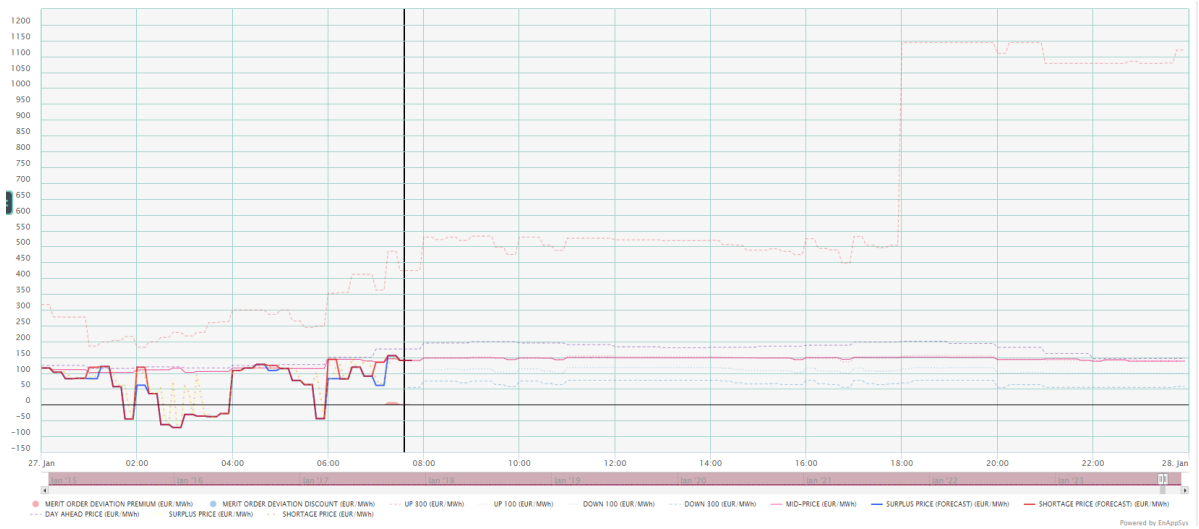
PTE	Periode	-Totale omvang	-Max	-600	-300	-100	-min	min	100	300	600	Max	Totale omvang
		MW	EUR/MWh										MW
1	00:00-00:15	-1237	-700	-255	-58,43	99,39	108,39	124,03	157,73	316,60		1144	490
2	00:15-00:30	-1246	-700	-255	-99,17	83,63	103,17	118,82	145,13	277,32		1144	510
3	00:30-00:45	-1265	-700	-255	-95,88	83,55	103,17	118,81	138,20	276,73		1144	530
4	00:45-01:00	-1233	-700	-255	-99,39	83,57	103,17	118,81	138,23	276,96		1144	512
5	01:00-01:15	-1119	-700	-255	-132,50	55,50	85,84	118,60	127,60	185,16		1144	537
6	01:15-01:30	-1119	-700	-255	-120,28	55,82	85,84	118,66	130,65	198,30		1144	568
7	01:30-01:45	-1118	-700	-255	-119,77	57,36	85,84	118,72	133,67	202,98		1144	568
8	01:45-02:00	-1114	-700	-255	-104,66	59,09	85,84	118,79	136,69	215,22		1144	554
9	02:00-02:15	-1155	-700	-255	-132,50	61,57	101,92	118,60	127,60	181,53		1144	554
10	02:15-02:30	-1142	-700	-255	-120,11	63,15	101,98	118,66	130,69	198,29		1144	564
11	02:30-02:45	-1139	-700	-255	-105,16	66,33	102,11	118,79	136,69	212,61		1144	568
12	02:45-03:00	-1134	-700	-255	-100,00	72,59	107,16	123,84	136,69	228,38		1144	562
13	03:00-03:15	-1112	-700	-255	-102,59	65,94	85,94	118,80	136,69	217,39		1144	562
14	03:15-03:30	-1110	-700	-255	-100,00	72,06	85,94	123,84	136,69	228,38		1144	568
15	03:30-03:45	-1104	-700	-251	-56,67	76,82	85,94	124,03	139,03	259,86		1144	568



NIEUWE STROOM energie voor slimme ondernemers

Markets – imbalance markets

- TenneT regulates
  - Max up-regulating price in interval
  - Min down-regulating price in interval
  - Assymetric prices



