A different production pattern in Europe in 2022

A previous note[1] showed that European electricity flows have changed significantly from 2021 to 2022. Most people have an explanation, often reflecting their political views:

- Russia is an unreliable supplier of gas.
- Failure of nuclear power, particularly in France.
- Wind and hydro resources change from year to year

The note left essential questions unanswered:

- Was the combination of circumstances in 2022 just a normal stochastic variation that should be offset by operational reserves?
- Which contingencies should the European power systems be prepared for?
- Which types of fuel replaced the missing production?
- Did the change have an impact on climate measures?
- How could Sweden discuss an electricity crisis and become Europe's largest electricity exporter at the same time?

Net import TWh			
	2022	2021	Change
SE	-33,0	-25,2	-7,8
DE	-27,6	-19,6	-8,0
ES	-18,2	0,8	-18,9
CZ	-14,2	-11,2	-3,1
NO	-12,0	-17,1	5,0
BE	-6,3	-7,6	1,3
NL	-4,2	0,4	-4,5
UK-IE	-4,0	26,4	-30,4
PL	-0,9	1,0	-2,0
EE	1,0	2,6	-1,7
DK	1,6	5,0	-3,4
LV	2,3	9,2	-6,9
CH	3,8	3,6	0,3
LT	8,8	9,2	-0,4
AT	9,7	8,3	1,4
FI	12,3	17,5	-5,2
FR	16,2	-43,0	59,2
IT	43,2	43,4	-0,3

Fig. 1 - European net imports of electricity 2022

This note will not answer all questions, but it will discuss the issues based on production per type for 18 countries as collected from ENTSO-E's Transparency Platform. See annual data for 2021 and 2022 on annex 1 and 2.

Inconsistent data

Net import per country was calculated from the exchange data (fig. 1). Net import can also be found from annual production and consumption. These data are in fair agreement for most countries, but unfortunately, there are some inconsistencies.

Most data for the transparency platform are collected from SCADA-systems[2] in control centers. Such data are called *non-validated data*. Data can be estimated or missing for some hours. The advantage is that non-validated data are available soon after the operating hour. It may take weeks or months before the final *settlement data* are available, and one or two years until the publication of official national statistics.

There is no realistic alternative to the *ENTSO-E Transparency Platform* when electricity data for many European data are needed. Therefore, it is necessary to read the conclusions in this note with reservations.

Lost nuclear and hydro power replaced by new wind and PV in 2022

The electricity consumption was 1.9% lower in 2022 than in 2021, and the total production decreased by 1.2% (fig. 2).

[1] http://pfbach.dk/firma_pfb/references/pfb_france_rushed_down_from_net_export_to_net_import2023_01_28.pdf
[2] SCADA: System Control And Data Acquisition

The fossil generation for all countries in 2022 was 47 TWh (5.5%) higher than in 2021. The share of non-fossil production changed from 67.8% to 65.6%.

The 47 TWh increase in fossil production mark a climatic decline from 2021 to 2022.

Nuclear and hydro energy had the largest falls in 2022 (all countries):

- Nuclear: -114 TWh (-17%)
- Hydro: -42 TWh (-10%)

The loss was counterbalanced by several technologies, including

- Wind onshore: +43 TWh (+13%)
- Solar: +28 TWh (+21%)
- Gas: +24 TWh (+5%)
- Coal: + 13 TWh (+7%)
- Wind offshore: +9 TWh (+13%)
- Lignite: +9 TWh (+5%)

The increased production from wind and solar are probably results of new plants.

Change from 2021 to 2022	Total	Total	
	2021	2022	Change
Production type	GWh	GWh	GWh
Biomass	95871	91608	-4.263
Lignite	167615	176729	9.114
Coal-derived gas	6797	7045	248
Gas	481214	505431	24.216
Hard Coal	192262	205480	13.217
Oil	10395	9005	-1.390
Oil shale	2180	4147	1.967
Peat	3561	3619	58
Geothermal	5736	5610	-125
Hydro Pumped Storage	42657	37507	-5.150
Hydro Run-of-River and poundage	162931	147900	-15.031
Hydro Water Reservoir	229622	208084	-21.538
Marine	0	0	0
Nuclear	675121	561031	-114.090
Other renewable	4955	4681	-274
Solar	132703	160706	28.002
Waste	19633	19225	-408
Wind Offshore	75303	84748	9.444
Wind Onshore	318864	361748	42.884
Other	53171	54982	1.811
			0
Total production	2680593	2649285	-31.308
Fossil production	864024	911454	47.430
Load	2695753	2645100	-50.653

Fig. 2 - Changes from 2021 to 2022 for 18 European countries

Nuclear generation declined in 2022 in three countries:

- Belgium: -6 TWh
- Germany -33 TWh
- France: -81 TWh

Other countries had increasing or constant nuclear output.

Was 2022 a special year or within normal variations?

The technical security of supply was quite normal in 2022. The technical systems worked as intended. The gas-fired generation grew in spite of interrupted Russian gas supplies. The result was higher energy costs.

