



## *Green Revolution: Greece as a renewable energy pioneer*

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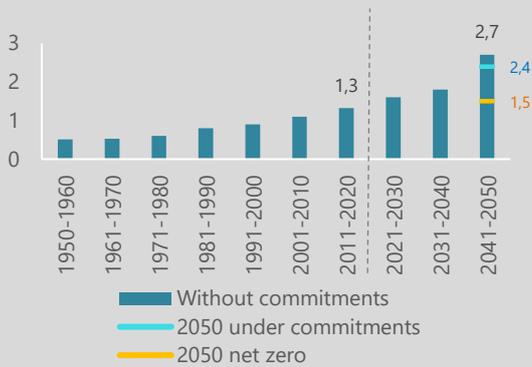
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- As evidenced by the high frequency of extreme weather conditions, climate change is developing much faster than anticipated. Scientists around the world agreed that policies for the reduction of CO<sub>2</sub> emissions need to become stricter, in order to achieve net-zero carbon emissions by 2050 – bringing the energy sector into the spotlight, as it is responsible for about ¾ of carbon emissions.
- The transition to a green energy mix is the main pillar of environmental policies, targeting the gradual phasing out of fossil fuels from the energy mix in order for the RES to cover at least 2/3 of total energy consumption by 2050 (from 12% in 2020). This is a challenging task as it requires significant investments of c. \$4.4 tr annually during 2020-2050, raising the issue of who carries the burden of the transition (developed vs developing countries). At the same time, the recent energy crisis (with skyrocketing prices of natural gas, carbon emission rights and electricity prices) highlighted the importance to balance the trilemma decarbonization-affordability-security of supply.
- The EU is a forerunner in Green Transition, already reducing its CO<sub>2</sub> emissions by 28% over the past 2 decades (vs. a world increase of 38%), while it has recently revised its energy targets with the “Fit for 55” package, aiming to become the first net-zero-emissions continent by 2050. The plan mainly aims at i) higher RES penetration in the electricity mix and ii) higher electrification of the total energy mix (requiring innovative investments).
- In line with EU objectives, Greece has already taken significant steps toward a green electricity mix, with RES accounting for 35% (a share that ranks Greece 8th in the world in terms of wind and PV), while lignite represents 15% of electricity production (from 60% in 2005). However, the high share of the (oil-fueled) transport sector, as well as inefficiencies regarding residential buildings and vehicles, limit the benefits of green electricity to the overall energy mix (with oil covering 54% vs 33% in the EU).
- The energy targets for Greece include RES covering 83% of total electricity in 2050 (from 35% in 2020), as well as a significant increase in the economy’s electrification (43% in 2050, up from 27% in 2020). This requires investments of c. €8.5 bn annually up to 2030 (mainly towards green electricity, networks/storage and energy efficiency) and c. €10.6 bn annually during 2030-2050 (with the focus turning to the transport sector).
- Through the transformation of the global energy sector, Greece has the potential to turn from an energy importer to a green energy hub, benefiting from natural advantages in terms of wind and solar conditions. Recent developments such as the agreement for interconnections with Egypt, the green hydrogen in Ptolemaida, as well as institutional reforms are steps in the right direction. Greece could go the extra mile and stand out as ‘Green Economy’, honoring its moral duty towards next generations, while attracting customers and investors in the process.

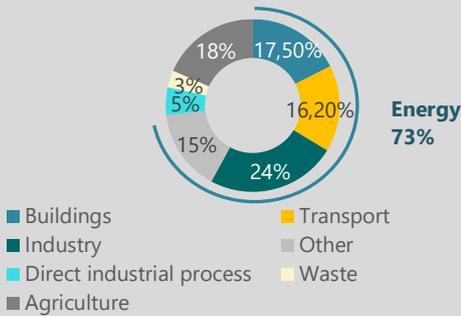
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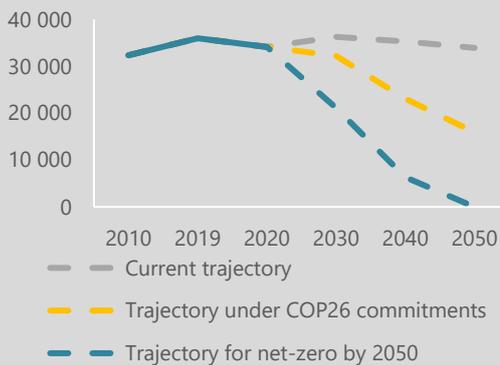
**Scenarios of global temperature change vs the pre-industrial period (°C)**