Tijdindicatie		IGCC Bijdrage		Geactiveerd vermogen					Prijsvorming		
				Regel		Reserve		Nood (0/1)	Hoogste	Midden	Laagste
Volgnr.	Tijd	Op	Af	Op	Af	Op	Af		Op		Af
458	07:37	31	0	64	0	0	0	0	137,84	139,89	
457	07:36	55	0	48	0	0	0	0	121,01	139,89	
456	07:35	77	0	36	0	0	0	0	118,01	139,89	
455	07:34	50	0	37	0	0	0	0	118,01	139,89	
454	07:33	111	0	52	0	0	0	0	121,01	139,89	
453	07:32	130	0	59	0	0	0	0	121,01	139,89	
452	07:31	40	0	66	0	0	0	0	137,73	139,89	
451	07:30	182	0	65	0	0	0	0	137,73	139,89	
450	07:29	128	0	65	0	0	0	0	154,67	145,13	
449	07:28	53	0	43	0	0	0	0	139,50	145,13	
448	07:27	45	0	27	0	0	0	0	132,05	145,13	
447	07:26	182	0	15	0	0	0	0	125,19	145,13	
446	07:25	106	0	9	0	0	0	0	125,19	145,13	
445	07:24	101	0	4	0	0	0	0	121,75	145,13	
444	07:23	126	0	1	0	0	0	0	121,75	145,13	
443	07:22	26	0	0	0	0	0	0		145,13	
442	07:21	17	0	0	0	0	0	0		145,13	
441	07:20	0	68	0	0	0	0	0		145,13	
440	07:19	0	13	0	0	0	0	0		145,13	
439	07:18	0	75	5	0	0	0	0	121,75	145,13	
438	07:17	0	12	7	0	0	0	0	121,75	145,13	
437	07:16	12	0	7	0	0	0	0	121,75	145,13	
436	07:15	38	0	5	0	0	0	0	121,75	145,13	
435	07:14	221	0	4	0	0	0	0	121,95	134,38	
434	07:13	215	0	0	0	0	0	0		134,38	
433	07:12	205	0	0	6	0	0	0		134,38	124,32

NIEUWE STROOM energie voor slimme ondernemers

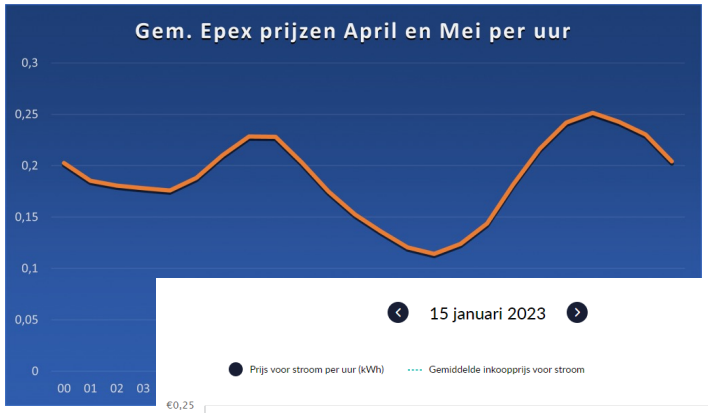
Markets – Balance service party (BSP)

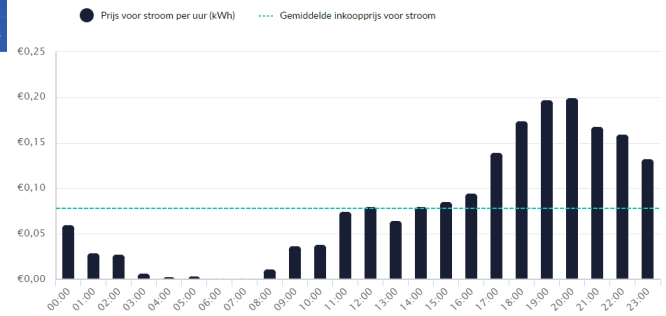
- Offer deviation from you planned behavior
- Send in planning and offer
  - Planning is evaluated, also when you are not “called”
- Minimal 1MW
- Platform (Equigy) blockchain based platform to combine assets to 1MW
- *Different imbalance markets (very short, short, longer – out of scope)*

