

The Greening of the EU Economy and Its Implications for the Southern Mediterranean

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The Greening of Europe: Wright's Law and Russian Aggression

Developments at the start of the present decade did not bode well for the European Green Deal (proposed by the European Commission in December 2019). The deflagration of the Covid-19 pandemic a few weeks later sent public finances into a tailspin. The international consensus, enshrined in the 2015 Paris Climate Accords, was already starting to fray. China was keen to sell the world solar panels; less so to phase out its coal-fired power plants. In the US, the first Trump presidency, inimical to anything green, was followed by the Biden presidency, that privileged greening through poorly focused public subsidies over regulatory constraints. Russia's invasion of Ukraine in February 2022 could also have pushed the EU into putting its greening objectives on hold while it sorted out even more pressing existential challenges, such as re-armament.

Despite this deleterious international context, the EU made considerable progress on its Green Deal, and in particular in shifting its electricity production toward renewable energy. The NextGenerationEU initiative, presented by the European Commission in May 2020, created a targeted recovery instrument designed to repair the economic and social damage caused by the Covid-19 pandemic. Beyond mere crisis management, the proposal's central goal was to "build back better," financing a structural transformation of EU economies to make them greener, more digital and more resilient.

But the greening of the EU economy was not only driven by policy choices and the financial incentives

created by these policies. In fact, renewable energies were becoming economically more attractive for some time. The price of Chinese solar panels fell by a factor of 10 in the decade between 2010 and 2020. In 2013, the European Commission, alarmed by their rapid penetration of the EU market, set in motion anti-dumping measures. However, in 2018, it thought better of this, concluding that industrial protection no longer served the broader EU economic and climate interest (downstream deployment, jobs and climate goals). The renewable energy train had finally left the station. Today the cost of solar panels represents less than 25% of the capital expenditure for electricity production. Thus, further decreases in their cost will have only a marginal impact on the price of solar electricity. However, substantial (10-30%) cost reductions for other capital expenditure related to electricity production and storage can be expected in the coming decade.

Geopolitical considerations also favoured decarbonization. The suspension of Russian gas deliveries following Russia's attack on Ukraine, far from putting the EU's green transition on hold, gave it an additional stimulus: not only because the spike in the price of natural gas created by the halt of Russian imports made alternative energy sources more competitive, but also because the introduction of renewable energy reduces dependence on energy imports. In May 2022, under the heading of REPowerEU, the European Commission proposed to speed up the transition to clean energy, increase energy efficiency (eg., better renovation of buildings and decarbonization of industry) and reduce reliance on Russian fossil fuels. Thus, a combination of public policy, economic logic and geopolitical realities all contributed to an acceleration of the EU's green transition. In parallel, while not contributing directly to the green transition, new Liquefied Natural Gas (LNG) terminals, and increased

TABLE 4		Maghreb. Share of Renewables in Electricity Generation and Share of Imports/Exports in GAE				
Country	Metric	2021	2022	2023	2024 (Est.)	2025 (Proj.)
Algeria	Renewables in electricity generation	0.8%	0.9%	0.9%	1.1%	1.4%
	Imports in GAE	-137.1%	-127.1%	-125.0%	-123.5%	-122.0%
Morocco	Renewables in electricity generation	19.5%	17.5%	20.1%	24.2%	27.0%
	Imports in GAE	91.2%	90.5%	89.8%	89.5%	88.2%
Tunisia	Renewables in electricity generation	3.5%	3.7%	3.8%	5.6%	7.5%
	Imports in GAE	48.0%	52.0%	55.0%	61.0%	64.0%

The Maghreb: Energy Transitions at Different Rates

Here we consider the greening of the economies of Algeria, Morocco and Tunisia (the continuing political instability in Libya impedes meaningful conclusions to be drawn).

While all three countries have announced their intention to develop renewable energies, only in Morocco has substantial share of renewable electricity generation been achieved (see Table 4). Hydrocarbons remain the priority of Algeria's energy strategy and represent the bulk of new investments. Tunisia's investments in renewable energies have markedly increased recently, but its transition is still in its early stages. As in the EU, the penetration of renewable energy into sectors other than electricity generation is slower.

Morocco's dependence on energy imports is very high and has hardly evolved in recent years despite the rapid rise of renewable energy production. Tunisia's dependence on imports has increased and Algeria's exports have been increasingly constrained by domestic consumption.

