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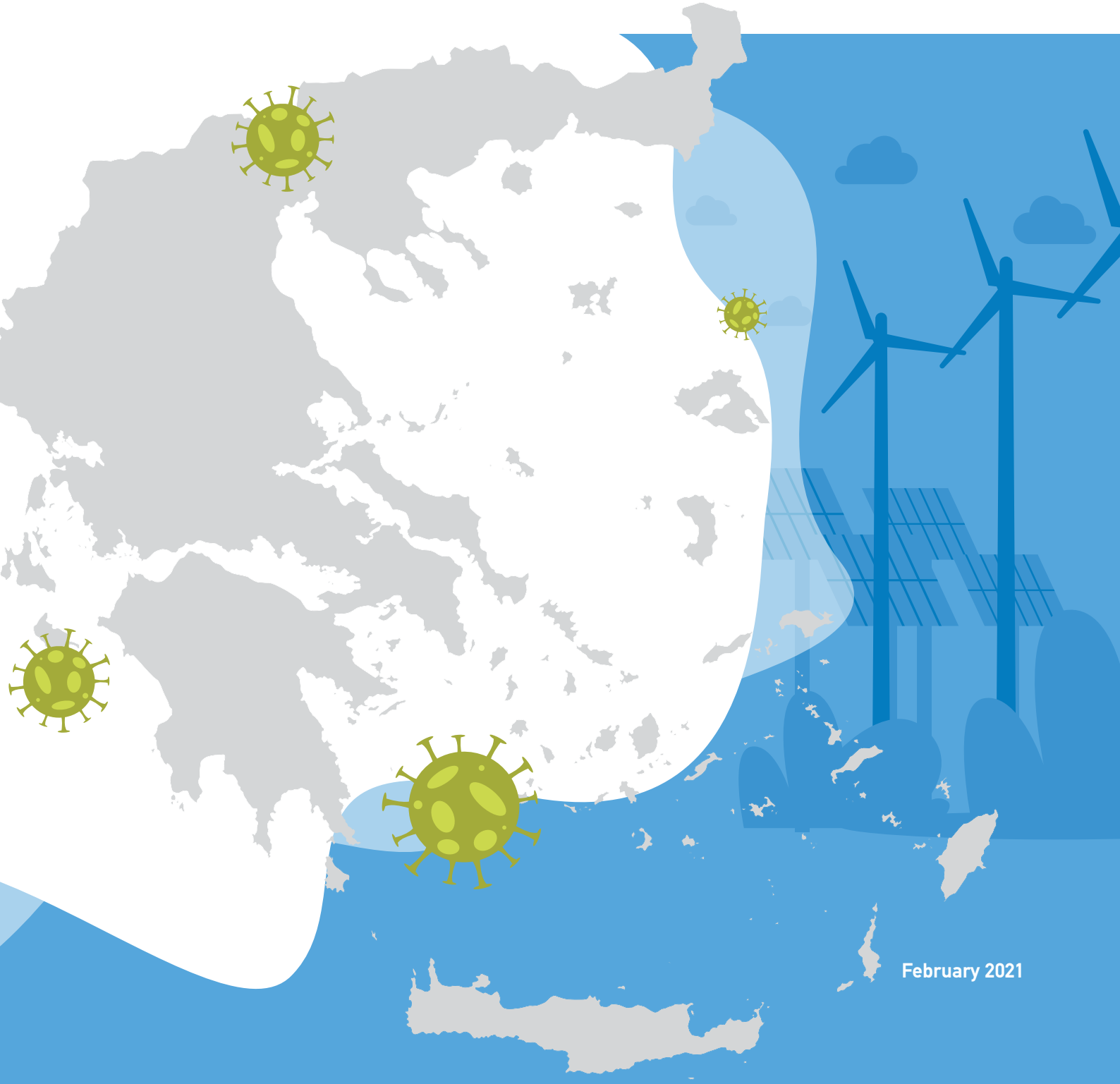
*further action on climate environment, energy, economy technology & sustainability*

# Energy Aspects of the COVID Impact in Greece: An Update



February 2021

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# Summary

The effects of COVID-19 have been devasting both to health and economics in 2020. At the same time, the lockdown and the downturn of economic activity resulted in a decrease of energy consumption and an accompanying in GHG emissions. This concurrent reduction in energy use and GHG emissions reduction has been estimated continuously by a number of groups worldwide. A first analysis specifically for Greece (see Lalas et al. 2020) has been carried out in June 2020 after the first Spring lockdown was relaxed in May. As a second, more severe, wave of the pandemic hit Greece in the Fall with known cases jumping from 0.01/100k at the peak of the first wave in April to 0.5/100k in late November a second lockdown was put in place. In this report, building on the previous analysis and utilizing additional data that became available, a comparison of energy use and GHG emissions for the full 2020 with those of the previous two years (2019 and 2018) has been carried out. The comparison included electricity, as well as oil and natural gas (NG) consumption and emissions in the residential/tertiary for which temperature adjustments have been applied. Oil consumption and emissions in the transport section has also be examined.

The reduction in electricity consumption, adjusted for temperature, between 2020 and 2019 and the corresponding reduction in GHG emissions have been found to be 3.53 TWh (of which 0.76 TWh from the Aegean Islands and Crete) and 1,341 $MtCO_2eq$ (of which 0.571 $MtCO_2eq$ from the Aegean Islands and Crete) respectively. Of that amount ca 1$MtCO_2eq$ can be assigned to reduced tourist activity (double that of emissions attributed to the islands, in view of the approximately equal international arrivals reduction in the mainland and the islands in 2020).

A fairer estimate of the effect of COVID-19 on emissions from electricity production should instead be made assuming the percentages of lignite and NG to total generation of 2019 to apply in 2020 as well, as in 2020 the lignite production was halved, not because of the pandemic but because of the high cost of EUAs and the low cost of NG. This would lead instead to total electricity emissions of the mainland grid of 1,243 $MtCO_2eq$ and to a total impact of the pandemic of 1,814 $MtCO_2eq$.

In the road transport sector. the reductions were 0.573 Mtoe and 1.97 $MtonCO_2eq$ which is of the order of ca 13% difference between 2020 and 2019 as opposed to only ca 1% between 2018 and 2019. Significant reductions of the order of 25% and 42% have been estimated in the internal navigation and domestic aviation resulting in reductions of 0.544 $MtonCO_2eq$ and 0.17 $MtonCO_2eq$ respectively.

In contrast, the final consumption, adjusted for temperature, of heating oil, LPG and NG in the residential/tertiary and NG in the industrial sector increased in 2020. For the consumption of oil and NG, an increase of the order of 11% is seen in 2020 compared to both 2019 and 2018, with the total amount estimated at 0.175 Mtoe and 0.544 $MtCO_2eq$.

In summary (see Table) the overall emission reduction in 2020 compared to 2019 or 2018 is found to be 3.48 $MtCO_2eq$, or 3.95 $MtCO_2eq$ if lignite production remained at the same percentage to the total reduced and temperature adjusted consumption in 2020 to account for the fact that the lignite production in 2020 was halved, not because of the pandemic but because of the high cost of EUAs and the low cost of NG.

Of interest are also the differences between the two lockdown periods in Spring and early Winter. Whereas the intensity of COVID in health was much stronger in terms of deaths per

| Changes 2020-2019 due to COVID impacts | | | |
|---|---|---|---|
| **Sector** | **Energy (GWh)** | **Emissions (MtCO2)** | **Emissions (%)** |
| **Electricity*** | -3528 | -1,34 | -4,3% |
| Mainland grid | -2764 | -0,77 | -2,8% |
| Islands & Crete | -764 | -0,57 | -16,6% |
| **Transport** | -10286 | -2,69 | -14,9% |
| Road | -7797 | -1,97 | -12,8% |
| Navigation | -1818 | -0,54 | -25,0% |
| Aviation | -671 | -0,17 | -42,0% |
| **Heating & other use*** | 1916 | 0,54 | 8.4% |
| **Total** | -11.898 | -3,48 | -6,7% |
| **Total with lignite adjust.** | -12.263 | -3,95 | -7,6% |

*Temperature adjusted

population, the impact in energy use and emissions was reverse. This is an indication that the population has by the time of the second lockdown both discounted the threat and adjusted its behavior to strike a balance between caution and work requirements as for example increased use of private cars to mass transit and teleworking, but also to circumvent the administrative mobility restrictions.

The travel restrictions and their effect on tourism is seen to account for a third of the emission reduction and is highlighted in the electricity consumption in Crete and the Aegean Islands where most of the reduction is found in the tourist period of May to October.

At the same time, the changes in work patterns and mobility restrictions did not seem to affect progress in both legislative actions to facilitate the installation of RES plants and in putting into effect programs for support of electromobility and energy upgrading of buildings, nor did the restrictions delay actual construction of wind and PV plants. Furthermore, the lignite decommissioning schedule was actually advanced and support plans for the just transition of the lignite regions have been finalized.

Even though COVID-19 concerns continue to require counter measures, their effect on GHG emissions in Greece does not seem to be long-term provided that vaccination and possible effective pharmaceutical treatments allow tourist activity to return to previous levels. It becomes then important to maintain efforts for decarbonization and the implementation of the Greek NECP. In this, the wise use of RRF funds will be pivotal which though remains to be seen, as details of the draft Greek RRF Plan have not been released yet.

# 1. Introduction

Greece, as all other countries, has been affected deeply by the COVID-19 pandemic. Its arrival in Greece dates from mid-February 2020. Yet its potential impact was not acknowledged till the beginning of March as the magnitude of the devastation in Italy became apparent.

The Greek Government, in a pro-active and well planned and executed response, decreed a lockdown that went into effect on 14 March and lasted for 45 days till 4 May 2020. This first lockdown included schools, retail stores, restaurants, and strict travel restrictions. The general population, possibly because of fear of an unknown threat for which no defense was known or even glimpsed in the horizon, adhered to the instructions and as a result, Greece registered one of the lowest number of infections and deaths in Europe.

This 45-day lockdown had an immediate effect on the economy and also on the energy demand. An initial analysis of the impact of this spring lockdown is provided in Lalas et al. (2020). The expected reduction of GDP was estimated then by both the Government and the Bank of Greece to reach ca 5% on a yearly basis but to spring back by an almost equal amount in 2021 (Greek Reforms Semester, 2020). Other organizations published decidedly gloomier projections, with the European Commission (2020) projecting a 9.7% reduction and the IMF (2020) an even higher one of 10.1%. These more pessimistic estimates were based on the large dependence of the Greek economy on tourism. Tourism contributes ca €18bil yearly and over 70% of the foreign income which, with indirect effects, amounts to close to 20% of Greek GDP.

With the advent of Spring and the improvement of the weather conditions which made possible an increase of outdoor activities and also with an eye on the start of the tourist season, the lockdown was lifted on 4 May 2020.

Despite efforts to co-ordinate travel restrictions within the EU, their lifting in Greece resulted in a spread of infections. Greece, eager to limit damage to tourism, did not manage tourist flows successfully while also a part of population did not comply with protective measures. Thus, the number of cases, as in most of the EU Member States, exploded in September and the second wave of the pandemic, feared and even expected by many epidemiologists, arrived with a vengeance. In some MSs, including most of Central Europe as well as in Greece, the impact was much more severe in this second wave, especially if judged by deaths per 100000 population (see Figure 1.1).

As the number of infections skyrocketed and more than 90% of the ICUs were full despite their doubling over the summer period, the Greek Government was driven to imposing a second full lockdown on 7 November 2020. This included a strict night curfew which lasted until 11 January 2021, at which time primary schools opened while retail stores were allowed to open on 18 January 2021 under specific rules for the number of customers allowed and time restrictions. This second national lockdown, coupled with smaller focused lockdowns of specific municipalities and even rgions where hot spots appeared in the Fall, made the previous estimates of the effect on the economy obsolete and forced both the Government and the Bank of Greece to revise them downward to ca -10% for the full 2020 with the recovery in 2021 to also drop from +5.1% to +4.2%.

The lockdown resulted in changes of the work and living habits with concurrent reductions in trade and industrial output, and energy use. This led to a noticeable decrease of GHG emissions which has been estimated for $CO_2$ emissions at ca 6.7%, worldwide in 2020 but with substantial differences between the major emitter countries as seen in Table 1.1 (Friedlingstein et al. 2020) with China on the light end of the spread at -1.7% and the US on the other end at -12.2%.

The fossil fuel emissions in the EU in 2020 are estimated to

**Table 1.1: Yearly emissions and y-t-y % changes**

| | 2019 | | 2020 | |
|---|---|---|---|---|
| BilliontCO2/yr | Emissions | Growth | Emissions | Growth |
| **China** | 10,2 | 2,20% | 10,1 | -1,7% |
| **USA** | 5,3 | -2,60% | 4,7 | -12,2% |
| **EU27** | 2,9 | -4,50% | 2,6 | -11,3% |
| **India** | 2,6 | 1,00% | 2,4 | -9,1% |
| **World** | 36,4 | 0,10% | 34,1 | -6,7% |

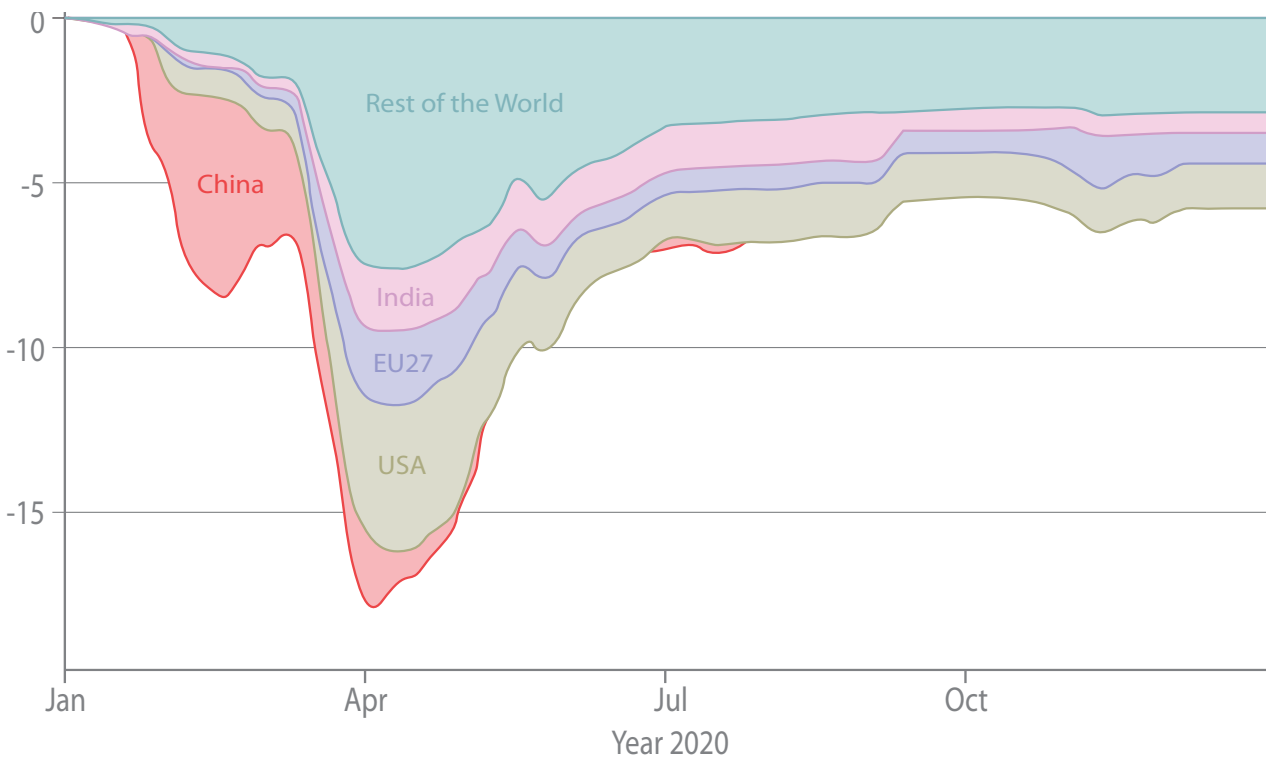


*Figure 1.1: Changes in global daily fossil $CO_2$ emissions in $MtCO_2$/day (Le Quene et al. and Global Carbon Project, 2020).*

drop by 11.2% to 2.6Gt $CO_2$ from reductions of 12.2% from oil, 20.2% from coal and only 3.3% from NG with an additional drop of 5.3% from cement production.