NIEUWE STROOM energie voor slimme ondernemers

Effect market price

- Oil/gas price offset, amount of renewable defines shape (consumption)



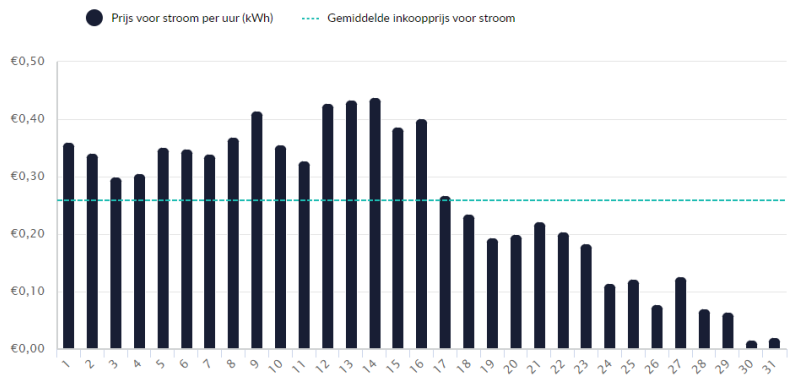


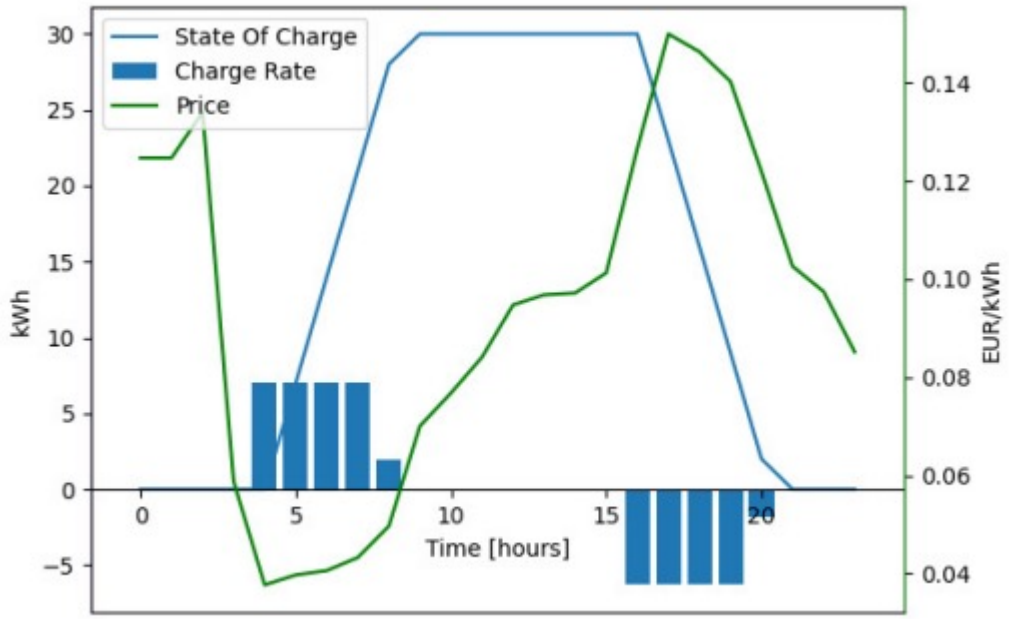
NIEUWE STROOM energie voor slimme ondernemers

Effect market price

- Incentive to move load to low price periods (a lot of renewable)
- Incentive for storage (move load)

Omschrijving	Aantal			Kosten		Bedrag
Vaste leveringskosten	31	dagen	€	0,05419	€	1,68
Levering	727	kWh	€	0,19273	€	140,08
Teruglevering	2	kWh	€	-0,30227	€	-0,60
Opslag						
GvO's uit Europese wind						
Voorschot energiebelasting						