The energy intensity and carbon intensity, already higher than the EU's at the start of the decade, decreased more slowly in the Maghreb countries (see Table 5). Morocco has systematically pursued the development of renewable energy for many years and has a credible prospect of catching up to the EU's greening effort in the medium term. Algeria and, to a lesser extent, Tunisia have domestic hydrocarbon resources. This has undoubtedly encouraged delays in their development of renewable energy sources and the implementation of energy saving measures,

TABLE 5		Comparative Energy & Carbon Metrics (2021-2025)				
Region / Country	Metric (2010 constant prices)	2021	2022	2023	2024	2025 (Est.)
European Union	GDP (€ Billions)	16,133	16,665	16,748	16,932	17,186
	Energy Intensity (toe/M€)	81.2	75.4	73.1	71.0	69.5
	% (2021=100)	100	93	90	87	86
	Carbon Intensity (gCO ₂ /€)	204	196	189	181	175
	% (2021=100)	100	96	93	89	86
Algeria	GDP (€ Billions)	148	153	159	165	170
	Energy Intensity (toe/M€)	405	398	392	385	380
	% (2021=100)	100	98	97	95	94
	Carbon Intensity (gCO ₂ /€)	850	835	828	820	812
	% (2021=100)	100	98	97	96	96
Morocco	GDP (€ Billions)	92	93	96	99	102
	Energy Intensity (toe/M€)	225	230	228	222	218
	% (2021=100)	100	102	101	99	97
	Carbon Intensity (gCO ₂ /€)	590	605	600	585	575
	% (2021=100)	100	103	102	99	97
Tunisia	Real GDP (€ Billions)	36	37	38	38	39
	GAE Intensity (toe/M€)	245	248	244	242	239
	% (2021=100)	100	101	100	99	98
	Carbon Intensity (gCO ₂ /€)	610	620	615	610	605
	% (2021=100)	100	102	101	100	99

and they will struggle to achieve a radical greening of their economies in the medium term.

The Impact of Europe's Green Transition on Mediterranean Countries

The structural changes in the EU's energy economy present the Maghreb with both challenges and opportunities.

The EU is, and will remain well into the 2030s, highly dependent on imports. This opens perspectives for increased energy trade with its southern neighbours (notably because of their geographic proximity to the EU), although these are constrained by political considerations, as well as by economic logic.

While the policy orientation and the economic signals are clear, the pace of the green transition will be determined by the balancing of the EU's "Green Deal" targets against the reality of industrial recovery, infrastructure bottlenecks, nuclear performance and demand conditions

Having had to free itself of dependence on Russian hydrocarbons, the EU would be foolish to let itself be drawn into dependence on another energy supplier. Thus, the drive for an increasing share for domestic energy production and the diversification of suppliers will surely guide future EU energy policy. The EU's demand for fossil fuel imports will continue to decrease (whether because renewable energies continue to decrease in price or because the price of Emission Trading System (ETS) certificates is raised). Furthermore, the EU Carbon Border Adjustment Mechanism (CBAM) may in time be applied to the EU's fossil fuel imports, at a level corresponding to the emissions "embedded" in their production and transport, in order to establish an incentive for their reduction. The CBAM is likely to lead to a further reduction in EU demand as well as a reduction of the profit margin of exporters. A CBAM for gas imports

would likely focus heavily on upstream methane emissions. Exporters with "cleaner" pipelines (like Norway) would see a competitive advantage, while those with leaky infrastructure (like, currently, Algeria) would see their margins eroded.

The Maghreb countries have policy considerations of their own. Key decisions will concern their own drive for energetic independence, their openness to foreign investments, and the development of intra-regional energy trade, as well as trade with Saharan and sub-Saharan Africa. The economic advantages of energy trade among the Maghreb countries, in particular, cannot be realized before the political tensions between them have been resolved.

In the following, three examples are considered: RES-generated electricity exports to the EU; gas exports (specifically from Algeria); and green hydrogen exports.

The Economics of Renewable Energy Exports to the EU

Estimates of the Levelized Cost of Electricity (LCOE) for utility-scale production from photovoltaic panels and wind turbines in the Maghreb and in southern Europe are compared in Table 6. In general, production costs in the Maghreb are somewhat lower than those in southern Europe. However, once transport costs (about €8/Mwh for the Gibraltar link and €15/Mwh for the Tunisia-Italy ELmed link) and resistive losses during transportation (about 5%) are factored in, the competitive advantage – particularly for Tunisian electricity exports to Italy – is significantly reduced.

