May 2018

Monthly Report on the Electricity System

Terna
TERNA GROUP

Monthly Report on the Electricity System

01 Focus of the Month
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The possible Italian and European heat pump development scenarios are discussed and compared in this focus of the month. Heat pumps are devices which absorb thermal energy from the environment, using electricity to produce heat. By using electricity from renewable sources, heat can be produced with no environmental impact.

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In May 2018, electricity demand in Italy (26 Bn kWh) recorded an increase of 1.3% compared to the volumes of May last year. As regards the monthly figure, seasonally-adjusted demand in May 2018 recorded a slight increase of +0.4% compared to April. The trend continues to be stable. In May 2018, electricity demand in Italy was covered 87.3% by national production, less pumping consumption, (+1.1% of net production compared to May 2017) and for the remainder by imports (foreign exchange +2.9% compared to May 2017).

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In May 2018, net national production was 22,875GWh, 52% from renewable sources (11,902GWh) and the remaining 48% from thermal sources. Focusing on monthly production from renewables, an increase was recorded in hydroelectric production (+69.7%), while there was a drop in wind production (-28.0%) and photovoltaic production (-13.6%) compared to the previous year.

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The May total for withdrawal programmes on the DAM was approximately €1.3 Bn, up 17% compared to the previous month and up 28% compared to May 2017.

In May, the spread between average bid-up and bid-down prices on the DSM was €138.1/MWh, up by 7% compared to the previous month and down by 25% compared to May 2017. Total volumes increased slightly compared to the previous month (+1%).

In May, the spread between bid-up and bid-down prices on the Balancing Market was €128.9/MWh, substantially in line with the previous month (€126.6/MWh) and up compared to May 2017 (€96.8/MWh; +33%). Total volumes decreased compared to the previous month (-5%).

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This month, we present a selection of AEEGSI resolutions relevant for dispatching and transmission activities.

Electric heating 2.0: prospects for heat pumps in Europe

Executive Summary

Together with a low-carbon transport sector, decarbonizing the heat sector represents one of the key challenges to mitigate climate change. In this month's focus, we discuss and compare the possible growth scenarios of heat pumps in Europe. Heat pumps are devices that produce heat from ambient energy and electricity. By using electricity from renewables or other CO2-free sources, zero-carbon heat can be provided. Moreover, primary energy consumption can be reduced, due to the high efficiency of heat pumps: for each unit of electricity consumed by a heat pump, between 3 and 5 units of heat energy are produced.

Heating constituted around 50% of the EU energy demand in 2015, the majority of which was consumed in the household sector. The generation mix comprises mainly of fossil fuels, especially gas, covering more than 44% of the demand. With the EU targets to reduce GHG emissions by up to 95% until 2050 and geopolitical concerns surrounding the supply of natural gas, new opportunities are expected to arise for alternative heat sources including heat pumps. Today, they constitute merely around 1% of the heating sources across Europe.

In January 2018, Terna published a document outlining future energy scenarios for Italy ("Documento di Descrizione degli Scenari", DDS), which forms an integral part of the Network Development Plan 2018 ("Piano di Sviluppo"), elaborating two scenarios: a base case ("Terna-Base") and a best case ("Terna-Sviluppo"). Compared to the latter scenario, the base case is characterized by a lower level of economic and demographic growth as well as a slower deployment of renewables. Under these conditions, there could be 3.7m HPs in 2030 according to Terna's projections. In the upper scenario, with its more favorable socio-economic development, a faster deployment of renewables and stronger electrification, deployment could reach 4.2m HPs by 2030.

The anticipated growth in the number of heat pumps will have a bullish effect on electricity demand and significantly alter the seasonal distribution of electricity demand.

Based on current projections, we expect a relatively limited impact on total electricity demand, even in a 2040 perspective, varying between 4% and 7% of today's total demand. Yet, it is clear that the combined electrification of heating and transport represents a sizable increase after a decade of stagnation. Without considering the use of HP for cooling, three quarters of this increase could be concentrated in the months between November and March, due to space heating demand being practically zero during the summer. For Northern EU countries, this is could mean an increasing spread between winter and summer electricity demand, while in Southern EU countries heat pumps could partly counterbalance the summer peaks caused by electric cooling.

Considering the relative ease storing of heat, an increased diffusion of heat pumps represents an opportunity for demand-side management (DSM) services to also grow. Heat pumps can consume electricity at the times of the day when electricity demand is low and store it in the form of heat which can then be utilized at the times when electricity demand is high. These kinds of demand shifting services are certainly a welcome ingredient to the future power sector which is expected to be dominated by intermittent wind and solar power.

Energy consumption patterns for heating in Europe

Total energy demand for heating was equivalent to 6,110 TWh in the EU-28 in 2015 and represented almost 50% of the overall energy demand in Europe in the same year (Catenazzi, et al., 2017). Germany, France, Italy and the UK are the countries with the highest heat demand, being the most populated countries in the EU. Germany alone had a share of 22% in the 2015 EU heat demand, followed by France (12%), Italy and the UK (11% each, see Table 1).

(1) http://www.terna.it/it-it/sistemaelettrico/statisticheeprevisioni.aspx

Tab 1: Heat demand by country in the EU in 2015 [TWh]

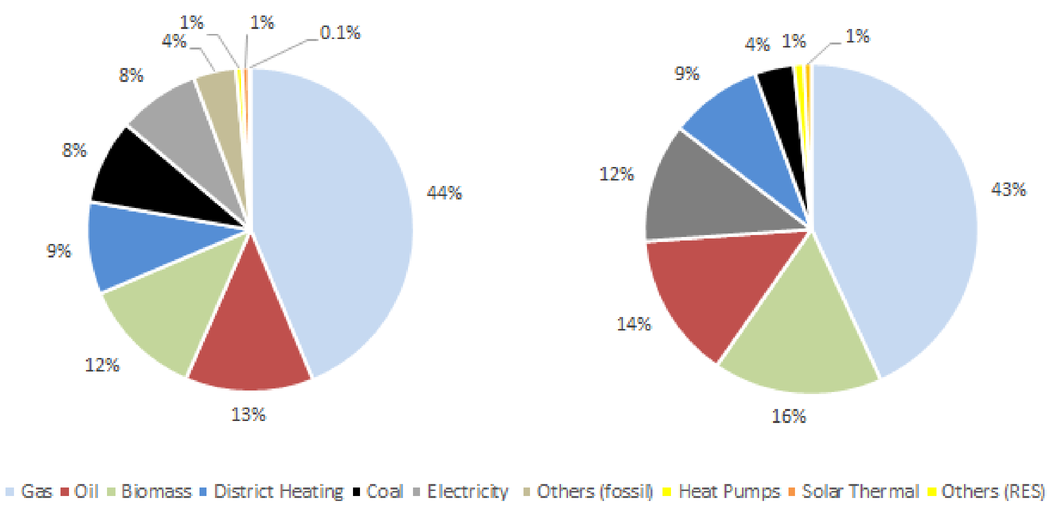
Country	Total (TWh)	Share	Country	Total (TWh)	Share
Austria	161	3%	Italy	684	11%
Belgium	207	3%	Latvia	27	0%
Bulgaria	48	1%	Lithuania	27	0%
Croatia	39	1%	Luxembourg	15	0%
Cyprus	5	0%	Malta	1	0%
Czech Republic	154	3%	Netherlands	272	4%
Denmark	74	1%	Poland	395	6%
Estonia	17	0%	Portugal	73	1%
Finland	166	3%	Romania	157	3%
France	729	12%	Slovenia	24	0%
Germany	1,346	22%	Slovakia	78	1%
Greece	75	1%	Spain	349	6%
Hungary	98	2%	Sweden	173	3%
Ireland	55	1%	United Kingdom	662	11%

Source: Heat Roadmap Europe 2050 – Profile of Heating and Cooling Demand in 2015

Total heat demand is the result of different end-uses, the share of which varies between the residential, industrial and tertiary sectors. For instance, in the residential and tertiary sectors, heat energy is mainly consumed due to space heating or providing hot water, whereas in the industry sector, energy is mainly used for process heating. Across all sectors, space heating and hot water supply constituted 64% of the overall heat energy demand in 2015, while the remaining energy was used for process heating (33%), mainly in the industrial sector, and for other various purposes (3%). In the residential sector, 93% of heat is used for space heating or hot water (Catenazzi, et al., 2017).

Most of the heat was derived from fossil fuels with natural gas dominating the generation mix with a share of almost 44% (see Figure 1). The share of electricity remained at merely 8%, noting that electricity itself is generated from different sources that include fossil fuels. The current role that heat pumps hold in the European heating system is below 1% of all different heat sources used (Catenazzi, et al., 2017).

Fig 1: Heat supply by source fuel in 2015: total (left) vs. residential (right)

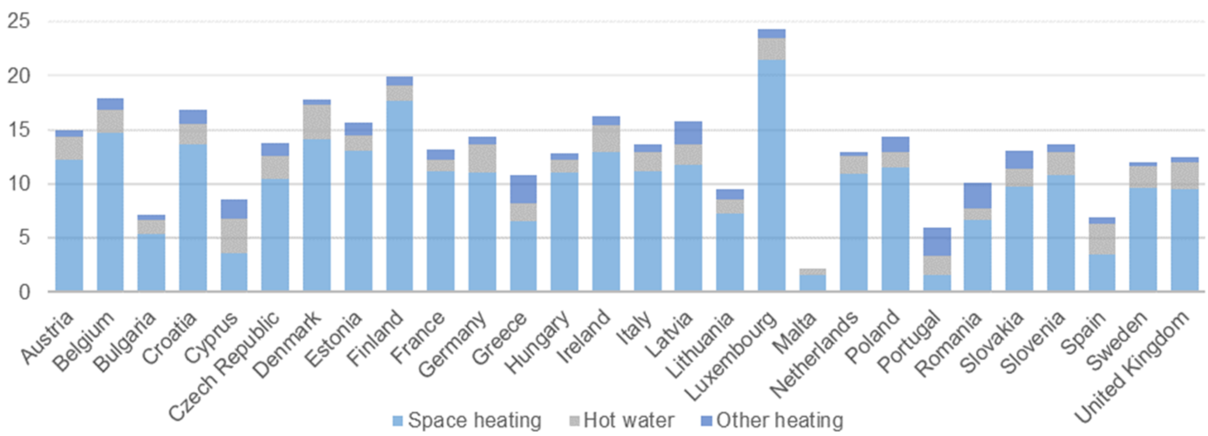


Source: Heat Roadmap Europe 2050 – Profile of Heating and Cooling Demand in 2015

In the following, we focus on the residential sector considering that heat pumps will mainly be deployed in this sector. The heat demand per household varies between countries and throughout the seasons. It is evident that some Southern European countries such as Malta, Cyprus, Portugal and Spain have a lower heat demand per household when compared to Central and Northern countries such as Luxembourg and Finland (see Figure 2).

This is mainly due to milder climate conditions in the South. On the other hand, we note that some Northern countries (e.g. Sweden and Lithuania) have lower demand than Central and Southern ones. This could be due to smaller dwelling sizes or better building insulation.

Fig 2: Residential heat demand per household and by country in 2015 (MWh/household/year)



Source: Terna's elaboration based on Heat Roadmap Europe -2015

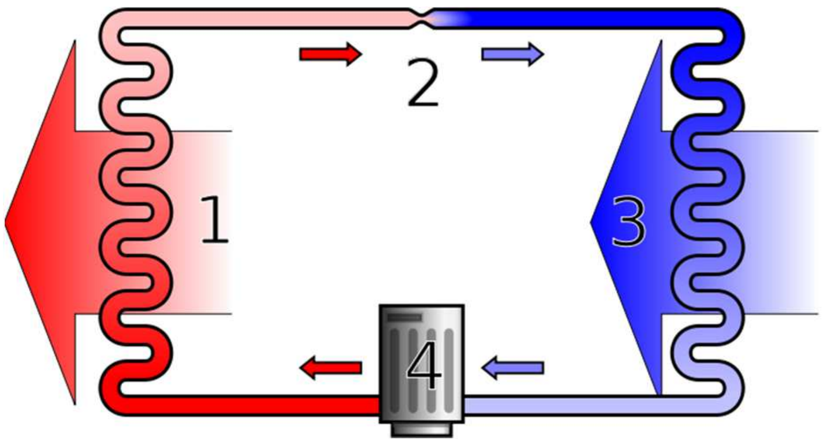
How heat pumps work

A heat pump is a highly efficient device that transfers thermal energy from a heat source to a so-called "heat sink". It reverses the natural flow of heat energy (warmer to colder place) by absorbing heat from a cold space and releasing it into a warm space. In this process, it consumes energy, which is usually in the form of electricity to realize an inverse thermodynamic cycle (see Figure 3).