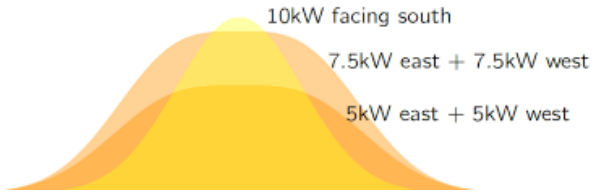


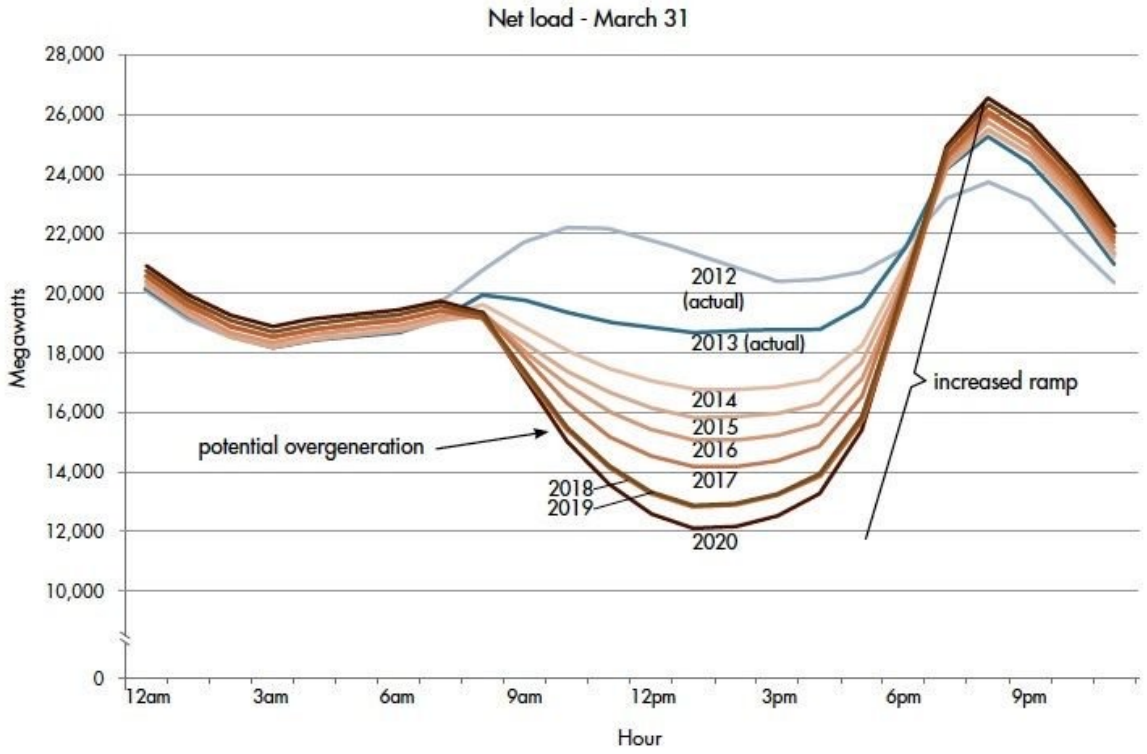


NIEUWE STROOM energie voor slimme ondernemers

Effect market price

- Incentives for solar
  - Still profit, no marginal costs
  - More east/west





NIEUWE STROOM energie voor slimme ondernemers

Effect market price - risks

- Too low prices for solar
- Bids switching off solar when price is negative
- Subsidy
  - SDE – get at least 0,10ct/kWh generation (average per year)
  - “Saldering” – Energy taks ánd prices
- Prices known only after market closure
  - Behaviour changed áfter bidding on the market - imbalance