Of interest is also the evolution of the reduction over the course of 2020. In Figure 1.1, the daily reduction for the largest emitters is shown.

Here again the difference in timing between China (February) and the rest of the world (April) is clear. The EU is seen to follow the rest of the world with a large dip in April, and a smaller dip in November with the recovery in between to never return fully. For Greece, the Global Carbon Project (2020) estimates that the decrease in $CO_2$ energy emissions will be of the order of 10% (60$MtCO_2$ in 2020 compared to 67$MtCO_2$ in 2019 and 72$MtCO_2$ in 2018 out of a total of 92$MtCO_2$eq.) which is close to the EU-27 estimate of -11.2%. In a previous study (Lalas et al., 2020) completed in June 2020, based on data available till the end of May, a 2-2.5TWh reduction of electricity demand over the full year was estimated resulting in a 1.5-1.9$MtCO_2$ reduction in GHG missions. For non-electricity energy use in mainly transport and the other sectors only qualitative estimates were made. It is then of interest now that data for the full 2020 year are becoming available and comparison with previous years can be carried out on a 12 month basis thus including all seasonal variations, to revisit the estimates of the impact of the measures to fight COVID-19 on energy consumption and emissions in more detail and try to discern whether any of this reduction, if any, will carry over in the years to come.

To this end, in Section 2, a brief overview of the trajectory of the Greek economy is provided together with some information on the impact of the pandemic in 2020 and its short term prospects in view of the new funding to shore up the EU economy as a whole. Section 3 provides a review of progress in 2020 in the energy sector which is responsible for ca 74-75% of all emissions in Greece, and expectations for further actions in 2021 to realize the ambitious national National Energy and Climate Plan (NECP) targets. Then in Section 4, the impact of the lockdown and accompanying measures to the energy sector are estimated for the main energy carriers of electricity, natural gas and oil and the consumption is compared to those of previous years with the resulting reductions of GHG emissions presented and discussed in Section 5. Finally, in Section 6, some concluding remarks on aspects of the results and their implications are offered.

# 2. The Greek Economy: Past, Present and Near Future

## 2.1 Structure of the economy: Trends up to 2019 and future expectations (pre COVID)

The last 10 years have been very trying for the Greek economy. Following the international crisis of 2008-9 and due to inherent structural deficiencies, the Greek economy collapsed in 2010-11 with the GDP contraction reaching 25% in 2015-16 wrt to 2009. Starting in 2017, a gradual recovery commenced with growth reaching 1.9% in 2018 despite the requirement to maintain a primary budget surplus of over 3.5%. The 1.9% growth rate was maintained in 2019. The pre-COVID 2020 budget as voted in December 2019 incorporated a GDP growth rate of 2.8%.

An overview of the structure of the Greek economy based on the latest available GVA breakdown from ELSTAT[1] is provided in Table 2-1 below.

In 2019, the last pre-COVID year, of the €159Bil total GVA, €44.6Bil (28%) are accounted for by the Trade, Accommodation and Food sector of which a significant part comes from tourism. The actual contribution of this sector is almost certainly higher as it is the sector with the highest black-market activity. The Public sector is the second highest contributor with 19.9%, followed by the Real Estate (16.2%) and the Manufacturing, Mining and Energy (13.5%) sectors. The remaining six NACE sectors account for the rest 22%, with none contributing more than 5.2%. It is important to underline the fact that

1 https://www.statistics.gr/el/statistics/-/publication/SEL45/-

**Table 2-1 GVA and GDP**

| Current prices (€Million) | 2008 | 2009 | 2010 | 2011* | 2012* | 2013* | 2014* | 2015* | 2016* | 2017* | 2018* | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture, forestry and fishing | 6793 | 6663 | 6698 | 6331 | 6482 | 6085 | 6352 | 6816 | 6134 | 6822 | 6576 | 6932 |
| Mining and quarrying; manufacturing; electricity, gas, steam and air conditioning supply; water supply; sewerage, waste management and remediation activities | 27.176 | 25.825 | 24.330 | 22.869 | 22.562 | 21.936 | 21.292 | 22.073 | 21.868 | 22126 | 21.501 | 21.413 |
| of which Manufacturing | 20.578 | 17.103 | 15.784 | 14.195 | 13.124 | 12985 | 13.961 | 13.577 | 13.938 | 13.733 | 13.689 | 13.689 |
| Construction | 10719 | 10550 | 9067 | 6360 | 5331 | 5154 | 3738 | 3495 | 3486 | 2253 | 2270 | 2222 |
| Wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities | 56917 | 54044 | 50808 | 44318 | 39878 | 39163 | 39577 | 39400 | 38038 | 40546 | 42589 | 44606 |
| of which Accomodation & Food and Beverages Services | 11797 | 10.066 | 10.131 | 8.751 | 8.428 | 9.537 | 9.995 | 10.202 | 9.350 | 10.211 | 11.157 | 12.461 |
| Information and communication | 8061 | 5944 | 4756 | 4358 | 4230 | 4067 | 3570 | 3696 | 3810 | 4077 | 4273 | 4521 |
| Financial and insurance activities | 9396 | 9775 | 9337 | 8651 | 6173 | 6946 | 8060 | 7867 | 8682 | 8807 | 8330 | 8339 |
| Real estate activities | 28303 | 29544 | 33630 | 32269 | 31983 | 30275 | 29104 | 28028 | 26826 | 26255 | 25629 | 25689 |
| Professional, scientific and technical activities; administrative and support service activities | 13649 | 13463 | 11031 | 9454 | 8730 | 8164 | 7991 | 7683 | 7419 | 7755 | 7949 | 8066 |
| Public administration and defence; compulsory social security; education; human health and social work activities | 43968 | 49097 | 41994 | 38117 | 35463 | 32223 | 31880 | 31666 | 30894 | 30973 | 31346 | 31623 |
| Arts, entertainment and recreation, repair of household goods and other services | 8835 | 9868 | 6079 | 5453 | 5327 | 5186 | 5041 | 4852 | 4783 | 4978 | 5318 | 5626 |
| Total A64 | 213819 | 212391 | 197729 | 178181 | 166159 | 159199 | 156606 | 155577 | 151939 | 154593 | 155780 | 159037 |
| Taxes less Subsidies on Products | 28172 | 25143 | 26395 | 25128 | 22230 | 20418 | 20743 | 20533 | 22298 | 22559 | 23947 | 24376 |
| Gross Domestic Product | 241990 | 237534 | 224124 | 203308 | 188389 | 179616 | 177349 | 176110 | 174237 | 177152 | 179727 | 183413 |

NB: Light Brown fill indicates minimum yearly values over the 2008-2019 period

| Table 2.2: Tourism Activity Overview | | | | |
|---|---|---|---|---|
| | International Arrivals (in thousands) | | Revenue (in Million €) | |
| | **2020** | **2019** | **2020** | **2019** |
| January | 790 | 660 | 287 | 230 |
| February | 627 | 504 | 240 | 198 |
| March | 411 | 773 | 92 | 318 |
| April | 35 | 982 | 7 | 543 |
| May | 56 | 2387 | 13 | 1566 |
| June | 256 | 4102 | 64 | 2558 |
| July | 828 | 5673 | 577 | 3703 |
| August | 1807 | 6762 | 1373 | 4104 |
| September | 1335 | 5111 | 825 | 2886 |
| October | 956 | 2773 | 709 | 1442 |
| November | 176 | 930 | 60 | 314 |
| December | 88 | 692 | 75 | 289 |
| **Total** | **7365** | **31349** | **4322** | **18151** |

despite the 2009-2012 crush and the difficult years of austerity and the effort for reforms, the structure of the economy as expressed by the relative contribution of the 10 activity sectors remained almost constant over this 10-year period. This underlines the fact that the necessary fundamental restructuring to a new more internationally competitive paradigm has not taken place. As a result, the economy remains vulnerable to variations of its main sectors of Trade, Accommodation and Food (including tourism), Real Estate (also related to tourism) and Public Expenditures.

### 2.2 Estimates of the lockdown impact

The measures to limit the COVID-19 pandemic in Greece as in most EU MSs, included lockdown with both national and targeted local coverage. The country-wide lockdown was imposed first from 14 March to 4 May and then in response to the second wave of the pandemic on 7 November and continued into the next year 2021.

A long list of subsectors of the economy were required by decree to close down which resulted in a large number of layoff and furloughs. The economic impact of the lockdown was felt immediately especially in the small retail shops and small and very small enterprises, which comprise 95% of the businesses, including restaurants and coffee houses which employ a large number of part time workers.

The major effect on the economy was the collapse of the tourist industry. The travel restrictions and the concerns for infection resulted in decreases of incoming tourists as shown In Table 2.2 that in the Spring reached almost 100%. Even after the travel restrictions were lifted in the Summer months, international arrivals were down by more than 70%. The full extent of the impact on the economy is expected to be equally severe as direct income of the tourist sector, also shown in Table 2.2, as estimated by the Greek Tourist Confederation (Insete, 2020) was down by a similar percentage of 75%.

The direct contribution of tourism to the Greek economy is estimated at about €18bil (with shipping adding another €16-17bil) which corresponds to ca 10% of GDP, contributing also more than 73% of foreign income from services plus an equivalent amount in secondary value added in over half of the other sectors. Hence the very high reduction of GDP by over 10% projected for 2020 by both the Government and the Bank of Greece as well as by IMF.

As the full impact of the lockdown to the economy became apparent, the Government put in place emergency measures to provide support to citizens affected, some of whom live paycheck-to-paycheck, as well as to enterprises that were compelled to close to cover overhead expenses and retain employees. These measures, initiated in tranches, included:

1. Loans to enterprises with 20 or more employees (with restrictions based on revenue lost) with 30% to 50% forgiveness rates if a year later they have retained their personnel and their gross is below 70% of that for the previous pre-lockdown period.
2. Reduction of rents by 40% with a portion of the reduction paid to landowners by the State.
3. Subsidy (€534 per month) to furloughed employees of enterprises and self-employed in the subsectors that were ordered to cease operation.
4. Social Security and Health contributions of furloughed or laid off employees and self-employed of said subsectors to be paid by the State.
5. Special support of €400 to long term unemployed and extension of the duration of unemployment benefits
6. Special support of €600 to specific self-employed pro-

fessional groups (e.g. lawyers, engineers, accountants, doctors) for their reduced activity during the first lockdown period

7. VAT and tax payments of said subsectors postponed by 3-6months.
8. Support of enterprises to meet their loan obligations (with restrictions based on revenue lost) to be repaid in 5 years with one-year grace period.
9. Establishment of a Support Mechanism to provide loan guarantees for development projects and coverage of the interest payments for three months for loans of SMEs which have not laid off personnel.

No filters or preferred status for green economy activities have been incorporated.

The total amount of support measures announced and put into effect in 2020 is estimated at €23.9Bil with an additional €7.5Bil budgeted for 2021 according to the statement of Ministry of Finance on 5 November when the 2021 Budget was submitted to Parliament. IMF in its latest report[2] for COVID-19 related support expenditures estimates them at $21.2Billion of which $0.7Bil for the health sector plus $9.3Bil of liquidity support of which $6.4Bil in the form of guarantees. The €23.9Bil figure is disputed by the opposition Parties who claim that the support expenditure did not actually exceed €9.5Bil.

Despite these government measures taken to support the economy, the impact of the lockdown led to drastic downward revisions of all indices. These are reflected in the 2021 National Budget as voted in late December 2020. The estimates for Fiscal 2020 and projections for Fiscal 2021 are presented in Table 2.3 below.

The contraction of the economy in 2020 is now estimated to be at over 10%, the highest in the EU. Of note is the overly optimistic estimates by official sources of the contraction of the economy during the first wave (March-April) of the pandemic as illustrated in the estimates of the Bank of Greece that have been found to be more than 100% off (-4.7% in April vs -10% in December).

A second point worth noting is the large reduction in exports as demand ebbed worldwide but also in imports as total private consumption decreased by ca 8%.

A third point refers to public investment expenditures for which €6,75Bil were inscribed in 2020 Budget as voted in December 2019. This amount was increased three times with the last one in 17 November 2020 to reach €10.42Bil mostly to finance extra measures to support enterprises affected by the lockdown. Some of these expenditures, such as subsidies for electric vehicles and bicycles will be eligible for ex-post RRF financing.