Heat pumps rely on three main sources of heat which are (1) air for aerothermal heat pumps, (2) water for hydrothermal heat pumps and (3) the underground for geothermal heat pumps. They transfer the heat from these sources to either air or to water..

A heat pump can be purely electric, relying only on electricity and ambient energy for heat production, or it can be hybrid, whereby the source of non-ambient energy could be switched between electricity and another type of combustion fuel such as gas, even if it has a lower efficiency compared to electric one (Heat Pump Systems, 2017). For the case of purely electric heat pumps, which is the type we consider in this report, the carbon footprint is highly reliant on the emission value of the electricity mix. In the residential sector, aerothermal heat pumps are the most commonly types installed as they are the easiest type to install.

Fig 3: Basic functioning of heat pumps



Source: Ilmari Karonen (Public Domain)

In general, heat pumps can be characterized by a coefficient of performance (COP), which represents the efficiency of a heat pump and is given by the ratio between the thermal output and electricity input. State-of-the-art electric heat pumps have a COP varying between 3 and 5. The higher the system's efficiency, the lower the input energy consumed and potentially the lower the emissions. The energy demand of buildings depends on the weather conditions, on the thermal insulation level and on the building's volume, while the heat pump's efficiency depends on the quality of installation and mainly on the temperature difference between source and sink: The larger the temperature difference, the lower will be the COP. Therefore, mild weather conditions like in Italy, favor the operation and installation of such devices. For the same reason, it is reasonable to combine heat pumps with low-to-medium temperature terminal units (e.g. radiant panels or fan coils), such that heat pumps can operate with a high COP. Adjusting the heat distribution system often requires rather deep renovations, which is why a wider penetration of heat pumps is mainly expected in new and renovated buildings.

Heat pumps on the rise across Europe

For Italy, we refer to Terna's future energy scenarios ("Documento di Descrizione degli Scenari", DDS) which outline two cases: a base case ("Terna-Base") and a best case ("Terna-Sviluppo"). Compared to the first, the best case is characterized by a higher level of economic and demographic growth as well as a faster pace of deploying renewables. Moreover, electrification of the heating and transport sectors is accelerated in this scenario.

For other European countries, we refer to the Ten-Year Network Development Plan (TYNDP) 2018 of ENTSO-E, which outlines two scenarios for the years 2030 and 2040: Sustainable Development (ST) and Distributed Generation (DG). The ST scenario portrays an energy transition realized through national regulation and by maximizing the use of existing infrastructure. The Distributed Generation (DG) scenario depicts the growth of small-scale generation and storage with the prosumers at the center of the transformation. This also leads to a higher level of electrification of the heating and transport sector.

Table 2 shows the number of heat pumps in each scenario for Italy, France, Germany, Belgium and the United Kingdom. In absolute terms, Italy and France would be leading the way with 3.7m and 2.9m heat pumps in 2030, respectively. However, due to the difference in population size, the absolute numbers are hardly comparable between countries. We therefore look at the penetration rate, i.e. the number of heat pumps per household (see Figure 4).

(2) Ten-Year Network Development Plan
(3) European Network of Transmission System Operators for Electricity

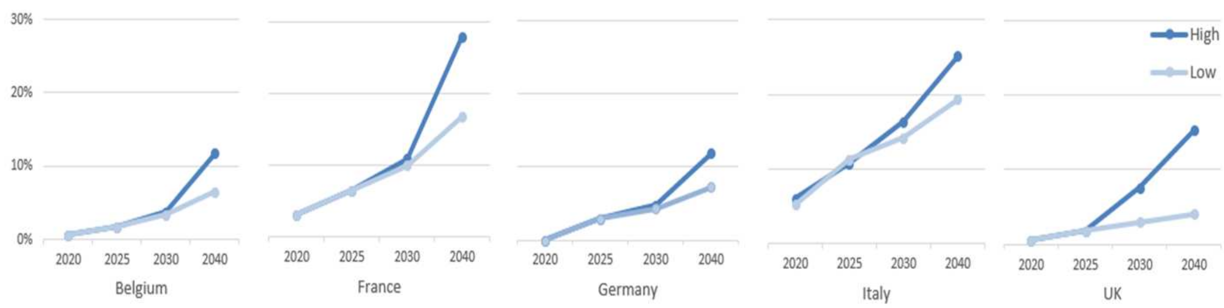
Tab: 2 Heat pump scenarios for Belgium, France, Germany, Italy and the UK (million units)

	Low		High	
Country	2030	2040	2030	2040
Belgium	0,16	0,31	0,18	0,55
France	2,90	4,89	3,17	8,11
Germany	1,75	2,92	1,92	4,82
Italy	3,66	4,98	4,22	6,49
United Kingdom	0,84	1,17	2,17	4,38

Source: TYNDP 2018, ENTSO-E (2018) and Terna's elaboration

According to this indicator, France would see the highest penetration of heat pumps, growing from 3% in 2020 to almost 28% in 2040 in the DG scenario, followed by Italy (25%), the UK (15%), Germany (12%) and Belgium (12%). It is important to note that France and Italy start with a relatively high penetration rate in 2020 (3% and 5%, respectively), because heat pumps are already diffused today in these countries, but primarily for cooling, not for heating. When we evaluate the potential electricity demand caused by heat pumps, we exclude this starting base, given the fact that these installations are not meant to be used as only heating source..

Fig 4: Heat pump penetration in Belgium, France, Germany, Italy & the UK [%]



Source: Terna elaboration based on TYNDP 2018- ENTSO-E, Eurostat 2018 and Terna's elaboration

New heat pumps representing up to 7% of Italy's current electricity demand

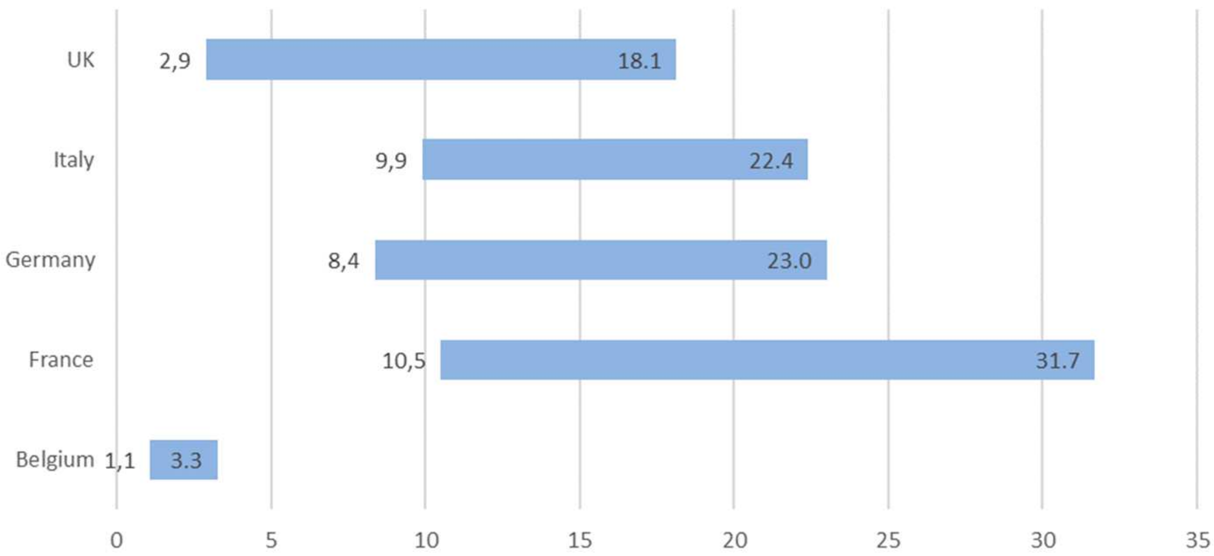
The impact of a growing penetration of heat pumps on the electricity system depends on consumer behavior and on climatic conditions and will thus vary across years, because households have a higher heating demand during cold winters (such as 2017/2018) than during mild winters (such as 2013/2014). As mentioned above, the performance of heat pumps (COP) depends on the outside temperature, on the required internal temperature level and on technological progress. To simplify, we consider a COP varying between 3 and 5, and assume that future heat pump installations will cover all the heating demand of a household, taking the 2015 average as starting point of our estimation (see previous sections).

The resulting range of electricity demand for the year 2040 is shown in Figure 5. We note that this is the electricity demand for heating purposes only. A combined usage of heat pumps for both heating and cooling will naturally lead to a higher consumption than indicated in the next paragraphs.

In line with the penetration figures, the highest impact is to be expected for France, where the projected new heat pump installations would lead to an increase of electricity demand by almost 32 TWh by 2040, which represents 7% of the current total electricity demand. In absolute figures, Germany and the Italy would follow, with 23 TWh (4%) and 22 TWh (7%), respectively. As far as Italy and France are concerned, as mentioned, this figure comprises the new installations only (i.e. the increase from 2020 onwards), because these units can be used as primary heating source, as opposed to the current installations, which are mainly meant to be used for cooling.

For the UK, the increase would be by 18 TWh, corresponding to 6% of current electricity demand. Despite the penetration rate in the UK being higher than in Germany, the required electricity would be lower, because the average heat demand of a German household is significantly higher than the heat demand of a British household (see Figure 2). For Belgium, the increase in electricity demand would be limited to roughly 3 TWh or 4% of today's consumption levels, which is at the lower end of the studied countries, also in relative terms.

Fig 5: Estimated electricity consumption of new heat pumps in 2040 [TWh]



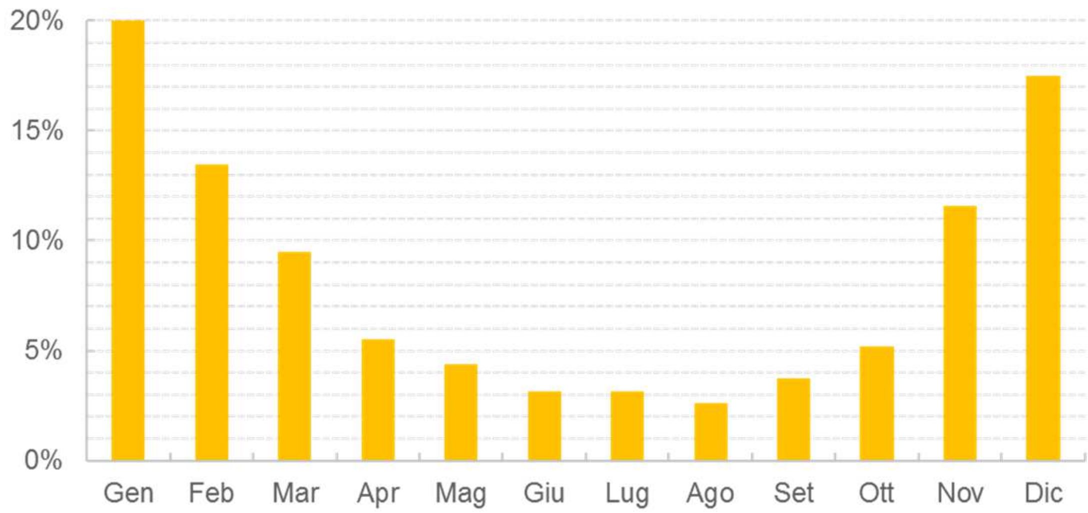
Source: Terna elaboration based on TYNDP 2018- ENTSOE, National Grid, 2017; BNetzA (2017), & Terna (2018)

Considering that it would take more than twenty years to reach this number of installations, one can conclude that even a strong level of HP penetration has a modest and certainly manageable impact on electricity demand, comparable to the uptake of EVs (see Terna's Focus of the Month, January Edition). Nevertheless, it is also evident that the combined electrification of the heating and transport sector is a key growth driver for electricity demand after a long period of stagnation that has characterized EU countries.

As mentioned, electrified residential heating and electrified passenger transport share similarities in terms of annual electricity demand volumes. However, the consumption profiles will differ significantly between the two sectors, a major difference being the seasonality of demand. Space heating demand occurs only during the winter, late autumn and early spring but is practically zero during the summer period. An indicator for the potential seasonal distribution of the heating demand in buildings is today's seasonality of gas demand in the distribution grid (see Figure 5), which includes both the residential and the commercial sectors (e.g. offices). The period from November to March comprises almost three quarters of the annual demand.