The reduced inflow of water to the hydro systems was a quite normal variation. The occurrence of dry and wet years have been known for decades. The reduced availability of nuclear power has been known for some time, both for Germany and France. There was sufficient time for preventive measures before 2022.

The high market prices for electricity suggest that larger storage capacity for natural gas and correspondingly larger amount stored gas could have resulted in more moderate price increases, while stronger electricity grids could have reduced the price differences across Europe.

Larger fuel storages and stronger transmission grids could have been efficient preventive measures.

Large changes in a few countries

France had the largest change in the electricity balance from 2021 to 2022. The nuclear generation was reduced by more than 80 TWh. On the top of that, the generation from hydropower went down by 12 TWh.

The French losses of nuclear and hydro production were partly relieved by increased gas fired production (10 TWh).

The nuclear decline is a combination of a planned upgrade program (the "Grand Carénage") and accidental variations, such as the COVID-19 pandemic and the drought, which reduced the amount of cooling water for the nuclear units. The drought was also responsible for the reduced inflow of water to the hydro systems.

It has not been possible to get complete data for Great Britain and Ireland after Brexit. The available data indicate an unchanged fossil generation, but a considerable growth of wind and solar energy from 2021 to 2022.

Spain increased the fossil generation by 18 TWh, of which 15.5 TWh was gas-fired and 2.8 TWh coal-fired. The electricity demand went down by 8.1 TWh, while the generation of solar energy increased by 5.7 TWh. Spain was a major supplier of replacement for the lost nuclear energy.

Electricity crisis in Europe's largest electricity exporting country

Sweden was also in 2021 a major supplier for the rest of Europe with 25.2 TWh. The net export increased to 33.0 TWh in 2022. The electricity production was practically unchanged, but the demand went down by 7.8 TWh.

In spite of the export success, *the electricity crisis* played an important role in the public debate in Sweden in 2022. There was no supply crisis, but a price crisis.

Sweden has four bidding zones (SE1 to SE4) in the electricity market. The four zones had similar spot prices until mid-2021, when the prices began to rise in the southern part of Sweden (SE3 and SE4, fig. 3). The dismay among consumers in the southern Sweden is understandable.

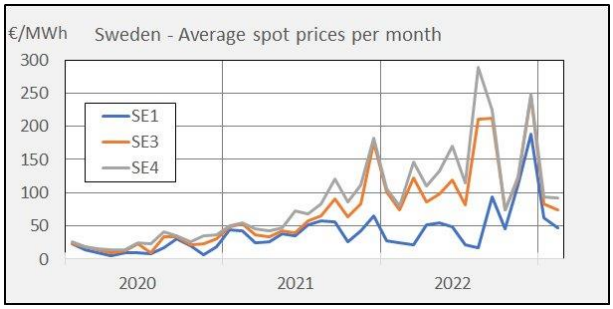

Fig. 3 - Price differences created consternation in southern Sweden in 2022

The high electricity prices are unfavorable to Swedish *consumers*, but an advantage to Swedish *producers* and particularly favorable for the Swedish export of electricity. This conflict of interests can be a national dilemma.

Several debaters suggested a return to a single price market as in Germany. The market design is a European problem, which should be solved internationally and not by national protective measures.

This interesting problem is beyond the scope of this paper, but it deserves a competent discussion elsewhere.

Annex 1
Production overview 2021

(Sources: ENTSO-E and Gridwatch)	2021	AT	BE	CZ	DE	DK	EE	ES	FI	FR
60/40% assumed:		Austria	Belgium	Czeck Republic	Germany	Denmark	Estonia	Spain	Finland	France
Production type		GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Biomass		1441	2187	2490	39460	4879	470	4154	6517	3122
Lignite	Fossil			27851	98194			0		
Coal-derived gas	Fossil			2148			410	0		
Gas	Fossil	9396	19162	6084	52403	2621	22	61594	4170	32454
Hard Coal	Fossil	0		2551	51840	5831		5139	3516	4058
Oil	Fossil	0	4	25	3195	357		1317	30	1692
Oil shale	Fossil						3720	0		
Peat	Fossil						19	0	3547	
Geothermal		0			207			0		
Hydro Pumped Storage		5350	908	1181	8722			4582		4558
Hydro Run-of-River and poundage		27038	211	1192	13279		18	8522	14448	40572
Hydro Water Reservoir		4548		1248	1178			24138		15726
Marine								0		
Nuclear			47963	29056	65401			54188	22609	359387
Other renewable		0		2352	1336		41	883	113	
Solar		843	4678	2185	46607	1407	329	25354		13667
Waste		876	1996	185	6881	1443	136	2474	191	1733
Wind Offshore			6781		24016	7204		0		
Wind Onshore		6954	3979	611	89429	8874	776	58996	7904	35174
Other		193	5566	118	2892		0	470	691	
Total production		56640	93433	79275	505040	32618	5941	251811	63735	512144
Fossil production		9396	19166	38658	205633	8810	4171	68050	11262	38204
Load		62937	84456	66639	504515	36293	8426	243916	84707	465753