Region	Estimated LCOE (solar and wind energy) – Maghreb and Southern Europe	
	Solar PV LCOE (€/MWh)	Onshore Wind LCOE (€/MWh)
Morocco	25 – 40	30 – 50
Algeria	35 – 55	40 – 65
Tunisia	35 – 50	40 – 60
Southern Spain	25 – 40	35 – 55
Southern Italy	40 – 60	45 – 70

Decreasing the cost of infrastructure financing (the Weighted Average Cost of Capital, or WACC) is probably the most promising avenue to make energy exports more competitive in the Maghreb: capital expenditure represents some 80-90% of solar energy

TABLE 7 Morocco – Estimated LCOE by Technology (2025)

Technology	Estimated Range (€/MWh)	Key Drivers
Solar PV (Utility)	€25 – €40	Low module prices and high solar irradiance (3,000+ hours/year).
Onshore Wind	€30 – €50	High average wind speeds (9.5-11 m/s) in coastal regions.
Concentrated Solar (CSP)	€65 – €95	High initial CAPEX, but valuable for night-time storage.
Coal (Existing/New)	€60 – €85	Volatile import prices.
Natural Gas (CCGT)	€70 – €110	Heavily dependent on gas import prices. Competitive for “firming” electricity production from renewable energy sources.

production costs, and a 1% change in the WACC can lead to a 10-15% change in the cost of production. The WACC reflects the risk assessment for investments, and is therefore strongly dependent on political and economic stability. The rising costs of land and permitting in the EU, and high utilization rates of the electrical links would all tend to make electricity exports from the Maghreb more competitive.

For countries that import fossil fuels, the energy transition is not driven so much by EU demand for green energy as by the economic logic of substituting renewable energy for fossil fuels in domestic energy production. Table 7 compares the LCOE of various production technologies in Morocco, demonstrating the clear competitive advantage of renewable energies, except for the natural gas (CCGT) generation needed for “firming” the intermittency of solar energy production (i.e., ensuring grid stability and allowing demand to be met reliably). Import substitution is the “low hanging fruit” in Morocco’s energy transition.

Algeria: The Closing Window for Gas Exports to the EU

For Algeria, the calculus for renewable energy exports to the EU follows a logic similar to Morocco’s, but its conclusions are somewhat less favourable: capital expenditure costs are higher, transportation distances are greater and the infrastructure is considerably less developed (there is no electrical interconnection in place). However, Algeria is a major consumer as well as producer of natural gas, and this gives it the possibility of increasing its gas export volumes by substituting domestic gas consumption with renewable energy.

The current estimated LCOE of electricity generation from gas (CCGT) in Algeria ranges between 25 – 40 €/Mwh, reflecting the very low domestic price of gas (5 – 12 €/MWh). This compares favourably with competing sources of electricity, even with the LCOE of “unfirmed” solar electricity (35 – 55 €/MWh). With such a low domestic price of gas, it is perhaps not surprising that Algeria’s energy transition is highly delayed, with domestic electricity production from renewable energy sources representing less than 3% of total production.

But while the accounting cost of gas fuel in Algeria is low, the economic cost is high. Every cubic metre of gas used domestically for electricity production is a cubic metre that cannot be exported to Europe (via the Medgaz or Transmed pipelines) where it could fetch a price that is two to five times greater. Table 8 shows the price of (domestic) solar electricity that breaks even with the revenue from the export of the gas that it substitutes. Substituting domestic gas with solar in Algeria is currently one of the most economically attractive energy transition paths in the Mediterranean. With considerable gas-fuelled generation capacity already installed, “firming” intermittent solar electricity production does not require massive investments (the cost of firming with gas is approximately half of that using battery storage). However, the window of opportunity to profit from the substitution of domestically consumed gas with renewable energy will close when the EU’s electricity grids have weaned themselves off gas – and they are already halfway to this goal.

Thus, developing renewable energy sources would not only contribute to Algeria meeting its Nationally Determined Contribution² and establish a viable basis for its economy in the period after its fossil fuel resources run out, but it would also be very profitable.

² <https://unfccc.int/sites/default/files/NDC/2022-06/Alg%C3%A9rie%20-INDC-%2003%20septembre%202015.pdf>.

