A Post-Covid Analysis of Energy usage and Economic Expansion in Developing Countries (2000-2021)

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Abstract

The main study purpose was determining the influence of energy usage on economic expansion of developing countries (2000-2021), a post-covid-19 analysis. The study adopted a panel data analysis as it included four countries such as Rwanda, Ethiopia, Pakistan and Cambodia. Having a mixed unit root results, the study adopted a Cross-Section-ARDL with Dumitrescu and Hurlin (2012)panel causality test. The findings reveal that the Renewable Energy (RE) importantly and in positive manner influences economic expansion in four countries investigated. Gas with Petrol (GP), Energy related Inflation (EI) and Dummy Covid-19 (D-COVID) significantly decreased expansion of economy in the regions while long-run and short-run. In Addition, the ECM indicated that there is a speed of 64.3% for the model to approach equilibrium every year. The bidirectional causality among the variables examined was illustrated by the panel causality test. In specific, the Renewable Energy (RE) and Gas and Petrol (GP) granger causes Gross Domestic Product (GDP), while it was found only a single direction causality moving from Energy related Inflation (EI) to Gross Domestic Product (GDP). This justified that policies that should make change in independent variables might cause changes Economic growth and vice versa. As a result of the findings, which showed that renewable energy had a positive and considerable impact on growth of economies. It was advised that countries increase their use of innovative and environmentally beneficial technologies. It was advised that the countries reduce their prices to encourage stronger economic performance. Hedging gasoline and gas prices should help manage their volatility. This suggests that the commercial policies in the developing nations covered in the study need to be changed and take both long- and short-term hedging of oil and gas into account. To protect gas and oil consumers, the governments of the researched nations should encourage the practice of setting a maximum price for gas and oil. Because a rise in energy items prices enhances the rise in prices of other products in the country, this will reduce inflation in those countries. In this approach, the countries' economic growth will be positively impacted by the usage of gasoline and gas. The findings showed that Covid-19 had defective impact expansion of economies into the researched countries and worsened gas and petrol shortages in the study countries. It is advised that the nations develop a habit of keeping ample supplies of gas and gasoline on hand for usage in the event of any importing difficulties.

Key terms: *Renewable energy, gas, petrol, GDP*

I. INTRODUCTION

From the beginning of 21st century, the global faced a lot of challenges including economic crisis of 2008, pandemics like covid-19, Russia-Ukraine war, etc. all these challenges disturbed social, economic, political and environmental activities on the world. The demand for commodity related to natural resources has been experienced fluctuations with a lot of fall and rise. The negative effects of the pandemic have expanded all over the world from the industrialized countries to emerging countries. As well as the health services are not advanced in developing countries, the negative impacts of the emerging challenges have affected more the developing countries. Due to the slowdown and long-term lockdowns developing countries experienced negative economic growth from the beginning of Covid-19 [1]

Global uncertainty in terms of economy and finance led to volatility in natural resources that impacted the macroeconomic growth, firms' revenue, expenditures of households and national economies [2]. In both developed and emerging nations, energyis the crucial input like capital and labour. In the same way, energy is the best determinant of economic development and economic growth [3]. Examining an association between energy

consumption with economic expansion is very necessary as the volatility in natural resources make changes in welfare level and policies of macroeconomics in the country.

Therise in price levels of natural resources products including gas prices and oil minimize a production in different mechanisms[4]. Because, the gas and oil prices shocks lower aggregate demand in the country. About the firms, the rise in prices of gas and petrol reduce labor productivity and capital due to the firm's budget constraints. The increase in prices of gas and petrol reduces energy consumption in the country and this causes unemployment and reduction in real wage [5].The reduction in real wage, causes to unemployment and diminishes real GDP in the country. Besides, decreasing the prices of oil minimizes product costs and increase entrepreneurship level and improve economic growth [6].

This study empirically investigated the long-run relationship between the energy usages including petrol, gas, energy related inflation and renewable resources and economic growth of developing countries including Rwanda, Ethiopia, Pakistan and Cambodia. This study was very important as there is no specific study existing investigating the pointed out variables, considering also the pandemic Covid-19. For this reason, this study examined the effects of fluctuations in energy consumption prices with the introduction of Covid-19 as a dummy variable. The previous studies explored influences of prices volatility in natural resources to the economic growth in before pandemic period. Although, this study filled the gap in literature.