**GHG emission by sector (Mtoe CO<sub>2</sub>)**



**World CO<sub>2</sub> emission projections (Mtoe CO<sub>2</sub>)**



Sources: IEA, Our World in Data, NBS estimates

## Climate change concerns put the energy sector under the spotlight

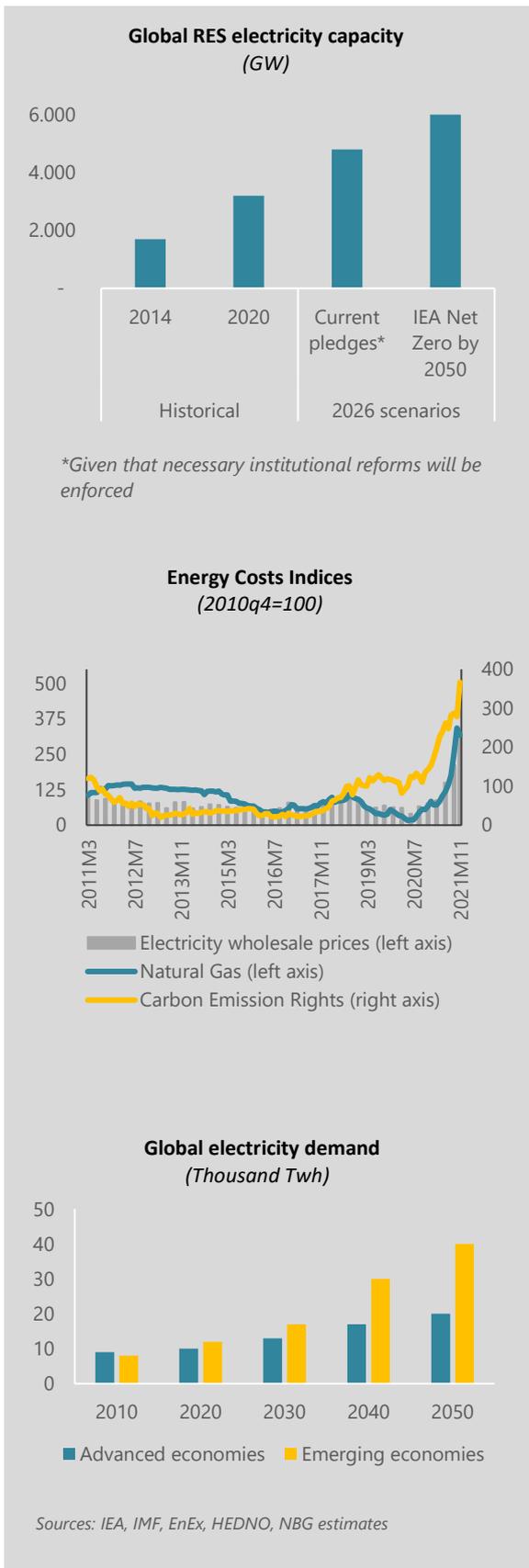
In recent months, amid increasingly violent weather extremes and high-profile conferences and reports, climate change has been thrust into the political spotlight. In particular, signs that climate change progresses much faster than anticipated were evident during the summer, with Europe hitting record high temperatures, extreme heatwaves, deadly floods and wildfires<sup>1</sup>. In fact, scientists have signaled Code Red in the recent landmark report of the UN Intergovernmental Panel on Climate Change (IPCC)<sup>2</sup>, by clearly stating that the current policy structure is not enough to limit the global temperature increase to 1.5 °C (identified as the threshold of keeping climate conditions stable), and that an astonishing sixfold increase in the reduction rate of CO<sub>2</sub> is required to achieve net-zero carbon emissions by 2050. At the recent 26th UN Climate Change Conference of the Parties (COP26), the world leaders have gone a step forward<sup>3</sup> (as it was the first time a 'coal phase-down' has been mentioned). However, with most countries being reluctant to commit to strict short-term targets, the pledges made at COP26 secure less than 1/3 of the reduction in emissions needed by 2030 to keep 1.5°C within reach (while even the most ambitious long-term targets leave a 50% gap by 2050).

Being responsible for ¾ of greenhouse gas emissions, the energy sector has been brought into the spotlight. Currently, coal and oil account for 55% of total energy supply (vs 60% in 2010) and 38% of total electricity production (vs 45% in 2010). While progress has been made, their phasing out must accelerate and renewable energy production must scale up if the net zero goal by 2050 is to be met. Specifically, RES penetration should increase until 2050 both i) in electricity generation (from 28% today to at least 88%) and ii) non-electricity uses such as biofuels and heat (from 5% of total energy today to 19%). Therefore, the share of RES in total energy supply is

<sup>1</sup> Greece in particular suffered by wildfires that were more than 6 times larger than the average in terms of area destroyed

<sup>2</sup> "It is a statement of fact, we cannot be any more certain; it is unequivocal and indisputable that humans are warming the planet."

<sup>3</sup> the reversal of deforestations was agreed, and the pledge of carbon neutral economies goals was renewed - Complimenting EU Green Deal to achieve net zero GHG emissions by 2050, the US and China have also agreed to achieving a net zero economy by 2050 and 2060 respectively.



expected to increase from 12% today to at least 2/3 in 2050. Focusing on the electricity sector, RES electricity capacity is planned to increase by 60% until 2026 (from c. 3,000 GW to more than 4,800 GW), with similar growth (+56%) expected in electricity storage<sup>4</sup> capacity (from c. 175 GW to 270 GW by 2026), due to the increasing need for system flexibility and storage to fully utilize and integrate larger shares of variable renewable energy into power systems. About 80% of the capacity increase is expected to come from 4 markets, with China leading with 43%, followed by Europe, US and India. Note that while the pace is accelerating, the current global plans still fall short as the projected RES capacity covers less than 2/3 of investments necessary<sup>5</sup> to reach the net-zero goal in 2050.

