Ready to Massively Increase Renewables in Southeast Europe?

How to Get There

By Program Director for the Electricity Market Initiative
for the U.S. Energy Association,
Elliot Roseman

In December 2019, the transmission system operators (TSOs) and market operators of the power systems in Southeast Europe (SEE) posed an important question: Can we reliably determine and anticipate the market, grid, and emissions impacts of seeking to add and absorb substantial utility-scale renewable energy sources (RES) through 2030? Are we ready for this huge wave, if not tsunami?

While simple to ask, the answer was far from obvious, since the tripling or quadrupling of RES anticipated could well strain individual network elements, depending on the RES project locations, and thus revamp their grid planning.

Further, this change would be taking place at the same time that these companies were integrating their markets with all countries in the region (a huge shift as well), with the potential for market price fluctuations.

And what about climate change? They were simultaneously seeking to chart a pathway to meet the EU's aggressive carbon dioxide emissions reductions targets, such as the Clean Energy Package and forty percent emissions reduction, while implementing carbon markets.

This in turn could massively affect existing generation, a large slice of which comes from lignite today. Further, new supplies of natural gas – both pipeline and LNG – could enter the market by 2030, serving as both an environmental bridge and an alternative to less secure fuel suppliers. Several new pipelines have recently started serving the region. Indeed, the RES and gas integration questions are a layered, complex undertaking, with regulatory and policy changes required to achieve its goals.

Enter the Electricity Market Initiative (EMI) for Southeast Europe, a group of fifteen energy companies in eleven countries in SEE, convened by the U.S. Energy Association (USEA) with the support and partnership of the U.S. Agency for International Development (USAID).

See Figure 1.

Since April 2018, the EMI has been helping these firms address their most pressing challenges for regional power market integration. This question about renewables, in the midst of so many other challenges, was the biggest one they had yet faced. In light of the regional natural gas developments, we added an assessment of new power generation from gas to the scope of work.

To our knowledge, this is the first systematic, detailed analysis of both the market and network impacts for all of SEE, under conditions that could easily put stress on both. It was designed to enable all stakeholders to look over this daunting horizon, to understand and adapt to these future challenges, and to support the next steps to integrate their electricity systems.

We spent much of 2020 addressing the EMI members' questions, and we now report on our findings. Readers may find the full EMI Report under "Related Publications" at Electricity Market Initiative (EMI) | United States Energy Association, found online at usea.org.

First, a word about our process. To answer the EMI members' questions required two sophisticated forecasting tools – Antares for market simulation, and PSS/E for network performance. This modeling duo enabled us to effectively organize the myriad of required inputs and data; reliably simulate the operation of both the markets and the grid in SEE in 2030; and produce granular results for each system (with an hourly time frame and all transmission network elements included) in light of the huge scale of changes expected to take place.

Enter the Electricity Market Initiative (EMI) for Southeast Europe, a group of 15 energy companies in 11 countries in SEE, convened by USEA with the support and partnership of USAID.

That is, we could not answer the question of absorbing RES without the right models, along with the savvy to utilize them.

With substantial support from the EMI members, and working closely with our expert consultants, we gathered data and evaluated eleven market scenarios, and twenty-two network scenarios for 2030. Some of the main inputs included the levels of:

Renewables (baseline and high, for both solar and wind), and their capacity factors; Power demand (baseline and low); Hydrology (baseline and dry); and carbon dioxide emissions prices (baseline and high).

Our baseline level of RES assumed values in the countries' official development plans for 2030, while high RES represented an additional twenty-five percent of RES capacities. Moreover, some countries already planned to retire old lignite plants, add natural gas facilities using new pipeline gas and LNG, and add hydro. We captured such changes as well.

On the network, we simulated all eleven countries' plans to upgrade their internal and cross-border transmission grids over the next decade, which can either facilitate or limit power exchanges.

To be comprehensive, we evaluated the impacts on day-ahead power markets in 2030 for all eight thousand, seven hundred

FIG. 1 **THE FIFTEEN EMI MEMBERS IN SOUTHEAST EUROPE**

and sixty hours, and set up the analysis to assess the impacts of RES on the grid during the most stressful hours of the year.