(Sources: ENTSO-E and Gridwatch)	2021	GB	IT	LT	LV	NL	NO	PL	PT	SE	
60/40% assumed:		Great Britain	Italy	Lithuania	Latvia	Netherlands	Norway	Poland	Portugal	Sweden	Total
Production type		GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Biomass		19021	6060	402	509	151	0	1923	3430		96215
Lignite	Fossil							41570			167615
Coal-derived gas	Fossil		3838					522			6919
Gas	Fossil	107635	116725	1109	1823	41693	740	12280	14539	3	484453
Hard Coal	Fossil	4984	13151			20533		80321	731		192655
Oil	Fossil	0	1705					2137			10462
Oil shale	Fossil										3720
Peat	Fossil										3566
Geothermal			5529								5736
Hydro Pumped Storage		1825	4206	708			7086	1016	3466		43608
Hydro Run-of-River and poundage		3247	34996	329	2625	0	12700	1701	7057		167933
Hydro Water Reservoir			5970				123211	136	2734	74199	253090
Marine										0	0
Nuclear		43414				3619				51708	677346
Other renewable							341				5068
Solar		11215	20144	126		316		4615	1719	1	133206
Waste			295	147		3238	234				19828
Wind Offshore		29369				7882			52		75303
Wind Onshore		19580	20752	1252	122	4740	10701	15253	12868	26672	324638
Other			17582	133	479	15871	0		241	8950	53186
Total production		240290	250953	4206	5559	98043	155014	161475	46836	161534	2724545
Fossil production		112619	135420	1109	1823	62226	740	136830	15270	3	869389
Load		260133	289268	12374	7312	106387	138909	174634	49470	139418	2735548

Annex 2
Production overview 2022

(Sources: ENTSO-E and Gridwatch)	2022	AT	BE	CZ	DE	DK	EE	ES	FI	FR
60/40% assumed:		Austria	Belgium	Czeck Republic	Germany	Denmark	Estonia	Spain	Finland	France
Production type		GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Biomass		2497	1948	2416	39609	4106	1204	4038	5950	3534
Lignite	Fossil			30486	103526			0		
Coal-derived gas	Fossil			142			364	0		
Gas	Fossil	10099	20025	5296	53490	2139	34	77100	1794	42311
Hard Coal	Fossil	0		2687	62895	5089		7898	3808	3051
Oil	Fossil	0	9	32	1040	317		1127	46	1837
Oil shale	Fossil						4147	0		
Peat	Fossil						9	0	3610	
Geothermal		0			194			0		
Hydro Pumped Storage		5146	1230	972	10603			2623		5273
Hydro Run-of-River and poundage		24089	99	994	11257		18	6743	12369	33268
Hydro Water Reservoir		3937		1081	1124			15037		9776
Marine								0		
Nuclear			41743	29319	32824			56033	24102	278229
Other renewable		0		2358	1029		27	841	26	
Solar		975	6420	2368	55441	2111	514	31074		17992
Waste		876	2224	185	6423	1301	123	2256	181	1410
Wind Offshore			6519		24746	8452		0		
Wind Onshore		7184	4375	641	100601	10523	684	58668	11104	36936
Other		193	5299	130	2303		0	260	611	
Total production		54996	89892	79109	507104	34038	7122	263698	63599	433616
Fossil production		10099	20034	38644	220950	7545	4553	86124	9258	47198
Load		61439	81726	64423	483036	34330	8172	235814	79219	443152

(Sources: ENTSO-E and Gridwatch)	2022	GB	IT	LT	LV	NL	NO	PL	PT	SE	
60/40% assumed:		Great Britain	Italy	Lithuania	Latvia	Netherlands	Norway	Poland	Portugal	Sweden	Total
Production type		GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh	GWh
Biomass		15000	5518	366	326	159	0	1613	3324		91608
Lignite	Fossil							42717			176729
Coal-derived gas	Fossil		6045					493			7045
Gas	Fossil	111867	116675	499	1099	36257	1251	9056	16435	5	505431
Hard Coal	Fossil	4303	20724			19310		75716	0		205480
Oil	Fossil	0	2391					2207			9005
Oil shale	Fossil										4147
Peat	Fossil										3619
Geothermal			5417								5610
Hydro Pumped Storage		1932	3125	553			1547	1267	3237		37507
Hydro Run-of-River and poundage		3348	22933	397	2659	0	24274	1456	3997		147900
Hydro Water Reservoir			3344				102560	90	1454	69680	208084
Marine										0	0
Nuclear		44720				3931				50132	561031
Other renewable							399				4681
Solar		8042	22386	352		371		9290	2543	825	160706
Waste			288	353		3361	244				19225
Wind Offshore		37019	20			7913			78		84748
Wind Onshore		24679	20042	1474	172	5425	14818	18776	12887	32757	361748
Other			17908	60	248	19215	0		181	8574	54982
Total production		250910	246817	4055	4503	95943	145093	162680	44136	161973	2649285
Fossil production		116170	145835	499	1099	55568	1251	130188	16435	5	911454
Load		261698	286244	12167	6812	100386	131609	172393	50363	132117	2645100