A fourth result of the pandemic measures is the reversal of the downward trend of the unemployment in the last five years from the heights of 25-27% registered in the heart of the Greek crisis of 2011-2012. Unemployment, bolstered by the severe reduction of the tourist sector activity and the restrictive terms and rules of the operation of retail stores and hospitality establishments including restaurants/coffee shops, is expected to increase slightly in 2020 and remain at the pre-COVID levels of ca 17-18%. This on the proviso that tourism will recover in 2021 to near previous levels and establishments that have closed will re-open. The earlier estimates of tourism activities reaching 50-60% of pre-COVID levels in 2021 seem to have been overoptimistic as the latest (January 2021) estimates hover at 35-40% which would imply a smaller overall recovery of the economy to ca 3% from the 4.5% assumed for the 2021 State Budget voted a few days before Christmas.

Fortunately, Greece unlike in the last crisis of 2010-2011, is in a better fiscal position to survive. In this, significant tools are in the relaxation of the constraint to maintain a 3.5% primary budget surplus until 2022 as agreed in the MoU with the Institutions in 2015 and the eligibility of Greek bonds for repurchase by the ECB (which has reached €14Bil by the end of 2020) till March 2022. This enabled borrowing in the last open auction in January 2021 of €3.5Bil at the very low rates of 0.8%. In addition, of the ca €34bil reserves which are left from the last 2015 assistance package over €17bil are unencumbered and available for support. To this amount, one should add, besides the MFF, Greece's share of the EU recovery package that includes the Recovery and Resilience Facility (RRF) as well as that of SURE, ECB and EIB facilities and shown in Table 2.4.

On 25 November 2020, the Greek Government put out for public consultation its draft Plan for the use of the RRF funds. At the same time, it submitted the draft Plan to the European Commission (EC) for first reactions. The draft released did not include substantial quantitative information except that shown in Table 2.5.

Despite the availability of funding, the Greek economy which is expected to have the largest GDP reduction in the EU in 2020, will need more than a year to regain the pre-COVID growth rates of ca 2% that it needs to make up for ground lost since 2010 and continue to meet its loan service payments.

The wise use of these EU funds and especially those of Next Generation EU, which IMF estimates can boost real GDP growth in the Euro area by 0.75% by 2023, is imperative for Greece. In the medium to long term, the challenge for Greece is to make use of these funds to reform its economy and in-

2 Fiscal Policies Database (imf.org)

| Table 2.3: Some basic parameters of the Greek economy | | | | | |
|---|---|---|---|---|---|
| (in billion €) | 2018 | 2019 | 2020 (as voted) | 2020 (estimated) | 2021 (as voted) |
| GDP (const values) | 179,73 | 183,41 | 185,61 | 162,78 | 171,93 |
| Yearly %change | | | | | |
| 2021 Budget (voted 21Dec) | 1,90% | 1,9% | 2,8% | -10,5% | 4,8% |
| Bank of Greece 14Dec | | | | -10,0% | 4,2% |
| Bank of Greece April | | | | -4,7% | 5,1% |
| Private Consumption | 1,10% | 1,9% | 1,8% | -7,8% | 3,0% |
| Public Consumption | -2,50% | 1,9% | 0,6% | 2,1% | -1,9% |
| Exports | 8,70% | 4,8% | 5,1% | -30,3% | 22,5% |
| Imports | 4,20% | 3,0% | 5,2% | -17,4% | 16,4% |
| Harmonized Consumer Price Index | 0,8% | 0,5% | 0,7% | -1,1% | 0,6% |
| Unemployment | 19,3% | 17,2% | 17,4% | 18,8% | 17,9% |
| IMF, Nov2020 | | 17,3% | | 18,9% | 17,5% |
| General Gov. Revenue | 88.56 | 89.83 | | 81.43 | 87.66 |
| General Gov. Expenditures | 86.72 | 87.03 | | 97.55 | 99.18 |
| Primary General Gov. Balance (ESA) | 7,9 | 7,88 | 7,49 | -11,14 | -6,59 |
| %GDP | 4,3% | 4,5% | 3,8% | -6,8% | -3,8% |
| Public Investments | 6,24 | 6,15 | 6,75 | 10,42 | 6,75 |
| additional RRF funds | | | | | 2,64 |
| Public Dept | 334,72 | 331,07 | 329,5 | 340,00 | 343,20 |

*From the Greek 2021 National Budget as voted December 2020

| Table 2.4: Available funds from Next Generation EU Program | | | | | |
|---|---|---|---|---|---|
| (in 2018 €Billion) | To Green Transformation | To Digital Transformation | Amount | of which grants | Budgeted for 2021 |
| Recovery and Resilience Facility | 38% | 20% | 28,9 | 16,4 | 2,64 |
| REACT-EU | 25% | 0 | 2,3 | 2,3 | 1,60 |
| Just Transition Fund | 100% | 0 | 0,4 | 0,4 | |
| European Agricultural Fund for Rural Development | 33% | 0 | 0,3 | 0,3 | |
| Total | | | 31,9 | 19,3 | 4,24 |

| Table 2.5: RRF Grant Distribution | | |
|---|---|---|
| (in 2018 €Billion) | Amount | % |
| Green Transformation | 6,2 | 38% |
| Digital Transformation | 2,1 | 13%* |
| Employment, skills and social cohesion | 4,1 | 25% |
| Private investments, economic & institutional transformation | 4.0 | 24% |
| Total | 16,4 | |

* An additional 7% is embedded in the other categories

crease its competitiveness by developing other sectors of its economy, including primary production and high technology and health services thus reducing its overdependence on tourism. To this end, the Government had tasked a Committee, headed by Nobel Laurate S. Pissarides, to provide guidance for such a transformation. The Committee submitted its final report (Pissarides, 2020) on 20 October 2020. Its recommendations which have been criticized severely by the Opposition Parties and have received mixed reviews also by a number of NGOs and analysts, have been taken into account according to the Head of the Committee for the Greek RRF Plan[3] in compiling the draft RRF Plan. That remains to be seen when its final form is published in April 2021.

3 https://www.capital.gr/oikonomia/3501266/th-skulakakis-stoxos-ependuseis-45-50-dis-meso-tou-tameiou-anaptuxis

# 3. The Energy Sector

### 3.1 Supply and Demand structure

The main features of the energy sector and their evolution in the last decade is shown in Table 3.1. Its Gross Inland Consumption has dropped from a high in 2009 of 31Mtoe to a low of 23.2Mtoe in 2014 and remained at that level of ca 24Mtoe till now. Greece has no indigenous oil or gas resources, except for a miniscule amount that tends to zero from the Prinos oil field. Its only resource, besides its good RES resource potential, is lignite used almost exclusively for electricity production, which though is scheduled to end completely by end 2023 with only the new Ptolemais V plant to continue operation until end 2028. This requires the import of 37,987ktoe (latest National Balance[4] figures – 2019 as of end January 2021) of which 33,696ktoe oil and petroleum products. Of that, 20,359ktoe are exported, with 99% of this comprising oil and petroleum products from the four Greek refineries.

Final energy consumption (FEC) is similarly dropping from a high of ca 20Mtoe in 2008-9 to a low of ca 15Mtoe in 2013-14 and has remained at that level since (see Table 3-2). The distribution between sectors remains in general unchanged over the 12-year 2008-2019 period, namely 18-21% for industry, 34-42% for transport, 10-14% for tertiary, 25-31% for households and about 2-3% for agriculture. If 2008 sectoral consumption is used as a basis, the 2019 sectoral FEC for industry is down to 61%, for transport to 80% (where road transport comprises consistently 85% followed by internal navigation with 10%), for households to 78% and for the tertiary sectors to 96%.

These figures clearly illustrate the effect on FEC of the 2010-2011 economic crisis with ca 10% yearly reduction of GDP for 2-3 years as well as the fact that consumption recovery is slow and remains coupled strongly to GDP. Sectorial consumption reached a minimum in the 2012-2013 period, as did the subsectors, with some exemptions such as the Non-ferrous production (namely aluminum, and mining and quarrying) which are influenced mostly by the international markets.

It is of interest then to see, to the extent possible with currently available energy data, whether and how these FEC trends presented in Table 3-2 have been affected by the COVID impact.

As the electricity sector is responsible for about 1/3 of all GHG emissions in Greece (see Table 5-3 below), we focus on its structure and generation trends first. The total installed capacity on 31 December 2020 was 20,555MW (see Table 3-3) of which 9,584MW conventional and the rest 11,065MW RES. The total electricity available for consumption is seen in Table 3-3 to remain virtually unchanged over the last five years with the inland generation variation matched by counterbalancing changes in net imports. This pattern though changes substantially in 2020. Consumption in 2020 dropped by 5% and 4% compared to 2019 and 2018 respectively. At the same time the production pattern also changed notably as lignite production was reduced by 45% wrt to 2019 following an almost equal one of 39% between 2019 and 2018 due to the increases in the price of ETS allowances.

### 3.2 Developments in 2020

The year that just ended, 2020, despite the difficulties and delays stemming from the anti-pandemic measures, saw a number of significant developments in the Greek energy sector.

- In April the Amyntaio I & II lignite units of 544MW total net power were retired in line with the 2023 deadline bringing together with Kardia I and II units which had ceased operation in 2019, the total of decommissioned lignite power to 1086MW. The 2022 Megalopolis III unit decommissioning was brought forward by 6 months. The decommissioning schedule for the rest is as follows: Ag. Dimitrios I & II in 2022, and Ag. Dimitrios III, Meliti, Megalopolis IV and Ag. Dimitrios V in that order in 2023.
- Auctions, on 2 April for 508MW of wind and PV (successful bids from €45.11/MWh to €54.82/MWh) and on 27 July for 142MW PV (successful bids from €45.84/MWh to €62.45/MWh) and 481MW wind (successful bids from €53.86/MWh to €57.7/MWh) were conducted with a last one for 350MW under the current regime scheduled for 24 May 2021. Six additional technology neutral auctions of 350MW each have been announced till 2024 for a total of 2.1GW.
- A new licensing procedure for RES installation) was voted into law and put in force on 7 May (Law 4685/2020) that will accelerate the currently lengthy and heavily bureaucratic procedure.
- On 27 May the Megalopolis V NG plant started operating at full power (814MW).
- On 24 August, a program for the subsidy of electric vehicles and bicycles/scooters was put into effect with a total budget of €100Mil which is estimated to cover 15000 ve-

4 https://ec.europa.eu/eurostat/web/energy/data/energy-balances

| Table 3.1: Total Energy Supply (ktoe) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Coal (98%<lign.) | Oil | Oil for electicity | NG | NG for electricity | RES | Net elect. imports | Total |
| 2009 | 8425 | 15789 | 1852 | 2971 | 1816 | 1924 | 375 | 29484 |
| 2010 | 7863 | 13854 | 1484 | 3234 | 2060 | 2189 | 491 | 27631 |
| 2014 | 6483 | 10760 | 1366 | 2484 | 1281 | 2506 | 758 | 22991 |
| 2015 | 5606 | 11226 | 1506 | 2677 | 1317 | 2840 | 826 | 23175 |
| 2016 | 4369 | 11396 | 1294 | 3490 | 2235 | 2704 | 756 | 22715 |
| 2017 | 4816 | 10936 | 1428 | 4204 | 2852 | 2915 | 536 | 23407 |
| 2018 | 4564 | 10344 | 1293 | 4117 | 2693 | 3141 | 539 | 22705 |
| 2019 | 5180 | 10688 | 4116 | 4489 | 3015 | 3162 | 855 | 24374 |

NB: Light Brown fill indicates minimum yearly values over the 2008-2019 period.

| Table 3-2: Final Energy Consumption | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (ktoe) | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
| Final energy consumption | 20.352,2 | 19.656,2 | 18.249,2 | 18.081,9 | 16.278,4 | 14.668,3 | 14.804,1 | 15.741,0 | 15.879,2 | 15.720,8 | 15.168,8 | 15.404,6 |
| Industry sector | 4.231,5 | 3.462,4 | 3.472,8 | 3.322,8 | 2.982,2 | 2.835,5 | 3.088,3 | 3.128,4 | 3.073,1 | 2.762,8 | 2.743,3 | 2.587,6 |
| Iron & steel | 225,2 | 188,4 | 177,1 | 182,7 | 156,2 | 140,8 | 134,7 | 90,7 | 130,7 | 128,5 | 129,6 | 143,5 |
| Chemical & petrochemical | 262,4 | 224,5 | 194,3 | 173,8 | 100,6 | 111,3 | 161,7 | 222,2 | 153,9 | 121,1 | 130,2 | 88,9 |
| Non-ferrous metals | 744,4 | 607,4 | 764,5 | 801,5 | 789,9 | 882,3 | 828,2 | 829,2 | 776,1 | 682,4 | 708,4 | 631,0 |
| Non-metallic minerals | 1.132,8 | 856,3 | 968,9 | 726,9 | 684,6 | 727,1 | 760,3 | 736,4 | 776,3 | 680,5 | 649,6 | 641,7 |
| Transport equipment | 34,9 | 34,1 | 25,6 | 37,5 | 17,0 | 12,1 | 20,2 | 21,2 | 15,5 | 18,3 | 22,2 | 7,1 |
| Machinery | 67,3 | 12,2 | 18,9 | 45,8 | 24,4 | 26,5 | 36,4 | 36,6 | 29,6 | 49,9 | 64,8 | 87,2 |
| Mining & quarrying | 91,2 | 76,9 | 59,4 | 33,9 | 64,2 | 74,2 | 75,4 | 87,3 | 80,5 | 90,9 | 115,3 | 89,8 |
| Food, beverages & tobacco | 658,2 | 618,3 | 580,5 | 595,4 | 539,9 | 470,3 | 522,8 | 523,0 | 445,2 | 423,6 | 459,7 | 455,8 |
| Paper, pulp & printing | 139,8 | 123,0 | 121,5 | 91,9 | 95,8 | 97,9 | 98,6 | 83,3 | 47,9 | 48,4 | 54,2 | 76,7 |
| Wood & wood products | 51,5 | 43,9 | 48,2 | 54,6 | 37,5 | 29,1 | 24,6 | 30,7 | 23,2 | 27,1 | 41,5 | 29,9 |
| Construction | 152,0 | 150,5 | 128,3 | 87,7 | 52,9 | 86,1 | 151,0 | 127,7 | 128,7 | 165,2 | 152,7 | 134,9 |
| Textile & leather | 169,4 | 93,5 | 88,9 | 76,3 | 46,2 | 43,5 | 32,9 | 31,3 | 41,2 | 38,0 | 98,7 | 86,3 |
| Not elsewhere specified (industry) | 502,4 | 433,3 | 296,7 | 414,9 | 373,2 | 134,4 | 241,5 | 308,9 | 424,3 | 288,8 | 116,3 | 114,7 |
| Transport sector | 7.521,5 | 8.278,1 | 7.352,3 | 6.602,1 | 5.512,1 | 5.608,8 | 5.635,5 | 5.753,4 | 5.897,0 | 5.815,3 | 5.903,9 | 6.046,0 |
| Rail | 44,4 | 38,3 | 24,3 | 20,2 | 30,3 | 27,2 | 57,9 | 59,0 | 56,5 | 55,5 | 54,6 | 26,5 |
| Road | 6.505,1 | 7.055,9 | 6.361,5 | 5.833,6 | 4.727,6 | 4.956,2 | 4.925,4 | 4.976,1 | 5.092,7 | 4.992,1 | 5.009,0 | 5.152,8 |
| Domestic aviation | 352,9 | 290,7 | 237,2 | 221,8 | 187,0 | 176,7 | 179,8 | 167,4 | 189,0 | 195,2 | 222,2 | 224,7 |
| Domestic navigation | 599,1 | 880,7 | 717,1 | 515,6 | 525,2 | 430,5 | 449,1 | 534,3 | 556,8 | 570,6 | 615,7 | 640,7 |
| Commercial & public services | 2.230,1 | 2.153,7 | 1.957,4 | 1.870,1 | 1.935,3 | 1.820,6 | 1.714,0 | 1.874,9 | 2.037,5 | 2.191,7 | 2.095,3 | 2.135,5 |
| Households | 5.270,4 | 4.887,5 | 4.666,5 | 5.526,0 | 5.096,0 | 3.821,3 | 3.844,9 | 4.460,6 | 4.348,7 | 4.413,3 | 3.916,7 | 4.116,2 |
| Agriculture, Fishing & forestry 1 | 1.098,7 | 874,6 | 800,2 | 669,1 | 316,0 | 323,9 | 280,6 | 271,3 | 283,4 | 303,6 | 279,2 | 292,2 |
| Not elsewhere specified (other) | 0,0 | 0,0 | 0,0 | 91,7 | 436,7 | 258,2 | 240,9 | 252,3 | 239,4 | 234,0 | 230,5 | 1,3 |