The network analysis was granular, down to the one hundred and ten kilovolt level, involving over eighty-five hundred buses, ten thousand branches, thirty-seven hundred transformers, and fifteen hundred power plants, and included both normal and stressed (n-1) operating conditions. Integrating the network models of all eleven countries into one regional grid model was a major accomplishment of this work.

We also simulated a lot of new renewables. Figure 2 shows the major additions of RES that we assessed in this EMI study, raising wholesale wind and solar capacity from 12.2 gigawatts in 2018 (sixteen percent of the system demand) to a range of 33.2 gigawatts (thirty-four percent) to 43.9 gigawatts (forty percent) in 2030.

Based on the EMI members' plans, we expect Greece to add over five gigawatts of wind and solar, with Bulgaria, Romania, Serbia, and Slovenia adding two to three gigawatts of RES apiece. Other countries such as Albania and Bosnia-Herzegovina, which started with little RES, will add considerable clean resources as well.

We also simulated the addition of eleven hundred and fifty-five megawatts of new gas generation capacities, as envisaged in the regional gas TSOs' development documents.

The addition of these substantial new resources will naturally affect the use of existing generation, particularly since load is expected to grow slowly, and will change the flows on the internal grids and cross-border lines.

See Figure 2.

FIG. 2 **EXPECTED SOLAR AND WIND INCREASE, BY COUNTRY (PERCENT OF DEMAND)**

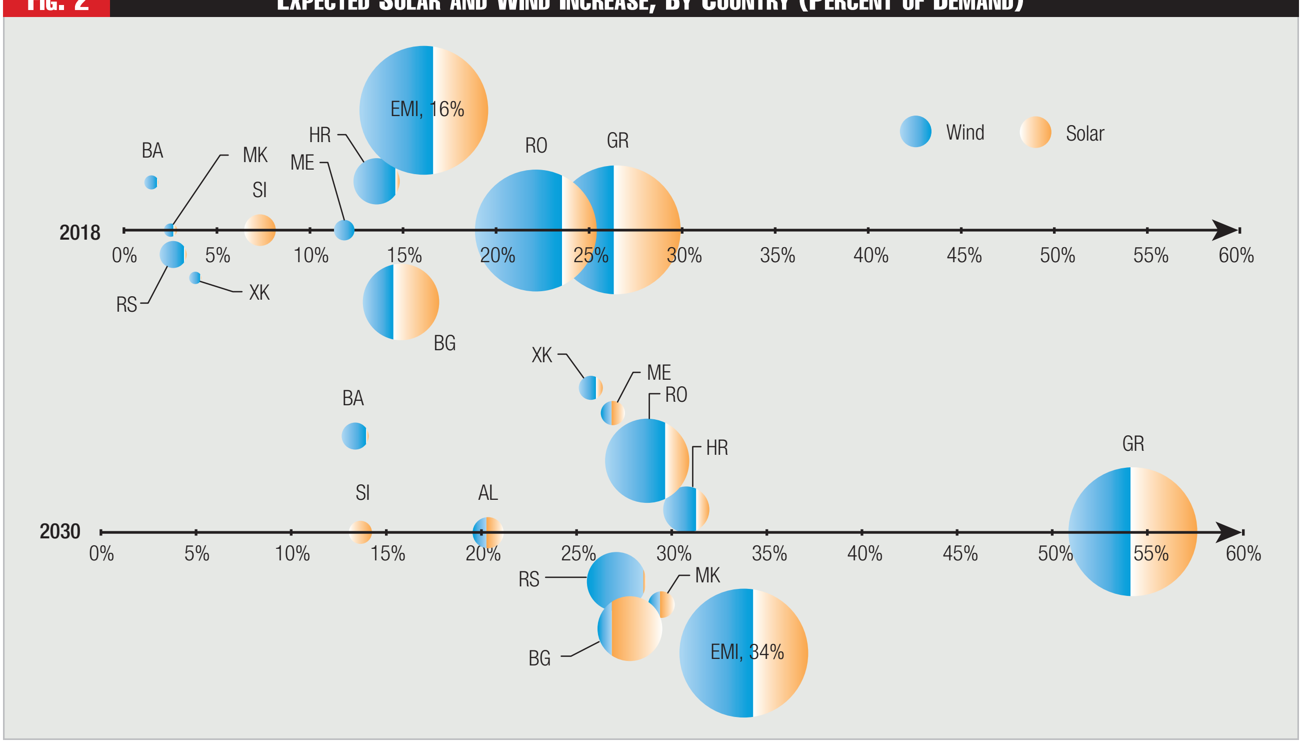
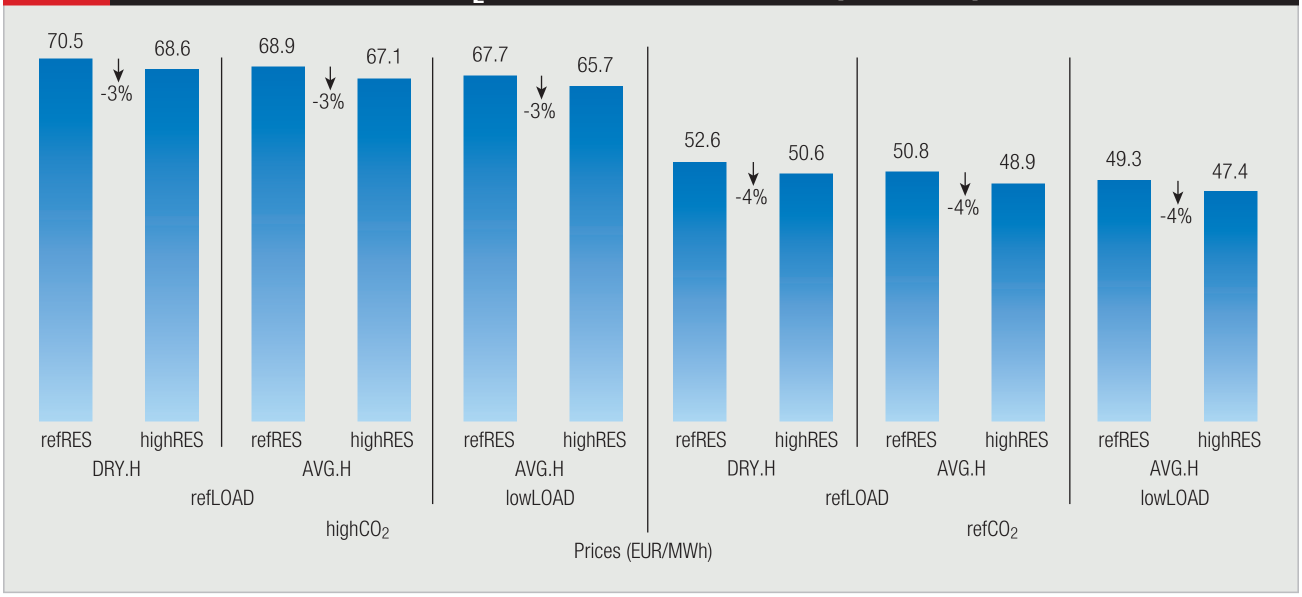


FIG. 3 **IMPACTS OF CO_2 PRICES AND HYDROLOGY IN 2030 (EUROS/MWH)**



The regional network is robust and is well prepared to absorb most of the added RES and gas generation, with attention to just a few spots.

So, what did we find for 2030? We divide our findings into those applicable to power markets and CO_2 emissions, and those that apply to the grid. In the first area:

Day-ahead markets can well accommodate this huge addition of renewable generation. In fact, the addition of such levels of RES will lower wholesale prices by three to four percent on average, since the marginal cost of RES is zero, compared to a positive cost for the generation they displace.