Applying this seasonal distribution to heat pumps would lead to the following result: Roughly 17 TWh of electricity out of the estimated total of 22 TWh for Italy would therefore occur during this cold period, while demand in the summer months would only grow by 5 TWh. In Northern EU countries like Germany, such a seasonal distribution is generally challenging, because electricity demand is already higher during winter than during summer. Heat pumps would therefore increase the spread between winter and summer electricity demand. In Southern EU countries like Italy, an increased penetration of heat pumps would be less challenging and might have a balancing effect on the seasonal distribution of electricity demand because currently July has a higher demand than January due to high diffusion of electric cooling devices. In any case, electricity production during winter months would have to be ramped up across Europe. Considering the overall objective to reduce GHG emissions in the power sector, an electrification of the heating sector would pair well with wind power, which has a higher output during winter than during summer.

Fig 6: Seasonality of gas demand in the distribution system in Italy (2017)



Source: Terna elaboration based on Snam (2018)

Apart from the seasonality, another aspect to consider is the hourly electricity demand profile resulting from the usage of heat pumps. In this respect, it is of key importance to avoid simultaneous peaks, i.e. heating houses and recharging electric cars at exactly the same time. In analogy to smart charging, this calls for smart heating activities, and more generally for further digitalization.

"Smart heating" to offer flexibility to the power system

When coupled with smart analytics, heat pumps can lower electrical energy consumption by constantly adjusting the temperature in a certain room or maintaining different temperatures within different rooms of one apartment. Moreover, heat pumps are mostly combined with a water storage tank, also referred to as thermal storage, which can accumulate heat over a period of multiple hours due to its highly insulated nature. Thanks to these systems, heat pumps can shift electricity consumption away from peak hours as they could be programmed to function in the off-peak hours and store the heat energy for later consumption. It is therefore possible to cut off heat pumps completely for a short time period (one or two hours) without any loss of comfort. In a 2040 scenario with several millions of installed heat pumps across the country, the flexibility potential therefore easily exceeds a couple of GW, which a system dominated by intermittent renewables certainly can put to good use.

Additionally, for space heating, a recent development has been an uptake of so-called heat batteries, which utilize phase change materials (PCM) for heat storage, as an alternative to hot water tanks. PCMs use the fusion and condensation phases to store and then release the latent heat associated to the material, working at a constant temperature level. Advantages of PCMs include a higher energy density of the substances used for these applications and the matching between operational PCM's temperature and heat pumps' working point. As a result, the demand shifting duration is likely to grow from a couple of hours to periods of up to one day in the foreseeable future.

Conclusions

The heating and cooling sector retains the highest level of final energy consumption in the EU. To meet the GHG reduction goals, the EU is putting extensive effort into transforming this sector and shifting away from fossil fuels. Electrification of heat production combined with an increased use of renewable electricity poses a viable strategy for meeting those targets, along with efficiency measures that help to reduce the overall energy demand of buildings. Moreover, due to the high efficiency of heat pumps, their deployment is an important instrument to reduce primary energy consumption.

Electricity grid operators will play an important role in enabling the uptake of heat pumps, both at distribution level and at transmission level. The increased usage of electricity in the residential sector will likely require distribution grid extensions, while the seasonality of heat demand will require transmission corridors that connect new electricity supplies such as wind power to consumers in cities.

While heat pumps should have a bullish effect on electricity demand and thus potentially also on peak load, they can offer flexibility to the grid at the same time, due to the low-cost nature of storing heat, which is a welcome ingredient of a low-carbon power sector dominated by solar and wind.

(1) http://www.terna.it/it-it/sistemaelettrico/statisticheeprevisioni.aspx

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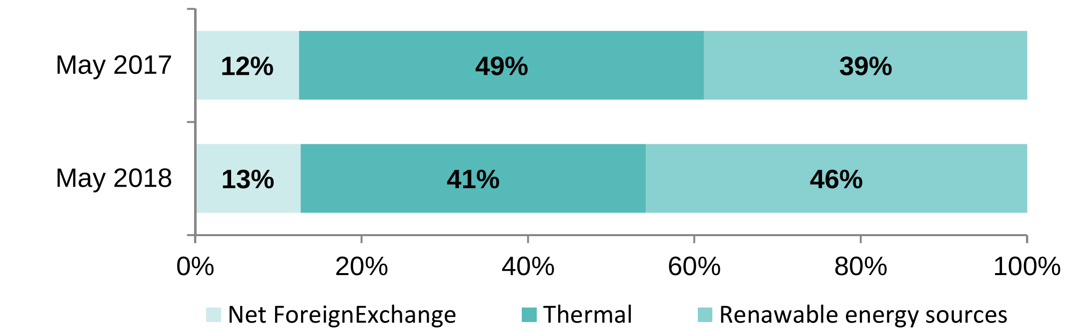
(1) http://www.terna.it/it-it/sistemaelettrico/statisticheeprevisioni.aspx

Monthly Summary

In May 2018, electricity demand was 25,969GWh, an increase compared to the same month of the previous year (+1.3%). In particular, an increase in renewable production (+19.7%), net foreign exchange (+2.9%) and a decrease in thermoelectric production (-12.3%) was recorded compared to the same month of the previous year.

Demand breakdown – coverage by sources



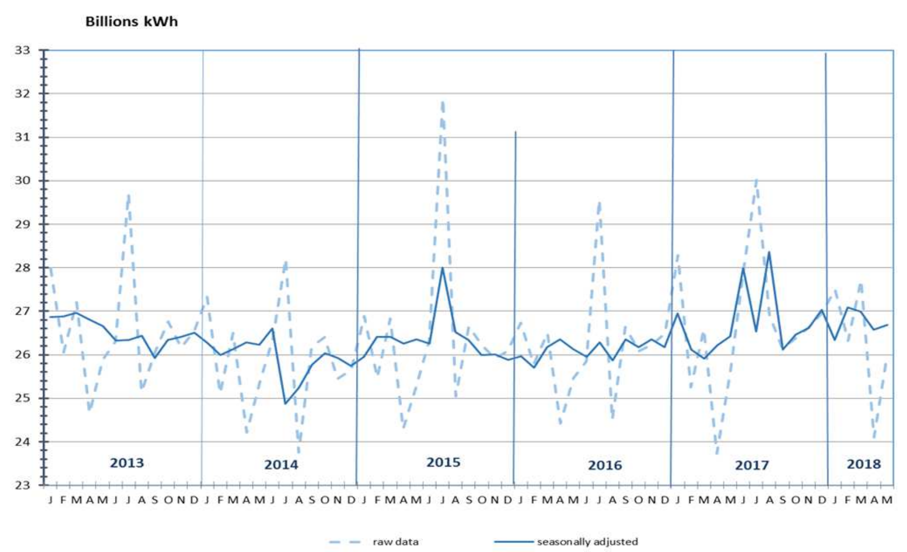
Source: Terna

In May, energy demand on the grid was up by +1.3% compared to the same month of 2017.

In May 2018, electricity demand in Italy (26 Bn kWh) recorded an increase of 1.3% compared to the volumes of May last year. The result is due to the fact that both the number of working days and the month's average temperature were in line with May 2017. In the first five months of 2018, demand rose by +1.6% compared to 2017; in seasonally-adjusted terms, the variation was +1.5%. At the regional level, in May 2018 the annual trend varied in different parts of the country: above the national average in the North (+2.1%) , and below it in Central Italy (+0.0%) and the South (+0.4%).

As regards the monthly figure, seasonally-adjusted demand in May 2018 recorded a slight increase of +0.4% compared to April. The trend continues to be stable. In May 2018, finally, electricity demand in Italy was covered 87.3% by national production, less pumping consumption, (+1.1% of net production compared to May 2017) and for the remainder by imports (foreign exchange +2.9% compared to May 2017).

Seasonally-adjusted demand

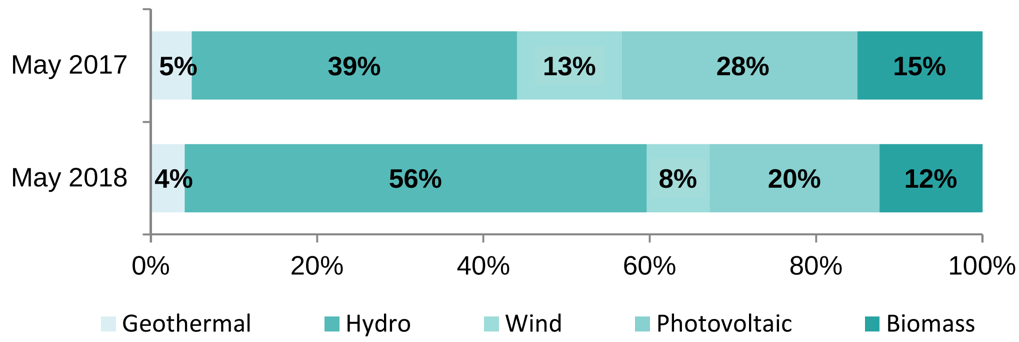


Source: Terna

The seasonally-adjusted value for electricity demand during May 2018 recorded an increase of +0.4% compared to April.

Focusing on monthly production from renewables, an increase was recorded in hydroelectric production (+69.7%), while there was a drop in wind production (-28.0%) and photovoltaic production (-13.6%) compared to the previous year.

RES Production - Breakdown



Source: Terna

In May 2018, the detailed breakdown of production from renewable energy sources recorded a M-o-M percentage increase (+15.5%).

Energy Balance Sheet

In 2018, cumulative demand (131,603GWh) increased (+1.6%) compared to the same period of 2017.

In May 2018, net national production was 22,875GWh, 52% from renewable sources (11,902GWh) and the remaining 48% from thermal sources.

Energy Balance Sheet

[GWh]	May 2018	May 2017	%18/17	Jan-May18	Jan-May 17	%18/17
Hydro	6.611	3.896	69,7%	19.941	14.356	38,9%
Thermal	12.445	14.186	-12,3%	73.134	80.546	-9,2%
of which Biomass	1.472	1.495	-1,5%	7.326	7.387	-0,8%
Geothermal	486	488	-0,4%	2.395	2.426	-1,3%
Wind	901	1.251	-28,0%	8.204	7.888	4,0%
Photovoltaic	2.432	2.816	-13,6%	8.631	9.904	-12,9%
Net Total Production	**22.875**	**22.637**	**1,1%**	**112.305**	**115.120**	**-2,4%**
Import	3.665	3.701	-1,0%	21.909	18.110	21,0%
Export	370	498	-25,7%	1.410	2.625	-46,3%
Net Foreign Exchange	**3.295**	**3.203**	**2,9%**	**20.499**	**15.485**	**32,4%**
Pumping	**201**	**204**	**-1,5%**	**1.201**	**1.118**	7,4%
Electricity demand(1)	**25.969**	**25.636**	**1,3%**	**131.603**	**129.487**	**1,6%**

(1) *Electricity Demand = Production + Net Foreign Exchange – Pumping Consumption.*

Source: Terna

In 2018, a decrease in exports (-46.3%) was recorded compared to the previous year.
In May 2018, a reduction was recorded in production from thermal (-12.3%), wind (-28.0%) and photovoltaic (-13.6%) sources compared to the previous year, along with an increase in hydroelectric production (+69.7).

In 2018, net total production (112,305GWh) met +85% of national electricity demand (131,603GWh).

Monthly Energy Balance Sheet

[GWh]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hydro	2.747	2.606	3.231	4.746	6.611								19.941
Thermal	16.907	16.287	15.623	11.872	12.445								73.134
Geothermal	495	446	492	476	486								2.395
Wind	1.972	1.708	2.409	1.214	901								8.204
Photovoltaic	1.026	1.052	1.693	2.428	2.432								8.631
Net Total Production	**23.147**	**22.099**	**23.448**	**20.736**	**22.875**								**112.305**
Import	4.899	4.610	4.731	4.004	3.665								21.909
Export	326	199	178	337	370								1.410
Net Foreign Exchange	**4.573**	**4.411**	**4.553**	**3.667**	**3.295**								**20.499**
Pumping	223	192	286	299	201								1.201
Electricity demand(1)	**27.497**	**26.318**	**27.715**	**24.104**	**25.969**								**131.603**

In May, net total production decreased (-2.4%) compared to 2017. In 2018, the month with the maximum demand for electricity was March, with 27,715GWh.

Source: Terna

(1) Electricity Demand = Production + Net Foreign Exchange – Pumping Consumption.

The evolution of the monthly statement for 2017 is given below.