| Table 3.3: Electricity Generation and Consumption (GWh) and Power (MW) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Lignite | NG | Hydro | Oil | RES | Distribution Grid Gen | Net Imports | Consumption |
| 2015 | 19418 | 7267 | 5391 | 4571 | 6031 | 4714 | 9609 | 57001 |
| 2016 | 14898 | 12512 | 4843 | 4627 | 6519 | 4734 | 8796 | 56929 |
| 2017 | 16387 | 15397 | 3457 | 4927 | 6834 | 4730 | 6237 | 57969 |
| 2018 | 14907 | 14136 | 5051 | 4579 | 7328 | 4732 | 6279 | 57012 |
| 2019 | 10418 | 16228 | 3361 | 4589 | 8150 | 4995 | 9944 | 57685 |
| 2020 | 5713 | 18197 | 2819 | 3831 | 9909 | 5580 | 8719 | 54768 |
| | | | | | | | | |
| Power | Lignite | NG | Hydro | Oil | RES | | | Total |
| Dec 2020 | 2816 | 5011 | 3170 | 1757 | 7895 | | | 20649 |
| | | | | | | | | |
| RES Power | wind | PV | PV roofs | Small hydro | Bio | Co-gen | | Total |
| Dec 2020 | 4114 | 2833 | 375 | 243 | 96 | 234 | | 7895 |

hicles and 12500 bicycles/motorcycles. It should be mentioned that a 30% subsidy for the installation of charging stations is already (since September 2019) in place. The budget may be increased if there is higher demand. In addition, legislation was passed to streamline licensing of charging stations.

- On 18 September, a very thoroughly documented Just Transition (JT) Master Plan (SDAM , 2020a, 2020b) was announced by the National Committee for Just Transition (set up on 23 September 2019) and put out for public consultation on 3 October with a final version published in December 2020. The Plan calls for support for Clean energy, Smart agriculture, Sustainable tourism**,** Green technology, and Education and support for Small industrial units to transform their economy and development model and maintain social cohesion. The funding includes the share of the €5.05bil from the JTF and ca €200mil from national sources plus additional funding from 2021-2027 Community Support funds from MFF.
- The market test for the planned floating NG terminal (FSRU) in Alexandroupolis was carried out with success (23 March), and three offers were submitted for the conversion of the depleted Kavala oil well to a NG storage facility on 13 October.
- The new electricity market model for day-ahead, intra-day and balancing markets was launched on 1 November with mixed results as it is still trying to get over its teething technical problems and the shallowness of the market. Wholesale price shot up to €83.03/MWh from an average price of €55.33/MWh for the 10 previous months with the balancing costs reaching ca €10/MWh. On 18 December, the Greek electricity day-ahead market coupling with Italy was initiated.
- In November, in response to a call by RAE, requests for production certification for 36.2GW of PV and 8.6GW of wind were submitted (in addition to 25GW already issued in 2020 plus 28GW of production permits already issued before 2019, plus a backlog of 10GW of old applications, some of which are to be rejected or withdrawn).
- The amended long-term development plan for the 2020-2030 period of ADMIE, the Electricity Transmission System Operator was submitted to RAE which put it out for public consultation on 2 November (ended on 6 December). It calls for investments for the upgrading and expansion of the grid totaling €4.3Bil (almost doubling that of the previous one) to enable installation of the RES units called for in the NECP.
- The very popular and oversubscribed "Exoikonomo kat Oikon" (Saving at home) program for energy upgrading of residences (2nd phase) with an overall budget of ca €275mil of which €241mil public expenditure continues without noticeable delays with expectations to service all applications already approved. On 11 December 2020, calls for applications for a more ambitious 3rd phase were announced. This 3rd phase has a budget of €897mill (up from €350mil originally planned) of which €805mil public expenditures to be financed from RRF funds. At the same time, measures for upgrading commercial buildings including hospitality establishments will most likely be postponed as a number of hotels and restaurants have not opened at all this year.
- On 14 December, a National Committee for H2 Generation and Utilization was instituted in the Ministry of Environment and Energy
- On 15 December in line with the privatization plans of the Government, a call for tenders for the 49% of the Greek Electricity Distribution Network Operator (DEDDHE) was announced.
- On 23 December, following the clearing of details for the legal separation of DEPA, the Public NG Company, into a commercial activities company (DEPA Commercial, S.A.) and an infrastructure company (DEPA Infrastructures, S.A.) cleared the way for privatization. A call for offers for the purchase of DEPA Commercial was announced with a similar one for DEPA Infrastructures expected in the Spring of 2021.
- In December, a Public Consultation for draft legislation for the operational and remuneration framework for RES hybrid plants and for the relevant framework for storage plants and offshore wind parks was opened by the Ministry for Environment and Energy.
- On 23 December, the first test of the Crete-Peloponnese electrical cable was carried out successfully. The laying out of the second cable from Crete to Attica started with 10km already completed.
- The TAP NG pipeline bringing Azerbaijan gas to Greece (and on to Italy) was completed and is providing NG to the Greek market from 1 Jan 2021.

Looking forward to 2021 a non-exhaustive list of items to be addressed or completed would include:

- Ensuring smooth operation of the Target Model by fixing teething problems especially in the Balancing Market , moving to a continuous intra-day market as soon as possible which is crucial to large scale RES penetration and initiating coupling with Bulgaria and Italy.
- Addressing concerns of industry as regards electricity pric-

es which continue to be among the highest in EU.

- Resolving the dispute with EC on access to lignite by third parties and providing compensation for the restrictions of the previous years.
- Progress in privatization of electricity DSO and the NG grid operations of DEPA.
- Ensuring the smooth operation of the new permitting procedures for RES together with a number of secondary legislative acts put in place to speed up installation also of distributed generation.
- Submitting to EC a plan for a permanent auctioning system for standby power availability and interruptability compensation.
- Completing the connection of Crete to Peloponnese and accelerating the second connection of Crete to Attica.
- Completing and approving of the new special RES spatial framework.
- Finalizing draft legislation for offshore wind.
- Notifying to DG Comp (individual notification) for the pumped-hydro storage plant of Amphilochia (of 670MW capacity), a PCI nominated project, foreseen under the NECP to be in operation by 2025.
- Introducing legislation based on the findings of the Working Group on electricity storage facilities convened by the Ministry of Environment and Energy in late May and the technical background work carried out by RAE (recommended storage for highest cost benefit of the order of 1500MW with about 500MW batteries of 10-100MW for 4h capacity units and the rest pumped hydro).
- Revising the National Building Regulation under the framework agreement signed in April 2020 between the Ministry of Environment and Energy and the Technical Chamber of Greece so as to be put into effect by mid-2021 and initiate the transition to nZEBs. Under the same framework agreement, new guidelines and schemes for the certification of the energy auditors are also to be developed.
- Elaborating (and publishing) the plans and procedures for the utilization of the RRF funds.
- Approving and initiating the detailed Just Transition Action Plan, announced in October 2020 and in final form in November 2020 for support of the lignite areas of West Macedonia and Megalopolis for a Just Transition to the post-lignite era.
- Initiating "ELECTRA', the flagship program for energy renovation of public buildings through the provision of energy services by the market (with a call for tenders to be issued in February 2021), with a budget of €500mil.

The partial shut-down of activity including of public authorities, and of travel had no permanent effect on the progress of RES project development and construction. The Government extended deadlines for permitting submissions and grid connection as well as the applied RES remuneration reference values, by three to six months. The duration of the construction workers lockdown was kept to a minimum, so delays have been limited and are not expected to exceed three to six months and overall, not to jeopardize the commissioning of new RES plants.

In this context, it should be emphasized that the RES share in Greece continues to increase at steady pace, leading to an overachievement of the national binding EU target of 18% of gross final energy consumption by possibly 2% to 20% by the end of the year. Especially in the electricity mix, the RES share is expected to exceed 30% by the end of 2020. In terms of RES investments, 2019 was a record year for the domestic wind sector (>700MW new installations, i.e., four times higher new yearly installed capacity than average) followed by an additional 512MW in 2020 reaching over 4GW of installed wind capacity. This continuation of activity is also due to the banking sector new liquidity provided by ECF that resulted in no discernable delays in approving new loans for RES ventures which seem to be of the few kinds of investments that meet bank risk criteria.

The lignite decommissioning plan is also driving ahead private investments for new CCGT natural gas power production plants (814MW under construction with an additional 2400MW with production licenses of which firm decisions for 1200MW to be finalized in 2021). The 2020 system adequacy study from the TSO that also integrates the NECP projections and policies, refers to the need of more than 1GW new gas capacity until 2025. The lignite decommissioning also brought out firm plans for over 500MW of PV as announced by PPC Renewables and ELPEDISON to be installed in lignite mine areas.

Most important though is the work that needs to start to revise the Greek NECP which was communicated to the EC in late December 2019 to bring it in line with the new EU-wide target of 55% emission reduction by 2030. In this, the RRF funds would be of great help if the final form of the Greek RRF Plan to be submitted in April 2021 which includes €6.2Bil for green transformation grants includes targeted use, realistic mechanisms for their dispersal, and monitoring of progress in their correct utilization.

# 4. COVID-19 effects

## 4.1 Introduction

The COVID pandemic started affecting Greece in late February when the first cases were reported. As the number of cases started rising, the Greek Government acting early and decisively imposed a full lockdown (retail trade, entertainment, restaurants, schools and mobility restrictions) on 14 March which lasted till the 4th of May. This lockdown was adhered to fully by the public even though it included the Easter holiday arguably the biggest holiday of the year in Greece. As a result, the number of deaths per 100000 was one of the lowest in Europe (see Figure 4.1)[5].

In view of the tourist season and its importance to the Greek economy in general and to the Aegean islands in particular whose economy is much more dependent on tourism, Greece relaxed its anti-pandemic measures and especially travel restrictions. As a result, starting in September, cases started rising with the rates increasing sharply in October although with a two-week lag with respect to EU as a whole and with both its neighbors, Italy and Bulgaria in particular.

As the ICU beds started filling up, especially in Thessaloniki and other northern Greek regions which are a favorite (and convenient) destination of tourists from the neighboring Balkan countries, the Government imposed a second nation-wide lockdown on 7 November which continued into 2021 awaiting the vaccination of as large a portion of the population as supply will permit. This second lockdown included schools, movies and theaters, restaurants, all retail stores except essential ones, home gatherings, curfew and travel restrictions to other prefectures.

The first lockdown in the Spring of 2020 resulted in clear reduction of energy demand in electricity as documented in a number of studies world-wide (McWilliams and Zachman, 2020) and also in Greece (Lalas et al., 2020). This is counter-intuitive as one would expect consumption to increase in the residential sector as higher use of electrical equipment for telecommunications/on-line work and schooling, as well as other equipment (e.g., for heating, cooling, ventilation, lighting, cooking) to support a longer stay of the members of households at home would have been expected.

In the tertiary sector on the other hand, during the lockdown period a significant part of the companies either did not operate at all or operated through teleworking, which resulted in a significant reduction in energy consumption. This is especially the case for enterprises in the tourist sector.

The transport sector is affected directly with the imposition of travel restrictions, especially aviation, and increased working at home resulting in reduction of liquid fossil fuel use.

Finally, in the industrial sector, the conditions during the lockdown created business opportunities for some (leading to increased production) and losses for most industrial sub-sectors as production declined accompanied by a commensurate energy consumption.

As more data have become available, it is of interest to examine this pandemic impact on energy demand over the full year of 2020 that includes the seasonal variations in climatic conditions and activity, so as to enable a better comparison with that of previous years but also to juxtapose the differences between the Spring and Winter lockdowns.

## 4.2 Methodology

The approach for the examination of the effect of the measures is based on a comparison of energy demand and consumption during the full 2020 year with that of the two previous years 2019 and 2018. Comparison with additional previous years was not considered as in the years before 2018, the Greek economy was still under the effects of the obligatory reforms of the Memorandum of Understanding (MoU) with the Institutions (IMF, ESM, EC, ECB) with negative growth rates (see Table 1.1) with the GVA contributions of most sectors reaching their lowest values in the last 15 years. Greece got out of the strict MoU terms in August 2018 although it is required to maintain a 3.5% primary general Government surplus until 2022 and enhanced supervision terms continue to apply. In addition, 2018 and 2019 are the first years since 2009 with a positive growth rate of 1.9% which makes comparison easier.