II. LITERATURE REVIEW

[7] In their study about effects of prices of resources from nature prices on economic expansion within dependent countries have revealed the existence of short-run and long-run association among prices of resources from nature and growth of economy between 2004 to 2014. This study used Panel ARDL and confirmed that price chocks resources of nature affect negatively the economic growth of the examined countries. The study concluded that the positive policies towards stabilizing energy resources prices rise in long-run per capita income.

[2]have conducted a study examining the impact and influence of prices of oil on policies related to economy in importers and exporters countries. Using VAR, the study revealed that uncertainty in economic policies is greatly influenced by shocks in oil prices. They also pointed also that economic policies fluctuates less due to shocks in oil prices than in oil-exporting nations.

In Nigeria, [8] analyzed the link between prices of oil and growth of economy using primary data collected from 320 sampled respondents. The study indicated that the rise in prices of oil causes a decrease in economic expansion in the country. In Nigeria also [3] examined the consequences of oil prices and non-renewable energy on economic performance. For the period between 1980 to 2013, through OLS and cointegration test, the study indicated the existence of long run connection among oil prices, non-renewable energy and economic growth. In the short-run, coal and consumption of natural gas are not influencing the real growth in the country.

In Pakistan, [9] examined the effects of remittances inflows, FDI and prices of oil on development of stock market. Using ARDL with time series data (1985-2017) the study pointed out that remittances inflows, FDI and prices of oil possess a direct effect to the development of stock market. The study indicated also that exchange rate affect negatively the stock market development. By contrast, [10] demonstrated that dependence and abundance in natural resources causes environmental degradation by increasing carbon level. At this point, we find another contrast in literature, where [11] examined the factors influencing ecological footprint and the importance of urbanization, resources of nature and renewable energy. Through examining the BRICS countries for the period between 1992 and 2016 revealed that resources of nature possess a direct effect to the environmental sustainability.

[12] in their study about the footprint of abundance in resources of nature and development in human resources on growth of economies within eleven countries for the period from 1990-2019. The study using AMG indicated that development in Human Capital (HC) enhances significantly the economic growth. [13] investigated the effects of energy prices on financial development in G-7 countries using CCEMG, AMG and SC-ARDL approaches. The study results revealed that abundance in natural resources rise financial sector development. The study concluded

that the rise in energy price has a reverse impact on the expansion of financial development. This was confirmed by the study of [14].

[15]in Saudi Arabia examined the impact of Covid-19 cases of death and volatility of prices of oil between January 22 to 14th June, 2020. Using ARDL, the study pointed out that Covid-19 significantly and negatively influence oil prices. The identified gap in literature is that no study conducted examining the link among energy consumptioncrisis and economic expansion in developing economies considering also the effects of Covid-19. For this reason, the study to analyze the renewable resources, gas and petrol consumption was very necessary to fill the identified gap in literature.

III. METHODLOGY

This section involves data used, model specification and econometrics techniques used in the study. The study adopted quantitative methods as it has used quantitative data. It used secondary data extracted from the World Bank annual reports.

3.1. Data

The data were found from World Bank dataset (2022) for the period of 22 years (2000-2021) within the selected developing countries. Those countries include Rwanda, Cambodia, Ethiopia and Pakistan. The data used were quarterly panel data for the stated four countries. Having 22 years implies having 320 observations as quarterly data were used.

3.2. Model specification

The general form of the model is in the following ways;

GDP = F(RE, GP, EI, D-COVID …) (1)

The econometrics model was in the following ways;

$LogGDP_t = \alpha + \beta_1 logRE_t - \beta_2 LogGP_t - \beta_3 LogEI_t + \beta 4 LogD\text{-}COV_t + U_t(2)$.

Where,

GDP; Gross Domestic Product

RE;Renewable Energy usage/Value per unit of time

GP:Gas and Petrol usage/Value per unit of time

EI:Energy Related Inflation

D-COVID19:Dummy Variable Covid-19

The dependent variable is GDP, and RE, GP, EI and D-Covid 19 are independent variables.

3.3. Econometrics techniques used in the study

Due to the use of panel data, the study first of all tested the slope coefficient homogeneity, then, after the study conducted the CSD test, next panel stationarity test then Augmented CS-ARDL Models. Finally, the study conducted panel causality test using Dumitrescu-Hurlin causality check. The econometrics techniques were valid and accurate as they have been able to provide the relevant results for the study.