RES additions only modestly decrease CO_2 emissions. This is because the capacity factors of wind and solar are not high, compared to the gas and lignite generation they displace, and a number of countries have a low RES starting point. CO_2 emissions fall just seven to ten percent due to this factor, in spite of the large RES additions.

By contrast, the carbon market (EU ETS) has a major impact on CO_2. We modeled two carbon prices – 27 EUR/tCO_2 and 53 EUR/tCO_2. These CO_2 prices would raise wholesale power prices, and in particular, making coal and lignite less competitive, and would reduce the capacity factor and emissions of these plants by ten to thirty-five percent.

Modest amounts of new gas generation would also reduce CO_2 emissions by lowering generation from older gas and coal plants and have a neutral effect on power prices. Regional stakeholders should evaluate increasing the level of gas-fired generation.

We conclude that from a market perspective, the combination of new RES, added gas generation, and carbon prices may cause lignite plants to retire at a faster pace than in the current resource plans. Utilities, their national regulators, and ministries should review the economics of lignite generation as other resources limit their utilization.

Wholesale prices converge throughout the region by 2030, as we expect all markets in SEE to be coupled and consolidated by then, but the highest wholesale power prices occur when there are conditions of low hydro, high demand, and high CO_2 prices.

At these levels, no RES generation is curtailed. Rather, regional transfers, along with imports and exports can adjust to times when RES generation varies, and these transfers provide a safety valve so that no RES generation is curtailed.

It is vital to monitor price impacts. Figure 3 shows that under reference RES, average and dry hydrology, and baseline and high CO_2 prices, we project that average wholesale regional prices will range from 47.4 to 70.5 EUR/MWh – a wide range.

High RES integration will reduce prices around 2 EUR/MWh or four percent in all scenarios. The impact of hydrology and electricity demand on wholesale market prices in the region is rather modest: 2 EUR/MWh higher in the case of dry hydrology, and 1.3 EUR/MWh lower in the case of low demand.

However, as mentioned, the main driver for changes in prices in SEE will be CO_2 prices: an increase from 27 EUR/tCO_2 to 53 EUR/tCO_2 would raise wholesale market prices in the EMI region in 2030 by around 18 EUR/MWh, or thirty-five percent, while substantially reducing lignite generation. The West Balkan countries will notice this impact most strongly, since they are not currently part of the EU ETS.

See Figure 3.

We also found that the addition of new gas generation will

Fig. 4 Critical Transmission Elements in SEE, 2030

decrease both lignite and older gas generation and have a positive impact on markets. In the added gas scenario, the combination of hydro, wind, and solar – the green technologies – will displace lignite and become the main generation technologies in the EMI region in 2030, supplying forty-five percent of total power needs.

Overall, we found that adding substantial RES and gas generation would have a benign impact on power markets in SEE, and reduce emissions, though prices could rise due to CO_2 markets, and that stakeholders should actively pursue the transitions required to implement these portfolio changes by 2030.

With regard to impacts on the region's power network, the analysis of RES and gas integration was also quite positive:

The regional network is robust and is well prepared to absorb most of the added RES and gas generation, with attention to just a few spots. This strength is due both to the countries' prior centralized planning, and the grid additions already planned in SEE between now and 2030.

Notably, we did not find a central corridor or trans-regional set of bottlenecks that would suggest the need for a large coordinated regional program of high-voltage network additions.

Rather, throughout the region, the need for upgrades is modest. Across thousands of elements, we found just twenty-two components that could raise congestion or reliability concerns due to the anticipated additions of RES and gas generation in 2030, across all the grid scenarios, including those with N-1 conditions. This is a positive finding for the integration of these new resources.

These components will require selective monitoring, de-bottlenecking, and upgrades. Figure 4 shows the locations and the grid elements they represent, which include internal lines, tie lines between countries, and transformers.

See Figure 4.

At the conclusion of the analysis, we trained the EMI members in the use of these models, so they are now able to use the tools and data we deployed for this market and network analysis – Antares and PSS/E – for their internal planning and regulatory filings.