TABLE 8	Algeria – Break-Even Price of Solar electricity against Exported Gas Revenue Assumes Various European Hub Prices, Transport Costs and Domestic Gas Plant Efficiencies Ranging from 33% (OCGT) to 45% (CCGT)		
Scenario	Net Gas Export Value (€/MWh _{th})	Plant Efficiency (Heat Rate)	Solar Electricity Break-Even Price (€/MWh _e)
Low Case (Lower Gas Prices)	€20 (€25 Hub – €5 Transport)	High (45% / 2.22 HR)	€44.40
Reference Case (Current Market)	€26 (€32 Hub – €6 Transport)	Mid (40% / 2.50 HR)	€65.00
High Case (High Gas Prices/Low Efficiency)	€34 (€40 Hub – €6 Transport)	Low (33% / 3.03 HR)	€103.00

ble in the short term. The fact that Algeria has yet to seize this opportunity provides an instructive example of the missed opportunities resulting from a delayed green transition.

Table 9 shows how Algeria's domestic gas consumption limits its export capacity. With its largest gas fields (like Hassi R'Mel) declining and massive amounts of gas being re-injected into oil fields to maintain pressure, nearly all increases in Algeria's marketed gas production in the decade 2016 – 2025 were used to meet growing domestic demand, while gas exports stagnated, and even decreased markedly in 2019-2020.

Before Russia's attack on Ukraine in 2022, Algeria was the EU's 3rd largest supplier. When the EU halted deliveries of Russian gas and gas prices surged,³ Algeria was completely unprepared to take advantage of the windfall profits that this could have generated. Not having developed renewable energy production or made significant efforts to achieve gas savings (whether in upstream production or in domestic consumption); not having addressed upstream limits and export infrastructure bottlenecks; and faced with a domestic consumption peak during record-breaking summer heatwaves, Algeria had no spare export capacity. While Norway increased its exports to the EU by 20% and the US quadrupled theirs, Algerian export volumes to the EU hardly changed. Efforts to increase, or indeed even maintain, export capacity have focused on decreasing gas flaring and reducing gas re-injection volumes, rather than decreasing domestic consumption.

The principal reason for this lack of reactivity appears to stem from institutional inertia and risk aversion, rather than any fundamental technical or economic constraints. The Algerian authorities see the

heavily subsidized domestic price of gas (with its concomitant wasteful consumption) as a cornerstone of social peace, allowing necessary political and economic reforms to be avoided. The energy sector is dominated by two state-owned monoliths (Sonatrach and Sonelgaz), whose focus is on extraction rather than innovation and diversification.

TABLE 9	Algeria – Natural Gas Statistics 2016-2025 in Billion Cubic Metres (bcm)		
Year	(1) Marketed Production	(2) Domestic Consumption	(3) Total Exports
2016	93.8	39.8	54.0
2017	94.0	40.2	53.8
2018	94.3	42.8	51.5
2019	87.7	44.9	42.8
2020	85.1	45.3	39.8
2021	100.7	46.5	54.2
2022	98.8	46.4	52.4
2023	104.3	52.3	52.0
2024	99.1	50.4	48.7
2025	105.4	53.3	52.1

Belatedly, the lessons of this missed opportunity are being drawn. Investments in the 3.2 GW Solar Programme referred to in section 2 are proceeding, with completion expected by 2027. Nevertheless, Algeria remains focused on its hydrocarbon sector, investing \$60 billion (2025-2029) mostly for "upstream" capital expenditure to maintain the volumes needed for both the domestic grid and export commitments. Changes to the domestic energy mix will be achieved too late for Algeria to reap the full benefits of the latest gas price surge, provoked, this time, by the war on Iran. Algeria's March 2026 agreement to increase exports to Spain by some 12.5% prioritizes exports via the Medgaz pipeline over exports via LNG hubs,

³ By a factor of more than four in August 2022 compared with January 2022, and remaining (until the US-Israel war on Iran) about double the historical average from the previous decade.

and gas production over re-injection to maintain older oil fields. The overall increase in export volumes is marginal. Significant decreases in domestic gas consumption or increases in gas production from the development of new fields are still some years away. Until they are realized, Algeria will struggle to maintain even its current export volumes.