Monthly Energy Balance Sheet

[GWh]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hydro	2.804	2.249	2.648	2.759	3.896	4.718	4.434	3.860	3.485	2.226	2.101	2.350	37.530
Thermal	21.089	16.850	14.618	13.803	14.186	16.333	17.292	16.079	15.243	17.081	19.032	17.894	199.500
Geothermal	504	454	501	479	488	473	492	478	462	480	476	498	5.785
Wind	1.797	1.536	1.935	1.369	1.251	915	1.255	1.079	1.353	1.265	1.509	2.228	17.492
Photovoltaic	1.081	1.193	2.322	2.492	2.816	2.845	3.023	2.920	2.195	1.918	1.074	932	24.811
Net Total Production	**27.275**	**22.282**	**22.024**	**20.902**	**22.637**	**25.284**	**26.496**	**24.416**	**22.738**	**22.970**	**24.192**	**23.902**	**285.118**
Import	2.073	3.568	5.155	3.613	3.701	3.290	4.161	3.012	3.887	3.782	2.991	3.662	42.895
Export	803	383	404	537	498	461	508	372	347	203	308	310	5.134
Net Foreign Exchange	**1.270**	**3.185**	**4.751**	**3.076**	**3.203**	**2.829**	**3.653**	**2.640**	**3.540**	**3.579**	**2.683**	**3.352**	**37.761**
Pumping	265	211	190	248	204	172	130	144	140	172	250	315	2.441
Electricity demand(1)	**28.280**	**25.256**	**26.585**	**23.730**	**25.636**	**27.941**	**30.019**	**26.912**	**26.138**	**26.377**	**26.625**	**26.939**	**320.438**

In 2017, the month with the maximum demand for electricity was July with 30,019GWh.

Source: Terna

Demand by Geographical Areas

In May 2018, there was an increase in demand in the Northern zone (TO-MI-VE) and on the Islands (CA-PA), while there was a decrease in the Centre (RM-FI) and in the South (NA) compared to the corresponding period of the previous year.

Demand by Geographical Areas

[GWh]	Turin	Milan	Venice	Florence	Rome	Naples	Palermo	Cagliari
May 2018	2.743	5.739	4.085	4.106	3.542	3.553	1.479	722
May 2017	2.668	5.679	3.902	4.079	3.602	3.583	1.430	693
%May 2018/2017	2,8%	1,1%	4,7%	0,7%	-1,7%	-0,8%	3,4%	4,2%
Cumulated 2018	13.606	29.060	20.249	20.703	18.064	18.653	7.575	3.693
Cumulated 2017	13.419	28.536	19.709	20.039	18.009	18.640	7.565	3.570
% Cumulated 18/17	1,4%	1,8%	2,7%	3,3%	0,3%	0,1%	0,1%	3,4%

In 2018, the Y-o-Y percentage change in demand was +2.0% in the Northern zone, +1.9% in the Centre, +0.1% in the South and +1.2% in the Islands.

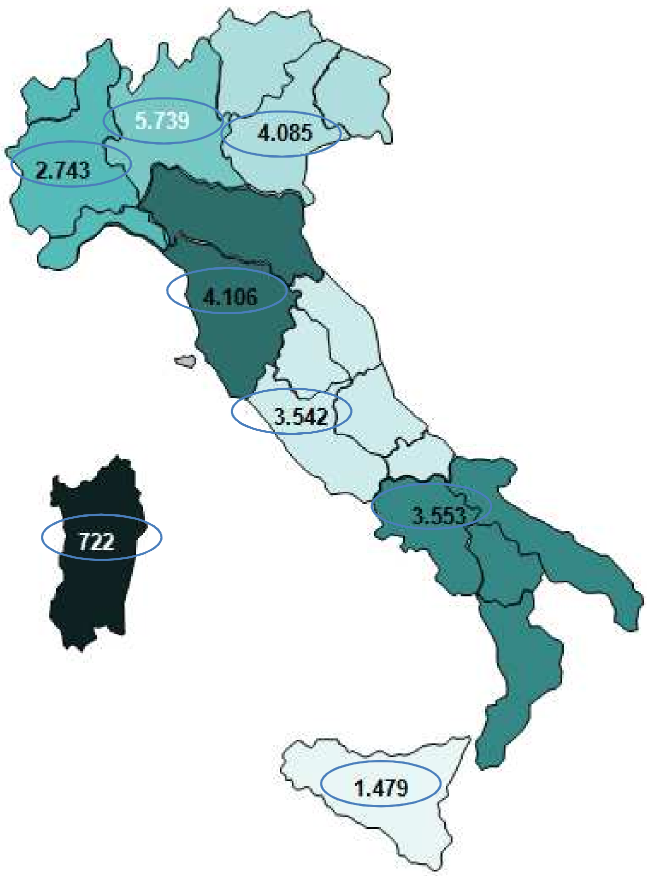
Source: Terna

Demand by Geographical Areas: map chart

[GWh]

The regions are combined in clusters on the basis of production and consumption:

- TURIN: Piedmont - Liguria - Valle d'Aosta
- MILAN: Lombardy (*)
- VENICE: Friuli Venezia Giulia - Greater Venice - Trentino Alto Adige
- FLORENCE: Emilia Romagna (*) - Tuscany
- ROME: Lazio - Umbria - Abruzzo - Molise - Marche
- NAPLES: Campania - Apulia - Basilicata - Calabria
- PALERMO: Sicily
- CAGLIARI: Sardinia



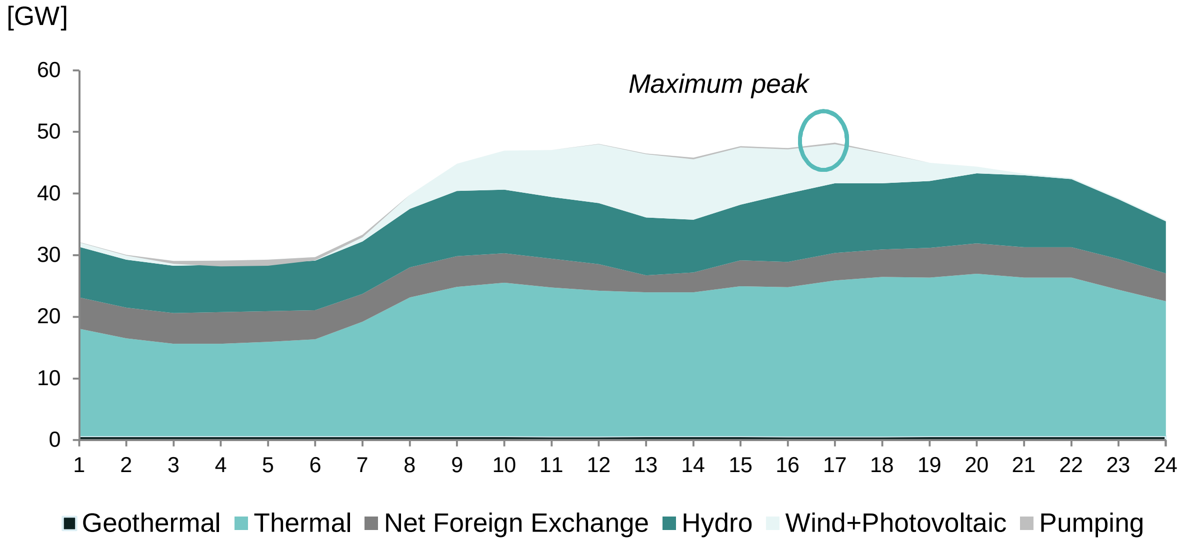
Source: Terna

(*) In these two regions the geographical borders do not correspond to the electrical borders. Lombardy includes production plants that are part of the geographical-administrative territory of Emilia Romagna.

Peak Demand

In May 2018, Peak Demand was recorded on **Wednesday 30 at 17:00** and was 48,018MW (-0.3% Y-o-Y). The hourly demand diagram of the peak day is presented below.

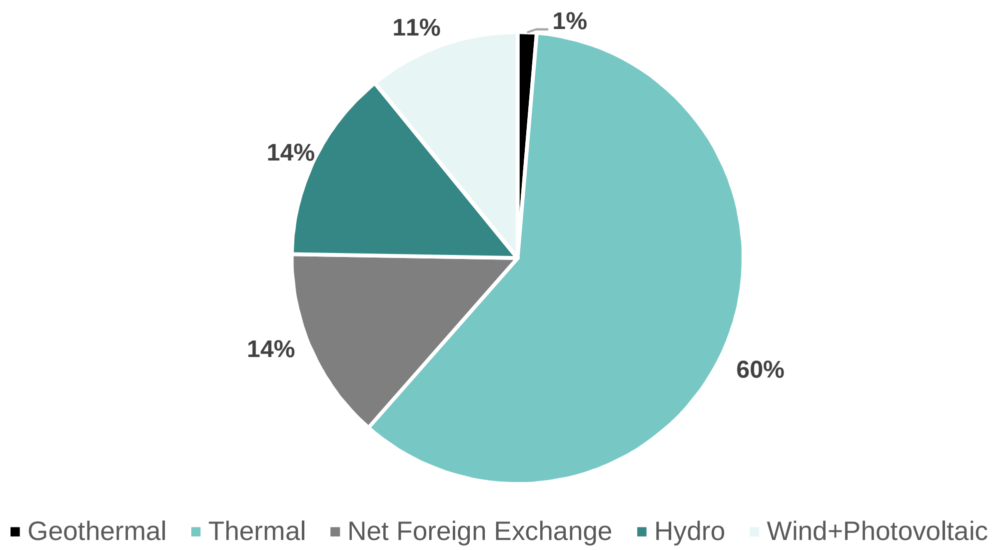
Peak Demand



Source: Terna

At peak, the contribution of thermal production was 25,311MW.

Coverage at Peak Demand – 30 May 2018, 17:00



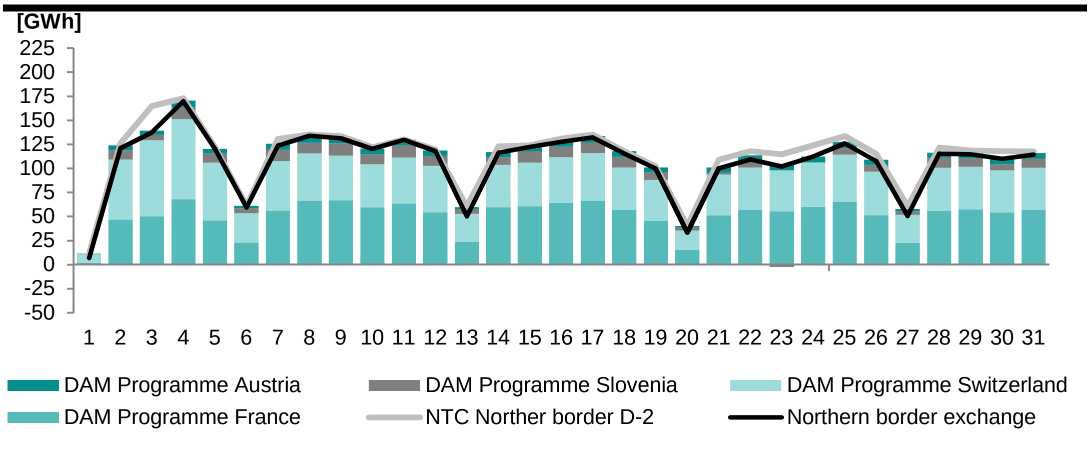
Source: Terna

At peak, production from renewable sources contributed to covering demand for 26%, thermal production for 60% and the remainder was the net foreign exchange.

Net Foreign Exchange – May 2018

In May, there was good saturation of the planned figure for NTC (Net Transfer Capacity) calculated in D-2 compared to the exchange programmes on the Northern border.

Net Foreign Exchange on the Northern border



In May 2018, there were imports of 3,665GWh and exports of 370GWh.