During this phase of “greening” the energy mix, natural gas is expected to serve as a transition fuel as it is both less pollutive than oil and coal and of more reliable production than renewables. Currently natural gas accounts for 24% of total energy supply and 23% of electricity production and is expected to play a significant role in both up to 2040.

In the path to net-zero emissions by 2050, apart from a “greener” energy mix (electricity and non-electricity), there are global targets for lower energy intensity (-35% by 2030) through energy efficient activities (transport, industry and buildings), electrification and behavioral change (switching transport modes, recycling).

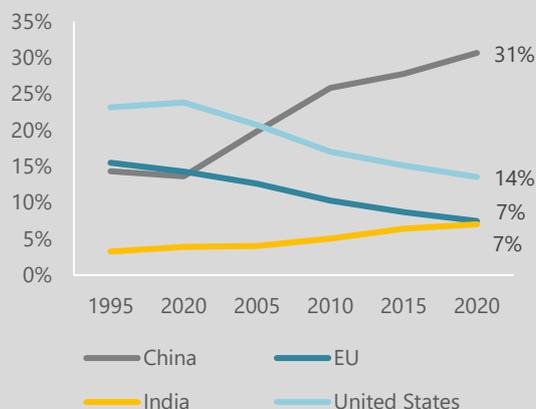
Transitioning to a green economy is, however, a multidimensional puzzle, creating several policy dilemmas:

- First and foremost, the recent energy crisis highlighted the importance of the balance between decarbonization, affordability and security. Specifically, the necessity to accelerate the transformation of the total energy mix, reduced the degree of diversification of the electricity production mix, which caused electricity wholesale prices to be heavily affected by fluctuations

<sup>4</sup> Note that energy efficient buildings and electric vehicles (acting as batteries) are also expected to support storage flexibility needs.

<sup>5</sup> Note that while there is a gap of about 40% in terms of electricity investment needs during the next decade (vs the targeted 2026 level to reach net-zero emissions by 2050), the respective gap in terms of CO<sub>2</sub> emissions is about 70% during the same period, implying that the electricity sector is moving relatively faster (but still not fast enough).

**GHG emission by country**  
(Mtoe CO<sub>2</sub>, % of global CO<sub>2</sub>)



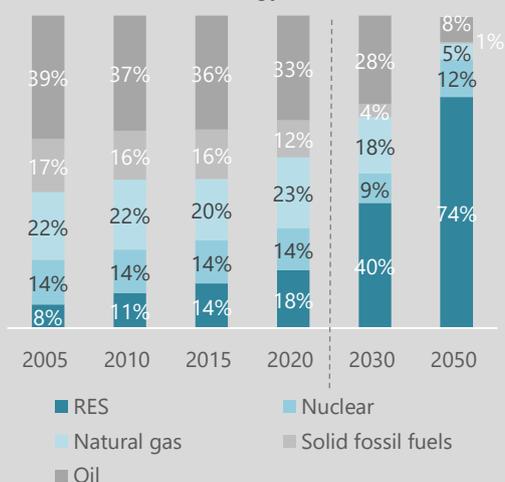
**EU Green New Deal Targets**

EU Green Deal			
	GHG emissions (vs. 1990)	RES in energy mix (%)	Energy efficiency improvement
2030	-55%	40%	35-40%
2050	-100%*	74%	41%-50%**

\*Emission will not be zero, but net zero, meaning that any CO<sub>2</sub> emissions will be offset by natural means and carbon capturing technologies

\*\* Long-term strategy scenarios range

**EU energy mix**



Sources: Our World in data, European Commission, NTUA, NBG estimates

in natural gas prices (natural gas' price correlation with electricity wholesale price in EU rose from 29% during 2010-2015 to 97% during 2019-2021). This, along with other exogenous events such as the pandemic and other geopolitical factors led to a short-term energy crisis at end of last summer as both natural gas prices and CO<sub>2</sub> emission rights prices skyrocketed, by 360% and 550% respectively (compared to their pre-pandemic 5-year average), thus fueling an increase in wholesale electricity prices by 360% (over the same period). So, the transition must not interrupt the supply of affordable energy towards business and households as it would both risk public support of green policies and undermine economic growth prospects.

- Moreover, as no country is able to prevent climate change on its own, a high degree of international cooperation is needed. Developed economies were those who benefited the most from cheap thermal energy over the last century, but emerging economies are projected to increase their electricity demand by 120% until 2050, thus raising the question of how the transition cost should be borne. To that end, developed economies during the recent COP26 summit agreed to provide annual funding to emerging economies reaching \$100bn by 2023, a commitment initially made during the COP25 (Paris Agreement), but was only partially honored.