Does this mean that as long as the EMI members pay attention to these twenty-two components, there are no significant grid concerns with regard to RES and gas integration? Not quite, for several reasons.

First, we did not test the ability of these systems to deal with balancing issues due to short-term (e.g., hourly and sub-hourly) forecast errors of wind and solar generation, so grid planners and operators must evaluate how RES additions at these more

We conclude that from a market perspective, the combination of new RES, added gas generation, and carbon prices may cause lignite plants to retire at a faster pace than in the current resource plans.

granular time domains will affect real-time operations, reserve margins, and reliability.

Second, our analysis did not dynamically evaluate generation and grid changes in the countries on the borders of SEE, so the congestion shown between countries such as Bulgaria and Turkey, Greece and Turkey, and Slovenia and Italy, merits further analysis.

Finally, actual RES locations and amounts over the coming decade may well differ from what the TSOs currently anticipate, which could place stress on the network in those places.

Based on this study, there are six important recommendations and next steps for national regulators, policymakers, and TSOs to consider.

We believe they should: Provide the proper incentives, interconnection and queueing policies, and locations for private investment in renewables; Prioritize the expansion of cross-border trade and coupling to foster regional clean energy projects and balancing markets; Assure adequate grid investment with enhanced tariffs and codes, and with regional planning; Strongly encourage bilateral and regional power exchanges and competitive markets for real-time, day-ahead, and longer-term markets; Anticipate and incorporate distributed energy resources into these markets, on an equal basis with wholesale power generation; and, Proactively integrate natural gas to transition to a clean energy future through long-term generation planning, coordinated efforts with gas system operators, and robust gas planning for electricity needs.

We did not find a central corridor or trans-regional set of bottlenecks that would suggest the need for a large coordinated regional program of high-voltage network additions.

The EMI's collaborative work continues. In the coming years, we plan to build on this solid framework to conduct in-depth analyses and training to support the expected transition in the generation mix, assess specific grid projects, and anticipate complex system dynamics, both within Southeast Europe, and with the rest of Europe. This in turn will accelerate the integration of the EMI members' power markets, as they develop multiple platforms to trade electricity.

From an energy perspective, this decade poses great opportunities and challenges for Southeast Europe. PUF

HVDC, Not Just For Long Distance

(Cont. from p. 63)

and a cable, is the one gigawatt, thirty-two mile Elec Link between France and Britain that will run through the channel tunnel. Tests of the terminal stations are underway, and after safety reviews, installation of the cable has been approved.

An example of an application within a synchronous HVAC grid is American Transmission Company's back-to-back VSC HVDC station connecting the Upper and Lower Peninsulas of Michigan. The system provides stability to draw more wind power to the energy mix.

A more elaborate application of HVDC within a synchronous HVAC grid is the four terminal HVDC ring in the Beijing-Tianjin-Hebei area of China first energized in June 2020. The system operates at ± five hundred kilovolts.

Two of the converter stations have capacities of three thousand megawatts, and two half that. This system will enable the integration of hydro, solar, and wind energy in a transmission ring that ensures optimization of power flow.

Already requiring a smaller station footprint than its LCC competitor, today's VSC systems can convert more than 25 times the power at more than six times the voltage of the first VSC station demonstrated in 1997.

In the twenty-three years since VSC-HVDC was first demonstrated, the technology has advanced considerably. Already requiring a smaller station footprint than its LCC competitor, today's VSC systems can convert more than twenty-five times the power at more than six times the voltage of the first VSC station demonstrated in 1997. Today, VSC is being used to increase renewable energy integration, add interconnections between HVAC grids, provide grid stability, and expand power markets. PUF

In 1940, of the seventeen thousand members of the American Institute of Electrical Engineers, only three were women. One of them was Vivien Kellems. In 1927, she founded Kellems Cable Grips, Inc. in Connecticut to manufacture an endless-weave electrical cable grip invented by her brother Edgar that was better than the wire mesh grip in common use at the time. A year later she had their first orders with Queens Electric Light and Power Company and Brooklyn Edison Company (both companies eventually became a part of Consolidated Edison Company).