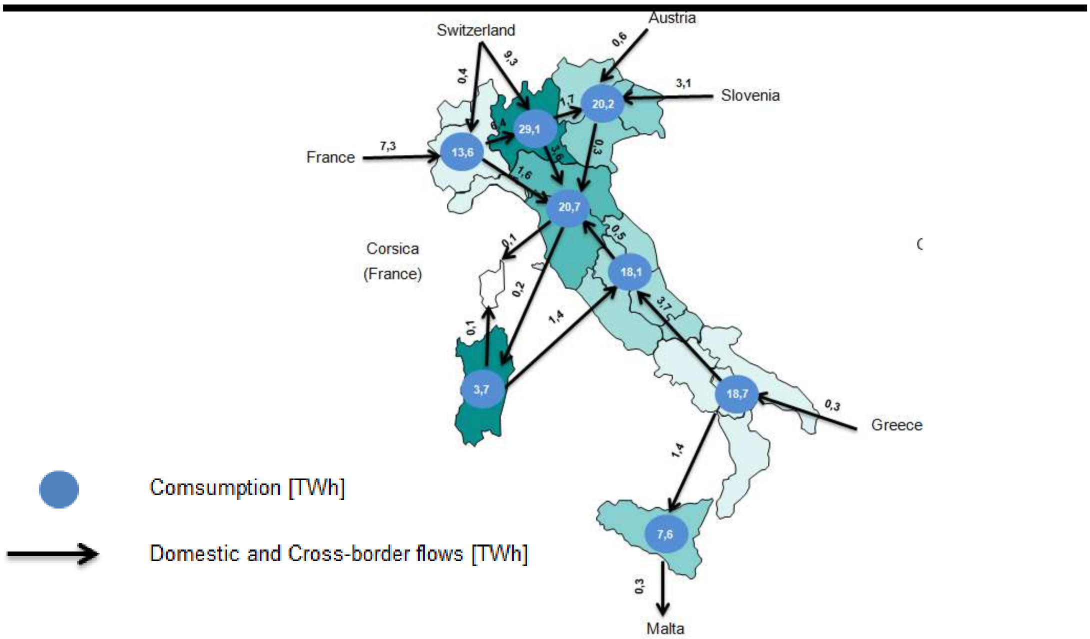
Source: Terna

Balance of Physical Exchanges – Annual Cumulative Figure

The balance of physical exchanges of electricity mainly shows the energy flows among the various areas identified in the Italian electricity system.

The 380kV connection between Sicily and the Continent ensures secure management of the electricity system in Sicily and Calabria.

Balance of physical electricity exchanges: map chart



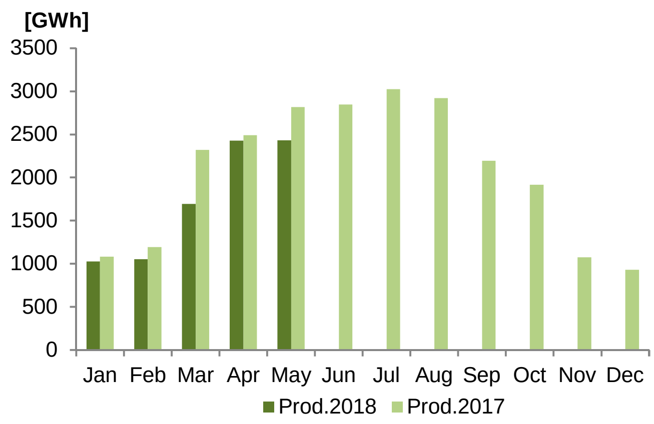
In 2018, a net exchange was recorded from the Northern zone towards Emilia Romagna and Tuscany of approximately 5.5TWh. The Continent recorded a net exchange towards Sicily of 1.4TWh.

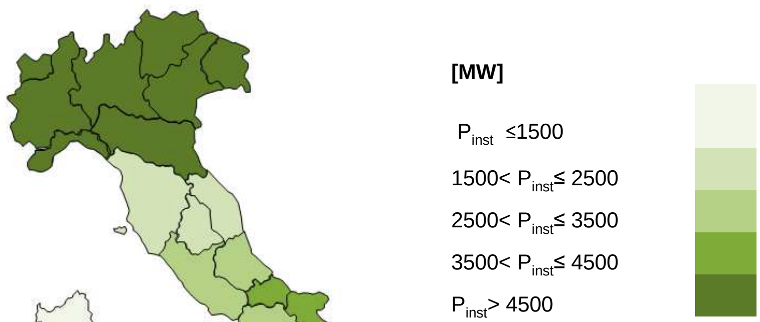
Source: Terna

Production and Installed Capacity

The energy produced by photovoltaic sources in May 2018 was 2,432GWh, up compared to the previous month by 4GWh. The annual cumulative figure fell compared to the previous year (-12.9%).

Photovoltaic Production and Capacity



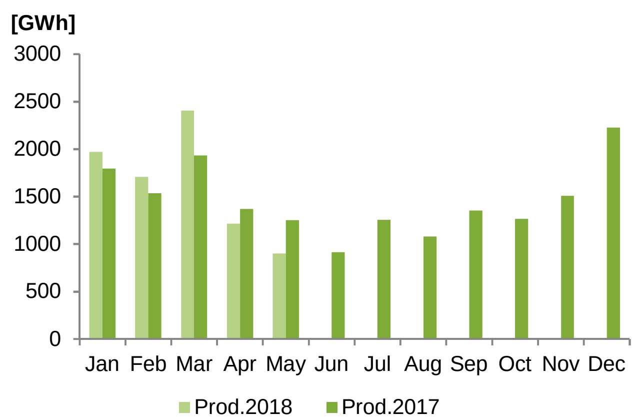


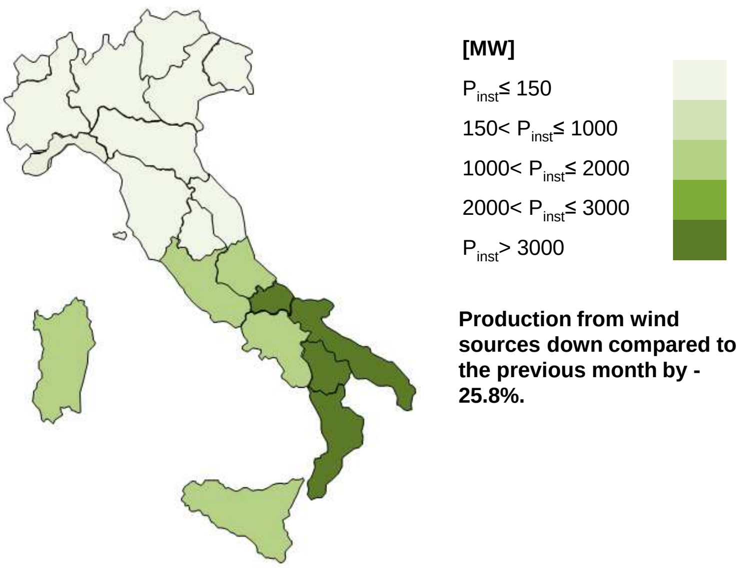
Production from photovoltaic sources in line (+0.2%) with the previous month.

Source: Terna

The energy produced by wind power in May 2018 was 901GWh, down compared to the previous month by 313GWh. The annual cumulative figure increased compared to the previous year (+4.0%).

Wind Production and Capacity



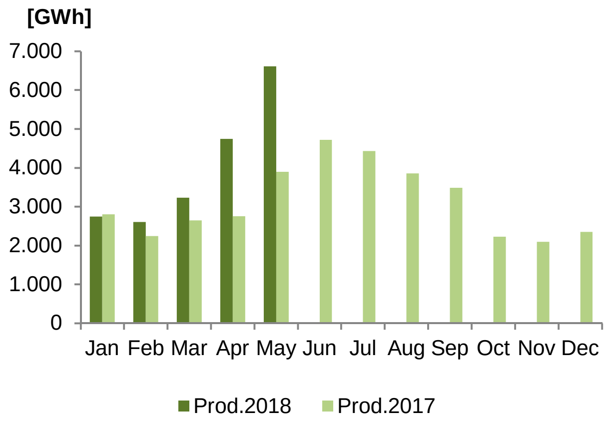


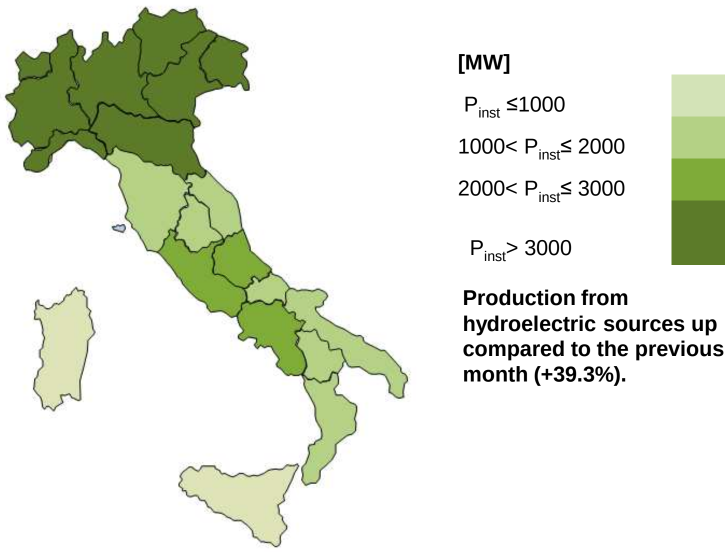
Production from wind sources down compared to the previous month by -25.8%.

Source: Terna

The energy produced by hydroelectric sources (e.g. reservoirs and run-of-river) in May 2018 was 6,611GWh, up compared to the previous month by 1,865GWh. The annual cumulative figure was up (+38.9%) compared to the previous year.

Hydroelectric Production and Capacity



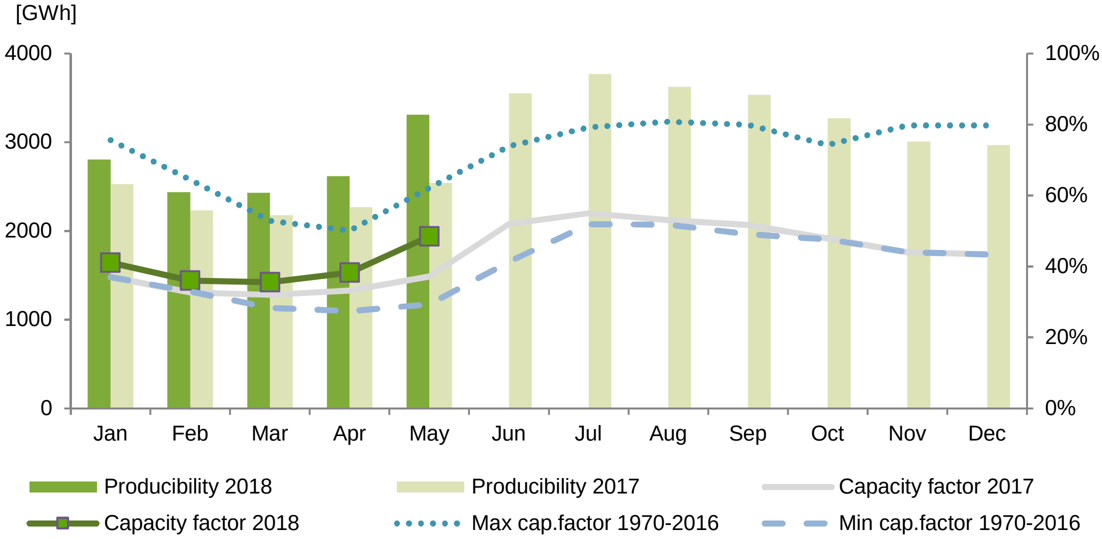


Production from hydroelectric sources up compared to the previous month (+39.3%).

Source: Terna

In May, hydroelectric producibility increased compared to the previous month.

Hydroelectric Producibility and Reservoir Percentage



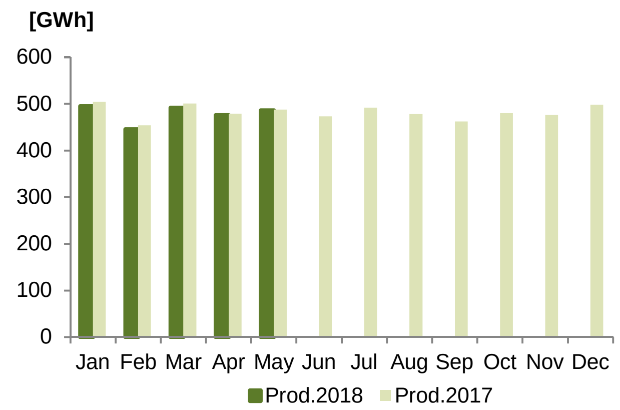
In May 2018, considering Italy as a whole, the current reservoir percentage compared to the maximum reservoir capacity was +48.4%, an increase compared to the same month in 2017.

	Reservoir Capacity	*NORTH*	*CENTRE SOUTH*	*ISLANDS*	*TOTAL*
2018	*[GWh]*	1,757	1,270	286	3,312
	% (capacity/max capacity)	37.8%	70.0%	75.0%	48.4%
2017	*[GWh]*	1,251	1,021	270	2 542
	% (capacity/max capacity)	26.9%	56.3%	70.8%	37.2%

Source: Terna

The energy produced by geothermal sources in May 2018 was 486GWh, up compared to the previous month by 10GWh. The annual cumulative figure was down (-1.3%) compared to the previous year.