### EU is a forerunner in Green Transition

EU aspires to be the first net-zero continent and has already reduced its CO<sub>2</sub> emissions by 28% over the last twenty years (vs. a world increase of 38%). Towards that end, renewable's share in EU's overall energy mix increased to 18% (from 8% in 2005) to compensate for the fossil fuel's share reduction, which, however, still remains significant (45% vs 55% in 2005). Nuclear energy and natural gas complement the energy mix with a share of 23% and 14% respectively (largely unchanged compared to 2005). When focusing on the electricity mix (accounting for 22% of total EU energy consumption, from 21% in 2005), renewables have a dominant role



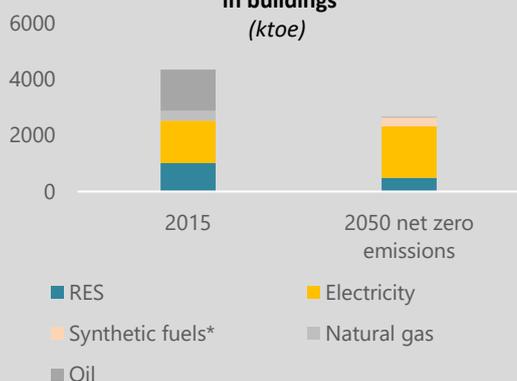
**Greece: National Environment Plan  
Targets  
(2030 and 2050 targets)**

**Greek Energy and Climate Strategy**

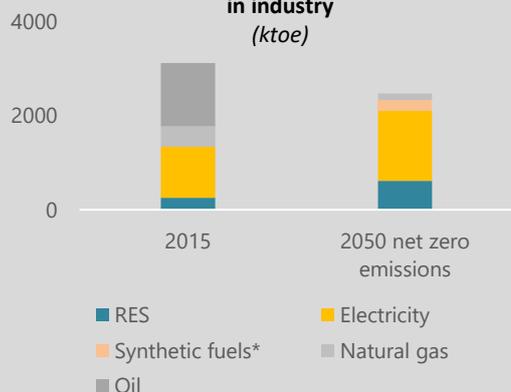
	GHG emissions (vs. 1990)	% RES in energy mix	Dependency on energy imports
2030	-55%	50%	70%
2050	-100%*	86%	30%

\*Emission will not be zero, but net zero, meaning that any CO<sub>2</sub> emissions will be offset by natural means and carbon capturing technologies

**Greece final consumption in buildings (ktoe)**



**Greece final consumption in industry (ktoe)**



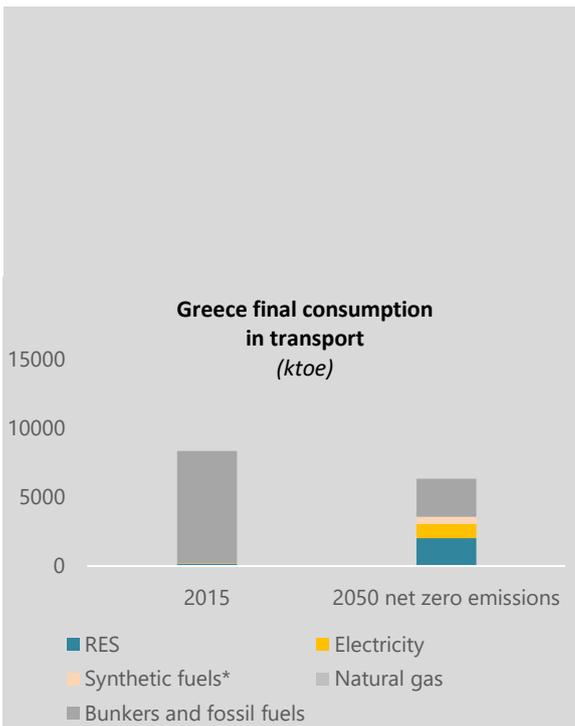
\*Synthetic fuels account for indirect electricity consumption due to their production process

Sources: Hellenic Ministry of Environment and Energy, NBG estimates

➤ The second phase of the green transition strategy extends from 2030 to 2050. Given the fact that this second phase extends far into the future, its roadmap is based on a mix of scenarios, each of which expects some degree of energy innovation. However, the overall strategy focuses on the electrification of the end use consumption such as climate neutral buildings and vehicles based on electricity either directly (electric cars) or indirectly (cars, airplanes and ships running on hydrogen or synthetic fuels, which are of zero GHG emissions). The degree to which the energy consumption mix is electrified is expected to be about 50%, depending on the development of RES electricity storage technologies to smooth intermittent production, and the successful utilization of efficiently produced green hydrogen (hydrogen produced through water electrolysis, using electricity from RES) and its subsequent synthetic fuels. Note that hydrogen innovation can be a game-changer during that period as the synthetic fuels derived by it can be compatible with current technology internal combustion engines, thus greatly reducing transition costs. Moreover, it can also aid in electricity storage in the form of cells, allowing electricity production to be heavily dependent on renewables (whose electricity output is variable). As a result, zero emission sources (renewable and nuclear) are estimated to account for the majority of both overall energy production (up to 86%) and electricity (up to 92%).