The energy streams to be examined are electricity, NG and oil products. Of the rest two streams, solid fuels and RES, solid fuels (5180ktoe in 2019) are used almost exclusively (>95%) for the production of electricity, and similarly of the 3162ktoe of RES only 810ktoe of solid biomass are not in electrical form. This solid biomass is mostly used for space heating, but it represents less than 3.7% of gross inland consumption. As a result, the three streams considered, electricity, NG and oil

5 https://ig.ft.com/coronavirus-chart/?areas=eur&areas=usa&areas=grc&areas=esp&areas=ita&areas=bgr&areasRegional=usny&areasRegional=usnj&areasRegional=usia&areasRegional=usca&areasRegional=usnd&areasRegional=ussd&cumulative=0&logScale=0&per100K=1&startDate=2020-03-01&values=deaths

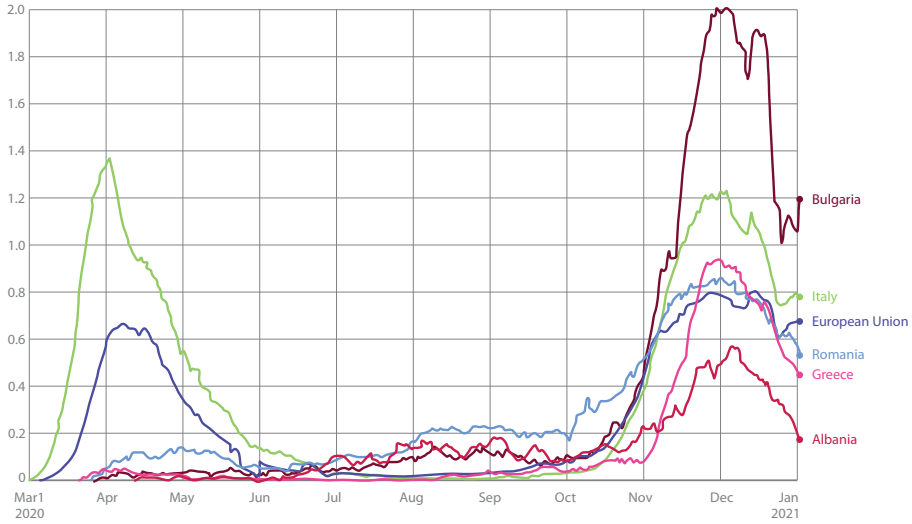


*Figure 4.1: Seven day rolling average of daily rates of new deaths per 100000 for the EU, Greece, Italy, Bulgaria, Romania and Albania as compiled by the Financial Times.*

**Temperature vs average electricity load nationally**

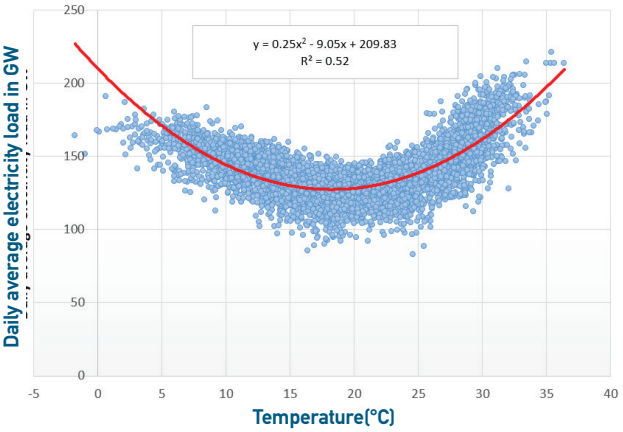


*Figure 4.2: Electricity load temperature dependence for the mainland grid of Greece*

products including LPG represent over 95% of the final energy consumption.

Currently, most of the Greek islands are not connected to the mainland grid. The electricity in the islands including Crete is generated locally by a combination of internal combustion and steam generators all fueled by oil, plus PV and wind RES. The islands grids are run by DEDDHE, the mainland distribution system operator who publishes load data monthly. The mainland grid is operated by ADMIE, the Greek TSO which publishes hourly load data and monthly summaries which also include estimates of grid generated electricity mostly from PV, but also submits data to ENTSO-E. For this analysis, daily load values of the mainland grid have been obtained from ENTSO-E and monthly values for the island grids provided by DEDDHE have been used.

As the electricity demand depends on temperature, a correction needs to be applied to make comparisons meaningful. To this effect, the temperature dependence of the load is derived from multi-annual periods and for specific areas (Kumar et al., 2020, Mukerjee et al. 2019 and references therein). For the mainland grid, such a dependence (Mirasgedis et al., 2006) was updated recently (Gakis et al., 2021) based on data for the 13-year 2006-2018 period, is shown in Figure 4.2, and has been utilized in this analysis.

As 2019 was the last pre-pandemic year, it has been chosen to be the basis for comparison and the temperature adjustments are applied relative to this year's temperature regime. Thus, the polynomial function given in Figure 4.2 has been utilized to compute the nominal daily load for each day of all three years, 2018, 2019 and 2020 and a correction has been applied to the actual daily loads of 2018 and 2020 which is the difference between the nominal loads as computed by the polynomial function given in Figure 4.2 between those years and the same day load of the 2019 year.

As no such temperature-load function is available for Crete and the rest of the non-connected grids of the Aegean islands, no temperature correction has been applied to the loads of the islands in view of the relatively smaller year-to-year temperature variations there.

The temperature data used are the daily average tempera-

ture values from the home station of the Greek Meteorological Service at its headquarters in Athens (GR000016716 Hellinikon) downloaded from the US National Center for Environmental Information (NCEI) website[6]. This station has been chosen because it is representative of the greater Athens area which is home to more than 35% of the population of Greece and 40% if the population of the Aegean Sea islands including Crete which are not connected to the national grid, are discounted.

Data for NG consumption on a monthly basis have been downloaded from the daily reports of the Greek NG Transmission System Operator (DESFA)[7] as well as EUROSTAT[8]. The NG consumption covers residential, industrial, and power generation needs. As the latter is already included in the electricity demand considerations, the total amount needs to be decomposed accordingly.

The dependence of NG consumption on temperature among other factors has been investigated extensively (see Tampa et al., 2018 for a thorough survey of relevant papers). As for electricity, the temperature dependence is regionally specific and unfortunately no relation for the NG consumption dependence on temperature is available at this time for Greece, the following procedure for adjustment has been adopted: (a) the monthly amounts for electricity generation have been subtracted from the monthly consumption amounts, (b) then the average monthly amount of consumption during the non-heating months (May to October) has been subtracted from the monthly amounts for the heating months, (c) an adjustment for the increase of costumers of 0.97 and 1.05 compared to 2019 is applied to the 2018 and 2020 values, (d) an average nominal consumption per Heating Degree Day (HDD) for the winter months of December, January and February is computed for 2018 and 2020, (e) an adjustment estimate for the retail consumption for heating for 2018 and 2020 heating months is then computed by the multiplying this nominal consumption per HDD with the difference in HDDs between 2019 and 2020 or 2018, and finally (f) the total NG consumption for the heating months is derived by adding to the value of the heat months for 2018 and 2019 the adjustment computed in (e). The values for the non-heating months for 2018 and 2020 have been adjusted only for the small annual increase of retail connections of 4% of 2019 compared to 2018 and 5% in 2020 compared to 2019.

The monthly values of HDD used have been obtained from the EUROSTAT data base. Again, the values for the Greater Athens area for the 3-year period of 2018, 2019 and 2020 have been used as proxies for all of Greece. In Figure 4.3 the variation of HDD and as well as of Cooling Degree Days (CDD) is presented. The first winter months (Jan-Apr) of 2018 are clearly warmer than the respective ones in 2019 and 2020 but the last months (Nov, Dec) of 2018 turned cooler with this trend continuing in the winter months of 2019. The cold months of 2019-2020 remained cold but these of 2017-2018 (Nov-Apr) are seen to be warmer than the same period of 2018-2019 which are similar to the 2019-2020.

As with NG, data for oil consumption have been downloaded from the same EUROSTAT energy statistics site. Of the various components of oil consumption, those of Motor Gasoline, Road Diesel, Heating and other Gas Oil and LPG have been chosen for comparison. LPG is used both for heating/cooking and in road vehicles. The ratio of LPG use in Greece, based on the Official Energy Balance data for both the previous 2019 and 2018 years is ca 57% and 36% for road and residential use respectively. The Heating and other Gas Oil category according to EUROSTAT definition includes "light heat oil for industrial and commercial use, marine diesel and diesel used in rail traffic and other gas oil used as petrochemical feedstock". From the detailed breakdown of the latest Energy Balances, the amount used in residential, tertiary and final demand industrial sectors is approximately 75% (79% for 2019 and 74% for 2018). As the 2020 Energy Balance is not available, the breakdown of both LPG and Heating and other Gas Oil amounts was carried out using these same percentages (57% and 75% respectively) for 2020.

The heating amounts for 2018 and 2020 have been adjusted for temperature in the same way as those for NG described above but without any adjustment to account for changes in customer connections. It should be pointed out that heating oil in housing, unlike NG, is sometimes purchased in April when its price is lower because of reduced taxation during the heating period which lasts till April 15, and stored to be used in the Fall. In 2020 this reduced tax period was extended to include May, which would render the heating diesel values for April and possibly May in 2020 less representative of actual consumption.

### 4.3 Results

In response to the evolution of the COVID-19 cases (see Figure 2.2 above), the Greek Government has put in place two periods of lockdown, one from 14 March to 4 May and the second from 7 November to the end of the year and beyond into 2021.

In Figure 4.4, a comparison of the electricity consumption (7-day running averages, after adjustment for temperature (as discussed in the previous Section 4.2), between the pre-COVID

6 Find a Station | Data Tools | Climate Data Online (CDO) | National Climatic Data Center (NCDC) (noaa.gov)
7 http://www.δεσφα.gr/scada/quantity-hourly.php?la=GR
8 https://ec.europa.eu/eurostat/web/energy/data/database

### Heating and Cooling Degree Days

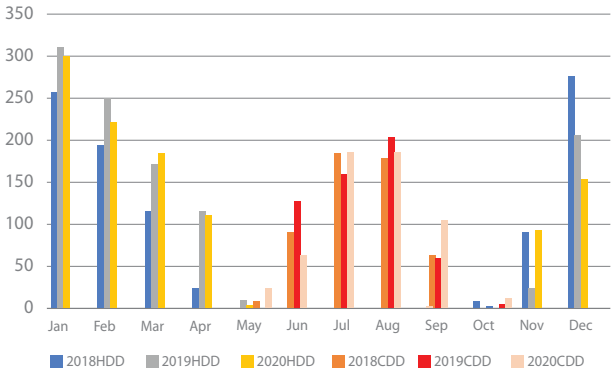


*Figure 4.3: Heating (HDD) and cooling (CDD) degree days for the Greater Athens region for 2018, 2019 and 2020[1].*

1 https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_chddr2_m&lang=en

### Electricity Consumption - Mainland grid

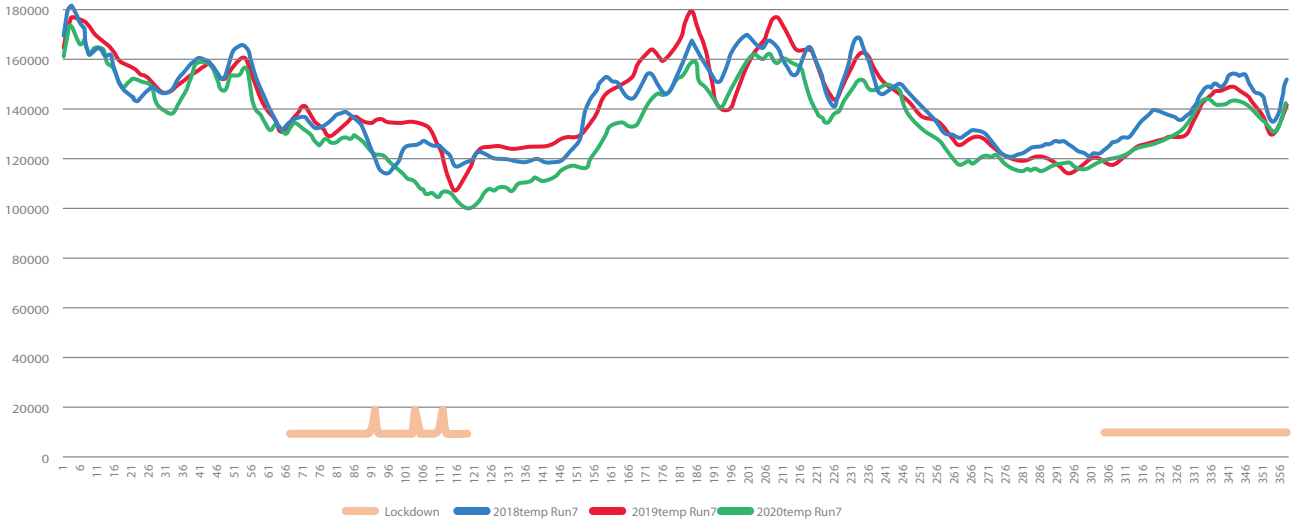


*Figure 4.4: Daily 7-day running averages for the electricity consumption in the mainland of Greece for 2019, and 2018 and 2020 adjusted for temperature (MWh). The lockdown periods and the Orthodox Easter are also indicated.*

2019 year and 2020. The consumption for 2018 is also included to illustrate the overall similarity of the yearly pattern of consumption between 2018 and 2019, and so to bring out more clearly differences.

The first point to be made is the very high correlation of the changes in the short-term basis. In particular, the overall pattern comprised a continuous reduction from the high of the beginning of the year to the end of January, a double sharp peak in February followed by a second reduction in March, a leveling in April and May, a continuous increase as tourism kicks in reaching a high at the end of June, when summer leaves typically start till the beginning of September when a gradual decline leads to a relative minimum toward the end of October from which point on, again there is a gradual increase as the days grow shorter till the end of the year. This overall pattern, driven by weather, economic activity and day length is repeatable over a decadal scale.

Of note though are also shorter sharp variations that can be clearly attributed to specific reasons that do not seem to have been influenced by COVID-19. These include the Easter holiday period with a clear drop of a few (3-4) days duration as can be clearly seen in Figure 4.4. This is made more noticeable as it changes dates from year to year (day # 98, 8Apr for 2018, day #118 28Apr for 2019 and day #110 19Apr for 2020 for the Orthodox Church). In 2020, the overall minimum is not at Easter as is the case in 2018 and 2019 but, after a slight upswing, almost two weeks later during the long weekend of 1 May at the end of which the lockdown was lifted.