3.3.1. Slope coefficient homogeneity

In panel data, it's feasible that some nations may share the same traits as others and depend on one another. The homogeneous nature of some nations may lead to skewed outcomes. Examining if a country's features are the same across the board (homogeneous) or varied across the board is preferable in this way (heterogeneous). [16] were employed in the slope coefficient test. The following equations was used in determining the coefficient Heterogeneity of Slope (SCH) and Coefficient Heterogeneity of Slope Adjusted (ASCH).

$$\widehat{\Delta}_{SCH} = \sqrt{\frac{N}{2k}}\left(\frac{1}{N}\acute{S} - K\right) \quad \widehat{\Delta}_{ASCH} = \sqrt{N}.\sqrt{\frac{T+1}{2K(T-K-1)}}(N^{-1}\acute{S} - 2K)$$

3.3.2. Test of Cross Section Dependence

The Cross section reliance test was used to confirm if cross section dependence existed or not. Using [17], the test of Cross Section Dependence was carried out. The Pesaran (2004) equation used to determine CD was the following:

$$CD_{Test} = \frac{\sqrt{2T}}{\sqrt{N(N-1)}} \sum_{i=1}^{N-1} \sum_{k=1+i}^{N} T_{ik}$$

3.3.3. Stationarity test

Because of cross section dependence in our data, the secondary generation panel stationarity test was employed. The stationarity test from [18] was utilized within the test of unit root.

3.3.4. Cross-sectional augmented ARDL model

Because the series were integrated at various levels, the study was forced to use Cross Section Auto-Regressive Distributed Lag econometric techniques to look at the long-term relationships between the studied variables and short-term relationships among the variables of the study. The CSD-ARDL was conducted using the regression below:

$$y_{i,t} = \theta_i + \sum_{l=1}^{n_y} \lambda_{l,i} y_{i,t-1} + \sum_{l=0}^{n_z} \beta_{l,i} x_{i,t-1} \sum_{l=0}^{n_\varphi} \varphi'_{i,l} \bar{z}_{i,t-l} + \varepsilon_{it}$$

The adjustment of the above regression has given the following equation:

$$\vartheta_{CS-ARDL,\,i} = \frac{\sum_{l=0}^{nz} \widehat{\gamma}_{l,i}}{1 - \sum_{l=0}^{ny} \widehat{\lambda}_{l,i}} \quad , \vartheta_{MG} = N^{-1} \sum_{i=1}^{N} \widehat{\vartheta}_i$$

Afterwards, the CSD-ARDL ECM was conducted using the following equation:

$$\Delta y_{i,t} = \omega_i \left[y_{i,t-l} - \widehat{\varphi}_i x_{i,t} \right] - \theta_i + \sum_{l=1}^{n_{y-1}} \lambda_{l,i} \Delta_l y_{i,t-1} + \sum_{l=0}^{n_z} \beta_{l,i} \Delta_l x_{i,t-1} \sum_{l=0}^{n_\varphi} \varphi'_{i,l} \bar{z}_{i,t-l} + \varepsilon_{it}$$

3.3.5. Panel causality test

The research has used[19] test as a causality test of 2012. We were unable to conduct panel causality tests using the conventional methods, such as the Pairwise Granger Causality test in the 1960s, because of the presence of slope coefficient heterogeneity and cross section dependence. The purpose of the causality test was to determine whether there was any bidirectional causality between the series. The following part covers the empirical analysis for the study.

IV. EMPIRICAL ANALYSIS

This section involves descriptive statistics, heterogeneity coefficient of slope test, cross section dependence test, test of stationarity, Cross Section ARDL test for long-run and short-run and panel causality test. Empirical analysis has been very important for formulating policy implications.

4.1. Data statistics

The descriptive statistics for data was conducted in order to provide a good summary to the data used in the study. Data statistics involves median, mean, maximum and minimum. The following table provides more details about descriptive statistics.