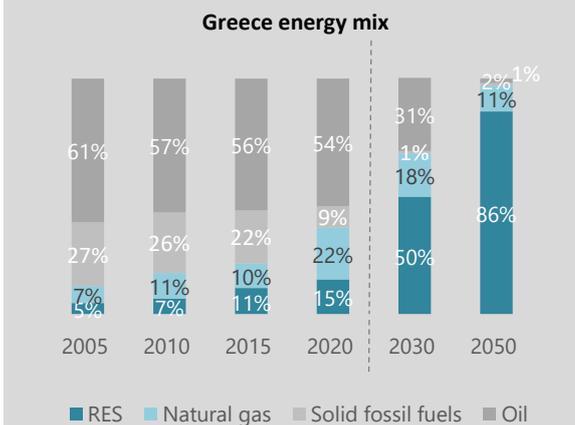
**The road towards a green Greece**

Greece, along with the rest Southern Mediterranean countries, is particularly vulnerable to climate change, with last summer's heatwaves and fires (6 times worse than the annual average in terms of area destroyed) being a highlight of that threat. It is estimated that the majority of enterprises are exposed to high physical risk (floods, wildfires), while economic losses due to climate change could be over 10% of GDP per capita by 2100 (Fitch estimates), calling for imminent action.



\*Synthetic fuels account for indirect electricity consumption due to their production process

Being in line with EU’s green transition priorities, Greece transforms its energy sector at an accelerating pace as electricity production is currently based on renewable energy sources (35%<sup>7</sup> - a share that ranks Greece 8th in the world) and natural gas (42%), with lignite representing only 15% of electricity production<sup>8</sup>. However, the benefits from a clean electricity mix are not passed through to the overall energy mix, as electricity accounts for 27% of the total energy consumption. Furthermore, Greece depends heavily on maritime transport, for which there are not green substitutes (transport accounts for 40% of total energy consumption vs 31% in EU). Other inefficiencies in the end consumption sectors concern the energy inefficient building stock (65% of which is classified as E-H energy class) and the old passenger vehicle fleet (with an average age of 20 years vs. 12 years in EU). As a result, fossil fuels account for 63% of overall energy consumption, with renewables being limited to 15% (vs. 18% on average in the EU).



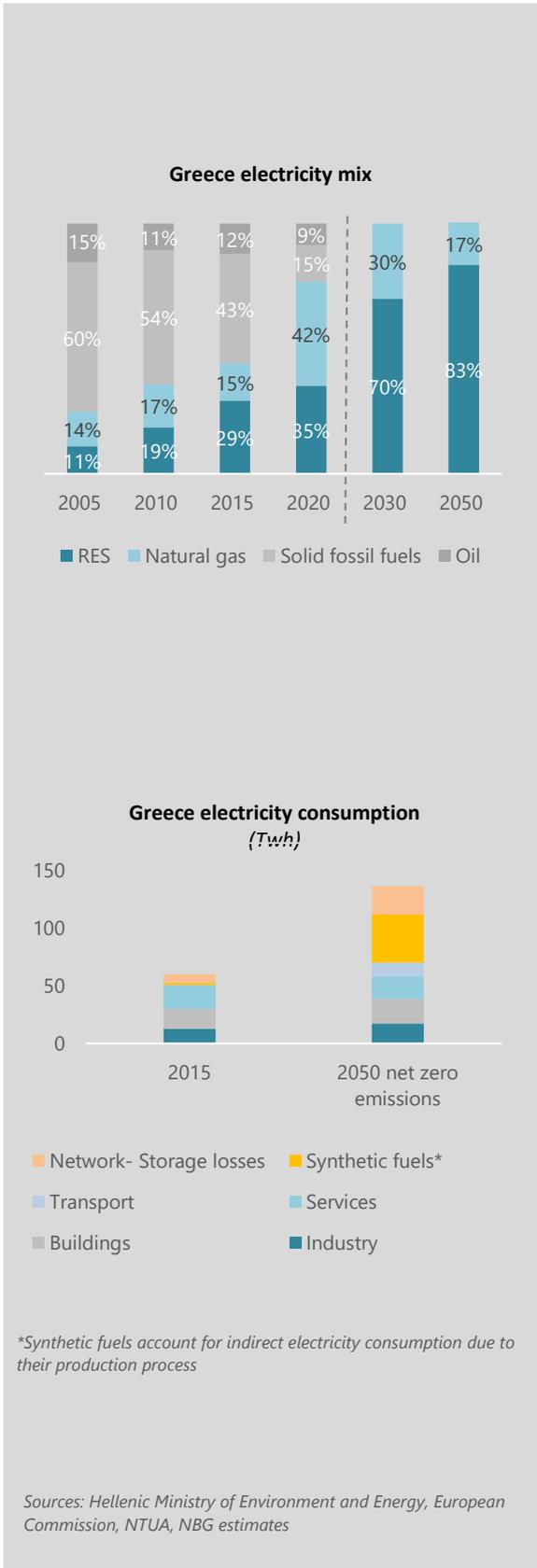
Sources: Hellenic Ministry of Environment and Energy, European Commission, NTUA, NBG estimates

Following the same two-step approach set in the Green Deal, Greece expects to complete the first phase ahead of the EU schedule, before moving on to implement the more demanding second phase of electrifying energy consumption. Anticipating the official announcement of the new national energy and climate plan, it is estimated that:

- By 2030 Greece’s electricity will be either produced from renewable sources (70%) or natural gas (30%). Lignite is expected to phase out no later than 2028. By 2030 oil will also be removed from the country’s electricity mix as islands will either get connected to mainland’s grid or rely on 100% renewable energy through the “GR-eco islands” initiative. However, due to inefficiencies mentioned above, the improvement in the electricity mix will only bring limited improvement in the overall energy mix as fossil fuels will still account for 32% (vs. the current 63%). Renewables will account for 50% (vs. the current 15%) of

<sup>7</sup> the majority of which comes from solar and wind energy (30%), a share that ranks Greece 8th in the world in terms of RES adoption.