Similar clearly discernable behavior is seen for other important fixed holidays such as 15 August (Dormission of the Virgin Mary) and Christmas. Less important holidays such as Greek Independence Day (day # 89, 25 March) and the combined Saint Demetrios-Start of WWII (days #304-306, 26-28 October) may also have some effect, with their magnitude though varying from year to year especially when they result in extended weekends.

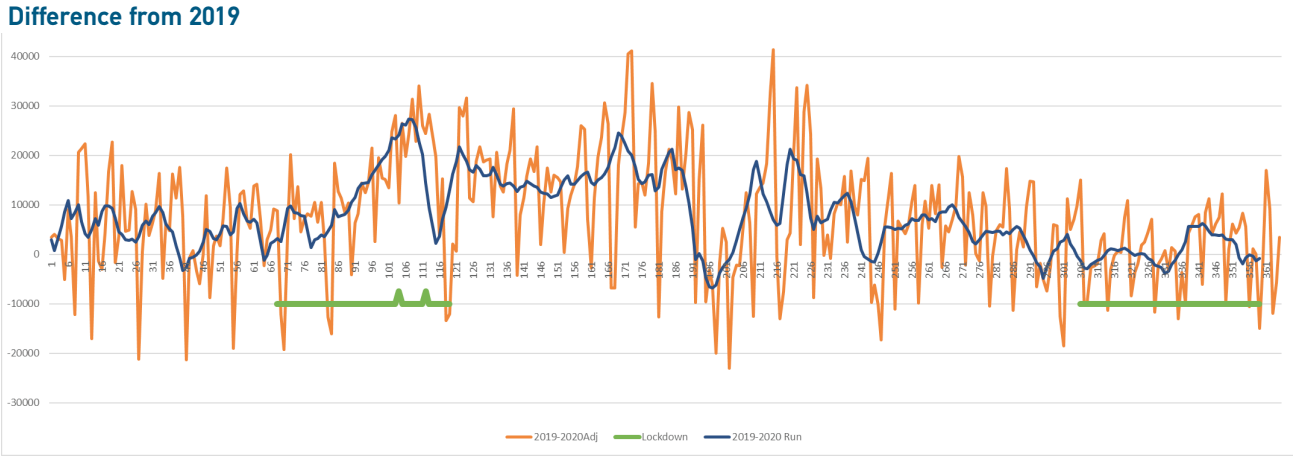


*Figure 4.5: Reduction of daily electricity demand in the mainland grid (in MWh) in 2020, adjusted for temperature, from that in 2019 including 7-day moving average values (blue). Easter holiday and lockdown periods are also indicated (Green).*

The overall difference between 2018 and 2019 is seen to be small. Both the actual (51.21 TWh) and adjusted for temperature (51.83 TWh) consumption for 2018 differ only slightly, i.e by less than 1% from that of 2019 (51.68 TWh). This is to be compared to the actual (48.77 TWh) and adjusted (48.91 TWh) consumption for 2020 which is more than 5.5% below 2019. It should be noted that these figures refer to the mainland grid which does not include Crete and the majority of the rest Aegean islands.

The overall effect then of the COVID-19 measures and consumer behavior in mainland Greece is also shown in Figure 4.5 and can be assessed on a yearly basis at ca. 5% (2.87 TWh) on adjusted consumption. This though is not evenly distributed between the two lockdown periods. In the first lockdown period (14 March to 4 May – 51 days) the difference between electricity consumption between 2020 and 2019 was 684GWh and in the second (7 November to 31 December – 54 days) was only 62GWh even though the two periods are of the same duration (51 vs 54 days until 31 December). This seems to be caused by the difference of general population conduct during the two periods, with that of the first being much more restrained abetted by a reduction of the Government guidelines for teleworking from 80% in the first lockdown as opposed to 50% in the second.

The impact of the pandemic is also noticeable in the consumption of the high voltage customers who are large industrial installations. The high voltage consumption represents ca 15% of the total demand and is not affected by variations of temperature, and consequently provides a good estimate of the lockdown effect on the activity of the industry sector. Whereas the mean monthly difference between 2018 and 2019 is less than 8% with the exemption of July which reaches 12.3% peak (see Figure 4.6), the monthly differences between 2020 and 2019 are much higher, with that for March exceeding 12% and reaching 30% in April, after which time they gradually decrease going below 10% after July and remaining at that lower level (similar to the 2018-2019 one) during the months of the second lockdown in November and December.

This pattern of year-to-year monthly differences is the same with that of the overall demand but with the decrease of the latter in April and May only reaching 13% and 12% respectively, i.e., three times smaller than that of the high voltage consumption.

It is of interest to also examine the effect of the pandemic on the islands of the Aegean including Crete which are not connected to the mainland grid and local demand is met by oil fired stations and RES installations. The electricity consumption of Crete and the rest of the Aegean islands is given in Figures 4.7a and 4.7b respectively.

Here the effect of the pandemic is much clearer. As travel embargoes were imposed both for domestic and international travel, electricity consumption started dropping in view of the strong dependence of the economy on tourism (GVA for the NACE sector of Wholesale and retail Trade and Accommodation and Food Services for Crete making up 35% of total,

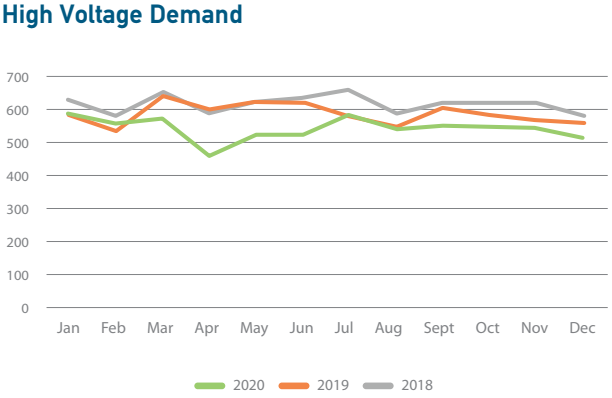


*Figure 4.6: Monthly amounts of electricity demand of the high voltage customers for 2018, 2019 and 2020 (GWh).*

**Consumption in Crete**

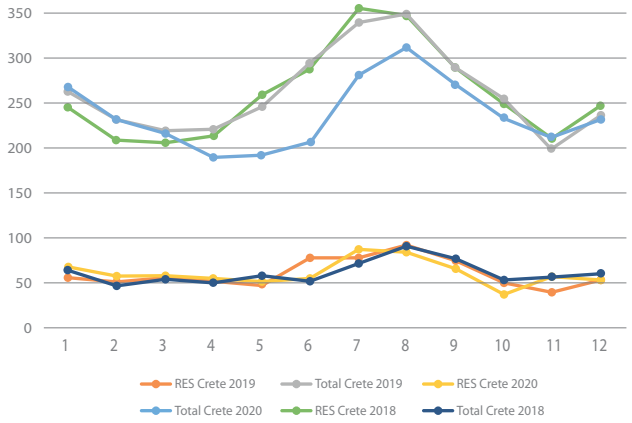


*Figure 4.7a: Monthly amounts of total electricity consumption in Crete and generation from RES installations for 2018, 2019 and 2020 (GWh).*

**Consumption in the Aegean Islands (minus Crete)**

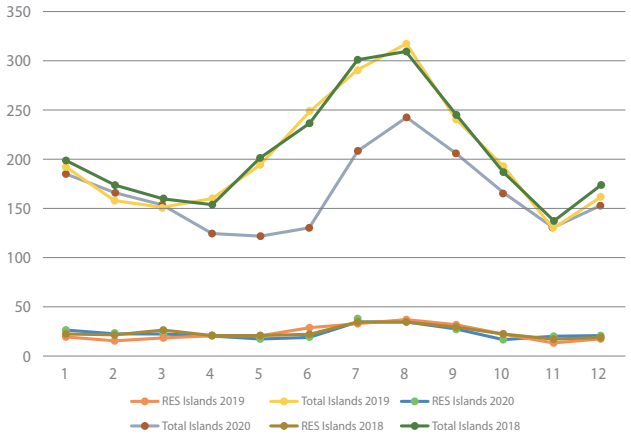


*Figure 4.7b: Monthly amounts of total electricity generation by all stations in the Aegean islands (excluding Crete) and those from RES installations for 2018, 2019 and 2020 (GWh).*

**Table 4.1: International arrivals by Air**

| | GR Total | | Crete | | Cyclades & Dodecanese Islands | |
|---|---|---|---|---|---|---|
| | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 |
| January | 407256 | 376113 | 3272 | 3203 | 0 | 84 |
| February | 367378 | 358381 | 10305 | 8085 | 270 | 118 |
| March | 279129 | 495734 | 5294 | 12245 | 120 | 957 |
| April | 5484 | 1232328 | 1740 | 256745 | 240 | 180251 |
| May | 14273 | 2362236 | 7820 | 554710 | 425 | 551337 |
| June | 86701 | 3225611 | 11000 | 746271 | 7600 | 811808 |
| July | 1122955 | 3881988 | 264439 | 870762 | 237112 | 984972 |
| August | 1662668 | 3835581 | 394194 | 856378 | 429018 | 979156 |
| September | 1090627 | 3063811 | 259072 | 717169 | 299830 | 745581 |
| October | 732195 | 1681571 | 163264 | 394626 | 219960 | 359614 |
| November | 73117 | 531117 | 4670 | 18556 | 3009 | 866 |
| December | 88744 | 451843 | 350 | 4907 | 51 | 7 |
| **Total** | **5930527** | **21496314** | **1099842** | **4420194** | **1197635** | **4614751** |

with the Cyclades and Dodecanese islands reaching as high as 48% (vs 25% for Greece as a whole).

As seen in both Figures 4.7a and 4.7b, consumption in 2018 and 2019 is almost identical. In 2020 on the other hand, a clear deviation starts already in April and persists till September with its maximum in June decreasing from July on as travel restrictions were gradually lifted. After the August tourism peak, the difference decreases to almost zero in November and remains so also in December. The pattern is the same in both Crete and the rest of the islands.

The pattern follows that in general tourist indices (Insete, 2020) such as international arrivals (see Table 4.1), where starting from March with the lockdown in effect for half of its days the arrivals drop to almost zero. The arrivals started increasing then but never reached more than 50% of those of 2019.

Focusing on the months of November and December, for which tourist arrivals in Crete and the Islands are very few, again the difference is almost zero which is in agreement with the minimal difference in the second lockdown, reenforcing the conclusion, a relaxation of guidelines for teleworking notwithstanding, that the population has adapted its activity so as to circumvent the administrative restrictions.

The very low electricity demand starting in March significantly affected electricity prices driving them downwards. In Figure 4.8, the weekly average Marginal Clearing Price (MCP) is shown for the years 2019 and 2020. Even though MCP is

### Marginal Clearing Price

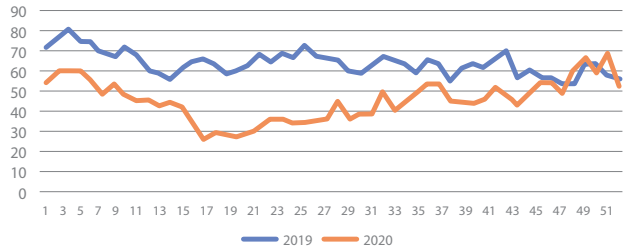


*Figure 4.8: Weekly Marginal Clearing Prices in 2019 and 2020 (in €/MWh).*

### NG consumption excluding electricity & heavy industry

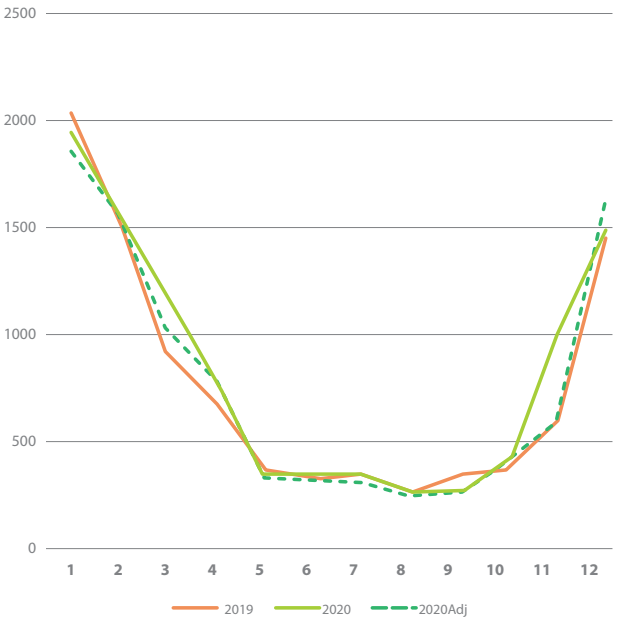


*Figure 4.9: Monthly amounts of NG consumption excluding those for electricity production and heavy industry (in GWh).*

a function of many variables including those of imports from neighboring countries, RES production, NG prices and even ETS allowance prices on a longer timeframe, the sharp drop after week #12 (16-23 March) is primarily due to the lockdown demand decrease although high generation of RES units and the decreased variable cost of the CCGT units because of the low prices of LNG in the terminal of Revithoussa, also contributed. It must be stressed that the average MCP of April 2020 is the lowest average MCP of the last four years, while also a number of hours of zero MCP occurred due to long periods of high wind generation. The difference in MCP between 2020 and 2019 is seen to follow that of both overall and high voltage industrial demand. As a side effect, in week #19 (4-10 May 2020) and #21 (25-31May) there was no lignite production notified in the day-ahead market of electricity, and on 8 June 2020 there was zero lignite production, a first since 1953 when the first lignite power plant went online in Greece. For the year, lignite production was down by 45% compared to 2019, reaching only 5713GWh.

Natural gas consumption was also affected by the pandemic. The majority (more than 60%) of the NG volumes is utilized for electricity production, yet the penetration of NG in the residential and tertiary sector is increasing as connections to the NG low pressure grid increase with an annual rate of the order of 4-5%. In Figure 4.9, the monthly consumption of NG for industrial and residential use excluding amounts used for electricity production with and without adjustment for temperature as described in the previous sector, is presented. Unlike electricity, consumption, both actual and adjusted, is higher in 2020 than in 2019 for the whole 10 months dropping below only slightly in the last two months of November and December. The differences in NG consumption between 2019 and 2020 during the lockdown months of April, November and December although present cannot be attributed with some degree of confidence to the measures and changes in behavior. The noticeable drop in May takes place after the lockdown was lifted on 4 May. The increase in actual consumption in November is most likely due to temperature differential as evidenced by the much lower adjusted value.