Table 1: Descriptive statistics

	GDP	RE	GP	EI
Mean	6.797720	74.19443	25.69193	7.735821
Median	7.061838	81.27500	18.72500	6.759076
Maximum	13.57260	95.80000	57.91000	44.35669
Minimum	-3.358853	42.09000	4.200000	-8.237845

Source Compiled by the authors from STATA results (2022)

The findings from the table indicated that the mean of Gross Domestic Product (GDP) in both countries is 6.7% annual growth. The highest annual GDP growth in all three countries is 13.5% annual growth. The lowest annual growth in GDP in all countries involved in the study is -3.3% annual growth. For Renewable Energy Consumption (RE), the mean for all the countries is 74.1%, the maximum in all the countries is 95.8% and the lowest Renewable Energy Consumption (RE) is 42.0%. At this point, it is clear that these countries use more renewable energy than non-renewable energy.

About Gas and Petrol Consumption, the mean is 25.69%, the highest Gas and Petrol consumption is 57.9% and the lowest Gas and Petrol consumption in all the countries is 4.2%. Energy related inflation (EI) mean was 7.7% which is not lower. The highest Energy related inflation (EI) has been 44.3% and the lowest Energy related inflation (EI) was -8.2%. The study pointed out how this energy related inflation influences economic growth in the four countries (Rwanda, Ethiopia, Cambodia and Pakistan) involved in the study.

4.2. Slope coefficient heterogeneity test

In panel data, it is possible that countries may have the same characteristics as some countries depend on other countries. When some countries have homogenous characteristics it may cause biased results. In this way, it is better to examine whether countries have the same characteristics (homogenous) or different characteristics (heterogeneous). The slope coefficient test used [19] and the hypotheses were established in the following ways:

H0: Being Homogenous

H1: Being Heterogeneous

The following table indicates the results of heterogeneity coefficient of slope.

Table 2: Heterogeneity of slope coefficient test

Delta	P-Value
14.122	0.000
adj. 15.346	0.000

Source: Compiled by the authors from STATA results (2022)

The results from the table indicated that the probabilities are less than 0.05. For this reason, it must be valid not to accept null hypothesis of having homogenous slope. As matter of fact, the alternative hypothesis of having heterogeneous slope is accepted. This means that countries don't have the same characteristics and the study cannot have biased results.

4.3. Cross Section Dependence (CSD) test

The CSD was conducted so as to verify the presence or absence of cross section dependence. The CSD test was conducted using Pesaran (2004). The hypotheses were established in the following ways:

H0: Absence of CSD
H1: Presence of CSD
The following table indicates the CSD results

Table 3:Cross section dependence test

Test	Statistic	Prob.
Breusch-Pagan LM	20.02512	0.0027
Pesaran scaled LM	4.048705	0.0001
Pesaran CD	3.874593	0.0001

Source: Compiled by the authors from STATA results (2022)

The findings from the table indicated that the H0 of not having cross section dependence is not accepted in favour of accepting the alternative hypothesis stating the CSD presence. This was caused by the fact of having all probabilities less than 0.05, especially on Pesaran CD which is the best indicator of cross section dependence. This implied that the units in identical cross-section are connected. For this reason, the unit root test must adopt second generation methods.

4.4. Stationarity test

The panel stationarity test named second generation was adopted due to the fact of having Cross section dependence in our data. Unit root test was done using Pesaran (2007) stationarity test. The hypotheses were established in the following ways:

H0: Unit root absence
H1: Unit root presence
The following table indicates the unit root test results at level, at trend and constant

Table 4: Test of Panel unit root with CSD using Pesaran test at level

Variables	Test statistic	Critical value	Probability	Conclusion
GDP	-3.45654***	-2.60	0.0100	Stationary
RE	-2.17463	-2.21	0.1000	Not stationary
GP	-2.22197	-2.34	0.1000	Not stationary
EI	-2.75660***	-2.60	0.0100	Stationary

Source: Compiled by the authors from STATA results (2022)

The findings from the table indicated that GDP and EI are at level stationary and GP and RE are not stationary at level. Those variables that are I(0) is caused by the values of critical values greater than test statistics and their probabilities that are less than 0.05. Those variables that are not I(0) is caused by the values of critical values less than test statistics and their probabilities that are greater than 0.05. As matter of fact, it was necessary to conduct first difference test of unit root. The following table indicates the unit root test results at first difference, at trend and constant

Table 5: Test of Panel Unit root with CSD using Pesaran test at first difference

Variables	Test statistic	Critical value	Probability	Conclusion
RE	-8.118864**	-2.986225	0.0000	Stationary
EI	-7.846127**	-3.603202	0.0000	Stationary

Source: Compiled by the authors from STATA results (2022)

The findings from the above table indicated that the two series (RE and EI) are stationary after the first difference. This is due to the fact that the probability values are less than 0.05 and all critical values are greater than the test statistics. The results from panel unit root test with CSD using Pesaran test indicated that there is a mixture of orders of integration in the series. Some of them are I(0) and others are I(1). For, this reason, ARDL was compulsory to be used.