<sup>8</sup> In 2021 lignite was further reduced by 5% on average. In April 2021 lignite’s participation in the electricity mix reached an all-time minimum (9%).



the total energy mix, compensating for the lack of nuclear energy production. The upcoming new climate law plans to introduce a series of measures to combat those inefficiencies (with substantial effects after 2030) and at the same time pave the way for the second phase of the green transition. Such measures include:

- Phasing out oil-based heating in building and substitution with natural gas or heat pumps.
  - PV installation in large buildings.
  - New taxis and rental cars must be of zero emissions, with a goal of reaching 30% of the fleet.
  - Carbon footprint reporting for businesses.
  - At least 30% CO<sub>2</sub> emissions decrease during 2022-2030 by energy intensive activities (projects, enterprises)
  - Introduction of sectoral carbon budgets.
  - Establishment of an R&D center for green maritime.
- In the second phase of the transition (2030-2050<sup>9</sup>), efficiency improvements are expected to lead to lower total energy consumption in main sectors (-26%), with renewable energy sources covering at least 86% of total energy production<sup>10</sup>. However, electricity demand will increase (by about 18% based on the average estimate) as it will be the dominant source of energy consumption (43% of total final consumption vs 27% in 2030 and 24% in 2015). Moreover, additional needs for electricity used for generating hydrogen and its subsequent synthetic fuels (about 16% of energy consumption), could increase the share of electricity to 60% in 2050. Overall, the need for electricity could increase by about 110% on average by 2050, accounting for network and storage losses, leading to significant infrastructure investment needs. Note that in this scenario, Greece's energy

<sup>9</sup> The estimates for 2050 are based on the average of the existing scenarios of Greece's long-term strategy to 2050 (energy mix, types of energy consumption, available technologies), consistent with achieving the 1,5°C target, based on the Primes energy model. Scenarios range from "energy efficiency, for 1,5°C" (with electricity needs increasing by 50% during 2030-2050 – requiring more changes in consumer behavior and buildings), to the more ambitious "additional energy carriers (innovation, synthetic fuels) for 1,5°C" (with electricity needs increasing by 160% during 2030-2050 – requiring more infrastructure and RES).

<sup>10</sup> Including RES contribution in electricity as well as non-electricity uses (heating, biofuels).

import dependency will be reduced to 30% from 70% in 2030 and 74% in 2020.

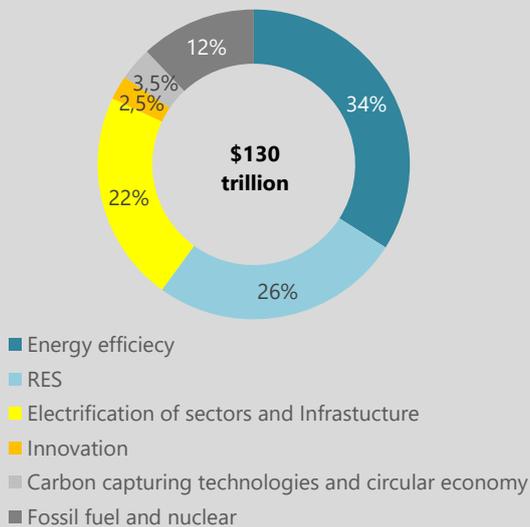
### Investing in the transition

The green transition period will need new infrastructure and technology funded by new investments. IEA estimates that there is a need for about \$4.4 trillion annual investment (about 4.5% of world GDP) to fulfill the target of net zero emissions by 2050 (\$1.1 tr. more than previously estimated), summing up to a total of \$131 trillion over the next three decades. This was necessary as the doubling of electricity, which is needed for the complete independence of carbon, requires new infrastructure such as renewables scale up and electricity grid upgrades and extensions. Importantly, there is strong private interest in funding the green transition, as during the recent COP26 summit for climate change, over 450 financial firms, managing \$130 trillion worth of assets across sectors pledged to cover this gap. It must be noted that not all the amount of investment needed for the period of transition is strictly related to the energy sector per se, but rather extends across sectors such as transportation, construction, and industry.

EU countries spent around 2% of GDP per year on energy and related infrastructure investments up to 2018. The Next Generation EU and 2021-2027 EU budget allocate €0.6 tr (circa 4% of 2019 GDP) towards green transition. To successfully transition to a green economy, energy investments (via leveraging private funds) should remain around 2.8% of GDP up to 2050.