Geothermal Production and Capacity



[MW]

$P_{inst} = 0$

$0 < P_{inst} \leq 500$

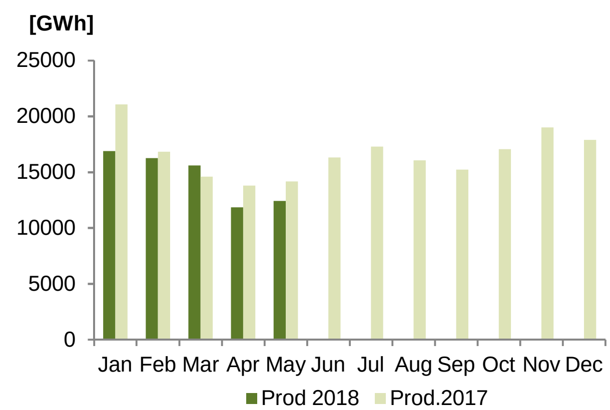
$500 < P_{inst} \leq 1000$

Thermal production increased (+2.1%) compared to the previous month.

Source: Terna

The energy produced by thermal sources in May 2018 came out at 12,445GWh, down compared to the previous month by 573GWh. The annual cumulative figure was down (-9.2%) compared to the previous year.

Thermal Production and Capacity



[MW]

$P_{inst} \leq 5000$

$5000 < P_{inst} \leq 10000$

$10000 < P_{inst} \leq 15000$

$15000 < P_{inst} \leq 20000$

$P_{inst} > 20000$

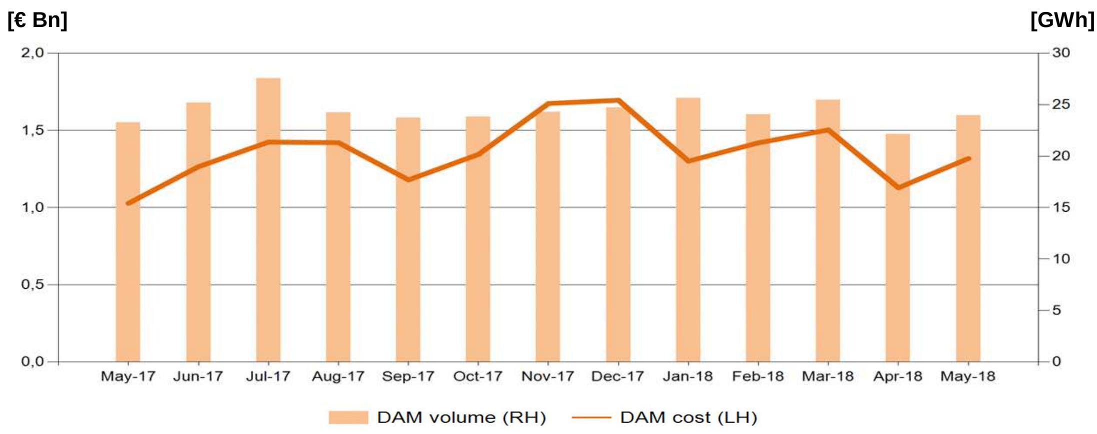
Thermal production was down (-4.6%) compared to the previous month.

Source: Terna

Day-Ahead Market

The May total for withdrawal programmes on the DAM was approximately €1.3 Bn, up 17% compared to the previous month and up 28% compared to May 2017.
The increase compared to April is due to an increase in both average PUN and demand, while the increase compared to the previous year is due to growth in average PUN from €43.1/MWh (May 2017) to €53.5/MWh (May 2018).

Day Ahead Market – amounts and volumes

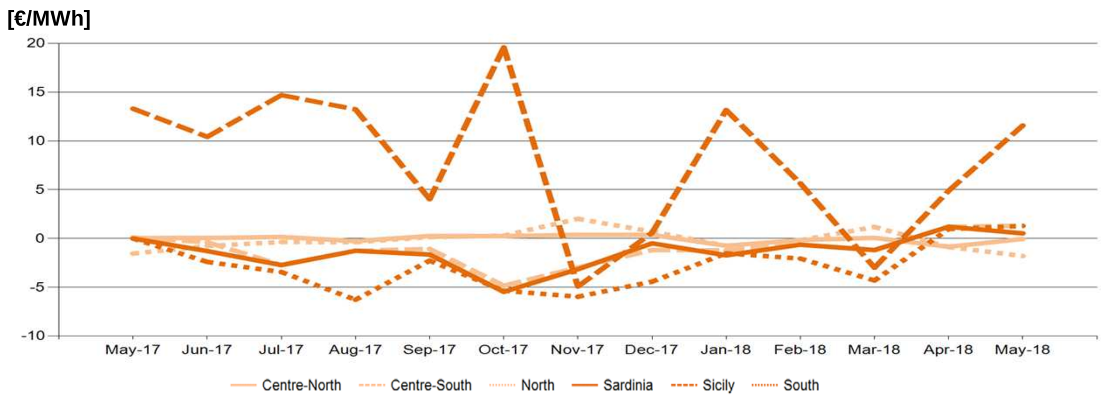


Source: Terna calculation on GME data

Total amount in May 2018 up by 28% compared to May 2017

In May, the zonal prices were basically in line with the PUN, with the exception of the Sicily zone, which recorded a spread of +€11.6/MWh.
Compared to May 2017, the price of the Sicily zone recorded an average increase of €8.7/MWh, while for the other zones there was an average increase of €11/MWh.

Spread compared to the PUN



Source: Terna calculation on GME data

May 2018 zonal prices in line with the PUN for all zones with the exception of Sicily

In May, the spread between the peak and off-peak prices was €11.7/MWh for the Northern zone, €7.8/MWh on average for the Centre-North, Centre-South and Southern zones, and €6.3/MWh on average for Sardinia and Sicily.
In April, the spread between the peak and off-peak prices was €8.8/MWh for the Northern and Centre-North zones and €5.7/MWh for the other zones.

Peak-off peak spread up compared to the previous month for all zones

Day Ahead Market – PUN and zonal prices [€/MWh]

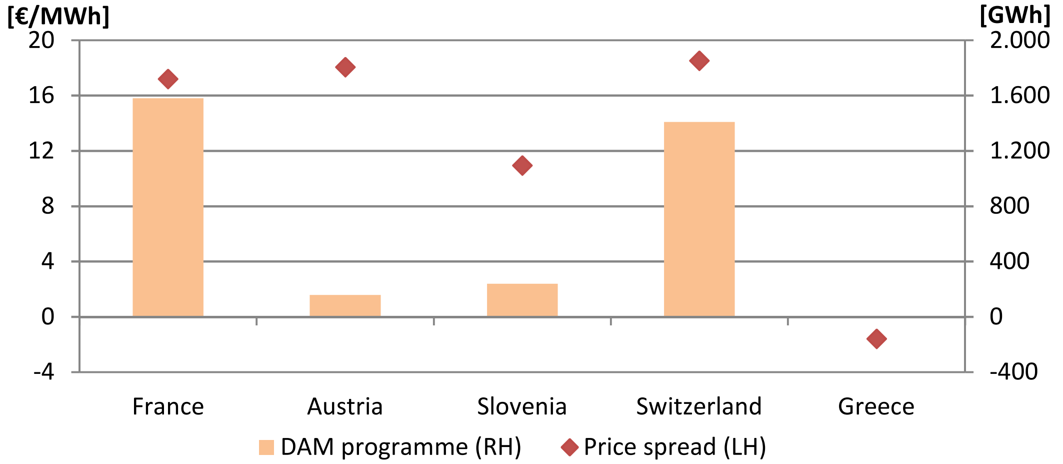
€/MWh	PUN	North	Centre-North	Centre-South	South	Sicily	Sardinia
Average	53.5	51.7	53.4	54.8	54.8	65.1	54.0
Y-o-Y	10.4	10.2	10.3	11.6	11.7	8.7	10.9
∆ vs PUN	-	-1.8	-0.1	1.3	1.3	11.6	0.5
∆ vs PUN 2017	-	-1.6	0.0	0.1	0.0	13.3	0.0
Peak	59.7	59.2	59.3	59.4	59.3	68.9	58.2
Off Peak	50.0	47.5	50.2	52.2	52.2	62.9	51.7
∆ Peak vs Off Peak	9.7	11.7	9.1	7.2	7.1	6.0	6.5
Minimum	14.9	14.9	14.9	14.9	14.9	14.9	11.2
Maximum	81.6	81.2	81.4	81.4	81.4	117.6	81.4

Source: Terna calculation on GME data

May saw a rise in price spreads compared with the previous month on all borders except Slovenia and Greece.

In May, imports totalled 3.6TWh, with France and Switzerland accounting for 44% and 40% of the total, respectively. Total exports were 0.2TWh, with Greece accounting for 89%.

Price spread with foreign exchanges and day-ahead programmes



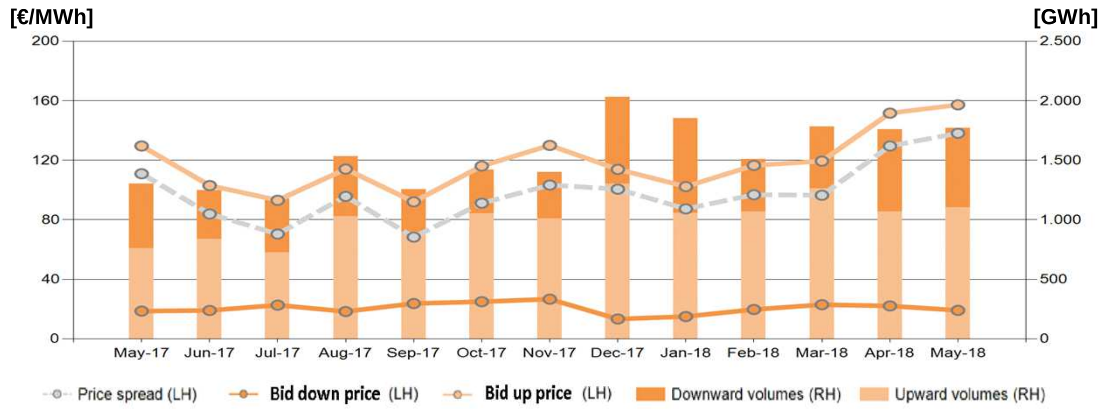
Net imports on the Northern border of 3.6TWh

Source: Terna calculation

Ex-ante Ancillary Services Market

In May, the spread between average bid-up and bid-down prices was €138.1/MWh, up compared to the previous month by 7% and by 25% compared to May 2017.
Total volumes slightly increased compared to the previous month (+1%), in particular, upward volumes increased by 4% and downward volumes fell by 4%.
The upward volumes increased by 45%, while the downwards volumes rose by 23% compared to the same month of the previous year.

Ex-ante Ancillary Services - prices and volumes

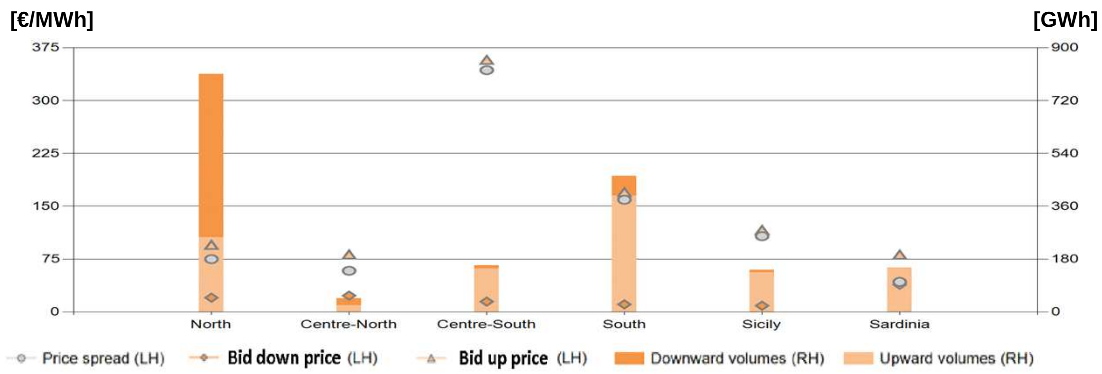


Source: Terna

Average bid-up price in May 2018 of €157.3/MWh
Average bid-down price in May 2018 of €19.1/MWh

The market zone characterised by the highest spread (€343.1/MWh) is the Centre-South, as in the previous month.
This spread recorded a 9% decrease compared to the previous month, due to the reduction in the average bid-up price of 6% (from €381.8/MWh in April to €357.7/MWh in May) and to an increase in the average bid-down price of 423% (from €2.8/MWh in April to €14.6/MWh in May).