4.5.CS-ARDL test of cointegration

4.5.1. Cross section Dependence (CD)-ARDL Long-run model

Having series integrated at different levels obliged the study to adopt Cross Section Auto-Regressive Distributed Lag econometrics technics while examining the long-term connection among the study variables. The hypotheses were established in the following ways:

H0: Absence of cointegration among the series
H1: Presence of cointegration among the series
The following table indicates the Cross Section Auto-Regressive Distributed Lag results:

Table 6: CD-ARDL in Lon-run

Variables	Coefficient	Std. Error	t-Statistic	Prob
RE	0.095179	0.007103	13.40003	0.0000
GP	-0.002613	0.013506	-0.193506	0.0350
EI	-0.007704	0.043648	-0.176500	0.0269
D-COVID	-2.593068	1.091354	-2.376010	0.0198

Source: Compiled by the authors from STATA results (2022)

The findings from the CD ARDL model indicated all the variables coefficients are relevant statistically as the probabilities are less than 5%. The findings indicated that consumption of RE has a direct impact on economic growth in the examined countries. This is because, the coefficient (0.095179) is positive. Gas and Petrol Consumption (GP) has a significant negative effect on economic growth in the examined countries as the probability is less than 5% and the coefficient (-0.002613) is negative. Energy related Inflation and Dummy Covid-19 have a reverse impact on economic growth of the four countries involved in the study. This is because, the coefficients are negative and the P-Values are less than 0.05. All of these confirm the existence of a long-run association among the variables in long-run. It is necessary to examine the short-run causality among the variables.

4.5.2.CD-RDL short-run model

The short-run modelwas pointed out so as to affirm confirm the long-run association among the variables. The following table indicates the Cross Section (CD) Auto-regressive Distributed Lag (ARDL) short-run model.

Table 7: CD-ARDL in Short-run

Variables	Coefficient	Std. Error	t-Statistic	Prob
RE	0.095179	0.007103	13.40003	0.0000
GP	-0.002613	0.013506	-0.193506	0.0350
EI	-0.007704	0.043648	-0.176500	0.0269
D-COVID	-2.593068	1.091354	-2.376010	0.0198
ECT (-1)	-0.6437	0.12649	-5.083405	0.0000

Source: Compiled by the authors from STATA results (2022)

The findings from the short-run model indicated that the ECT(-1) is negative and significant due to its probability which is less than 0.05. As well as all the probabilities are less than 0.05, it is true to confirm that all independent

variables (Renewable resources consumption, Gas and Petrol Consumption, Energy related Inflation and D-Covid) have significantlyimpact on Economic growth in the four countries in Short-run. The ARDL-ECM proved that at the speed of 64.3% the equilibrium is approached. For this reason 100% of errors will be corrected after 1year and 6 months. After determining the short-run relationship among the series, it was necessary to conduct panel test of causality.

4.6. Panel causality test

While causality test, the study adopted Dumitrescu-Hurlin test (2012). Having heterogeneity of coefficients slope and dependence in cross sections,we could not conduct panel causality test using the traditional techniques including Pairwise Granger Causality test in 1960s. The causality test was conducted to as to check the presence or absence of bidirectional causality between the series.