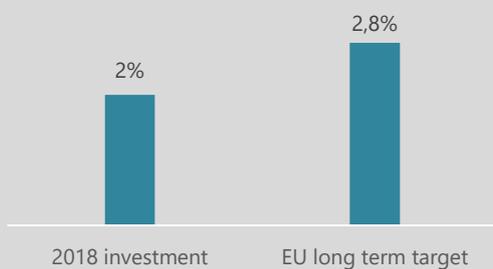
Focusing on Greece, despite good performance in terms of renewable energy generation, there are deficiencies in terms of network infrastructure. Indicatively, over the past 20 years energy infrastructure investments were in the range of 0.4% of GDP per year (vs 0.7% in EU), but this amount needs to scale up if Greece is to meet its 2030 goals. Across sectors, for the first phase (2021-2030) an average of €8.5 bn per year is needed (4.5% of 2019 GDP), with 20% of it going towards electricity and related infrastructure

**Global investments 2021-2050  
by technology\***



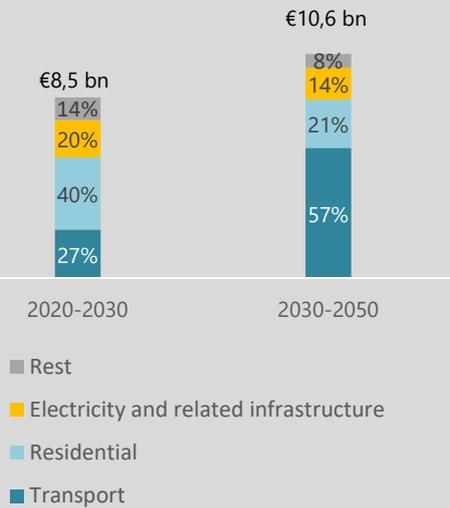
\*Energy efficiency and Electrification are largely about the transport and residential sectors

**EU investment need for net zero by 2050  
(% of EU GDP)**

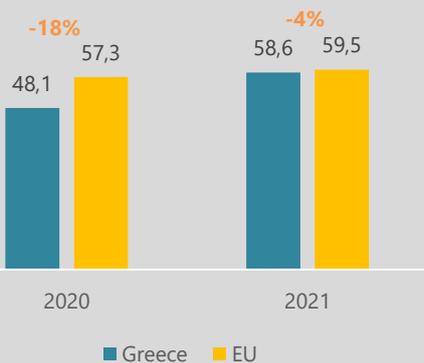


Sources: IRENA, European Commission, NBG estimates

**Greece investment needs  
to reach net zero by 2050**



**Climate change policy index  
(from 0 to 100)**



Sources: Hellenic Ministry of Environment and Energy, Germanwatch, NewClimate Institute & Climate Action Network, NBG estimates

investment, 40% towards residential energy efficiency improvements (including household appliances), 27% towards transport and 14% in other sectors.

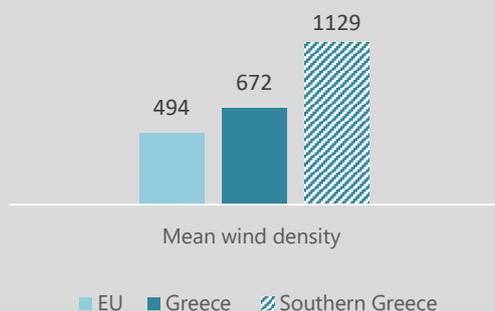
During the second period of the transition (2030-2050), investments focus more on the end use consumption. Greece will have to invest, on average 10.6 € bn. annually (5.7% of 2019 GDP) with most of them being directed towards the transport sector (57%), followed by the residential sector (21%), electricity and related infrastructure (14%), services and agriculture (6%) and industry (2%).

To kickstart this process Greece is fortunate enough to be able to utilize the funds made available through the Recovery and Resilience Fund which promotes the green transition's investments. Specifically, €11 bn from the RRF (subsidies and loans) are directed to green transition. The actions are mainly relevant to the building stock's energy upgrade, both for businesses and households (€1.6 bn subsidies), sustainability projects e.g. water supply, irrigation and wastewater treatment (€1.1 bn subsidies). Other emblematic projects include electricity storage important for RES (€0.45 bn subsidy), strategic urban innovation (€0.47 bn subsidy), green manufacturing and transport (€0.3 bn subsidy). Apart from the RRF, funds are €8.3 bn are expected to be mobilized through ESPA and the common agricultural policy for sustainability investments, while the €1.6 bn from the Just Transition fund will help smoothen the transition for areas and businesses connected to carbon intensive sectors (i.e. PPC suppliers). Furthermore, the publishing of the first Greek sovereign green bond is scheduled in mid-2022, to further finance green investments.

**Turning (and branding) Greece into a green economy**

Against this background, the phasing out of fossil fuels will allow new players to emerge in the energy market and Greece could benefit by turning from an energy importer (74% import dependency vs 55% in the EU) to an energy producer and exporter. To grasp this opportunity Greece will have to move at a fast pace in

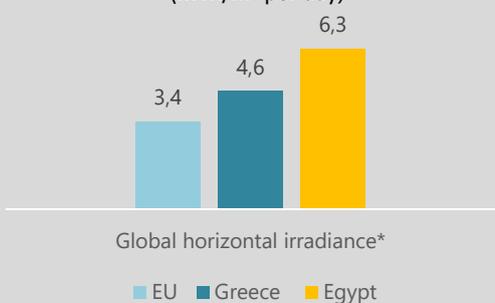
**Wind Capacity**  
(W/m<sup>2</sup> in 10% of windiest regions)