Ex-ante Ancillary Services - prices and volumes by market zone



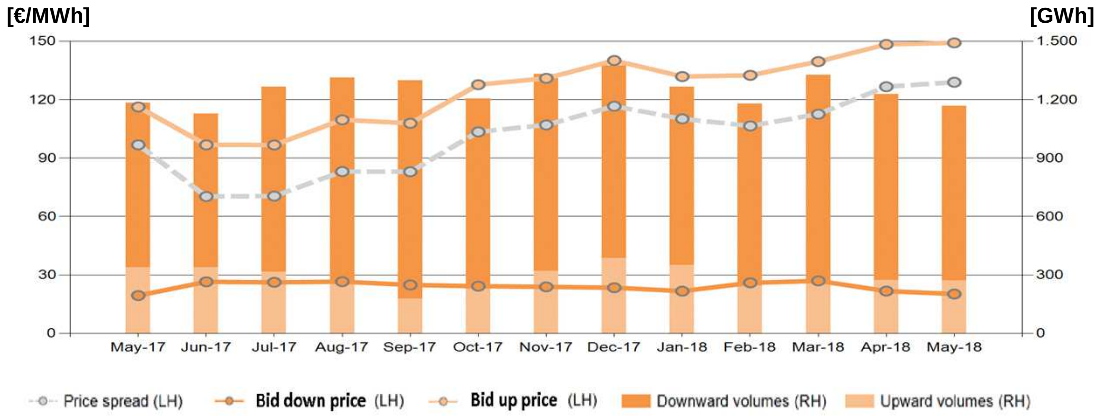
Source: Terna

Centre-South: zone with the highest price spread
North: zone with the most volumes moved

Balancing Market

In May, the spread between bid-up and bid-down prices was €128.9/MWh, substantially in line with the previous month (€126.6/MWh) and up compared to May 2017 (€96.8/MWh; +33%).
The total volumes decreased compared to the previous month (-5%), in particular upward volumes fell by 1% and downward volumes fell by 6%. Compared to May 2017, upward volumes decreased by 20% and downward volumes rose by 6%.

Balancing market – prices and volumes



Source: Terna

Average bid-up price in May 2018 of €149.2/MWh
Average bid-down price in May 2018 of €20.2/MWh

The market zone characterised by the highest spread (€408.7/MWh) is the Centre-South, similar to the previous month (spread of €422.1/MWh).
In May, the Northern zone was confirmed as the zone showing the highest downward volumes (641GWh), followed by the Centre-South zone (104GWh).
The price spread increased across all zones, with the exception of the Centre-North and Centre-South.
The Centre-South was the zone with the greatest decrease in absolute terms over the previous month (-€13.5/MWh). The zone recording the greatest percentage increase is the South (+9%).

Balancing market – prices and volumes by market zone

Source: Terna

Centre-south: zone characterised by the highest price spread
North: zone with the most volumes moved

Spot Commodities Market

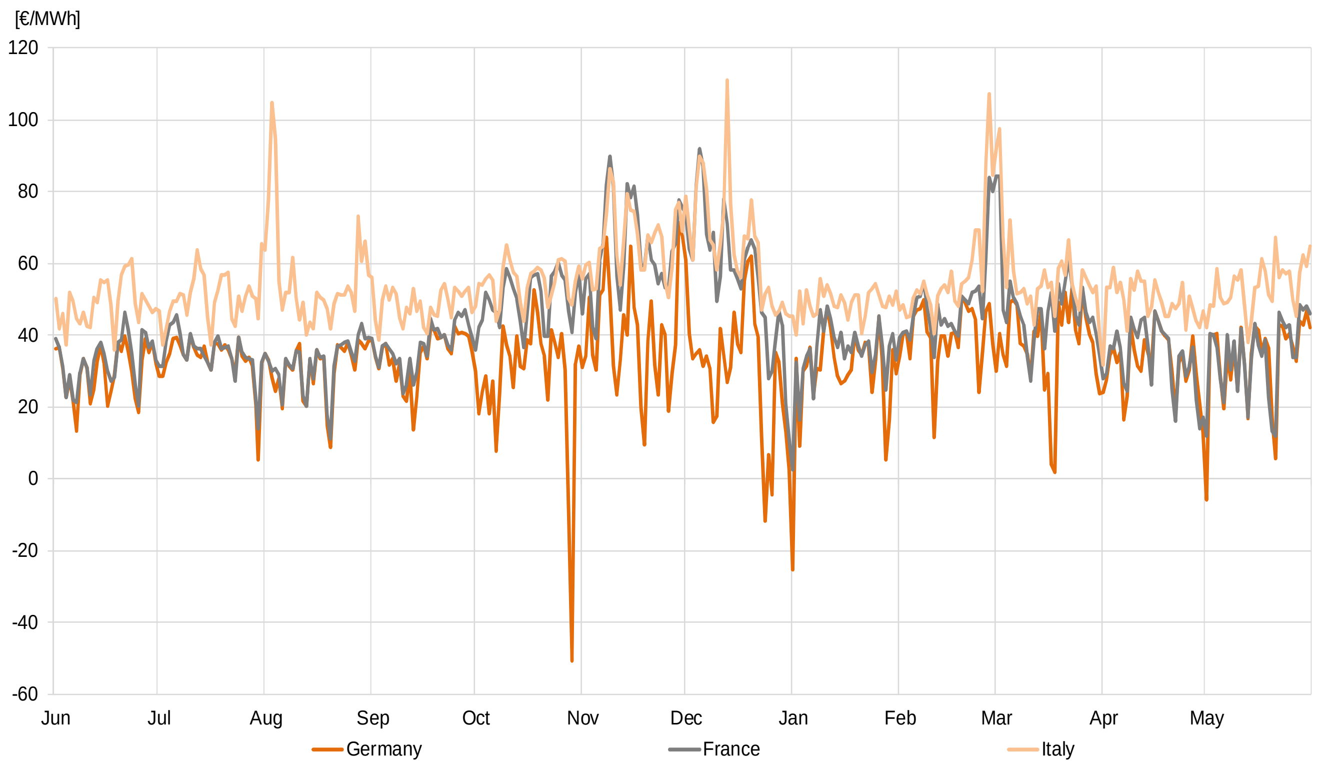
In May, the prices of Brent stood at around $77/bbl, up compared to the $72/bbl of April (+7%).

Coal prices (AP12) came out at approximately $89/t, an increase compared to the prices in April which were around $82/t (+9%).

Gas prices in Europe increased in May, stabilising at €22/MWh compared to the previous month; the PSV recorded an average of €24/MWh, up compared to the €22/MWh in April.

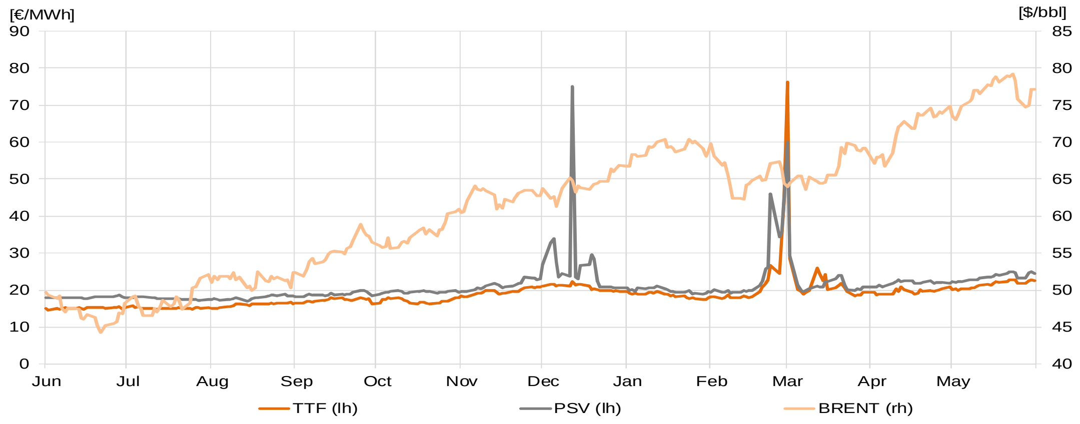
Electricity prices in Italy increased in May compared to April, with a monthly average of €55/MWh (+7%).

Spot electricity prices



Source: Terna calculation on GME and EPEX data

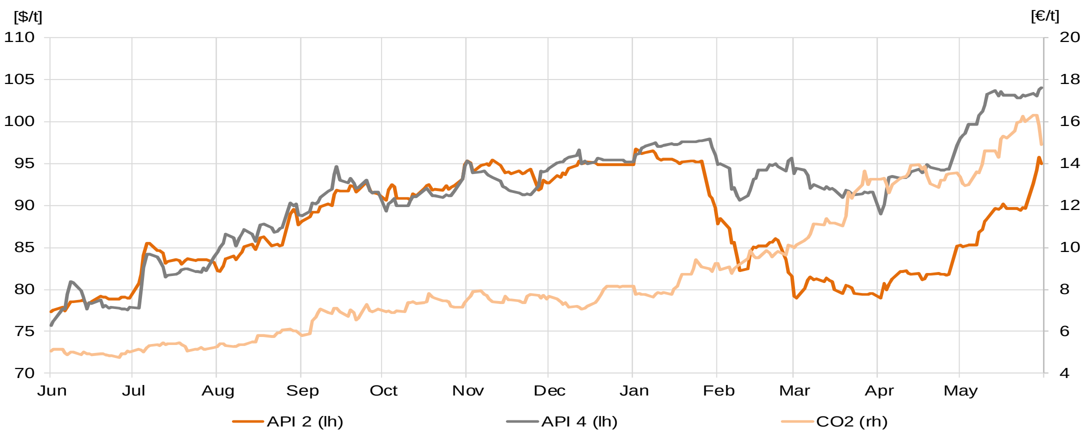
Gas & Oil spot prices



Source: Terna calculation on Bloomberg data

Monthly average change PSV-TTF = €2.0/MWh

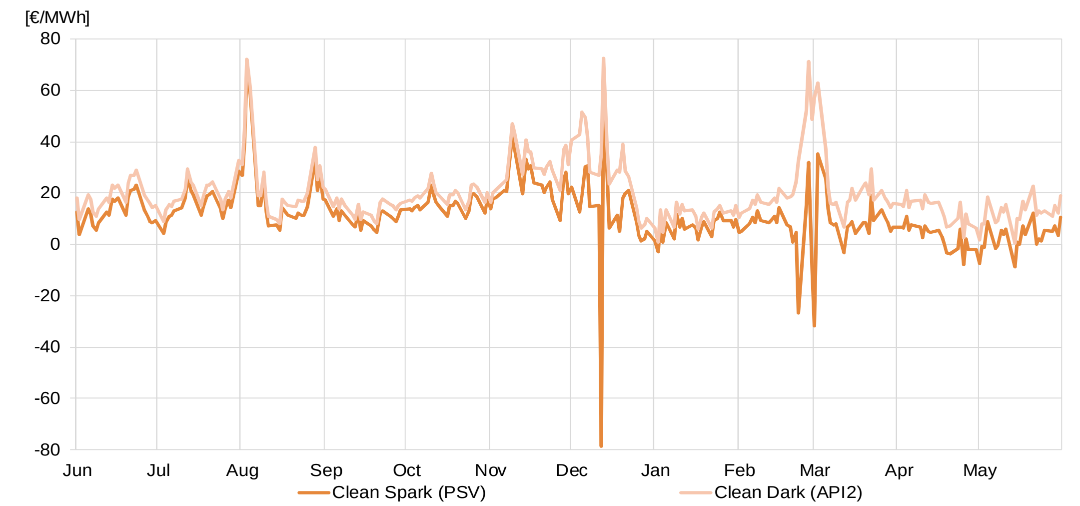
Coal & Carbon spot prices



Source: Terna calculation on Bloomberg data

Monthly average change API2-API4 = $12.8/t

Clean Dark & Spark spreads Italy



Source: Terna calculation on Bloomberg data

Clean spark spread PSV monthly average = €2.8/MWh (-2% M-o-M)

Clean dark spread API2 monthly average = €12/MWh (-8% M-o-M)