NIEUWE STROOM energie voor slimme ondernemers

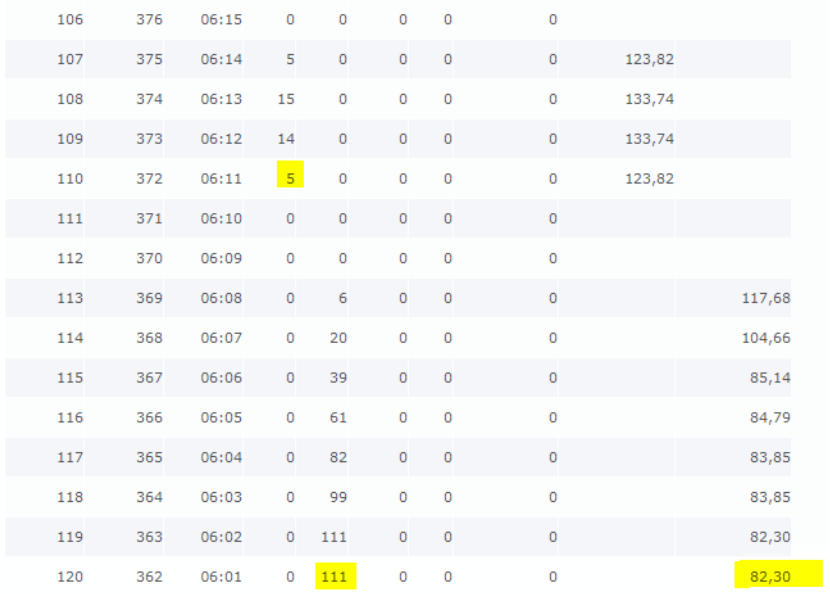
Effect market price - opportunities

- Market gives incentives to adjust supply and consumption
- Incentives to invest in
  - Renewable generation
  - Adjustable load
  - Storage
- Market price shape will flatten
  - More load during renewable generation -> higher prices, more renewable generation, etc.
  - But there will be a deviation in price during the day to keep incentives

NIEUWE STROOM energie voor slimme ondernemers

Grid stability

- TenneT is responsible for balancing, but has no regulating power
- Offer flexibility to TenneT
  - Switch off generation (or switch on when switched off due to low price)
  - Switch on/off load (cooling, EV, etc.)
  - Batteries (deviate from planning)
- “Speculate” on the imbalance market
- Making money helps!



106	376	06:15	0	0	0	0	0		
107	375	06:14	5	0	0	0	0	123,82	
108	374	06:13	15	0	0	0	0	133,74	
109	373	06:12	14	0	0	0	0	133,74	
110	372	06:11	5	0	0	0	0	123,82	
111	371	06:10	0	0	0	0	0		
112	370	06:09	0	0	0	0	0		
113	369	06:08	0	6	0	0	0		117,68
114	368	06:07	0	20	0	0	0		104,66
115	367	06:06	0	39	0	0	0		85,14
116	366	06:05	0	61	0	0	0		84,79
117	365	06:04	0	82	0	0	0		83,85
118	364	06:03	0	99	0	0	0		83,85
119	363	06:02	0	111	0	0	0		82,30
120	362	06:01	0	111	0	0	0		82,30

NIEUWE STROOM energie voor slimme ondernemers

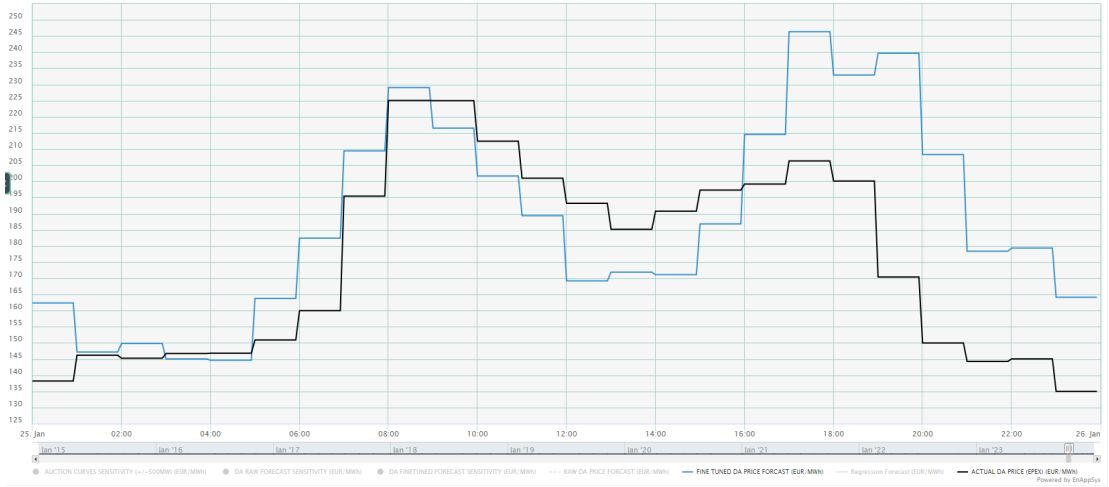
Grid stability - congestion

- Copper plate assumption
- Parts of the network can be congested
- DSOs are responsible
  - Dispatch expected congestion
  - Re-dispatch on different location to maintain national stability

NIEUWE STROOM energie voor slimme ondernemers

Challenges - Forecasting

- Consumption – quite easy (weekly)
- Renewable production – weather
- Day-ahead price
- Imbalance price
  - What influences this?