Table 8: Dumitrescu-Hurlin test of causality

H0 (Null hypothesis)	Observations	Probabilities
RE does not Grander cause GDP	240	0.0034
GDP does not Grander cause RE	240	0.0107
GP does not Grander cause GDP	240	0.0035
GDP does not Grander cause GP	240	0.0200
EI does not Grander cause GDP	240	0.0340
GDP does not Grander cause EI	240	0.2602
D_Covid does not Grander cause GDP	240	0.0000
D-Covid does not Grander cause EI	240	0.0113
D-Covid does not Grander cause GP	240	0.0004

Source: Compiled by the authors from Stata results (2022)

The findings from the table indicated that there is a bidirectional causality between Renewable energy (RE) resources consumption and Gross Domestic Product (GDP) within the countries involved in the study. The results indicated also that there is bidirectional causality between Gross Domestic Product (GDP) and Gas and Petrol Consumption (GP). The results indicated also that there is unidirectional causality moving from Energy Related Inflation (EI) to Gross Domestic Product (GDP). The results indicated also that the Dummy Covid-19 has short-run causality on Gross Domestic Product (GDP), Energy Related Inflation (EI) and Gas and Petrol Consumption (GP).

V. CONCLUSION

These research results of the aforementioned technique show that Renewable Energy has a considerable and favorable impact on the economic growth of the four nations studied. GP, EI and D-Covid severely impair countries economic performance in both short and long run. Additionally, the ECM demonstrated that the model is nearing stability at a rate of 64.3% every year. Furthermore, the accuracy of long-run projections was examined in this study. Moreover, the panel causality test developed by Dumitrescu and Hurlin (2012) demonstrates a two way causal relationship between the research variables. In particular, the RE and GP cause GDP, while there is just unidirectional causality from EI to GDP. This also implies that any rule change in the explanatory variables would have a considerable impact on the dependent variable and inversely. In conclusion, a post-COVID analysis of energy usage and economic expansion in developing countries requires a comprehensive policy approach that promotes renewable energy sources, energy efficiency measures, energy access, energy diversification, and international cooperation. By implementing these policy implications, developing countries can achieve a more sustainable and inclusive energy future.

VI. POLICY IMPLICATIONS

Due to the results of the study, the following policy implications are very important to the developing countries involved in the study;

- There is a need of improving innovations and friendly environmental technologies in the renewable energy usage as the results pointed out that natural resources driven energydirectly and significantly contribute on economic growth.
- The results indicated that Inflation related to energy affects negatively the economic growth, it is recommended to the developing countries included in the study to lower prices to promote higher performance of the countries' economies.

- Moreover, hedging petrol and gas should be beneficial in managing their prices volatility. This is why the commercial policies within the developing nations included in the study should be revised and considers hedging of petrol and gas in long-term and short-term.

- Governments in investigated countries should promote a culture of setting a maximum price for Petrol and Gas in order to protect the consumers of petrol and gas. This will minimize inflation in the countries due to the fact that increase in prices of energy products lead to increase in prices of other products in the countries. In this way, the consumption of petrol and gas will have a direct effect on economic expansion of the countries.

- The study findings revealed that Covid-19 has reversely affected economic growth in the investigated nations and increased shortage of gas and petrol in the countries under the study. The countries are recommended to adopt a culture of maintaining enough gas and petrol that should be used in case of some importation challenges.

- The countries have to invest more in research and development in order to change the habits of relying more on non-renewables resources and shift to the more dependence of renewable resources.

- Increase investment in renewable energy sources: Developing countries should increase investment in renewable energy sources such as solar, wind, and hydropower. This will not only reduce their reliance on fossil fuels but also help mitigate the effects of climate change. Governments should provide incentives for private sector investment in renewable energy projects and increase access to financing.

- Promote energy efficiency measures: Energy efficiency measures such as the use of energy-efficient appliances and buildings can significantly reduce energy consumption and costs. Governments should promote the adoption of energy-efficient technologies and practices by providing incentives and creating public awareness campaigns.

- Increase access to energy: In many developing countries, a significant portion of the population does not have access to electricity. Governments should prioritize increasing access to energy by providing subsidies for off-grid solutions such as solar panels and microgrids.

- Promote energy diversification: Developing countries should diversify their energy mix to reduce dependence on a single source of energy. This will increase energy security and provide a more stable energy supply. Governments should provide incentives for the development of alternative energy sources such as geothermal and biomass.

- Address energy poverty: Energy poverty, which is the lack of access to modern energy services, is a significant issue in many developing countries. Governments should prioritize addressing energy poverty by providing subsidies for clean energy technologies and promoting energy access programs.

- Encourage international cooperation: International cooperation can help developing countries access financing, technology, and expertise to develop their energy sector. Governments should prioritize building partnerships with international organizations and donor countries to support their energy goals.

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