The Hydrogen Future

A low-carbon electricity grid with a large component of (intrinsically intermittent) solar and wind power generation needs some form of energy storage or complementary generation to provide firming. Currently this is done by gas-fuelled generation but ultimately, the green transition requires firming to come from renewable fuels. One attractive option is to use solar power to ionize water and to use the resulting “green” hydrogen as the fuel for complementary power generation (a variant on the use of green hydrogen is to use ammonia, which can also be generated using solar or wind energy. Although the storage and shipping of ammonia is simpler and less expensive than that of hydrogen, its use for electricity generation is more complex and much less efficient. Furthermore, ammonia is toxic and presents a number of safety and environmental concerns that hydrogen does not. For these reasons, the ammonia “variant” is not considered here).

At 2025 prices, the cost of green hydrogen is at best 2.0-2.5 €/kg, whereas it needs to be 1-2 €/kg if it is to be competitive with gas-fuelled firming. It is likely, however, that the cost of green hydrogen will decline with continued PV and electrolyser⁴ cost declines, while the cost of gas will increase in line with the rising cost of ETS carbon permits.⁵ This perspective opens significant opportunities for the Maghreb exports of green hydrogen to central Europe, where EU demand is concentrated. Production in the Maghreb benefits from high solar irradiation and low land and labour costs. By virtue of its proximity to the EU, hydrogen from the Maghreb can be delivered by pipeline, which is significantly cheaper than shipping it by sea or transmitting equivalent

energy via high-voltage cables over very long distances. Furthermore, existing gas pipelines can be retro-fitted to transport hydrogen, reducing transport costs by 50-70% compared to new builds, and they serve as inherent storage, eliminating the need for expensive storage infrastructure at the point of electricity generation.

In the 2030-2040 time frame, the estimated cost of green hydrogen delivered to central Germany is 3.20 – 3.75 €/kg (produced in the Maghreb) and 3.10 – 3.50 €/kg (produced in Spain). This difference is marginal in a market where local German production could be €4.00 – 7.30 €/kg and where demand cannot be met by local production. Moreover, even if Spain’s green hydrogen production capacity can rival that of the Maghreb – its solar resource is somewhat lower, but this is offset by lower financing costs – the EU’s expected demand is such (REPowerEU aims for 10 million tonnes of domestic production and 10 million tonnes of imports by 2030) that it cannot be met by Spain alone.

The infrastructure investments necessary for green hydrogen exports to the EU are getting underway. Germany, Algeria, Italy, Austria and Tunisia have signed a Joint Declaration of Intent for the development of the SouthH2 Corridor, a 3,300 km pipeline network foreseen to transport annually up to 4 million tonnes of green hydrogen to Europe. Germany adopted legislation (the “Hydrogen Acceleration Law”) to fast-track the permitting and construction of cross-border hydrogen connections. Snam S.p.A. has pledged €380 million for the Italian leg of the SouthH2 corridor. EU initiatives like the European Hydrogen Bank and the H2Global mechanism are designed to address the higher financing costs of North African projects.

In parallel, the H2Med project (Iberian Corridor), designed to transport up to 2 million tonnes of hydrogen, is expected to be commissioned in 2030. While H2Med primarily transports Iberian production, it could connect to North African hydrogen via the existing Maghreb-Europe Gas Pipeline (GME), which links Morocco to Spain. However, this connection is currently complicated by regional political tensions.

⁴ Electrolyser costs are currently following “Wright’s Law.” For every doubling of global capacity, costs drop by ~18%.

⁵ The Carbon Tax (ETS) is currently €100-€120 per tonne. If it rose to €200-€300 per tonne, green hydrogen would be competitive with gas even without any decrease of production costs.

Conclusions

The accelerating green transition in the EU is creating a growing demand for renewable energies. Transport costs, in particular, strongly favour the Maghreb countries (because of their geographic proximity to the EU) in comparison with many alternative external suppliers, but they penalize the Maghreb in comparison with EU domestic renewable energy production, notably in Spain and Italy.

On the domestic markets of the Maghreb countries, however, renewable energy production is in competition only with hydrocarbons, whether these are domestically produced or imported. Thus the economic logic for the development of renewable energy sources in the Maghreb rests on the incentive to replace expensive hydrocarbon imports or to maximize lucrative hydrocarbon exports. For North African hydrocarbon exporters, geographic proximity to the EU (in comparison with many alternative suppliers) compounds this economic logic. However, as the EU progresses further with the greening of its economy, demand for hydrocarbons will wane and the “window of opportunity” for hydrocarbon exports will close.

A completely green EU economy will create a huge demand for green hydrogen. The Maghreb countries are well placed to profit from this.

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