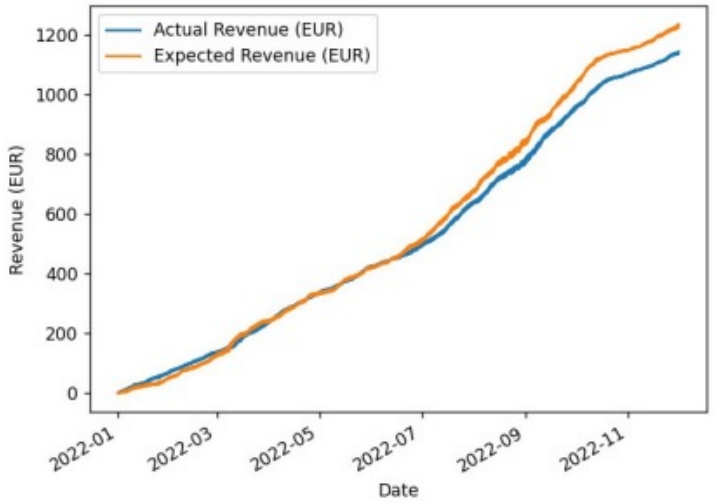
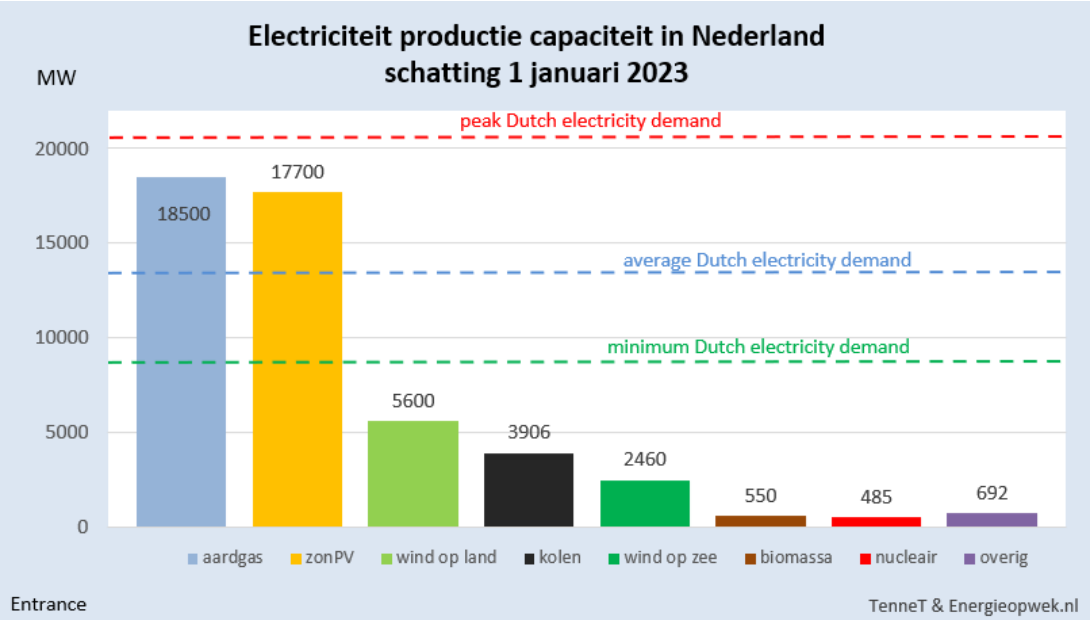


Fig. 2. Expected and actual revenues in EUR over time

NIEUWE STROOM energie voor slimme ondernemers

Risks

- Long periods of no / little renewables or large forecast errors
  - No generation capacity - outages
  - Extremely high prices – keep gas plants for minutes per year
- No benefit for renewables, a lot of over-production
- Energy poverty
- Subsidy



NIEUWE STROOM energie voor slimme ondernemers

Conclusion

- Current day-ahead and intraday markets give the correct incentives
  - Prices will level out, lower peaks, except for extreme days
  - Incentives will be there, self fulfilling prophecy
- Intraday should have smaller intervals to prevent speculation problems
- Copper plate assumption
  - Integrate DSO/TSO regulation
  - More local prices?

NIEUWE STROOM energie voor slimme ondernemers