Mean wind density

■ EU ■ Greece ■ Southern Greece

**Solar Capacity**  
(kWh/m<sup>2</sup> per day)

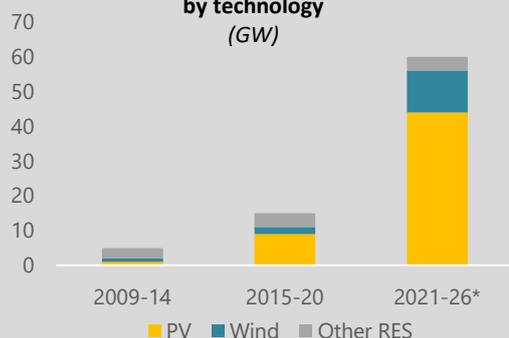


Global horizontal irradiance\*

■ EU ■ Greece ■ Egypt

\* Global Horizontal Irradiance is the total amount of shortwave radiation received from above by a horizontal surface. This value is of particular interest to photovoltaic installations

**MENA RES electricity capacity additions by technology (GW)**



\*Assuming acceleration in infrastructure investments

Sources: IEA, Wind Atlas, Solar Atlas, NBS estimates

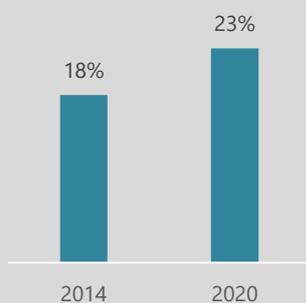
terms of both investments and institutional reforms. Steps are already made to the right direction, as evidenced by more efficient RES licensing procedures (digital applications, minimum guarantees) and the recent climate law promoting the green transition. These developments are largely depicted in the sharp improvement in the country's ranking in the relevant climate change policy index (24<sup>th</sup> in the world form 34<sup>th</sup> in 2020), published by Germanwatch, NewClimate Institute & Climate Action Network.

Greece can establish itself as an energy hub and thus attract significantly more investment capital by combining its natural advantages<sup>11</sup> in terms of sunshine and wind, with innovative technologies. Indicative projects towards that objective are:

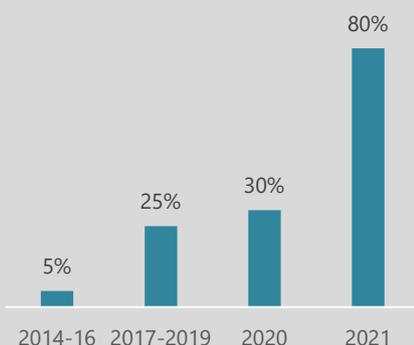
- The Ptolemaida-based "White Dragon" green hydrogen project, which can be used either as a means of energy storage or for exports through the TAP pipeline to other European markets. The project is expected to add capacity of about 1,5 GW, which covers c. 4% of EU plans for hydrogen projects (40 GW up to 2030).
- Offshore wind projects of about 2GW by 2030 are targeted by the Greek government's strategic planning, through auctions concerning specific areas with high return on investment and after resolving licensing issues (spatial planning). It is estimated that the total capacity for offshore wind parks in Greece is about 40-50 GW.
- Furthermore, with our neighboring countries of Middle East and North Africa also speeding up their RES projects (RES capacity additions expected to quadruple by 2026), opportunities arise such as the recently signed interconnection with Egypt (which is 84% more efficient than EU in solar energy production due to its location).

<sup>11</sup> Greece has average global horizontal irradiance level of 4.6 kWh/m<sup>2</sup> per day (against an EU average of 3.4 kWh/m<sup>2</sup>) and 672 W/m<sup>2</sup> of mean wind density in its windiest regions (against an EU average of 494 W/m<sup>2</sup>).

### Consumers considering the environmental impact of products they purchase



### Renewable energy companies' performance vs MSCI Index



Sources: EY, IEA, NBG estimates

Transitioning to a green economy can yield benefits for a wide range of sectors such as:

- Sustainable tourism, with the Gr-eco islands initiative being a first step towards this direction
- Green shipping, as Greece has both the highest percentage of ship ownership and the establishing of the green maritime R&D center can let national shipyards and marine equipment manufacturers have a significant competitive advantage from the innovations produced.
- Agriculture may also benefit, as the favorable climate (which leads to a lower need for greenhouses) and the rich nature value of the majority of agricultural land (68%), make Greece able to turn into an example of sustainable agriculture and become a leader in sustainable product market niches.

In turn, all the above could indirectly boost the activity in a wide range of sectors such as metals and machinery, while creating favorable conditions for the promotion of innovation through centers of excellence. Also note that green transition is already gaining ground among consumers (with 23% of consumers considering environmental impact in their purchases, vs 18% in 2014) and investors (with RES companies outperforming global benchmarks in terms of stock returns) – therefore, the «greening» of the economy could do wonders for the global brand of Greece.

On the whole, while combating climate change is a daunting challenge that requires global cooperation, any country (especially geographically-privileged ones, like Greece) could go the extra mile and stand out by going green – therefore, honoring their moral duty towards next generations, while attracting customers and investors in the process.

# SECTORAL REPORT

December 2021



## NATIONAL BANK OF GREECE

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