Forward Commodities Market

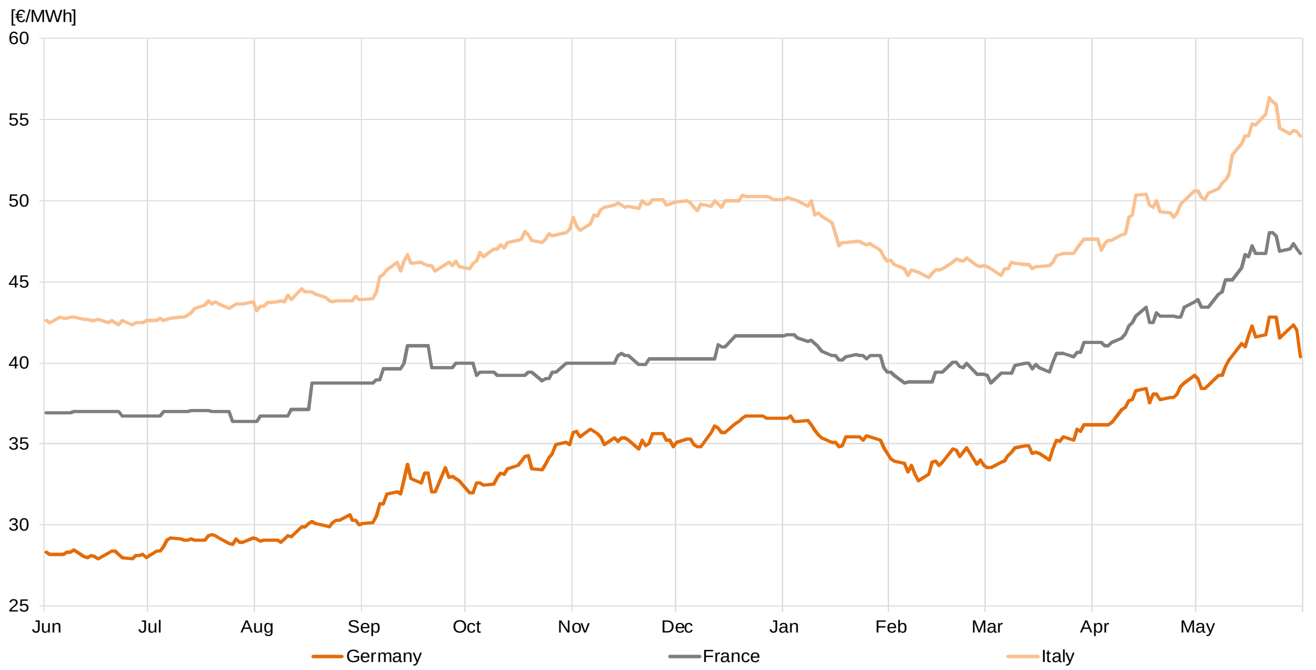
In May, the 2019 Brent forward prices were around $72/bbl, up compared to the $66/bbl of April with an increase of +10%.

The 2019 average forward prices of coal (API2) increased to approximately $87/t (+7%) compared to the $81/t recorded in April.

The 2019 average forward prices of gas in Italy (PSV) increased between May and the previous month, coming out at approximately €22/MWh (+12%).

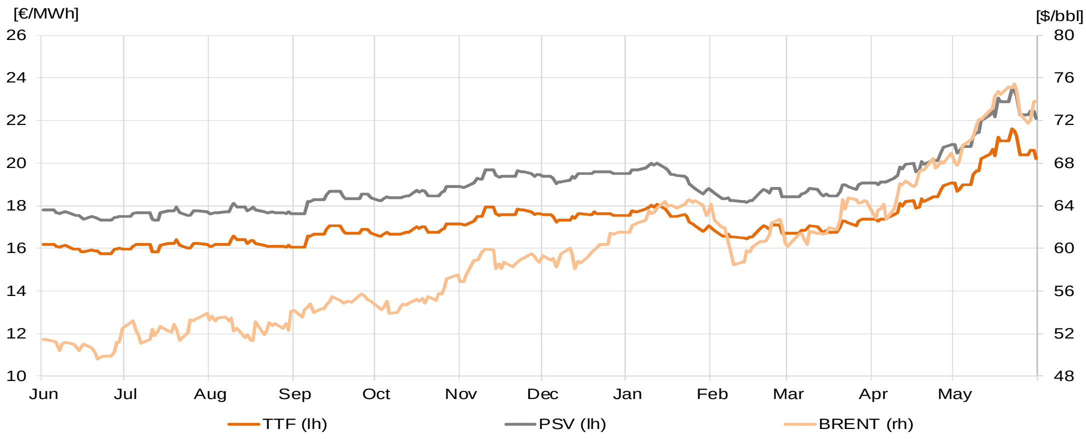
The 2019 average forward prices of electricity in Italy stood at around €53/MWh, an increase of +9% on the previous month. A positive trend was recorded for the French exchange where the price was approximately €46/MWh, while in Germany it came out at approximately €41/MWh.

2019 Forward Electricity Prices



Source: Terna calculation on Bloomberg data

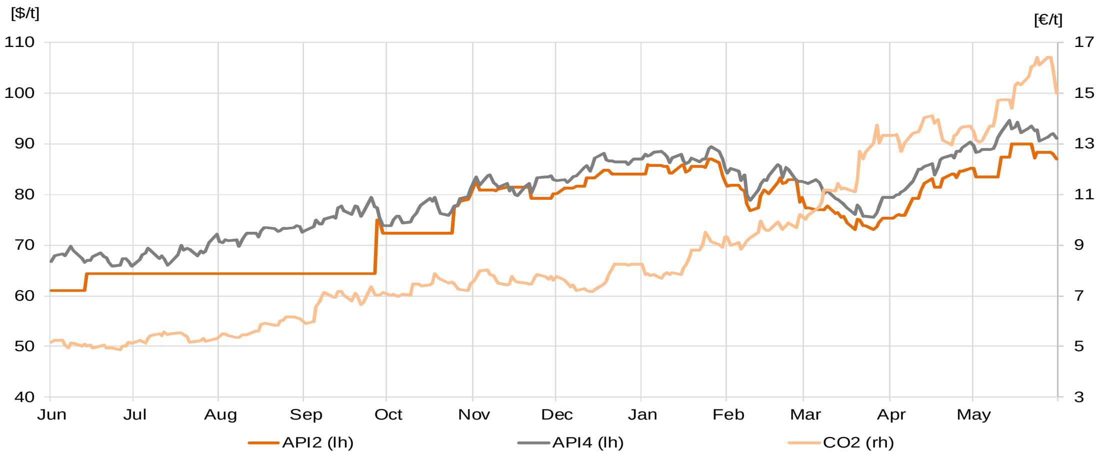
2019 Forward Gas & Oil prices



Source: Terna calculation on Bloomberg data

Monthly average change PSV-TTF = +€2.1/MWh

2019 Forward Coal & Carbon prices



Source: Terna calculation on Bloomberg data

Monthly average change API2-API4 = -$4.6/t

Clean 2019 Forward Dark & Spark Spreads Italy

Source: Terna calculation on Bloomberg data

Clean spark spread PSV monthly average = €3.0/MWh (-29% M-o-M)

Clean dark spread API2 monthly average = €11.0/MWh (-1% M-o-M)

Below is a selection of ARERA provisions of major interest for dispatching and transmission activities in May 2018. This selection is not exhaustive with respect to the regulatory framework.

Approval of the proposal for the distribution of regional costs relative to the intraday coupling on the Italian borders pursuant to article 80 of EU Regulation 2015/1222 (CACM)

Resolution 290/2018/R/EEL

The Authority has approved the joint proposal set forth by the TSOs and NEMOs (Nominated Electricity Market Operators) for the distribution of regional costs relative to the implementation of intraday market coupling on the Italian borders for the intraday allocation of cross-border capacity.

Instructions to Terna S.p.A. for implementing amendments to the proposal to define load frequency control blocks (LFC Blocks) for the synchronous area of continental Europe, unanimously requested by all the European Regulatory Authorities in the synchronous area, under the terms of EU Regulation 2017/1485 (System Operation Guidelines - SOGL)

Resolution 291/2018/R/EEL

The Authority, in coordination with all the other Regulation Authorities of the continental Europe synchronous area, has requested that Terna amend the proposal to define LFC Blocks prepared by continental Europe synchronous area TSOs, under the terms of EU Regulation 2017/1485 (System Operation Guidelines - SOGL).
The proposal modified by the TSOs must be submitted by 15 July 2018.

Verification of the contractual obligations of Terna S.p.A. and the company Gestore dei Mercati Energetici S.p.A. for the launch of the single intraday coupling.

Resolution 292/2018/R/EEL

The Authority has verified the contractual schedules submitted by Terna and GME for the launch of the single intraday coupling on the Italian borders, with a positive outcome. In particular, the Authority has approved:
The Intra Day Operational Agreement (IDOA) which sets out the rights and obligations of the TSOs and NEMOs involved in the European project for the implementation of a Continuous Trading platform to allocate Cross-Border Intraday capacity;
The TSO Cooperation of Intraday Coupling (TCID) which sets out the rights and obligations of the TSOs involved in the European Cross-Border Intra Day Project (XBID).

Key

Ancillary Services Market: the trading venue of the resources for the dispatching service.

API2 – CIF ARA: the reference index for the coal price (with PCI of 6,000 kcal/kg) imported from north-west Europe. It is calculated on the basis of an assessment on the CIF (Cost, Insurance and Freight) prices of coal contracts, with delivery to the ports of Amsterdam – Rotterdam – Antwerp (ARA).

API4 – FOB Richard Bay: the reference index for the coal price (with PCI of 6,000 kcal/kg) exported from Richards Bay in South Africa. It is calculated on the basis of an assessment on the FOB (Free On Board) prices of contracts excluding transport starting from the port of Richards Bay.

Balancing Market (BM): the set of activities for selecting the offers presented on the market to resolve the congestions and establish secondary and tertiary reserve power margins, carried out on the same day as that to which the offers refer.

Brent: the oil price as global reference for the crude oil market. Brent Crude is the result of a mixture deriving from the union of different types of oil extracted from the North Sea.

Clean Dark Spread: the difference between the price of electricity and the cost of the fuel of a coal power station and the cost of the CO2 emission quotas.

Clean Spark Spread: the difference between the price of electricity and the cost of the fuel of a gas power station and the cost of the CO2 emission quotas.

Dirty Dark Spread: the difference between the price of electricity and the cost of the fuel of a coal power station.

Dirty Spark Spread: the difference between the price of electricity and the cost of the fuel of a gas power station.

Day-Ahead Market (DAM): the trading venue of offers to buy and sell electricity for each relevant period of the day after that of trading.

Ex-Ante Ancillary Services: the set of activities performed for selecting the offers presented on the Ancillary Services Market to resolve the congestions and establish secondary and tertiary reserve power margins, carried out in advance with respect to real time.

NET TRANSFER CAPACITY - NTC: the maximum transfer capacity of the grid for interconnection with other countries. NTC D-2 indicates the same capacity defined in day D-2.

Peak hours: are the hours between 8:00 and 20:00 of working days only. **Off-peak hours**: all the other hours.

PSV - Punto Scambio Virtuale: the price at the virtual exchange point for the buying and selling of gas in Italy.

PUN - Prezzo Unico Nazionale: the electricity national price calculated as a result of the Day-Ahead Market.

TTF - Title Transfer Facility: the price at the virtual exchange point for the buying and selling of natural gas in the Netherlands.

Territorial Areas: these consist of one or more adjacent regions and are aggregated as indicated:

TURIN: Piedmont - Liguria - Valle d'Aosta;
MILAN: Lombardy (*);
VENICE: Friuli Venezia Giulia - Greater Venice - Trentino Alto Adige;
FLORENCE: Emilia Romagna (*) - Tuscany;
ROME: Lazio - Umbria - Abruzzo - Molise - Marche;
NAPLES: Campania - Apulia - Basilicata – Calabria;
PALERMO: Sicily;
CAGLIARI: Sardinia

(*) In these two regions the geographical borders do not correspond to the electrical borders. The Lombardy region includes production plants that are part of the geographical-administrative territory of Emilia Romagna.

The data related to the reservoirs table of tanks are aggregated by **ZONE** as indicated:
NORTH – includes the Territorial Areas TURIN, MILAN and VENICE;
CENTRE and SOUTH – includes the Territorial Areas FLORENCE, ROME and NAPLES;
ISLANDS – includes the Territorial Areas PALERMO and CAGLIARI.

Zonal Price: the price of each zone calculated as a result of the Day-Ahead Market (DAM).

Disclaimer

Data reported for 2017 (Energy Balance Sheets) and 2018 are reported on a provisional basis.

Provisional data can be subject to adjustments and recalculations.