In Figure 4.10, the consumption of oil products in the inland transport sector is shown. As in the electricity consumption, a significant drop in the consumption of oil products in the transport sector is observed in the lockdown months of March-April with a gradual return to pre-COVID levels in May and June, after which time the difference decreased. Specifically, for the road transport, whereas the difference of consumption in the months of the lockdown between 2018 and 2019 is less than 3%, an overall 21% reduction was observed in 2020 for the month of March half of which the lockdown was in effect and a 37% reduction in the month of April. This difference then decreased to 20% in May, 10% in June and returned to pre-COVID levels in July. The imposition of the second lockdown on 7 November also had a noticeable effect on road gasoline and diesel consumption although less pronounced than the Spring one. The yearly reduction in all road transport fuels in 2020 compared to 2019 was ca 13% corresponding to 667ktoe.[9] This pattern is confirmed by the data published[10] by the Region of Attica Traffic Control Center on 24 December 2020 which showed that the traffic in the Athens basin was 49.5% less in March 2020 compared to March of 2019 while for

9 On the basis of preliminary data

10 http://www.patt.gov.gr/site/index.php?option=com_content&view=article&id=37992:kata-37-5-afksimeni-i-kykloforia-stis-kentrikes-odikes-artiries-tis-attikis-metaksy-tou-protou-kai-deyterou-lockdown-kai-molis-15-4-meiomeni-se-sygkrisi-me-to-proigoymeno-etos&catid=3&Itemid=709

the November-December 2nd lockdown period the reduction was only 15.4% compared with the same period in 2019.

Also shown, in Figure 4.11, is the consumption of diesel and LPG mostly for heating in the residential, tertiary and light industry, both as reported and as adjusted for temperature effects which are pronounced in the November to February of 2018-2019 in line with the HDD variation shown in Figure 4.3.

Here the opposite pattern to that of the transport consumption is seen with a large increase in the months of the first lockdown reaching over 100% in its peak in April. This though is partially due to the collapse of the oil prices (a drop of 15% in the Transport CPI between February and May which has not returned to the pre-COVID levels) in that period with the retail price of the heating oil reduced by almost 30% leading to off-season record sales, meant to be used in the next winter season. On a yearly basis, the increase in heating oil consumption, adjusted for temperature, in 2020 compared to 2019 was ca 12%, that is 188ktoe, which is to be compared with the difference between 2018 and 2019 which was less than 1%.

There is a significant effect in the internal navigation and domestic aviation sectors. Both have been affected by the lockdown prohibition of travel as flights and sailings have been reduced. Both of these means of transport are obligated to provide service despite reduced passenger and cargo loads especially in the islands. As no detailed data are currently available proxies have to be utilized. For domestic aviation, the ratio of the number of flights between 2020 and 2019 (58%) has been used to adjust 2019 consumption to reflect 2020 fuel (jet kerosene and gasoline) use. For navigation, similarly the reduction of vehicles and passengers transported in 2020 (17.2% and 37.1% respectively for the main harbor of Piraeus[11]) was taken as the proxy with an overall coefficient taken to be 25% in view of the fact that especially in the lockdown months commercial vehicles continued to be ferried at a higher rate than passengers).

**Road Consumption**

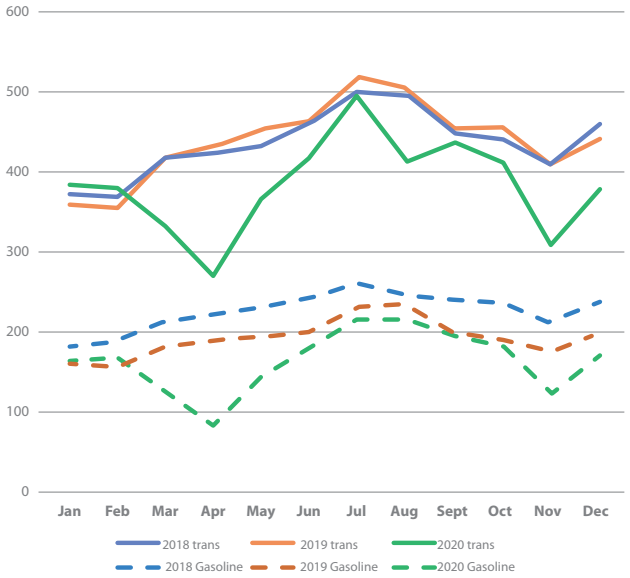


*Figure 4.10: Comparison of road total fuel consumption and gasoline (in ktoe) for the years 2018 (blue), 2019 (red) and 2020 (Green) - provisional data.*

**Oil in Residential/tertiary & Industry**

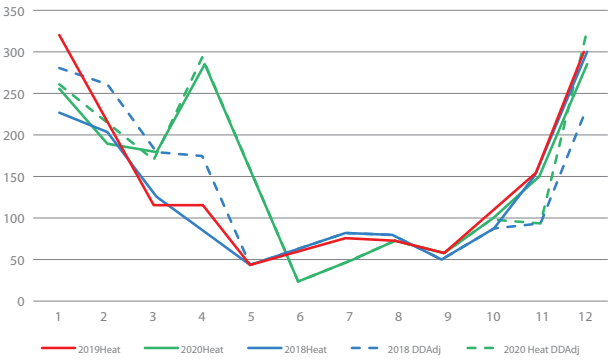


*Figure 4.11: Comparison of oil consumption, actual and adjusted for temperature variation, (ktoe) in the residential, tertiary, and industrial sectors for the years 2018, 2019 and 2020 (2020 provisional data).*

11 http://www.olp.gr/el/investor-information/annual-reports

# 5. The effect of COVID measures on GHG emissions

### 5.1 The Greek GHG emissions the profile

GHG emissions in Greece starting from the 1990 FCCC base year rose till 2005, a base year for a number of EU targets, and have been declining since. In Table 5-1 the evolution of the emissions taken from the latest submission[12] (April 2020) of Greece to UNFCCC is provided.

Total emissions are seen to increase gradually from 103.3 $MtCO_2eq$ in 1990 to a maximum of 136.5 $MtCO_2eq$ in 2005 and to decrease to a minimum of 91.9 $MtCO_2eq$ in 2016 at which level they remain till 2018.

The energy sector, which in UNFCCC Inventories includes energy related emissions of the transport, as well as of the industry and residential/tertiary sectors, accounts for close to three quarters of the emissions with its share ranging from ca 75% in the 1990-2000 decade up to ca 80% in the 2004-2013 period with a gradual return to ca 73-74% in the last five years. Of the other three sectors in the Inventory, waste emissions have remained virtually unchanged at about 4.7 $MtCO_2eq$, as have those of the agriculture sector at about 7.7 to 7.9 $MtCO_2eq$. Finally, the Industrial Processes and Product Use (IPPU) sector exhibits a trend similar to the overall emissions increasing from about 11 $MtCO_2eq$ in 1990 to a maximum of 16.4 $MtCO_2eq$ by 1999 and declining back to 11-12 $MtCO_2eq$ in the last ten years till 2019. It is thus worth focusing in the energy sector emissions in view of their major contribution and their volatility.

In the IPCC energy sector, the energy industries subsector (electricity generation and refineries) which comprises mostly the electricity generation activity is seen (see Table 5.2) to account for more than 50% in the 2000-2010 period and about 47% in 2011 down to 42% in 2018, of total energy sector emissions. The reduction from 55.01 $MtCO_2eq$ to 38.89 $MtCO_2eq$ is almost entirely due to the electricity emissions reduction as evidenced from the fact that of the 38.9 $MtCO_2eq$ emissions of the energy industries sector in 2018, fully 33.5 $MtCO_2eq$ are the result of electricity generation, to which one should add an additional ca 0.9 $MtCO_2eq$ coming from fugitive emissions (mostly $CH_4$) at the lignite mines.

A more detailed look of electricity sector emissions is provided by the latest (April 2020) EU ETS verified emissions presented in Table 5.3 in which the 2020 values have been estimated using the latest available (2019) emission factors.

After the contraction in electricity emissions due to the 2010-2014 crisis, the precipitous drop in 2016 which was the year with the lowest GVA of the last 10 years (see Table 2.1 above), is due also to the almost doubling of the electricity produced by NG that was caused by the very large drop in NG prices, accompanied with a similar decrease of lignite production. As the economy started recovering starting in 2017, in the second half of 2018 the ETS allowance prices started increasing (see Figure 5.1) from ca €5/EUA in 2016-17 to €8/EUA in the end of 2018 and continued to climb to ca €22/EUA in 2019 reaching €28-30 in 2020 with a sharp drop in April/May down to ca €16/EUA from ca €25/EUA in January/February 2020 and on to ca €30/EUA by the end of 2020. The negative spikes seen in 2020 correspond to the first and second waves of the pandemic, which were of limited extend and with quick recovery.

At the same time NG prices also went from ca €25/MWh in 2017 and 2018 to over €30/MWh in 2019 which was followed by a large drop down to ca €22/MWh in all 2020. The high UA price led to a 25% drop of lignite production in 2019 which combined by even higher EUA prices in 2020 and NG prices dropping by 25% to ca €22/MWh led to halving of the emissions from lignite generation in 2020 and a further increase

12 https://unfccc.int/ghg-inventories-annex-i-parties/2020

**Table 5.1: GHG Emissions by sector (IPCC Inventory)**

| (ktCO2eq) | 1990 | 1995 | 2000 | 2005 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Energy | 77026 | 81091 | 96797 | 107297 | 93155 | 92036 | 88304 | 77926 | 74491 | 71190 | 66966 | 70259 | 67307 | 61224 |
| IPPU | 11277 | 13603 | 15193 | 15432 | 11760 | 10424 | 11245 | 11966 | 12328 | 11995 | 12503 | 12794 | 12387 | 11668 |
| Agriculture | 10140 | 9488 | 9147 | 8959 | 8839 | 8596 | 8405 | 8405 | 7990 | 7846 | 7856 | 7888 | 7781 | 7714 |
| Waste | 4864 | 5151 | 5356 | 4758 | 4769 | 4537 | 4409 | 4409 | 4468 | 4451 | 4515 | 4646 | 4746 | 5001 |
| Total | 103309 | 109332 | 126492 | 136446 | 118522 | 115593 | 112323 | 102705 | 99277 | 95482 | 91840 | 95586 | 92222 | 85607 |
| LULUCF | -2107 | -2872 | -1941 | -3301 | -3043 | -3131 | -3086 | -1582 | -126 | -3719 | -3473 | -3209 | -2978 | -3300 |

NB1: IPPU includes industrial processes and products use including use of PFC, HFC and SF6.

NB2: 2019 data provisional.

| Table 5.2: Energy Sector (IPCC) Emissions | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO2eq (Mton)** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** |
| Energy Industries | 55,01 | 55,76 | 50,28 | 46,79 | 41,70 | 41,70 | 37,57 | 40,58 | 38,89 | 31,97 |
| of which electricity | 42,23 | 44,78 | 46,53 | 41,69 | 38,80 | 36,57 | 32,22 | 35,81 | 33,53 | 27,32 |
| Industry | 4,98 | 5,52 | 5,28 | 5,46 | 5,24 | 5,24 | 5,35 | 5,78 | 5,11 | 4,62 |
| Transport | 20,06 | 16,69 | 16,52 | 16,50 | 17,05 | 17,05 | 17,38 | 17,18 | 17,40 | 17,81 |
| Other sectors | 11,21 | 19,58 | 5,17 | 5,08 | 6,49 | 6,63 | 6,13 | 6,13 | 5,43 | 5,93 |
| Others | 1,24 | 1,31 | 1,18 | 1,13 | 1,02 | 1,02 | 0,77 | 0,84 | 0,76 | 0,89 |
| Total | 92,50 | 98,86 | 78,44 | 74,96 | 71,49 | 71,63 | 67,20 | 70,51 | 67,59 | 61,22 |

| Table 5.3: Electicity Verfied Emissions | | | | | | | |
|---|---|---|---|---|---|---|---|
| **(tCO2eq)** | **2010** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020 (Estimated)** |
| Lignite | 35.615.245 | 29.404.777 | 23.127.444 | 25.592.109 | 24.141.421 | 17.458.805 | 9.574.021 |
| NG | 2.949.333 | 3.684.139 | 5.585.659 | 6.553.222 | 6.012.912 | 6.720.643 | 7.536.082 |
| Oil | 3.661.240 | 3.484.773 | 3.502.571 | 3.660.999 | 3.373.380 | 3.430.795 | 2.864.105 |
| Total - Electricity | 42.225.818 | 36.573.689 | 32.215.674 | 35.806.330 | 33.527.713 | 27.610.243 | 19.974.208 |
| Total - ETS | 54.924.268 | 49.886.664 | 46.309.794 | 49.262.141 | 47.105.456 | 40.475.982 | N/A |
| Total - National | 118.436.490 | 95.330.370 | 91.697.730 | 95.420.780 | 92.221.660 | 85.607.105 | N/A |

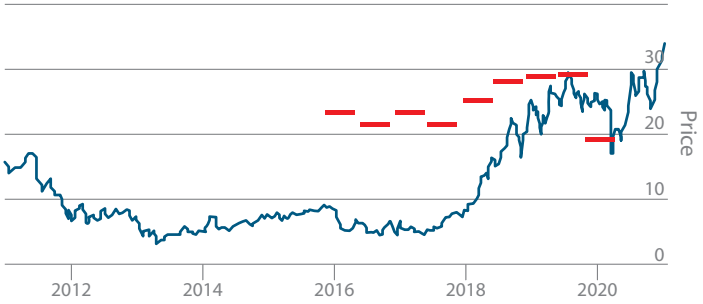


*Figure 5.1: EU ETS weekly allowance prices (€/EUA)[1] and NG semester average non-household consumers prices (€/MWh) indicated by bars*

1 https://ember-climate.org/data/carbon-price-viewer/

of NG generation. It should be pointed out that the emissions from oil powered plants which cover exclusively the demand in the Aegean islands remains virtually constant from 2010 to 2019 and drops by ca 17% in 2020.

Whereas the electricity sector emissions dropped by over ca 35% in the last 10 years, those of the second larger contributor to emissions, the transport sector, have decreased much less (ca 15%). The major reduction has taken place in the 2011-2012 period of the crest of the economic crisis and the emissions have remained at the same level of about 17 $MtCO_2eq$ as the renewal of the fleet with less polluting vehicles remained very small.

A similarly large decrease of emissions in 2012-2013 is also seen in the Other Sectors category which includes direct energy use in the residential and tertiary and agriculture sectors again reflecting the economic stress especially in households which resulted in reduction of the energy (mainly for heating) expenditures.

### 5.2 COVID-19 effect on emissions

The effect of lockdown reduces economic activity and affects the behavior of the population as mobility is constrained by decree or by choice. In this analysis, as discussed in the previous Section 4, the focus is on electricity, heating and transport sectors. These sectors accounted for over 55% of the national emissions in 2018 (latest available).

In the electricity sector, as discussed in Section 4, there is a clear reduction in demand in 2020 of ca 3.53 TWh which is mostly seen during the first lockdown in March-April though it persisted for the rest of the year. How this translates into emissions reduction though is not clear as it depends on the generation mix and net import amounts which are affected only tangentially by the lockdown through fuel and EUA prices. In Table 5.3, the estimated 2020 emissions from electricity production are presented which were computed from the actual production with the use of the 2019 emission factors for lignite, NG and oil (1.675$tCO_2eq$/MWh, 0.414$tCO_2eq$/MWh and

| Table 5.4: Road transport emissions (ktCO2) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | Year | % |
| **2020** | 1121 | 1109 | 957 | 787 | 1066 | 1216 | 1449 | 1202 | 1272 | 1199 | 893 | 1100 | 13370 | 0,87 |
| **2019** | 1045 | 1034 | 1216 | 1257 | 1317 | 1352 | 1510 | 1471 | 1327 | 1327 | 1188 | 1285 | 15327 | 1,00 |
| **2018** | 1082 | 1070 | 1219 | 1234 | 1269 | 1351 | 1461 | 1442 | 1312 | 1281 | 1181 | 1339 | 15241 | 0,99 |

NB: Dec 2020 Provisional estimates

0.748t$CO_2$eq/MWh respectively).

If the difference in electricity consumption between 2019 and 2020 (corrected for temperature) of 2.76 TWh is taken as a measure of the COVID-19 impact on mainland electricity emissions and the same ratio of lignite and NG production to total consumption per month is utilized, the resulting drop in emissions is estimated at 0,77Mt$CO_2$eq. A fairer estimate of the effect on emissions should instead be made assuming the percentages of lignite and NG to total generation of 2019 are applicable also in 2020 to account for the fact that the lignite production in 2020 was halved, not because of the pandemic but because of the high cost of EUAs and the low cost of NG. This would lead to total emissions reductions in the mainland grid of 1,243 Mt$CO_2$eq.

In the Aegean islands where there are no electricity imports and all emissions come from oil combustion and, as seen in Figures 4.7a and b, the production from RES is more or less constant, the difference in consumption would lead to a reduction of oil use of 764 GWh which corresponds to 0.571 Mt$CO_2$eq.

As a result, the total impact of the pandemic is estimated at 1.341 Mt$CO_2$eq (or 1.814 Mt$CO_2$eq with analogous lignite emission contribution). Of that amount ca 1Mt$CO_2$eq can be assigned to reduced tourist activity (double that of emissions attributed to the islands in view of the equal parts of international arrivals reduction in the mainland and the islands seen in Table 4.1).

The lockdown also affected the transportation GHG emissions, as well as other pollutants. In fact, the ground transportation sector's emissions can be very responsive to policy changes and economic shifts. Ground transport accounts for nearly half the decrease in emissions during confinement. A concurrent increase in active travel noticed (walking and cycling, including e-bikes) might help if it is maintained to cut back $CO_2$ emissions and air pollution as confinement is eased (Kissler et al., 2020).

In Table 5.4, the effect of the reduction in road mobility GHG emissions is clearly evidenced. The difference between the emissions in 2020 and 2019 is of the order of 13% as opposed to 1% between 2018 and 2019.

This difference is very pronounced in the months of April and November-December during which the tourist activity is very small and evidently is an indication of the behavior of the native population. There is also a reduction in August, smaller

| Table 5.5: Emissions from Heating Oil and NG in residential, tertiary and industrial sectors (ktCO2) | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Oil** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | **Year** | **%** |
| 2020 | 738 | 547 | 515 | 830 | 451 | 53 | 115 | 200 | 153 | 270 | 435 | 833 | 5140 | 1,11 |
| 2020 Adj | 759 | 622 | 483 | 845 | 451 | 53 | 115 | 200 | 153 | 270 | 255 | 972 | 5179 | 1,12 |
| 2019 | 929 | 629 | 323 | 327 | 117 | 167 | 203 | 210 | 156 | 282 | 448 | 833 | 4624 | 1,00 |
| 2018 | 660 | 585 | 356 | 224 | 125 | 178 | 226 | 215 | 131 | 238 | 462 | 873 | 4272 | 0,92 |
| 2018 Adj | 815 | 751 | 519 | 497 | 125 | 178 | 226 | 215 | 131 | 238 | 268 | 670 | 4632 | 1,00 |
| **NG** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | **Year** | **%** |
| 2020 | 385 | 303 | 231 | 158 | 71 | 67 | 66 | 53 | 57 | 86 | 200 | 293 | 1971 | 1,07 |
| 2020 Adj | 369 | 312 | 205 | 154 | 67 | 63 | 62 | 50 | 53 | 81 | 119 | 327 | 1860 | 1,01 |
| 2019 | 406 | 305 | 183 | 139 | 75 | 68 | 69 | 54 | 67 | 78 | 119 | 288 | 1850 | 1,00 |
| 2018 | NA | NA | NA | NA | NA | NA | NA | 49 | 64 | 81 | 165 | 333 | 691 | 1,14 |
| 2018 Adj | NA | NA | NA | NA | NA | NA | NA | 52 | 67 | 85 | 104 | 277 | 584 | 0,97 |

| Table 5.6: Changes 2020-2019 due to COVID impacts | | | |
|---|---|---|---|
| **Sector** | Energy (GWh) | Emissions (MtCO2) | Emissions (% wrt 2019) |
| **Electricity*** | -3528 | -1,34 | -4,9% |
| Mainland grid | -2764 | -0,77 | -3,2% |
| Islands & Crete | -764 | -0,57 | -16,6% |
| **Transport** | -10286 | -2,69 | -15,1% |
| Road | -7797 | -1,97 | -12,8% |
| Navigation | -1818 | -0,54 | -26,3% |
| Aviation | -671 | -0,17 | -42,0% |
| **Heating & other use*** | 1916 | 0,54 | 8,4% |
| **Total** | -11898 | -3,48 | -6,7% |
| **Total with lignite adjust.** | -12263 | -3,48 | -7,6% |

*Temperature adjusted

than those during the two lockdown periods, which most likely is due to the reduction of tourist activity. The yearly road reduction is 1,969 Mton$CO_2$eq which is ca 2% of total national emissions.

The other transport means, rail, and domestic navigation and aviation have contributed less than 15% of the total transport emissions in the last years, with navigation, domestic aviation and rail contributing ca 11%, 3% and less than 1% respectively. As no detailed data are available for domestic aviation consumption from September to December 2020, taking the reduction in the number of domestic flights (42%) as a proxy, the emissions in 2020 can be estimated to be 0,173 Mton$CO_2$eq (down from 0,403 Mton$CO_2$eq in 2019 provisional Inventory data). Similarly, for internal navigation, in view of the fact that connections to the islands have schedules that are not directly dependent on the number of passengers (who are down ca 37% in 2020 compared to either 2019 or 2018) and extrapolating available data from January to July 2020, a similar percentage reduction of 25% of 2019 emissions (2,177 Mton$CO_2$eq provisional inventory data ) would lead to ca 0.54 Mton$CO_2$eq fewer emissions.

This would result in an overall reduction of emissions in the transport sector of ca 2.688Mton$CO_2$eq.

The effect on emissions from the use of heating oil and NG in the residential and tertiary sectors is shown in Table 5.5. For oil use, an increase is seen, after adjustment for temperature, of the order of 11% in 2020 compared to both 2019 and 2018, with the total amount estimated at 0.544 Mt$CO_2$eq.

In the IPPU FCCC Inventory category, more than half of GHG emissions come from the contribution of F-gases which are not expected to be affected noticeably by the lockdown. The rest, mostly process emissions in the cement and lime industries which supply the construction sector, are expected to be affected by the downturn of the overall economic activity but in particular of tourism whose infrastructure upgrading and enlarging comprised pre-COVID a large percentage of construction but no data ae available at this time for an estimate.

Looking at the other main IPCC categories, no reduction should be expected in the Agriculture and Waste ones as these activities are not directly affected by the lockdown.

In summary, (see Table 5.6), a noticeable reduction in emissions should be expected in 2020 which is estimated at 3.48 Mton$CO_2$eq or 3.95 Mton$CO_2$eq if the lignite electricity had remained at the same percentage of total production of the previous years.

In the short term (ca 2021-2022) a reduction of GHG emissions in Greece from the COVID-19 lingering effects, can be expected, mostly from reduced tourism activity in 2021 in view of the still real concern for infection which though will be much less than in 2020 as a larger part of the population is vaccinated. Past this immediate period, a more permanent decrease may be caused by a change in mobility patterns, as on-line work and use of soft transportation means hopefully increase.

# 6. Some Concluding Remarks

The results presented in the previous Sections 4 and 5 lead to two main conclusions. The first refers to the magnitude of the energy use and emissions reduction and the second to the noticeable difference between the two lockdown periods. Even though as seen in Figure 5.1, all countries have experienced two waves (so far) of the pandemic, the timing of the crests and ebbs is different, and the national responses also differ both as to specific measures taken including the different activities closed by decree, as well as to their duration and rate of the subsequent opening by activity. The structure and strength of each economy also differs from country to country. It is thus important to state that the results presented here, and the conclusions drawn from them, refer to Greece and may not apply directly to other countries.

Starting with the impact of the COVID-19 measures on GHG emissions, one should note that the total reduction is the result of a decrease in the electricity consumption and the road and navigation transport sector emissions and an increase in the use of diesel oil and NG mostly for heating and for other uses in the residential and tertiary sectors. The electricity consumption is lower in the residential sector despite the increase of the use of electric appliances for working at home, accompanied by an even deeper percentage decrease in electricity use in the industrial sector.

The recovery after the first lockdown was lifted, is seen to be, unlike its initiation, gradual. This is to be attributed to the timing of the first lockdown whose lifting coincided with the beginning of the tourist season that itself was severely affected and although it slowly started again it never fully returned to the levels of previous years.

The nature of the second lockdown in November is different and worth analyzing as for these two months at the end of the year the incoming tourism is minimal and so is its effect. In this second lockdown, the electricity consumption in the mainland grid, adjusted for temperature, is seen to be of the same order as those of the previous years. This is more clearly the case in Crete and the rest of the Aegean islands. As tourist activity is negligible in these winter months, the implication is that the general public has adjusted to or partially ignored lockdown measures and returned to pre-COVID behavior. This is not the case for the oil consumption in road transport which is due in part to the restriction of outdoor circulation after 2100h. The drop though is smaller than that of the first lockdown partly due to a decrease of teleworking guidelines from 80% in the first lockdown to 50% in the second and accommodation by the public, but also to circumvention of the measures.

The overall tentative conclusion is that, as the initial strong fear of mortality in the initial stages was ameliorated, the public has found ways to align its behavior with the measures so as to return, to the degree possible, to its previous patterns. This may also reflect the reduced efficacy of the measures due to faulty design or to inadequate policing. In short, the reduction of GHG emissions seen in 2020 caused by measures to address the pandemic, at least in Greece, is not expected to continue in the coming years as no indications of permanent changes in behavior are discernable despite the increase of teleworking. This conclusion is further supported by preliminary data from the extension of the lockdown in the first part of January 2021 which was lifted gradually after the first week of the year with only primary schools opening on 11 January and retail stores opening, with restrictions, on 18 January 2021. According to the Traffic Control Department of the Region of Attica[13], traffic actually increased in January 2021 by 1-5% compared to the same period in 2020. A partial cause of this increase is the reluctance of the public to use the means of mass transit to avoid congestion for fear of contagion and turning instead to private vehicle use. This tentative conclusion that the overall residual effect of COVID measures will be small remains to be confirmed when information from other sectors of activity and covering longer periods as measures are further relaxed, become available.

Luckily, the lockdown measures and the resulting difficulties in the operation of the State agencies did not affect progress in implementing NECP policies beyond some small delays in RES installation and in permitting, as evidenced by the 511MW of wind that were added in 2020 and the continuing interest in investing and participation in RES auctions. Also added in 2020 was enabling legislation voted in 2019 and a substantial increase of funding for energy upgrading of the building stock. Another optimistic note is provided by the fact that the proposed revision of the Greek NECP to bring it in line with the new 55% reduction target will not introduce any difficulty as possible readjustments in the non-ETS sector national target which covers mainly energy conservation in the residential and tertiary sectors and the electrification of the transport sector, are already addressed. To this though one should add measures to change energy use behavior which does not seem to have changed permanently by the pandemic, so as

13 http://www.patt.gov.gr/site/index.php?option=com_content&view=article&id=38338&catid=3&Itemid=709

to improve conservation without affecting comfort (Fotouli et al., 2019).

In case some patterns of behavior, especially regarding energy use in the residential sector and transport activity, seen in the lockdown periods take a permanent form, the revision of the NECP to meet the enhanced targets by 2030 would require the redefinition of baselines. This in turn would call for more detailed data from appropriate surveys including the Household Budget Survey conducted by the Statistical Service.

As hope for a more permanent reduction of energy consumption and its associated emissions that might have resulted from the pandemic experience seems to fade, it becomes even more imperative that attention should be concentrated on ensuring that the measures to support the economy, with those of the EU funds in the forefront, meet strict "green" guidelines. In this respect, of crucial importance is a thorough evaluation of the proposals in the Greek RRF Plan which is now under negotiation with the EC. Unfortunately, the version released publicly did not provide any specific quantitative information to do so. Already, some warning signs have appeared that the use of the EC Taxonomy as a uniform screening tool has been questioned by the Greek Government.

With the advent of the wholesale vaccination, the lifting of the restrictions and the recovery of the economy, the proclaimed effort to reform the economy and increase its competitiveness and added value by developing other sectors of its economy, including primary production and high technology and health services thus reducing its overdependence on tourism, should be carried out with a clear sustainable developmental orientation and focus. This would be greatly facilitated if a wide agreement between the political parties, business and civil society is achieved.

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